**ENTRO**
**EASTERN NILE TECHNICAL REGIONAL OFFICE**

# BARO-AKOBO-SOBAT MULTIPURPOSE WATER RESOURCES DEVELOPMENT PROJECT STUDY

## *BASELINE, DEVELOPMENT POTENTIALS, KEY ISSUES AND OBJECTIVES REPORT*

*Final version - April 2017*

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# BARO-AKOBO-SOBAT MULTIPURPOSE WATER RESOURCES DEVELOPMENT STUDY

## Baseline, Development Potentials, Key issues and Objectives report

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# ACRONYMS AND ABREVIATIONS

| | |
|---|---|
| AADE | Alwero Agricultural Development Enterprise |
| AfDB | African Development Bank |
| ACORD | Association for Cooperative Operations Research and Development |
| ACTED | Agency for Technical Cooperation and Development |
| ASPF | Agriculture Sector Policy Framework |
| BAS | Baro Akobo Sobat |
| CAMP | Comprehensive Agriculture Development Master Plan |
| CBA | Cost Benefit Analysis |
| CBD | Convention on Biological Diversity |
| CFA | Cooperative Framework Agreement |
| CMA | Catchment Management Association |
| CMS | Convention on Migratory Species |
| COMESA | Common Market for Eastern and Southern Africa |
| CRA | Cooperative Regional Assessment |
| CRU | Climatic Research Unit |
| CSA | Central Statistic Agency |
| CWA | Consolidated WaSH Account |
| DEM | Digital Elevation Model |
| DFID | Department for International Development |
| EAC | East African Community |
| EAPP | East Africa Power Pool |
| EC | Electrical conductivity |
| EEP | Ethiopian Electric Power |
| EEPCO | Ethiopian Electric Power Corporation |
| EEU | Ethiopian Electric Utility |
| EHA | Erosion Hazard Assessment |
| EIA | Environmental Impact Assessment |

| | |
|---|---|
| ENID | Eastern Nile Irrigation and Drainage |
| ENCOM | Eastern Nile Council Of Ministers |
| ENPM | Eastern Nile Planning Model |
| ENPT | Eastern Nile Power Trade |
| ENSAP | Eastern Nile Subsidiary Action Plan |
| ENTRO | Eastern Nile Technical Regional Office (NBI) |
| EPA | Environmental Protection Authority |
| EQSA | Ethiopian Quality and Standards Agency |
| ERR | Economic Rate of Return |
| ESIA | Environmental and Social Impact Assessment |
| ESIF | Ethiopian Strategic Investment Framework |
| EU | European Union |
| EVDSA | Ethiopian Valley Development Study Authority |
| EWCA | Ethiopian Wildlife Conservation Authority |
| EWNRA | Ethio Wetlands and Natural Resources Association |
| EWRP | Emergency Wetlands Reserve Program |
| FAO | Food and Agriculture Organization |
| FPEW | Flood Preparedness and Early Warning |
| FTU | Formazin Turbidity Unit |
| GCM | Global Climate Model |
| GDEM | Global Digital Elevation Model |
| GDP | Gross Domestic Product |
| GEF | Global Environment Facility |
| GHCN | Global Historical Climatology Network |
| GIS | Geographic Information System |
| GoE | Government of Ethiopia |
| GoSS | Government of South Sudan |
| GTP | Growth and Transformation Plan |
| GWh/y | GigaWatt hour/year |

| | |
|---|---|
| HEP | Hydroelectric Power |
| HPP | Hydro Power Plant |
| HRW | Human Rights Watch |
| ICI | International Climate Initiative |
| ICSHP | International Center On Small Hydro Power |
| IDEN | Integrated Development of Eastern Nile |
| IDP | Internally Displaced People |
| IGAD BMP | Intergovernmental Authority on Development Biodiversity Management Programme |
| ILWRM | Integrated Land and Water Resources Management |
| IPCC | Intergovernmental Panel on Climate Change |
| IPP | Independent Power Producer |
| IUCN | International Union for Conservation of Nature and Natural Resources |
| IWMI | International Water Management Institute |
| IWRDMP | Integrated Water Resources Development and Management Plan |
| IWRM | Integrated Water Resource Management |
| JMP | Joint Multipurpose Project |
| LFDP | Lake Fisheries Development Project |
| LGP | Length og Growing Period |
| LVBC | Lake Victoria Basin Commission |
| MAE | Mean Annual Evapotranspiration |
| MAFCRD | Ministry of Agriculture, Forestry, Cooperatives and Rural Development |
| MASL | Meters Above Sea Level |
| MAP | Mean Annual Precipitation |
| MAR | Mean Annual Runoff |
| MCA | Multi Criteria Analysis |
| MDG | Millennium Development Goals |
| MDTF | Multi Donor Trust Fund |
| MEDIWR | Ministry of Electricity, Dams, Irrigation and Water Resources |
| MERET | Managing Environmental Resources to Enable Transitions |

| | |
|---|---|
| MLFI | Ministry of Livestock and Fisheries |
| MoA | Ministry of Agriculture |
| MoEN | Ministry of Environment |
| MoFEP | Ministry of Finance and Economic Planning |
| MoWIE | Ministry of Water, Irrigation and Energy |
| MSIOA | Multi Sector Investment Opportunity Analysis |
| MTR&B | Ministry of transport, roads and bridges |
| MW | Mega Watt |
| MWC&T | Ministry of Wildlife Conservation and Tourism |
| NABU | Nature and Biodiversity Conservation Union |
| NAM model | North American Mesoscale model |
| NB-DSS | Nile Basin Decision Support System |
| NBI | Nile Basin Initiative |
| NBRP | Nile Basin Research Program |
| NCORE | Nile Cooperation for result project |
| NDVI | Normalized Difference Vegetation Index |
| NELSAP | Nile Equatorial Lakes Subsidiary Action Program |
| NEPAD | New Partnership for Africa's Development |
| NGO | Non-Governmental Organization |
| NIDPS | National Irrigation and Drainage Policy and Strategy |
| Nile-COM | Nile Council of Ministers |
| NTEAP | Nile Transboundary Environment Action Project |
| OESPO | Oromia Economic Study Project Office |
| OIDA | Oromia Irrigation Development Authority |
| OWNP | One WaSH National Program |
| PA | Protected Area |
| PBF | PeaceBuilding Fund |
| PBO | Programme Based Operations |
| PFM | Participatory Forest Management |

| | |
|---|---|
| PIM | Project Implementation Manual |
| PLSPP | Policies, Legislation, Strategies, Plans, and Programs |
| PPA | Power Purchase Agreement |
| PPP | Private Public Partnership |
| PMU | Project Management Unit |
| PRSP | Poverty Reduction Strategy Program |
| PV | Photo Voltaïc |
| RATP | Regional Agricultural Trade and Productivity Project |
| REF | Rural Electrifiction Fund |
| RPSC | Regional Project Steering Committee |
| RSS | Republic of South Sudan |
| RUSLE | Revised Universal Soil Loss Equation |
| RWSS | Rural Water Supply and Sanitation |
| SAP | Subsidiary Action Program |
| SAR | Sodium Adsorption Ratio |
| SCRP | Soil Conservation Research Project |
| SEA | Strategic Environmental Assessments |
| SIS | Soil Information System |
| SLMP | Sustainable Land Management Program |
| SMHI | Swedish Meteorological and Hydrological Institute |
| SNNPR | Southern Nations, Nationalities and Peoples' Region |
| SREP | Supervisory Review and Evaluation Process |
| SRFE | Satellite Rainfall Estimates |
| SRTM | Shuttle Radar Topographic Mission |
| SSEA | Strategic Social and Environmental Assessment |
| SSI | Small Scale Irrigation |
| SSRF | South Sudan Recovery Fund |
| SVP | Shared Vision Program |
| SWAT | Soil and Water Analysis Tool |

| | |
|---|---|
| SWC | Soil and Water Conservation |
| SWOT | Strength Weakness Opportunity Threat |
| SWSC | Soil-Water Storage Capacity |
| TCU | True Color Unit |
| TDS | Total Dissolved Solid |
| TLU | Total Livestock Unit |
| UN | United Nations |
| UNDP | United Nations Development Program |
| UNEP | United Nations Environment Programme |
| UNHCR | United Nations High Commissioner for Refugees |
| UNICEF | United Nations Children's Fund |
| UNIDO | United Nations Industrial Development Organization |
| UNWTO | United Nations World Tourism Organization |
| USAID | United States Agency for International Development |
| UWSS | Urban Water Supply and Sanitation |
| WaSH | Water Sanitation and Hygiene |
| WA | Wetland Action |
| WB | World Bank |
| WBISPP | Woody Biomass Inventory and Strategic Planning Project |
| WCS | Wildlife Conservation Society |
| WCYA | Women, Children and Youth Affairs |
| WEES | Water for Eastern Equatoria |
| WFP | World Food Program |
| WM | Watershed Management |
| WRMA | Water Resources Management Authority |
| WRMD | Water Resources Management and Development |
| WSS | Water Supply and Sanitation |
| WTTC | World Travel and Tourism Council |
| WUA | Water Users Association |

# EXECUTIVE SUMMARY

# INTRODUCTION

## OVERVIEW OF THE STUDY AND PREVIOUS ACTIVITIES

The objective of the consultancy services is to assist ENTRO in preparing an Integrated Water Resources Development and Management Plan (IWRDMP) based on a Strategic Social and Environmental Assessment (SSEA), and further develop investment packages for cooperative development in the Baro-Akobo-Sobat sub-basin. The study is divided into four components.

- Component 1, which runs throughout the study and culminates in the production of the Integrated Water resources Development and Management Plan (IWRDMP). It includes the following steps:
  - Scoping of work for the baseline phase. This step has been completed
  - Establishment of a baseline, including the identification of potential development interventions (identified and otherwise). Understanding of issues, challenges and opportunities.
  - Screening of development and management options through a SSEA developed as part of the study. A draft SSEA framework has been prepared.
  - Stakeholder-driven development of an Integrated Water Resources Development and Management Plan (IWRMDP).
- Component 2 is aimed at fast-tracking the preparation of a limited number of short-term projects. A Concept Note covering at 7 potential projects has been prepared and the next step will be the screening of projects and selection of 3 projects for project preparation and climate proofing
- Component 3 comprises the identification and profiling of medium and long-term projects. This activity will follow directly on from the development of strategic actions and will be in line with the strategic objectives. Medium to long-term projects are seen as mainly large infrastructure projects that will require a significant amount of preparation and associated cost. Compilation of terms of reference (ToR), comprising ToR for feasibility studies and ToR for Environmental
- Component 4 concerns the provision of Project Implementation Support and stakeholder participation.

## BASELINE, DEVELOPMENT POTENTIALS, KEY ISSUES AND OBJECTIVES REPORT

The main purposes of this report, the **Baseline, Development Potentials, Key issues and Objectives report** are i) to ensure that the required information is available to build the SSEA and ii) is to reach consensus on the vision and strategic objectives required to develop water resources in the Baro-Akobo-Sobat Basin and iii) provide insight into possible short-term interventions. For greater clarity, this report has been divided in three parts:

- Part 1: Baseline Study :

  The baseline study aims at providing a clear view on the current situation in the basin in terms of bio-physical (supported by a water balance model), socio-economic and legal/institutional environments. This situational analysis, has been combined with a review of the ongoing initiatives to develop water resources uses in the basin.
- Part 2: Potential developments in the Baro-Akobo-Sobat basin

  A sectoral approach has been developed to list the existing development projects and identify new projects and the potential for development. The key output of Part 2 is to identify the water related opportunities in the basin.
- Part 3: Summary of the findings – key issues and objectives for the Baro-Akobo-Sobat basin

  Part 3 aims at integrating the information from Parts 1 and 2 in order to propose a vision and strategic objectives for the basin. It should be noted that the vision and strategic objectives for the basin must be agreed and shared by the key stakeholders in the basin to ensure that the proposed IWRDMP will be implemented. This will be one of the objectives of the baseline workshop.

# PART 1: BASELINE

## Spatial and Temporal Limits

### Spatial boundaries

The study area is the Baro-Akobo-Sobat Basin as defined by its hydrographic boundaries. The existing boundaries were reviewed during the baseline and some modifications made. Although minor, they did result in the Kinyetti River, which takes its source in the Imatong Mountains now being included in the basin.

It is important to recognize that the development and management of water resources cannot take place in isolation of other parts of the countries in which the basin is situated. Influences such as the location of export markets, communication and transport infrastructure, electrical interconnection and the location of administrative and commercial centres outside of the basin have to be taken into consideration.

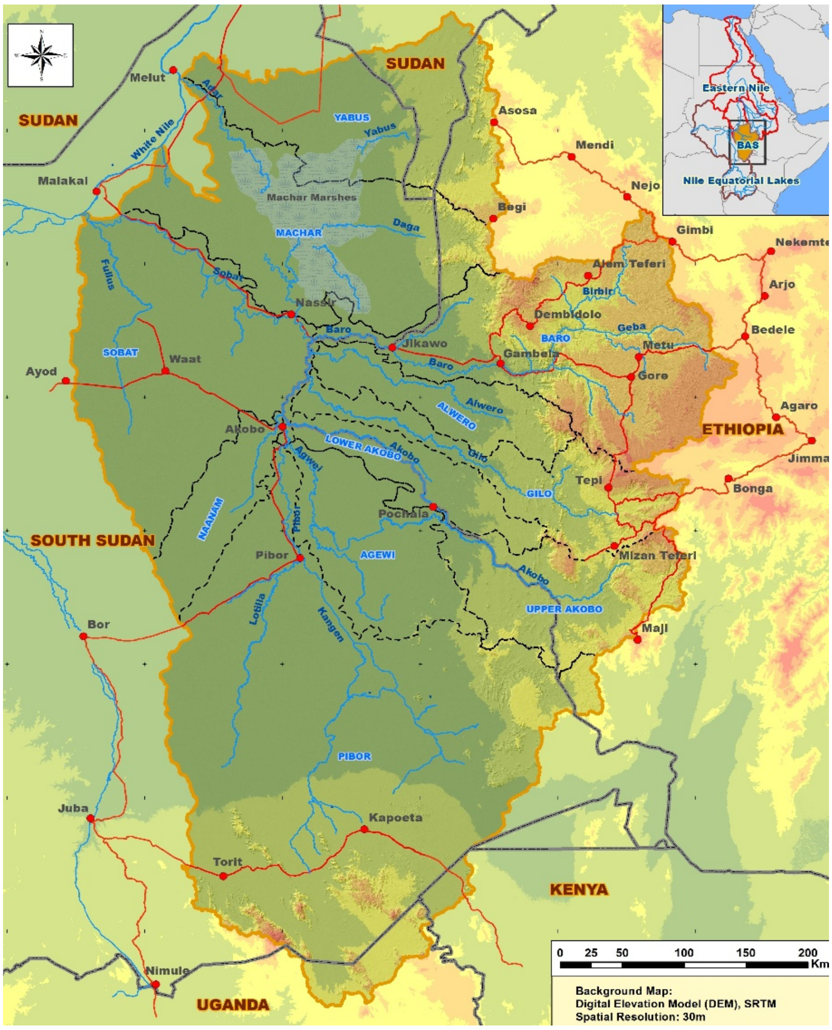



*Figure 2-1: Drainage and Relief of the Baro-Akobo-Sobat Basin, showing basin limits*

### Temporal limits

The planning horizon for the IWRDMP has been taken as 25 years. Within this time frame "short-term" is taken as up to 5 years, "medium term" as 5 to 15 years and "long-term" as 15-25 and beyond.

# BIOPHYSICAL ENVIRONMENT

## Physical Environment

| Sub-basin | Area (km$^2$) |
|---|---|
| Baro | 31,234 |
| Alwero | 7,368 |
| Gilo | 12,081 |
| Upper Akobo | 14,980 |
| Agwei | 14,388 |
| Lower Akobo | 7,920 |
| Pibor | 77,309 |
| Nanaam | 7,403 |
| Sobat | 34,625 |
| Machar | 46,753 |
| TOTAL | 254,061 |

The Baro-Akobo-Sobat Basin can be delineated into 10 primary sub-basins as shown in the adjacent table. The Baro, Gilo and Akobo River originate from the south-western part of the Ethiopian Plateau and then flow westward where they join the Pibor River flowing from the south. As these rivers enter the low-lying plains, they disperse through small channels in some areas or spill into floodplains and wetlands and even across into adjacent catchments during high flow events. Downstream of Gambella, the Baro River is joined by the Jokau stream from the north. Along the same reach, the Baro River bifurcates into the Adura River to the south, which joins the Baro River again upstream of its confluence with the Pibor River.

Along this reach, the Baro River also spills its banks towards the Alwero River to its south, which later on joins the Baro River. The Baro River discharges significant water volumes through the Khor Machar and by means of overbank spills to the Machar marshes during the high flood season. The Machar marshes, which has a maximum area of around 8 000 km$^2$, lies to the north of the main channel of the Baro River and from local runoff via the "eastern torrents", which originate on the Ethiopian escarpment. In the rainy season these wetlands expand to cover a large area east of Malakal and north of the Baro River. Small amounts of water from the Machar marshes occasionally enter the White Nile northeast of Malakal through the Khor Adar.

## Climate and Climate Change

The Baro-Akobo-Sobat Basin is characterised b
precipitation across the basin is considerable due
across the basin is shown on the adjacent map.

Across the basin, July and August are typically th
significant rainfall. In the eastern highlands and C
and September, with about 80% to 90% of the rai
part of the basin, the rainfall season tends to be s

The IPCC Fifth Assessment Report (AR5) indica
Akobo-Sobat basin by the end of this century, pa
However, the report provides no certainty on the
the potential impacts of climate change over the
(CGCM3.1) as well as a regional climate model
methods.

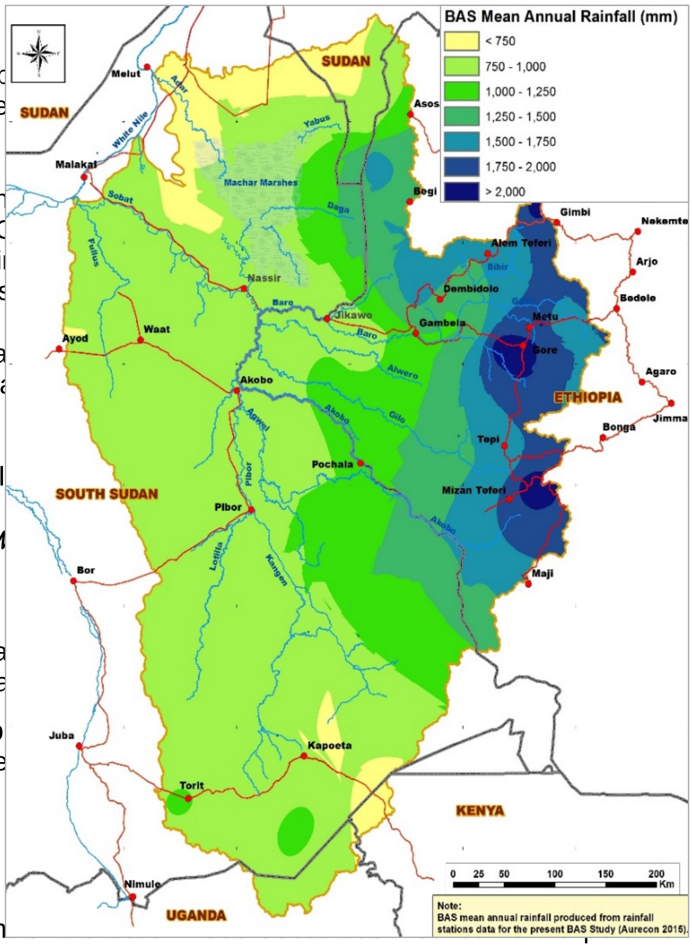



*Figure 2-2: M*

The results showed:

- A general incremental increasing trend of a
also appears to increase with decreasing a
- A general increase in mean annual precip
potential slight reduction in the MAP for the
was observed.

## Surface Water

A critical component related to the developmen
impacts of development interventions and management options on the surface water regime in the basin, both in terms of quantity and spatial and temporal impacts. The mean annual outflow of the Baro-Akobo-Sobat Basin into the White Nile of 12.56 billion m$^3$/a contributes about half of the flow of the White Nile at

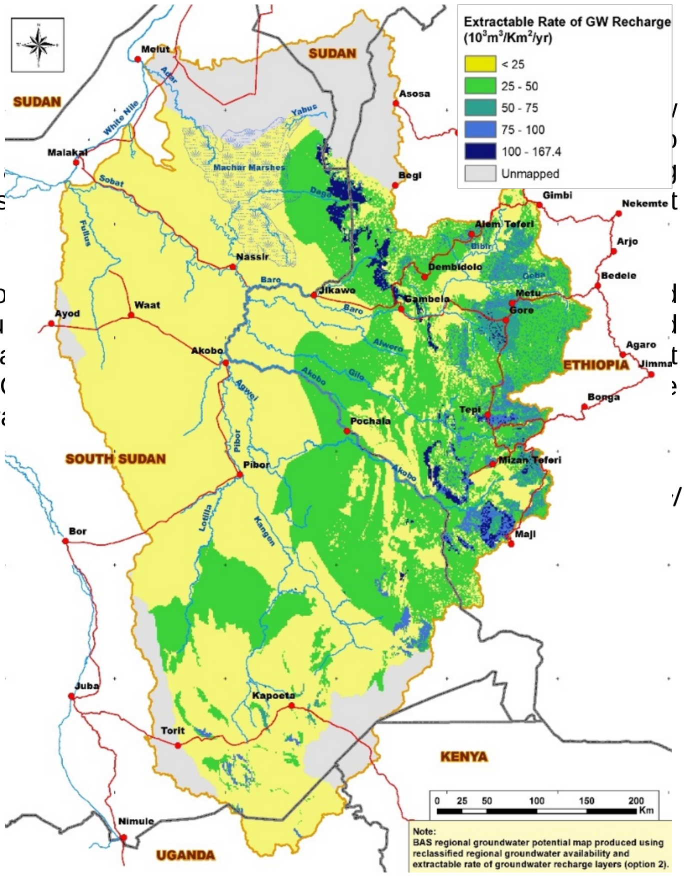
Malakal and about a sixth of the flow of the Main Nile at Aswan. The Baro-Akobo-Sobat Basin has distinct hydrological regions, with most of the runoff being generated in the mountainous, high rainfall areas of the Ethiopian Highlands. Due to overbank spillage and evaporation, significant losses occur in the Gambella Plains, the *Machar marshes* and the wetlands and swamps in the southern and central parts of the Pibor sub-basin.

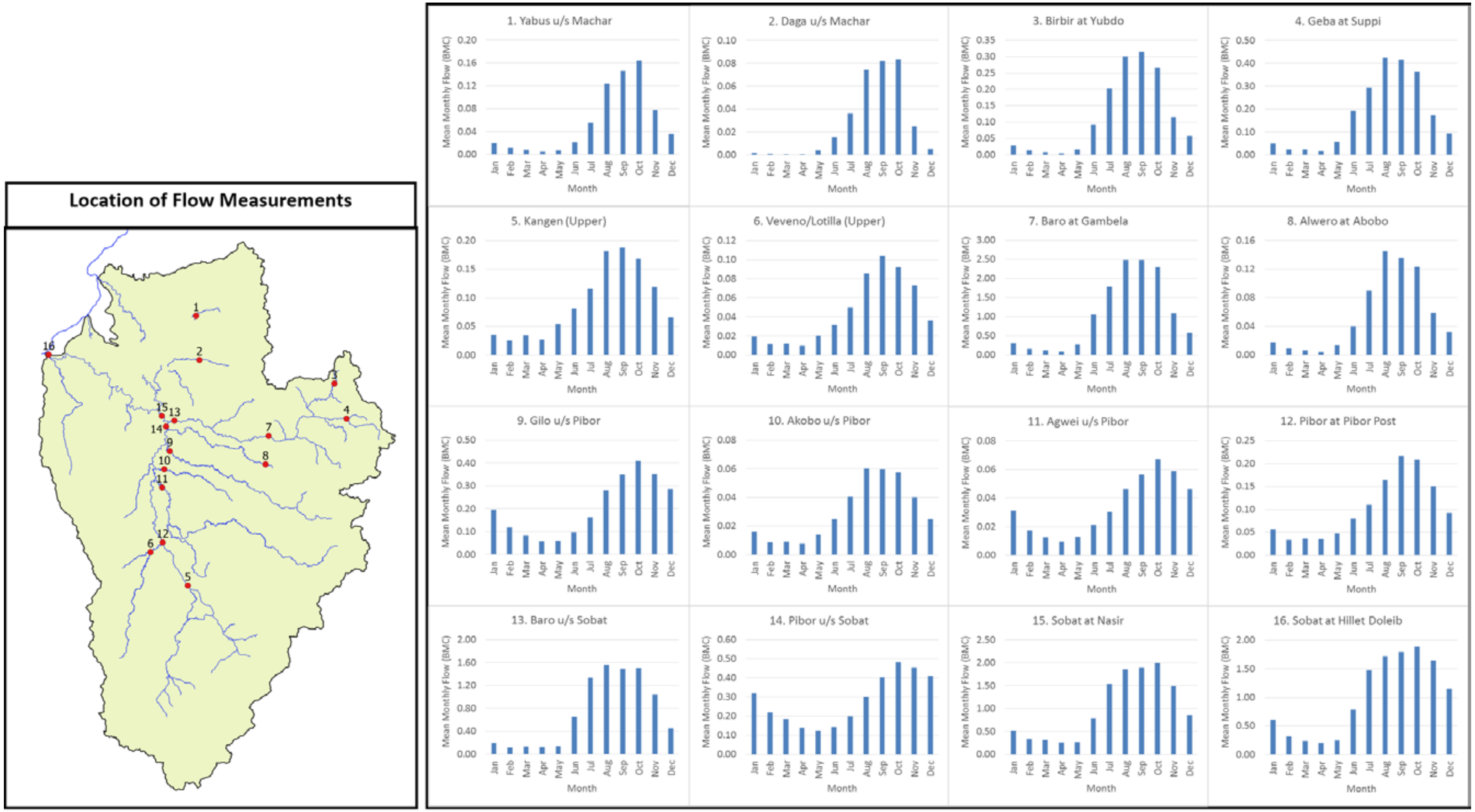
In terms of flow volume, the Baro River constitutes the main river in the basin. At Gambella, the Baro River has a mean annual flow of about 12.9 billion $m^3$/a. Downstream of Gambella, this volume gets significantly reduced as the Baro River frequently overtops its banks during the wet season with spills onto the Gambella floodplains and also to the *Machar marshes*, while the river receives some inflow from the Alwero River. At is confluence with the Pibor River, the mean annual flow of the Baro River has reduced to 9.69 billion $m^3$/a. Figure 2-4 displays the seasonal flow patterns at key locations in the major rivers within the basin and also provides information on the mean annual flow at each location.

## **Groundwater**

The groundwater supply potential for the entire
approach was developed and involved collating,
areas without data, developing a system to group
an approach to quantify these areas. The yields s
this stage.

There is considerable variation in water quality o
geochemical processes. The available literatu
throughout the Blue Nile Basin part of the study a
uses. There are, however, localized exceptions.
unconsolidated sediments, and where water is dra






| Mean Annual Runoff in BCM | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 Yabus u/s Machar | 0.68 | 5 Kangen (Upper) | 1.10 | 9 Gilo u/s Pibor | 2.46 | 13 Baro u/s Sobat | 8.73 |
| 2 Daga u/s Machar | 0.33 | 6 Veveno/Lotilla (Upper) | 0.55 | 10 Akobo u/s Pibor | 0.36 | 14 Pibor u/s Sobat | 3.38 |
| 3 Birbir at Yubdo | 1.42 | 7 Baro at Gambela | 12.69 | 11 Agwei u/s Pibor | 0.41 | 15 Sobat at Nasir | 12.11 |
| 4 Geba at Suppi | 2.13 | 8 Alwero at Abobo | 0.67 | 12 Pibor at Pibor Post | 1.23 | 16 Sobat at Hillet Doleib | 12.07 |

*Figure 2-4: Hydrology of the Baro-Akobo-Sobat Basin*

## Water Quality and sedimentation

### *Water quality*

There is no form of regular water quality monitoring in the E basin. Surface and groundwater quality data have been collected on an ad hoc basis for various studies but these have not been collated into a central database that is accessible to water resources managers and to consultants alike. The ENTRO One System Inventory report (ENTRO, 2007) concluded that water quality in the Baro-Akobo-Sobat sub-basin was not threatened. Although water quality is not yet a problem in the Baro-Akobo-Sobat system, there are worrying signs of impacts that could, cumulatively, start to have a negative impact on water users in the basin. These include localised impacts of solid waste and wastewater impacts from urban and rural settlements, oil exploration and extraction in the Marchar Marches, deforestation in the Ethiopian highlands and the impacts on sediment loads in the rivers draining the highlands, artisanal gold mining in the highlands and the impacts on sediment loads and trace metal pollution, and invasive aquatic weeds starting to impede navigation and impacting on the dissolved oxygen concentrations in the water.

It is recommended that routine flow and water quality monitoring be implemented as recommended by the current NBI Hydromet Project (NBI, 2014a) in order to improve the water quality knowledge base in the Baro-Akobo-Sobat sub-basin and to provide a platform for the early identification and investigation of potential water quality problems in the sub-basin.

ENTRO (2007) identified malaria as a major concern that was increasing as it was difficult to control. Other water related diseases included Schistosomiasis, Typhoid, Diarrhoea, Helminthiasis, Leshimaniasis, and Onch ocerchiasis. Outbreaks appeared to be associated with the seasonal flooding of the low-lying areas.

### *Sedimentation*

A major issue in all of the Baro-Akobo-Sobat Basin concerns suspended solid loads in surface waters as a result of erosion. The high sediment loads in the rivers are the results of high topographic slopes, high intensity rainfall patterns, poor farming practices and deforestation due to population pressure and commercial exploitation of wood resources.

There is no sediment database available in the basin and available data are too limited to deduce any meaningful sediment yield-discharge relationships. Consequently, the SHETRAN model (Ewen et al., 2000) was used to develop a sediment yield map for the basin and the results are summarised in Figure 2-5.

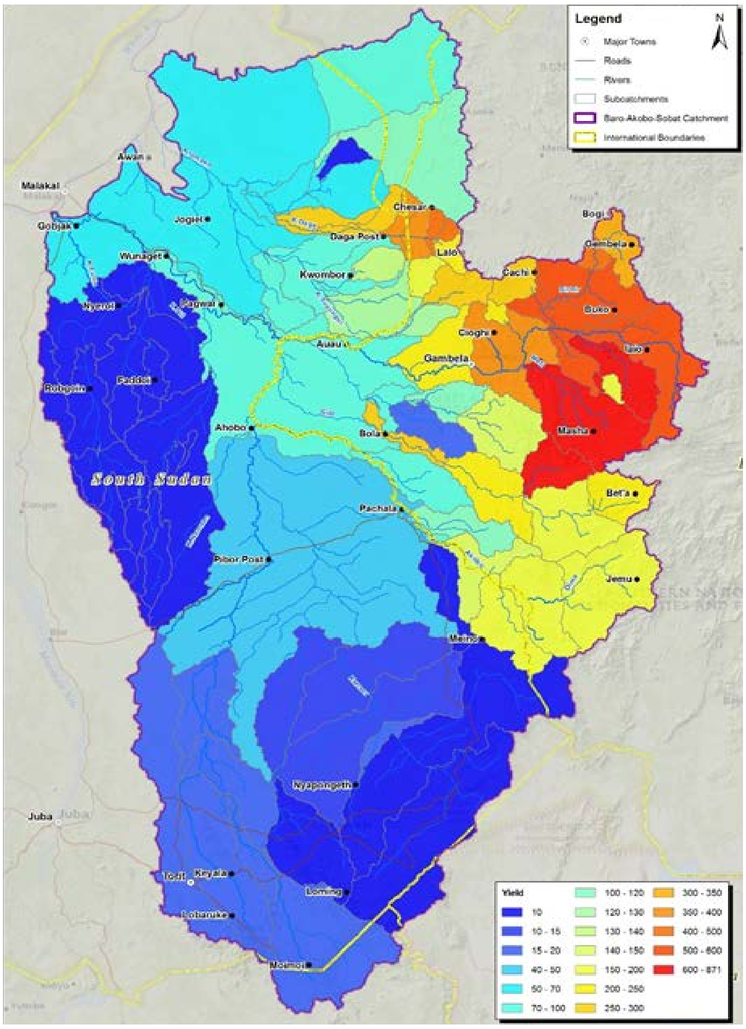



*Figure 2-5: Cumulative sediment yield in the basin in t/km2/a*

## Floods and droughts

The Gambella Plains to the west of Gambella flood almost every year. This flooding is mainly caused by the limited conveyance capacity of the mild sloping Baro, Alwero, Gilo and Akobo rivers and is exacerbated by the backwater effects from the Pibor and Sobat Rivers, direct heavy rainfall over the flood plains and deforestation in the upper catchment areas, which increases the flood runoff response and flood volumes and also leads to excessive sedimentation. The flooded area can be extensive, in 1988, an area close to 10,000 km$^2$ was inundated along the Gambella Plain during October and November. Apart from the seasonal flooding along the plains, there are also occasional flash floods, especially in the southern and south-western parts of the basin in South Sudan. Extreme floods in the region have occurred in 1934, 1946, 1962, 1996, 2007 and 2010.

The regularly flooded areas within the plains are mainly used as pastures and for recession agriculture and many people in the Gambella region live along the river banks. Structures within the floodplain include cattle enclosures, isolated tukuls and several large villages, especially along the Baro River. During the 1988 flood, a significant portion of Gambella and almost the entire town of Itang were flooded with severe socio-economic impacts. Although the flooding has severe negative impacts including loss of life, structural damage to infrastructure, displacement, health risks and water logging of pastures and crops, the annual floods also support recession agriculture and provide fertile pastures to support the extensive cattle farming in the area.

The flood season in the upper part of the Gambella Plain typically extends from July to October, but due to the attenuating affects of the floodplains, the flood season along the lower part of the Plain can last up to November and even December. Figure 2-6 shows the progression and extent of inundation in the Gambella Plains and *Machar marshes* for the period July to Dec 2007.

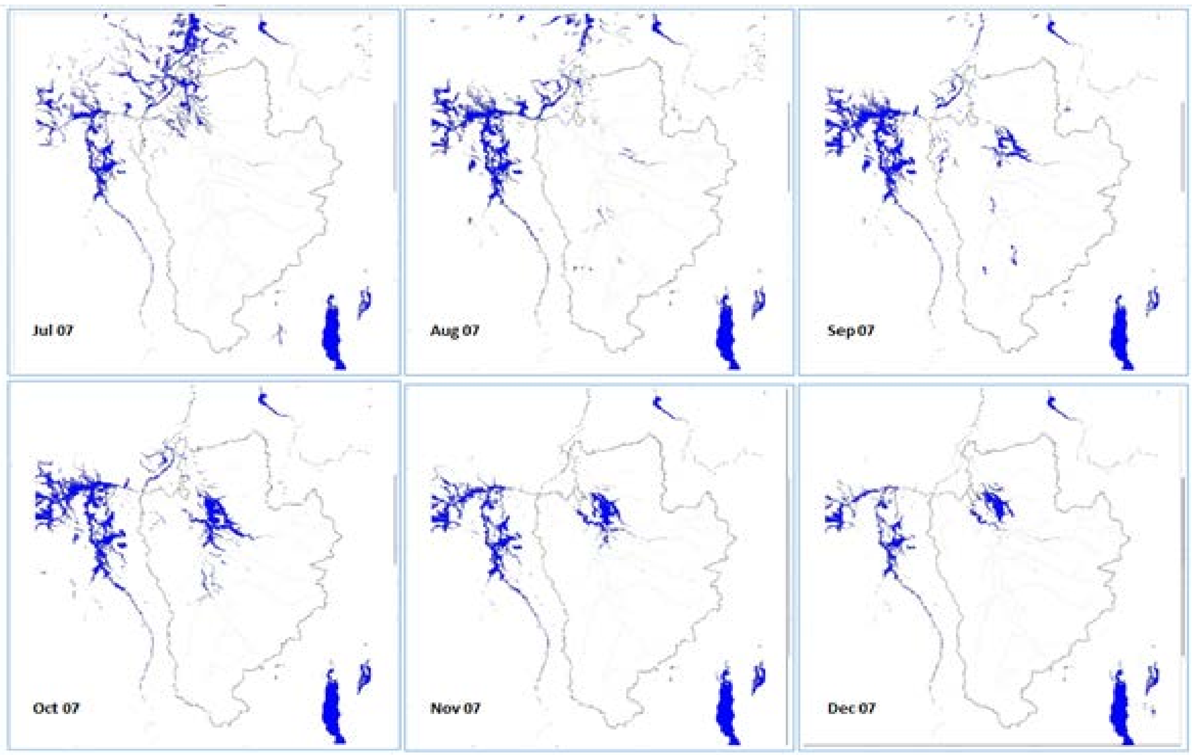



*Figure 2-6: Flood progression in the Gambella Plains and Machar Marshes during the 2007 floods*

*(Miolane et al., 2015)*

Flood protection measures along the Gambella Plain should ideally involve a combination of structural measures (e.g. dikes or upstream flood attenuation dams) and non-structural measures aimed at reducing the impacts of flooding in vulnerable areas. It is imperative that flood protection works are constructed to adequately protect future developments within the Gambella Plain such as commercial agriculture schemes, from flooding, and that the cost of these protective measures are included in the economic and financial evaluation of these schemes.

The potential impacts of droughts are many and varied and have environmental, agricultural, health, economic and social consequences. The effect varies according to vulnerability. It affects humanity in a number of ways including loss of life, crop failures and food shortages which may lead to famine in many regions, malnutrition, health issues and mass migration in search of food and water. It also causes damage to infrastructure and the environment and is regarded as a major cause of land degradation, aridity and desertification. Within the Baro-Akobo-Sobat Basin, the main livelihoods systems include pastoralism, farming and ex-pastoralism – those who have dropped out of pastoralism and now survive on petty income-earning activities. Subsistence farmers and pastoralists have attempted to build resilience to meteorological droughts by selecting crops that are more sturdy to survive in stressed climatic conditions or by migrating to areas less affected by droughts. However, this causes social and political tensions.

The spatial variation of rainfall in the Baro-Akobo-Sobat Basin is considerable due to the significant variation in elevation across the basin. High altitudes (above 2000 masl) are characterised by high moisture and longer wet periods than the lower lying areas (less than 500 masl). On the Gambella Plain, only about six years in ten have a dependable rainfall of at least four months, which is required to support good yields of most annual crops (ENTRO, 2014). Inter-annual variability is much higher around Gambella than in the highlands.

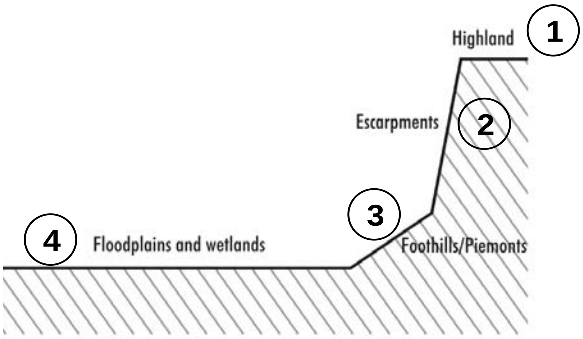
South Sudan and Ethiopia, including the Baro-Akobo-Sobat Basin, have experienced recurring droughts followed by food shortages and famines over the last fifty years. Droughts occurred in 1965, 1969, 1972/3, 1980, 1983/4, 1987, 1990, 1989, 1991, 1997, 2000, 2003, 2006, 2008, 2009 and 2012.

# BIOLOGICAL ENVIRONMENT

## Flora and Fauna, Land Use and biodiversity features

### INTRODUCTION/DELINEATION OF BIOPHYSICAL AREAS

The baseline information concerning environmental features of the BAS is organized by biophysical areas. This should allow a better understanding of the BAS environment functionalities and their interlinkages with water resources and uses than a classical thematic approach.




| Biophysical area of the BAS | Surface area (km$^2$) | % of the BAS |
|---|---|---|
| Escapments | 57439 | 22% |
| Highlands | 13956 | 5% |
| Piedmont / FootHills | 65563 | 25% |
| Flood plain and plain | 125668 | 48% |
| Total basin | 262626 | 100% |

*Figure 2-7: Proposed biophysical area in the BAS*

### HIGHLANDS

These mountains areas are characterised by very high rainfall (from 2000 to 2500 mm per year) and moderate evapotranspiration compared to floodplains. They are the sources areas for significant rivers such as the Baro, Alwero, Gilo, Akobo and Kineti and the population density is very high.

The Ethiopian highlands of the BAS are part of the Ethiopian Upper Montane Forests, Woodlands, Bushlands and Grasslands ecoregion and South Sudan highlands are part of the East African Montane Forests ecoregion.

Currently, the highland areas are still largely covered with forest, even if forests have been severely encroached by agriculture. Elsewhere in the ecoregion (outside the BAS), these forests have almost disappeared. These forest remnant areas in the highlands are playing a crucial role in regulating river flows.

### HIGHLANDS

The main threats to the BAS Highlands can be summarised as follows:

- Global threats to the BAS Highlands: The Ethiopian Upper Montane Forests, Woodlands, Bushlands and Grasslands ecoregion as a whole is severely threatened. Very high population density (1,000 hab/km$^2$ and associated subsistence farming, demand for more land natural products are the predominant reasons for the widespread loss of vegetation.
- Specific threats to highlands forest ecosystems: Highland areas of the basin were formerly covered with high forest. Natural forest has significantly depleted with only a small part intact.
- Annual average deforestation rate in the basin is expected to be around 1.2 - 1.6 %. The recent estimated rate of loss of highland forests reaches 80,000 - 200,000 ha/year in the Kafa region, a rate that would imply complete disappearance of natural forest within 10 years. Drivers or deforestation Kafa are:
  - “Agriculture expansion: Mainly observed at forest borders, with harvested wood used as an additional income (fire wood, or charcoal) or for own consumption.
  - Resettlement: Widespread illegal/uncontrolled use, conversion of forest land for settlement.
  - Concessions (coffee): Large scale coffee investment (coffee investment area).
  - Property rights: The unsecure defined allocation of property rights and the land tenure system
  - Unsustainable use of forest resource: Legal and illegal forest use is increasing since customary user rights have been replaced by state sanctioned rights.
- Specific threats related to highland wetlands ecosystems: Several studies have revealed that wetlands have been drained for growing food crops for more than a century. Highland wetlands also support other important uses for local communities, but even these traditional uses can, when not properly managed, can contribute to wetlands degradation.

### ESCARPMENT

The area supports East African evergreen and semi-evergreen forests, woodlands, and shrublands. Moister sites in southwest forest patches are dominated by tall trees, chiefly *Aningeria* and other Sapotaceae, species of Moraceae, and species of *Olea* (Burgess N. & al, 2004). Transitional forests occur between 500 and 1,500 m in Illubator and Kefa and have rainfall close to 2,000 mm per annum. These transitional forests change to Afromontane forests at approximately 1,500 m altitude in the southwest, where the rainfall is between 700 and 1,500 mm. *Coffea Arabica* is the dominant natural understory shrub and wild coffee is harvested.

The Ethiopian Lower Montane Forests, Woodlands, and Bushlands ecoregion supports a variety of forest types with associated bushland and woodland habitats and consequently have high species richness and endemic species. For example, the Mejang area is characterized by a very rich biodiversity, many rare and endemic species and endemic plants (three are endangered). *Coffea Arabica* grows naturally in the escarpments, contrary to higher areas, where it has been transplanted.

The main threats to the BAS Escarpments can be summarised as follows:

- For the time being, there is no significant pressure and human encroachment in the very steep parts of this area. They are covered with woody grass land and are used for grazing and wildlife habitat. This is why the escarpments host the largest areas of natural forest found in the Ethiopian Lower Montane Forests, Woodlands, and Bushlands ecoregion. However, with the development of access roads and the increasing demand for fuel wood and charcoal, people could start exploitation of fuel wood and charcoal that would deplete woodland and cause degradation.
- In accessible parts of the escarpments, all natural habitats are highly threatened because they have been reduced to small patches and are severely fragmented.
- Specific causes of deforestation in Mejang area are identified expansion of coffee plantation, Settlements and Agricultural expansion,Logging, Fire ,and Local wood consumption.

The BAS escarpments ecosystems have been long poorly protected. As already mentioned, recent biosphere reserves on both highlands and escarpments have been created in the basin:

- Government of Ethiopia has adopted biosphere reserve approach for the first time in 2010 by creating the Yayu Coffee Forest in Oromia and the Kafa in SNNP regional states;
- The neighboring Sheka Forest has also become the third biosphere reserve in 2012 initiated and supported by MELCA Ethiopia (MELCA, 2014).

National Forest Priority Areas theoretically cover the entire forests areas of BAS highlands, escarpments and Foothills but do not provide effective protection and are not known at local level.

### FOOTHILLS / PIEDMONTS

Foothills or Piedmonts are situated between 700 and 1,100 m and form a transition area between escarpments, characterized by very steep slopes and flood plains which are extremely flat. The rainy season lasts from April to September. The foothills areas are part of the eastern block of **East Sudanian Savanna ecoregion** in Ethiopia and southern part of the basin and **Northern Accacia Commiphora Bushland an Thicket ecoregion** in the southwestern part of South Sudan. Both ecoregions belong to the Tropical and Subtropical Grasslands, Savannas, shrublands and Woodlands Biome. They are mainly covered by shrubs, dry savannas and Woodlands.

These ecoregions have low rates of faunal endemism, but are importants area for endemic plants. Threatened mammal species include elephants (Loxodonta Africana), wild dog (Lycaon pictus), cheetah (Acinonyc jubatus), and lion (Panthera leo). The roan antelope’s (Hippotradus equinus) can also be found.

Main threats to the BAS Foothill ecosystems include seasonal shifting of cultivation, overgrazing by livestock, cutting of trees and bushes for wood, burning of woody materials for charcoal and and uncontrolled wild fires.

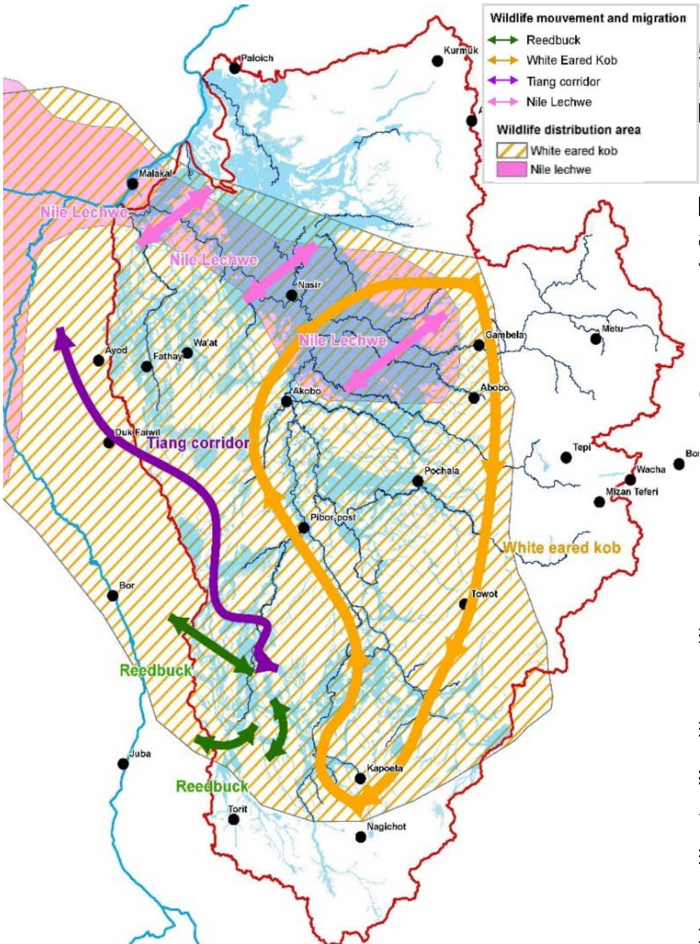
The main threats to the species come from overgrazing, poaching and overhunting for meat. Climate change is an additional threat exacerbating these impacts.

## FLOOD PAINS AND WETLANDS

Situated between 370 and 700m, this biophysical area covers more than the half of the BAS. It comprises very flat clay plains that stretch from northwards South Sudan foothills and westwards from Ethiopia foothills to the Sobat river. Vertisols have developed in the waterlogged conditions over these nutrient poor sediments, although fluvisols and patches of luvisols can be found along the river courses. This biophysical area is included in the two following ecoregions:

- The East Sudanian Savanna, which belongs to the Tropical and Subtropical Grasslands, Savannas, Shrublands, and Woodlands biome
- The Sudd Flooded Grasslands, which consists of Flooded Grasslands and Savannas.

The floodplain ecosystem supports a variety of plant species ranging from those adapted to wet environments, under water during several months in a year, to those adapted to more dry environments, occasionally flooding or only by rainfall. Seasonal floodplains, up to 25 km wide, are found on both sides of the main swamps. Wild rice (*Oryza longistaminata*) and *Echinochola pyramidalis* grasslands dominate the seasonally inundated floodplains. Wild rice support a flooded period from 5 to 9 months, whereas *Echinochola pyramidalis* is inundated during less than 3 to 4 months in a year. The seasonally river-flooded grassland forms the 'toich', which yields dry season grazing areas important to the Nuer and Dinka agro-pastoralists. Yield is affected by the duration, timing and intensity of the flood, varying from 1 tonne/ha when non inundated to 7 tonne/ha when inundated.




5 up to 1.2 million. Migration routes **are**
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le and East African eland all followed by

ly in the Sudd swamps, *Machar marshes*
amps and marshes subject to seasonal
**ıfluence on the species** as they follow
moving up and down the flood tide lines

etween Africa and Europe and hosts an

*Figure 2-8: Emblematic mammal species habitats and migratory routes of the BAS*

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t.

anized farms in Gambela can be a major

h Sudan part of the basin, in Upper Nile
State where there are 3 oil fields in activity: Water quality issues have an impact on local communities which usually rely on surface water for drinkable water and to provide water for the livestock.

- Poor sanitation and waste management leads to lead to local water quality problems.

- Siltation of the rivers;.
- Invasive species in waterbodies; Water hyacinth was observed during the site visit in Baro River below the Baro bridge at Gambella town. It is also mentioned during the discussion with South Sudan Transport office as a barrier for boat movement in Sobat River.

## Ecosystem Services provided by the BAS Ecosystems

### *Introduction*

The BAS natural resources are the main source of livelihood of the major part of the BAS population. In each biophysical areas of the basin, communities rely heavily on natural resources for food resources, construction material, fuel, coffee and timber production.

### *Domestic water use and food resources*

- Wetlands are vital for domestic water use once rivers start to dry up.
- An large part of highland wetlands have been drained and are used for cultivation.
- In some parts of the lowlands of the basin, recession agriculture occur.
- In western Ethiopia, the production from wetlands has been estimated to contribute up to 50 – 60% of the household's food security. Harvesting can be after the end of the dry season
- Floodplains and wetlands are key resources for livestock in the dry season since they provide high quality grass and water for cattle grazing and watering. The main valuable plants for grazing are flooded grasslands such as:
  - Oryza providing high quality grazing for much of the year and which has a much higher yield (7x) where flooded for long periods and can also be used as a crop at the end of the dry season when other sources of food become rare.
  - Echinochloa pyramidalis which also grows even during the dry season providing year-round pasture
- According to (Hailu A, 2006), it "would be no exaggeration to claim that the survival of the country's livestock is directly linked to the abundance of wetlands".
- Waterbodies and other wetlands provide important fish resources. Fish is the main source of protein for Agnuak communities, who live along the banks of the Baro and Gillo Rivers.
- In the southern part of the basin, wildlife also provide sources of proteins and a source of income.
- Afromontane natural forests also provide a variety of food products such as honey, spices, palm, wildfruits. In the Akobo catchment around Bench-Maji and Sheka zones, edible roots like Taro and Enset are common and support livelihood of people. These edible roots are drought resistance and also help to soil conservation. Wild honey produced in the forest by the Sheka lakes a major contribution to livelihoods and the associated customary forest management (Kobbo) is effective.
- Sale of wild coffee, growing under Afromontane highland and lowland Ethiopian forests
- Medicinal plants are also found especially in highland wetlands.

### *Construction materials*

- Sedges (carex) found in the BAS wetlands are widely used for thatching. In Illubabor Zone it is estimated that an estimated 85% of the local households use sedges or cheffe for roofing.
- Bamboo forest are also used for construction in western and southern part of the basin.
- Brick making is also reported in Oromia wetlands (EWNRA, 2008) and in South Sudan.

#### *Energy*

- Charcoal is considered as the main source of fuel used in the BAS urban centers and play an important role in forest and bushland degradation.

#### *Timber*

- Afromontane highlands and lowlands forests offer large old high quality wood from Daniellia oliveri and Khaya senegalensis trees for instance. Asseffa (2007) has estimated that households from Sheka forests generate about 44% of their income from forest and forest products.

#### *Headwater catchment forests and Hydrological Services*

Headwater catchments, wetlands and forests play an important role in flood regulation, micro-climate regulation and erosion control. Given potential water resources developments downstream, the natural regulation and reduced sediment load provided by these services can play a major role in reducing the costs of infrastructure.

- It is reported that before deforestation and wetland drainage intensified in Highland Illubabor there was no history of flooding in the neighbouring Gambella Township. Now it is a major threat.
- Local experts in Majang zone revealed that some streams which were permanent some years back have now become seasonal as a result of deforestation and land use change.
- At the basin-scale, highlands and escarpment forests also play a critical role in carbon sequestration. The following figure illustrates impacts of deforestation on carbon sequestration and emission.

#### *Rich biodiversity of flora and fauna*

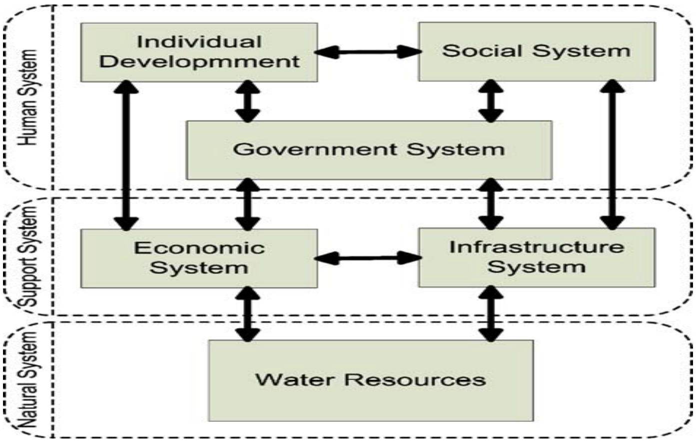
The BAS ecosystems support habitats hosting a rich flora and fauna, characterised by a high rate of endemism in the mountain and large endangered and threatened herds of mammals in the plains.

#### *Flood patterns influence wildlife habitats and play a critical role in their migration*

- Flood patterns have a major influence on the Nile lechwe.
- Birds habitats are also directly linked to flood recession areas.
- The entire socio-economic organization and livelihood of the plains depend on floodplains and wetlands seasonal variations.
- Biodiversity, pristine landscapes and tourism
- The variety of ecosystems of the BAS, its relatively pristine, the importance of the mammal and bird migration offer a huge potential for natural-resources based tourism.
- Wildlife experts consider that the mammal migration of the BAS is equal to that of the Massai Mara – Serengeti. Between 300,000 and 400,000 tourists visit this transboundary park annually.

# SOCIO-ECONOMIC ENVIRONMENT

## Introduction




The socio-economic environments presents the main demographic and socio-economic features of the BAS basin, including population dynamics, Education and Health , Gender Relations, Ethnic Groups and Relations, Conflicts, Humanitarian Assistance, Livelihoods, Poverty and markets. In view of the focus of water in this project it is useful to conceptualize the complex interrelationships between water resources and the social and economic domains of human life.

The focus here is on the social system.
The social system is a domain where government, economics and individual development systems merge, interact and are "rationalized" and harmonized to form the foundations of a nation, society or social group. The social system is characterized by Reproduction, identity, kinship roles, socialization of individuals, moral values

## Demographic and Social Drivers of Change

The main socio-economic drivers of change in the basin include the following:

- Population dynamics (Population density and growth rates, Migration, displacement and resettlement
- Government policies/actions (Ethnic relations, Allocation of land and other resources)
- Conflicts (Interethnic, Political)
- Food security
- Market forces (Linkages, Disruption )

## Population dynamics

The population is in the western part of the basin in Jonglei and Upper Nile state in South Sudan and parts of Benishangul-Gumuz and Assosa regions in is highly dynamic, being affected by layered conflicts and resulting displacement.

The population is estimated to at around 5.7 million, 2.9 in South Sudan, 3.04 in Ethiopia. The is overwhelmingly young, nearly half is under 15 years old. Fertility and birth rates are also high, averaging 5 births per woman and a birth rate of over 40 per 1,000 population.

The population is unevenly distributed across the basin, and its density within the basin shows considerable variation. Population mobility includes migration, resettlement, internal displacement and refugees and can be voluntary, or involuntary. The most common movements are migration from the eastern highlands to the lowlands in Gambella Region and internal displacement due to ethnic and political conflicts. Over 250,000 people in the basin have been affected by internal displacement since the outbreak of political conflicts in South Sudan in December 2013. The areas most affected by displacement due to political and ethnic conflicts are Jonglei and Upper Nile States in South Sudan and Gambella and parts of Benishangul-Gumuz regions in Ethiopia.

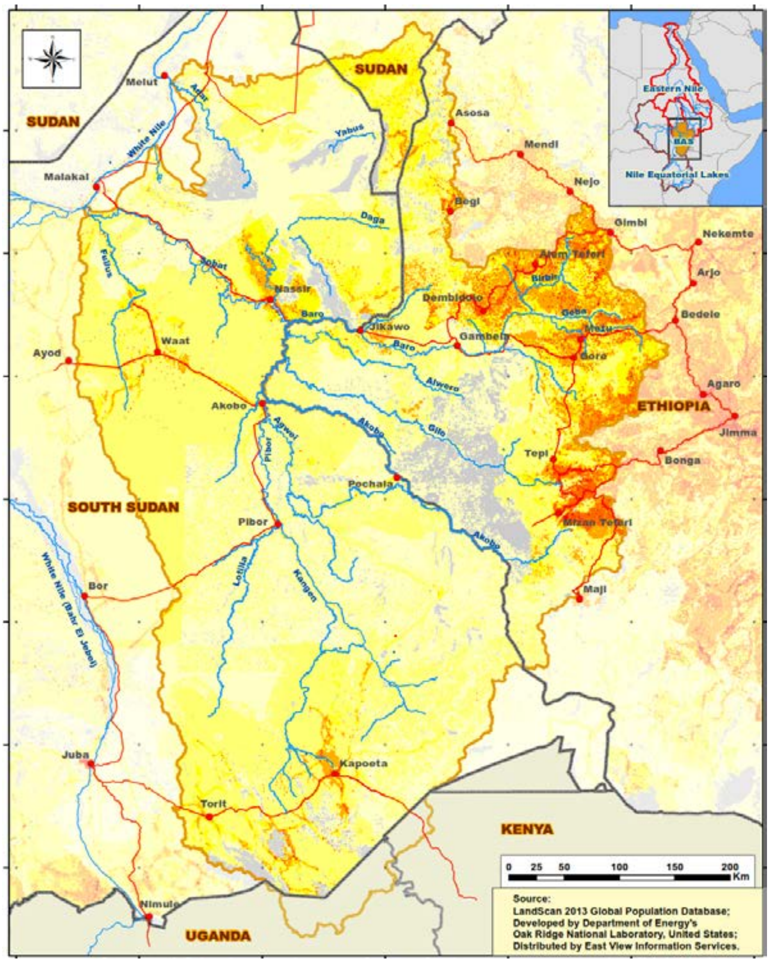



*Figure 2-9: Population density in the Baro-Akobo-Sobat Basin*

## Gender Relations and Gender Inclusion

In most parts of the basin the female population is legally disenfranchised, socially limited and excluded from important economic activities and resources such as property as well as effective political representation. Conditions vary but there are some common issues.

Equality in access to education: Women are only half as likely (19%) to be as literate as men. The gap is narrowing but significant in secondary, vocational and higher education.

Access to employment is limited in the formal public and private sectors by a combination of restrictive social norms and lack of formal educational qualifications and skills.

Access to wealth, measured in ownership of land, shelter, cattle or cash, is severely curtailed for women in the basin. Women have very few resources that confer social status and political power.

Inheritance rights are limited for women. This has disinherited widows and divorcees, especially those from polygamous relationships, as well as their children.

Opening up economic opportunities for women, especially the most marginalized, is critical for the rights and aspirations of future generations of South Sudan as well as the future of economic growth.

## Health

The health status of a human population is important in determining the development potential of an area or group and their ability to respond to opportunities. The general picture of the health status of the basin's population is poor. The conditions are not amenable to rapid change or quick results and will require a concerted effort and considerable resources to improve. Particularly alarming are the high maternal mortality rates, especially in South Sudan, the high birth rates in both countries, and low life expectancy, especially in South Sudan, and access to improved sanitation facilities in both countries. A rare positive item is the relatively high health expenditure in Ethiopia as a percentage of the country's GDP.

## Ethnic groups

### *Introduction*

The basin is home to over 150 ethnic groups and sub-groups who exhibit a wide range of cultures, values, norms and practices. They encompass nomadic pastoralists, agro-pastoralists, hunters and gatherers, sedentary farmers, gardeners, fishermen, traders, warriors, raiders and soldiers. Languages spoken by these groups are in most cases not mutually understandable, and bridge languages such as Arabic and English are necessary to communicate and conduct business across ethnic boundaries.

Traditional practices and a string dependence on natural resources for livelihoods for the vast majority of the population highlights the importance of ecosystem services. Details are provided in the main report for each of the ethNic groups in the basin.

### *Implications of Ethnic Diversity for the Future development of the basin*

The high degree of ethnic diversity found in the basin is an issue in itself and has a number of important implications for development objectives and potentials in the basin, among which are:

- Ethnic diversity coupled with population growth, depletion of natural resources and unequal political power and patronage creates the conditions for increasing tensions and conflicts in the basin.
- In Ethiopia, some areas in the basin such as Gambella and Behishangul Gumuz have recently been prioritized for development by the government, resulting in the influx of outsiders as investors and settlers which has increased tensions and conflicts with the existing ethnic groups in the area. In Oromia, the largest population in the basin, some of the federal government's development policies have been effectively opposed by local ethnically-based organizations.
- In South Sudan, political power and patronage is closely correlated with ethnicity, with dominant ethnic groups controlling the allocation of state resources and means of violence. As long as this situation persists, there will be little chance of achieving the broad-based stability and security necessary for sustainable development in the basin.
- As long as ethnicity remains the primary, and in some cases, the sole identity for the largest number of people the basin, national governments will not be able to forge a common identity, sense of purpose and support for development priorities and programs, which are often seen as zero-sum games with few winners and many losers.
- Any relevant, effective and sustainable development effort should not be imposed from outside and should be planned in close consultation with local ethnic groups, respect their identities and livelihoods and obtain the consent of their representatives.
- Conflicts
- Conflicts in the basin occur as interrelated and mutually reinforcing layers consisting of three main types of conflicts.

- Resource-based conflicts in South Sudan can be a consequence of oil exploration and extraction activities as oil have potential impacts on water quality. Another potential impact related to these activities results from the management, allocation and control over land and water resources.
- Resource allocation conflicts between national and state/regional governments and indigenous people over land allocation policies and practices..
- Historical pastoralist conflicts: cattle raids, communal clashes, revenge attacks and selective violence in the Jonglei and Upper Nile areas in South Sudan) and in the Akobo area bordering Gambella in Ethiopia. The frequency and intensity of these conflicts has increased.
- Political conflicts in the basin take two forms. In the area of the basin in South Sudan, there are political rivalries accompanied by armed conflicts, occurring in Jonglei and Upper Nile states. In the area of the basin in Ethiopia, the fault lines are between the national Government and Oromo people in Oromia region and the Anurak people in Gambella.

The breakdown of customary means of conflict resolution means that governance structures on managing and allocating land and water resources need to be strengthened and applied equitably if a fair distribution of resources and benefits is to be achieved. Legal and institutional frameworks to address issues such as land tenure, water rights and conflict resolution need to be developed and implemented.

## Humanitarian Assistance

Various forms of humanitarian assistance are a major feature of the basin and have been so for many years, dating back to the decades-long conflict between South Sudan and Sudan. This assistance is provided by such agencies and UNHCR, WFP, FAO, OCHA, UNICEF and many others. This assistance is wide-ranging, consisting of food aid, shelter in reception centers along the borders of South Sudan and in refugee camps in Gambella and Benishangul-Gumuz regions in Ethiopia, medical care, mother and child health and nutrition programs, water supply and sanitation, basic supplies and perhaps most importantly, protection and security.

At the end of February 2016, there were 268,352 registered refugees in South Sudan, of which 131, 871 were in Upper Nile State. In the beginning of February 2016 there were 270,942 refugees from South Sudan in Gambella, of whom 237,946 were in six camps and 33,026 were living with host communities (UNHCR, 2016). Some 180,000 of these refugees were under 18 years old.

## Livelihoods

### *Introduction*

Security, resilience and adaptability of livelihoods are important aspects of vulnerability. There is a highly diverse and complex mix of livelihood systems in the basin. These have been mapped.  as can be seen in Figure X.

The large number and variation in livelihood characteristics are defining features of the basin, and present a complex and demanding challenge to development planners. Standard, top-down approaches to development planning are very likely to create more losers than winners. Therefore, a culturally sensitive and consultative approach is a necessary condition for a relevant, efficient and sustainable plan for managing water resources the basin.

Characteristics of the major livelihood zones in the basin are described in greater detail in Annex 3.

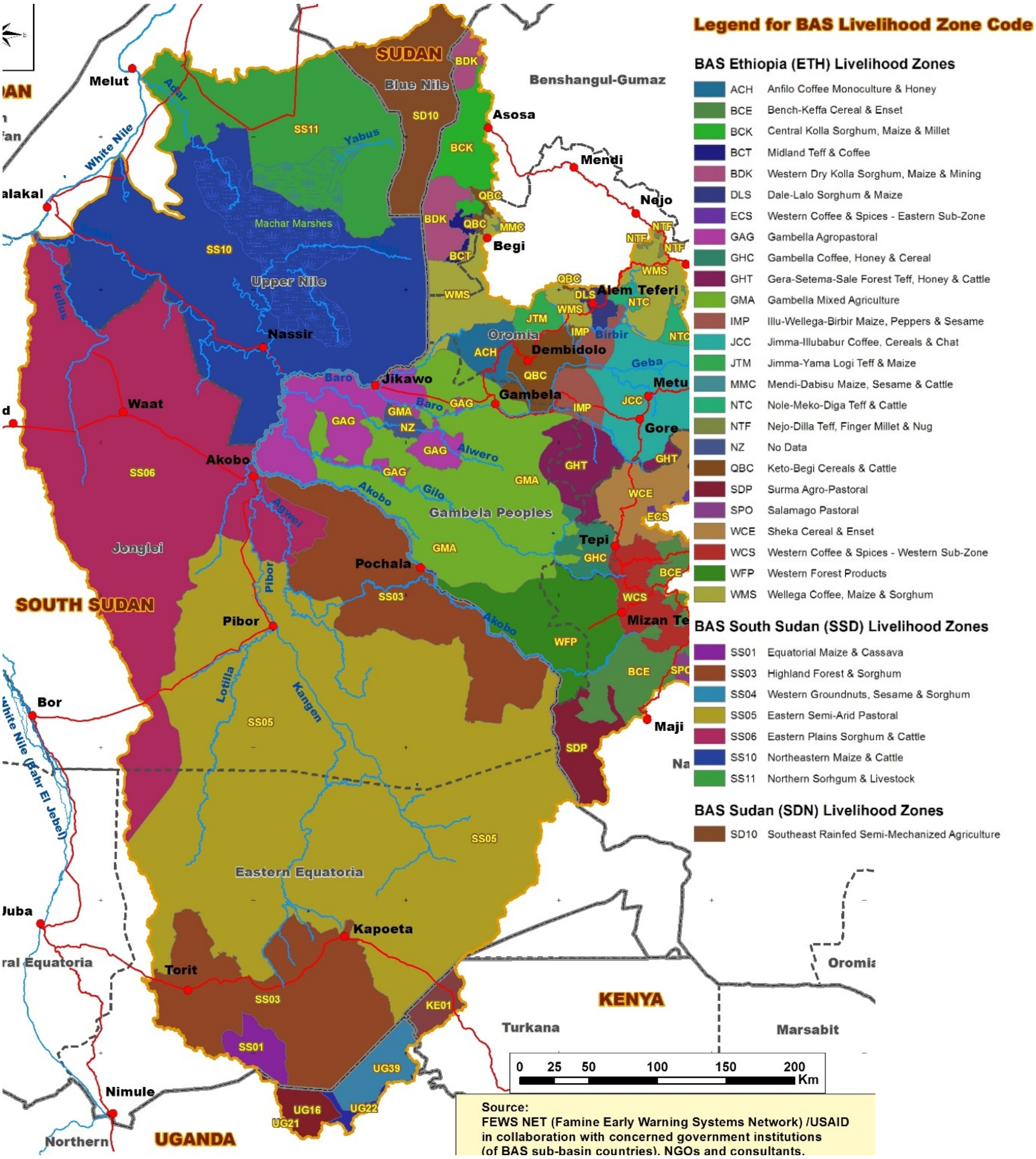



*Figure 2-10: Main Agricultural and Livelihood Systems in the Basin*

## Poverty

Poverty in the basin is both pervasive and deep, but is also differentially distributed across the basin. Any future development and investment plan for the basin will have addressing and alleviating poverty as a central objective

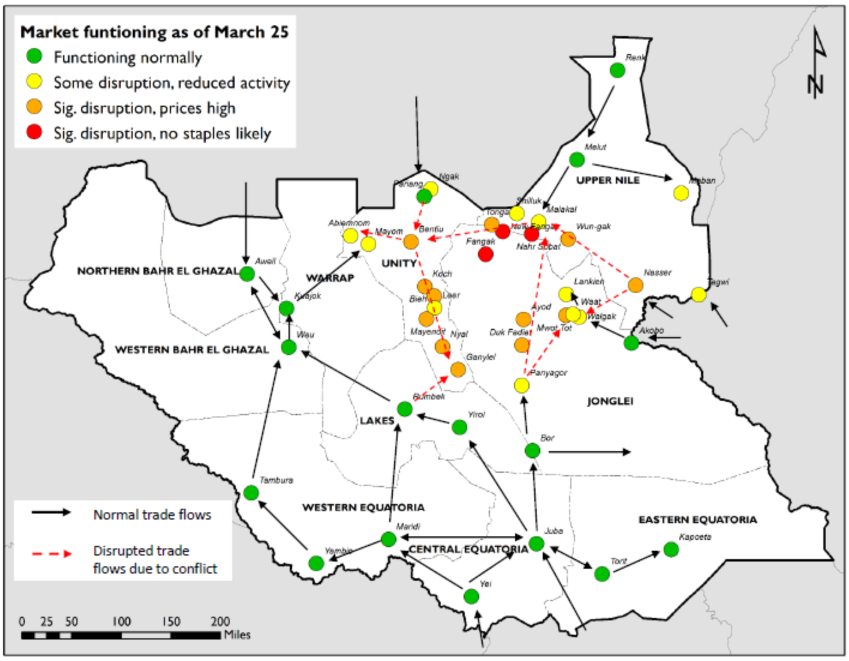
The differential distribution of poverty in the basin states in South Sudan and basin regions in Ethiopia are shown in Table 2-1. It can be seen from that poverty is unevenly distributed in the basin states and regions, with the basin regions in Ethiopia having generally lower poverty headcounts than those in South Sudan and that the basin regions have a somewhat higher headcount than the national average. Gambella Region has a somewhat higher poverty headcount than the other basin regions. In South Sudan, Eastern Equatoria has a large arid pastoral area, which may account for its high poverty levels. Upper Nile State has oil resources, perhaps explaining its relatively low poverty level.

*Table 2-1: Poverty Headcount Ratios in the BAS*

| South Sudan[1] | | Ethiopia[2] | |
|---|---|---|---|
| **xLocation** | **Headcount (%)** | **Location** | **Headcount (%)** |
| Upper Nile | 26.0 | Oromia | 28.7 |
| Jonglei | 48.0 | Gambella | 32.0 |
| Eastern Equatoria | 50.0 | SNNP | 29.6 |
| **South Sudan** | **50.6** | B. Gumuz | 28.9 |
| | | **Ethiopia** | **25.7** |

The above information suggests that the root causes of poverty in Jonglei and Eastern Equatoria states need to be further understood and addressed in future development programs and projects in the basin.

## Agricultural Markets




Markets for agricultural produce in the basin are stratified into local, regional and international markets. The linkages between these levels and access are important to stimulate production, to connect urban demand with rural source of supply and to generate more cash income to farmers.

Market status and disruptions in the South Sudan part of the basin (Jonglei, Upper Nile and Eastern Equatoria states) are shown in :

*Figure 2-11: Market functioning in South Sudan, March 2015*

## Institutional Arrangements

Institutional and organizational arrangements, based on relevant legal grounds as well as policy and strategy documents, are a key issue when it comes to practical considerations of implementation of such an ambitious and complex IWRDM plan for the Baro Akobo Sobat river basin. The most prominent questions to be addressed are:

- How to address the multipurpose (i.e. inter-sectoral) nature of the Plan?
- How to properly and efficiently cooperate when activities with transboundary effects are planned?
- How to address the short, medium and long terms for a Plan which will certainly be developed over several decades?
- Can we imagine an arrangement which is at the same time robust and flexible and which could also be adapted in the medium and long term if necessary?

The main report provides an assessment of the current institutional background and framework at national and international scale, and then identifies key issues as well as preliminary ideas for the future. These ideas are aimed at being discussed with stakeholders and further developed in the Plan itself. In this summary only the strengths, weakness, opportunities and threats are discussed:

- Strengths

  The major strength lies obviously in the existence of NBI/ENSAP/ENTRO. This is at the same time a legal framework and a source of various services. The existence of ENTRO as a major strength. It is endowed with full legal status and is able to conduct directly or to steer numerous and various activities.

  Another strength is that the BAS river basin is almost pristine. This keeps the door wide open for formulating development strategies and organizational arrangements to support such strategies.

  The BAS river basin is also endowed with multiple natural resources, not only water but also land, the natural environment, fishes etc. This brings the idea in mind that a real IWRM process can be imagined and set up with a true integrated approach. There is the potential to address the nexus food-energy-environment, with significant benefits shared by the two countries and various categories of stakeholders.

- Weaknesses

  Purely from an institutional point of view, it is to be stressed that the Cooperative Framework Agreement has not been put into force.

  Due, among others, to the insecure situation of South Sudan in the most recent years, there is little preparedness for large developments based on water in general. Despite several master plans have been issued recently at national scale (agriculture, irrigation…), it is doubtful that grass root level consultation of stakeholders was possible..

  One major weakness is relating to data, for water resources and many other items. A lot of data are old or totally missing and the literature references often cross quote each other. This is first a technical issue, but not only. This is also an organizational issue when considering that developing a much more extensive and reliable monitoring network should be put at the first rank of priorities (hydro-meteorology especially).

- Opportunities

  Mutual confidence of the two countries and comparable arrangements for water management and development

  Shared idea of keeping flexible with ad hoc arrangement depending on the nature of activities/investments

- Threats

  In such an ambitious endeavour, threats are potentially numerous and of high impact. Some of them deserve to be identified.

  Case by case approach and implementation remaining in charge of each country separately: several stakeholders expressed this idea during consultations. If this idea may prove efficient for some "simple" activities (for instance, developing drinking water supply on basis of boreholes), as soon as the transboundary nature of the BAS is concerned, this will be much more complex or even hazardous (example of a series of big dams). A series of activities are to be carefully planned and conducted at river basin scale, such as:

  - Feasibility studies, ESIA
  - Detailed design, in depth mitigation measures, regime of storage/release, environmental flows, cost benefit analysis and optimal/equitable sharing of effects
  - Decision to do the considered development
  - Financial resources mobilization
  - Construction
  - Operation and maintenance
  - Another important threat is related to possible lack of attention to the long term..

The present study is addressing strictly the BAS; the original idea and intention was to incorporate the White Nile up to Khartoum, as previously done in preliminary studies. For financial resources obstacles, this was not made possible. The question remains of the relationship and fair discussions with the downstream countries along the Nile. The suggestion is that this could be organized at early stage when the first drafts of the Plan are available.

# DEVELOPMENT OF WATER RESOURCES: CURRENT SITUATION

## Rainfed Agriculture

### *South Sudan*

Over 95% of the territory of South Sudan is arable and 50% of it is prime agricultural land suitable for various crops" but that only 3.8% is utilised. Almost all crop-farming is rainfed, with the main crops cultivated being sorghum, maize (in the north), cassava, groundnuts, sesame, pearl and finger millets, beans, peas, sweet potato and rice. Sorghum is the staple food and is widely grown countrywide. About 78% of households are engaged in agriculture and the average area harvested per household is about 1.12ha. The majority are subsistence farmers using traditional methods, seed of variable quality and generally low-yielding.

Crop-farmers in South Sudan are categorised into three main types (CAMP, 2015):

- Subsistence farmers. These represent the large majority of crop farmers. Average yields (1t/ha) are low and the areas harvested (2feddans) per household too small. Other challenges include lack of financial resources, scarcity of labour, outdated and inefficient farming methods and large post-harvest losses.
- Medium scale commercial farmers (progressive farmers). The CAMP presents a positive picture of this sub-sector and indicates that there is already relatively rapid expansion and a potential for further rapid expansion.
- Large-scale commercial farmers. In Renk County, Upper Nile State in the Eastern Flood Plains Zone and outside of the BAS basin.

### Ethiopia

While it was reported that many famers have indicated that they need access to at least some supplementary irrigation, there has been a major increase in productivity in recent years. This is largely due to progress with the generalisation of improved farming practices and access to credit.

The highland areas of the basin are extensively and intensively cultivated. Due largely to population pressures and improved access roads, cultivation in the highlands is still expanding, in places (close to roads etc) very rapidly. This is leading to the cultivation of increasingly marginal lands and the clearing of woodland.It should be noted that there are large plantations of coffee and tea in the basin highly profitable.

## Irrigated Agriculture

### Existing infrastructure and irrigation in the basin

There is one dam/reservoir on the Alwero River, in Ethiopia. The reservoir was initiated in 1987 for agriculture purposes, but the proposed irrigation scheme never completed. The construction of 21 km long main canal and associated field irrigation faculties for a command area of 10,000 ha is currently ongoing. The Baro-Akobo Master Plan Study in Ethiopia (MoWR, 1997), had also identified 5 dams/reservoirs for irrigated agriculture development purpose out of which one was multi-purpose.

Twenty river diversion head-works for small scale irrigation schemes are available in the upper most part of the basin in Gambella region and West Wollega, Qelem Wollega and Illubabor zones of Oromia region. Small scale pumps irrigation schemes (10hp -20hp) that use surface water from rivers for irrigation purposes are also found in the areas.

According to the South Sudan Comprehensive Agricultural Master Plan, key infrastructure for crop production and marketing such as main roads, feeder roads, irrigation facilities, storage, drying yards and market facilities are not well developed in either the public or private sectors in the entire South Sudan.

- Large Scale Irrigated Schemes

  There is no existing operational large scale irrigated agriculture in the basin apart from the ongoing development of Alwero irrigation project.

- Small Scale Irrigation Schemes

  Within Ethiopia, both traditional irrigated farming is practised and communal owned modern small scale irrigation is also practised in the basin, The development of traditional irrigation has been practised in different parts of the upper part of the basin in the highlands of Oromia for a century. Wetland edge cultivation with residual moisture locally called 'Bone' is widely practised in the Oromia region part of the basin.

*Table 2-2*: Summary of Irrigated Area under Small Scale and Production (2014/15)

| Region | Total Area (ha) | Total production (ton) | Area managed by Households (ha) | % Area produced by househods | % Production produced by households |
|---|---|---|---|---|---|
| GMB | 3,052.00 | 23,710.00 | 3,470 | 4.71 | 2.83 |
| SNNP | 8,016.17 | 161,729.69 | 43,702 | 12.38 | 19.29 |
| Oromia | 53,705.98 | 653,158.21 | 132,823 | 82.91 | 77.89 |
| **Total** | **64,774.15** | **838,597.90** | **179,995** | 100.00 | 100.00 |

*Source: Computed from field survey, March, 2016*

The total crop production from the irrigated area was 838,597.90 tonnes.

Four categories of small Scale Irrigation (SSI) schemes are recognized in the basin based on water sources and abstraction system. These include (1) traditional (2) Modern (3) pump and (4) Hand dug well. Wetland Farming in the Bench Maji zone around Mizan Teferi, and in Sheka zone around Tepi is also practised.

Operation and maintenance of the Small Scale Irrigation Schemes is as follows:

- Traditional schemes: The responsibility for operating and maintaining the schemes lies on the beneficiary farmers. Traditionally, the beneficiaries organize themselves into associations led by elected leaders, the "Aba-Laga", who coordinate irrigation turns and annual maintenance works:
- Modern Schemes: Operation and maintenance of small scale irrigation scheme is the responsibility of the beneficiaries through their Water User Association (WUAs) and technically supported by district agricultural offices' subject matter specialists. T

## Hydropower and Interconnection

Ethiopia occupies a key position within the EAPP. The country is one of the main sources of power generation either existing or planned to be developed in the next 20 years and located strategically to provide interconnection between the Southern part of the region (Kenya) and the Northern part (Sudan, Egypt). With respect to the study basin, BAS, a major effort has taken place to connect the main load centres of the country to the integrated network.

With reference to the BAS sub-basin the extension of the 230 kV network to the south west has been completed along the route Gilgel Gibe-Jimma-Agaro-Bedele-Metu-Gambela and is currently being commissioned. This represents the major infrastructure in the sub-basin.

Once the 230 kV line to Gambela is fully functional, it will represent the major energy source of the basin. Connected to this line is the existing small scale Sor HPP (5MW).

With the exception of urban centres, most of the basin is not connected to the grid. The BAS sub-basin is one of the least developed areas of the country hence the rural population has access to traditional sources of energy, mainly biomass fuel.

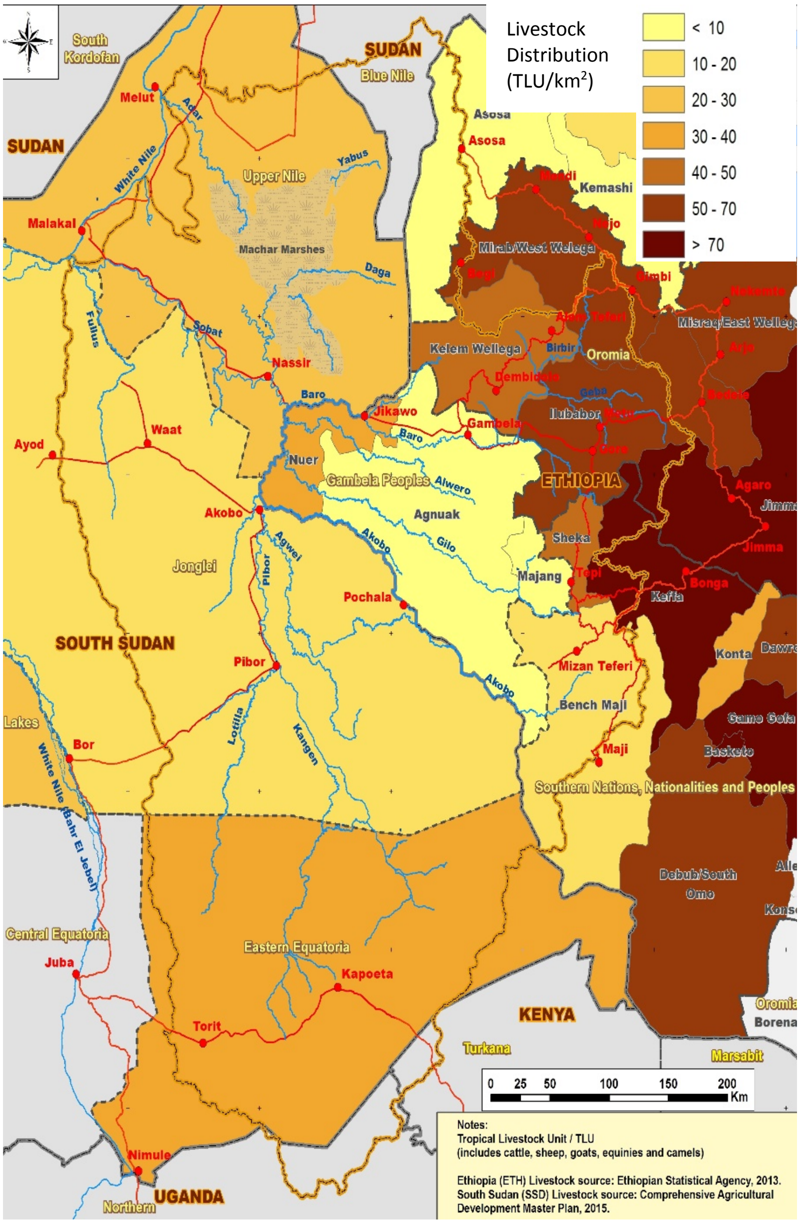
The South Sudan portion of the sub-basin is also in the same condition, without access to an integrated power network. Only one per cent of the South Sudan population has access to power, though intermittently during a 24-hour period. Only seven per cent of the urban areas in South Sudan are electrified and virtually no rural areas have electricity.

The level of rural electrification in the BAS sub-basin is currently nil, although with the new interconnector to Gambela, the situation may change at least in the medium term in Ethiopia. The Rural Electrification Fund (REF) with its loan programmes for diesel-based and renewable energy based projects is the main implementing institution. With an initial budget of €29 million, REF has been supporting 180-200 rural micro-hydropower and photovoltaic (PV) mini-grids for educational and health care facilities.

No information could be identified that provides the MW capacity of the line to Gambela. However the most recent transmission planning study specifies that the Metu-Gambela leg of the 230 kV line consists of a single circuit on double circuit carrying poles, indicating that a second line can be installed as the need arises. Thissingle line size can typically carry around 200 MW. It should also be noted that this line will eventually be extended to Malakal in South Sudan where part of the power carried by the line will be exported.

## Livestock Farming

### *Overview*




Three production systems are observed in the Baro-Akobo-Sobat (BAS) basin namely pastoral, agro-pastoral and mixed farming systems. In all of these production systems, livestock play multitude of economic and socio-cultural functions. They are the means for store wealth and providers of food and income. Milk is the most important nutritious diet derived from livestock in both production systems.

The distribution of livestock around the basin is shown in Figure 2-12.

Although some level of variability exists amongst different livelihood and ethnic groups, the application of improved livestock husbandry practices is very much limited throughout the basin. Change is vital for improving the socio-economic benefit of livestock to their owners, and the conservation of water and the sustainable management of livestock and the grazing resources

*Figure 2-12:Distribution of livestock around the BAS*

Irrespective of the parts of the basin, feed shortage constrains livestock production in all parts.

In the agro-pastoral areas of the lower basin, seasonal flooding and the absence of tradition to conserve excess fodder in the form hay is the major cause for the imbalance of the feed supply. For the pastoral systems, overgrazing around watering points and inaccessibility of rangelands distant from watering-points are the major problems.

Absence of watering facilities such as troughs that help to physically separate livestock of different species and age groups along the perennial rivers and other natural water sources does also compromise domestic animals' state of health as it encourages disease transmission.

The trading of livestock products specifically those of milk and butter literally is highly under developed in the BAS basin. Trade of live animals takes place throughout the basin, although the level of its development varies amongst the socio-economic groups and production systems. The major challenge for livestock marketing is price fluctuation. Livestock prices fluctuation from year to year and within the year, and this was identified as the major problem.

***Stock watering***

The problem of seasonal water shortage is specifically critical for pastoral communities of residing within the basin. Here, pastoralists are forced daily to trek their animals longer distances to watering points under high temperature and often insecure conditions. Water supply sources for these households and their animals are mainly perennial rivers. As these water sources are often polluted and lack mechanism to refine them, the communities are predisposed to water-borne diseases such as diarrhoea, bilharzia, and amoebic dysentery. No less serious is the livestock water supply in the agro-pastoral and mixed farming areas. Here, too, the problem of livestock water scarcity escalates during the dry season. Estimated livestock water requirements have been estimated and are included in the main report.

## Fisheries and Aquaculture

The main fish markets are the major towns in Gambella closer to water bodies (Gambella Town, Itang, Abobo and Pugnido). In these towns it appears that there is great demand for fish, far in excess of availability. Fish processing (value addition) is rarely practised and in most cases, the fishers sell whole fish which brings low price at landing sites as well as secondary markets. Transport issues are a major constraint to the development of fisheries.

Fish appear to be one of the major protein sources for the people who live in nearby major water body of the region. The existing food culture for these people depend on predominantly on fish and they strongly desire fish for daily consumption.

It appears that currently there is no aquaculture practised in the region, despite favourable conditions for development of the sector (abundant water and land, low altitude and high temperature, appropriate and proven indigenous fish species for aquaculture, inexpensive labour and compacted clay soil that can retain water for long). Aquaculture will produce more fish year round and also reduce the pressure that could otherwise be exerted on the natural system.

## Ecotourism

Currently, tourism and ecotourism are largely underdeveloped in the BAS despite the huge potential offered by its rich natural resources, especially by water resources. Since 2001, International visitor arrivals in Ethiopia have shown a strong upward trend. Ethiopia has become a quite important tourism destination in Africa, not far behind Kenya in terms of tourism and travel’s direct and total contribution to GDP. However, the Ethiopian part of the basin does not benefit yet from tourism growth, mainly because of a lack effort to develop infrastructure at all levels that facilitate tourism and lack of coordinated management.

In South Sudan, tourism has emerged recently but is currently insignificant for security reasons.

## Water Supply and Sanitation

### *South Sudan*

The Water, Sanitation & Hygiene (WASH) Sector Strategic Framework of the Ministry of Water Resources and Sanitation dated August 2011 prioritised the strategic approach for each of the main WASH subsectors and indicated the current status at that time which is similar to the current status on account of the war:

- Water Resources Management: These requirements were not being taken into account.
- Sanitation and Hygiene: Access to sanitation was 14.6% one of the lowest worldwide.
- Rural Water Supply: The average consumption was 6 l/capita/day, only 20% of the population contributed to operation and maintenance costs and between 20% and 50% of water points were not operational.
- Urban Water Supply: Technology only exists in some parts of Juba and a few regional capitals.

Limited data available indicates that the majority of potable water is supplied from boreholes but that a large proportion are not functional due to maintenance issues.

### *Ethiopia*

The general objective of GTP II water supply sector is to provide access to safe, sustainable, efficient and reliable water supply service to all Ethiopian Citizens by the Year 2020 using appropriate technologies at affordable cost and improve waste water management capacity of major cities and towns that contribute to the country's vision of reaching at the level of middle income countries. By the Year 2020, GTPII plans to:

- Meet the universal target of providing access to safe and sustainable water supply for all citizens of the country in the planning period as per the minimum water supply access standard level set for GTP-1, i.e. for rural water supply 15 liter per capita/day within a distance up to 1.5 km and for urban water supply 20 l/c/day within a distance up to 0.5 km particularly for Somali and Afar regions that would have un-served rural population by the end of the 2015.
- Provide 85% rural water supply access coverage with upgraded minimum service level of 25 l/c/day within a distance of 1 km from the water delivery point, out of this coverage 80% are beneficiaries of tap water service
- Provide 75% urban water supply access coverage with upgraded minimum urban utilities service levels of 100 l/c/day, 80 l/c/day, 60 l/c/day, 40 l/c/day and 30 l/c/day for category 1, 2, 3, 4, and 5 towns/cities respectively,

**One WaSH National Program (OWNP)**: This is the Government of Ethiopia's (GoE) instrument for achieving the goals set out for Water Supply, Sanitation and Hygiene (WaSH) in the Growth and Transformation Plan (GTP). The Program's Development objective is to improve the health and well-being of communities in rural and urban areas in an equitable and sustainable manner by increasing access to water supply and sanitation and adoption of good hygiene practices. The intermediate objectives of the program are directed towards attaining:

- GTP targets of 98% and 100% access to safe water supply for rural and urban areas respectively
- Access to basic sanitation to all Ethiopians having:
  1. 77% of the population practicing hand washing at critical times, safe water handling and water treatment at home, and
  2. 80% of communities in the country achieving open defecation free (ODF) status.

The program was designed to be implemented in two Phases: Phase I from July 2013 to June 2015 and Phase II from July 2015 to June 2020.

## Navigation

The river corridors in the BAS basin are used during the rainy season for transporting goods and passengers into South Sudan from Ethiopia through the Baro and Sobat Rivers via Nassir to Malakal and along the White Nile to join Khartoum in Sudan. On the other hand, there are navigational waterways stretching from Khartoum in Sudan up to Juba in South Sudan. The river is serviceable throughout the year and a key element of the transport network.

*Table 2-3:* Summary Chart for the navigable rivers along the White Nile and the Baro River

| Country | River corridors | Main Port | Periods of navigability | Storage Total Capacity (tonnes) | Available Open Area (m²) | Status / remarks |
|---|---|---|---|---|---|---|
| Ethiopia | Baro River | Gambella | From July to October | Information required | Information required | |
| | | Itang | From July to November | | | |
| | | Matar | From July to December | | | |
| | | Burbe | All year long | | | |
| South Sudan | Baḥr al-Jabal (White Nile) | Malakal | All year long | 400 | - | Need complete rehabilitation for good functionality |
| | | Juba | All year long | 200 | 1500 | |
| Sudan | White Nile | Kosti | All year long | 400 | 6000 | |
| | | Khartoum | All year long | - | - | |

There are four river ports in Gambella Region, Gambella : accessible from July to October; Itang : accessible from July to November (distance from Gambella : 50 km), Matar : accessible from July to December (distance from Gambella : 152 km) and Burbe : accessible all year (distance from Gambella : 185 km). Depending on water levels, in dry season, the standard barges used on Baro River have a capacity of 30 to 50 tonnes and in rainy season, it is possible to utilize a larger barge that can carry up to 1600 tonnes.

## Floods and Drought Mitigation

The impacts of floods in the basin are numerous. These impacts are mostly negative (loss of life, damages to infrastructure, etc.) but it should be kept in mind that annual floods also support the livelihood of many farmers who rely on recession agriculture and cattle farming. Finally, these floods are also an essential component for the good status of the wetlands. The main existing programme for flood mitigation in the basin is the Flood Preparedness and Early Warning project (FPEW). This project was launched in 2007 by ENTRO to support national, regional and local authorities on flood preparedness.

As for floods, droughts can have devastating impacts: on agriculture, on potable water supply, on health, etc. In order to mitigate the impacts of droughts, several actions are already implemented in the basin. These actions are based on securing access to potable water with boreholes, use of new crops resilient to drought, development of irrigation, etc.

### Livelihood-based watershed management

Total soil eroded in the Baro-Akobo Catchment is estimated to be 43.7 million tons per annum and that from cultivated land 21.5 million tons per annum

In the Ethiopian part of the basin, a few livelihood-based watershed management projects under SLMP2 (World Bank) and Government funded mass mobilisation. In South Sudan, ogoing livelihood-based watershed managemen projects in the Imatong Mountains (supported by AWF) “Improving South Sudan’s Livelihoods and Ecosystems Through Water Management in the Imatong mountains”

### Biodiversity, habitats and landscape conservation

Around 30% of the basin surface area is covered by protected areas. The BAS includes over 30 protected areas which are briefly presented in the table below. Despite this large number and important coverage, important issues have been identified:

- Important (for biodiversity and livelihoods) and threatened ecosystems are not covered by any type of specific protection. This is for example the case of the Machar marshes
- Effective protection is quasi-absent insignificant in the basin. However, recent planning initiatives may bring some change to this situation.
- Little general updated information is available, especially concerning National Forest Priority Areas, Forest reserves, and Game reserves.

## WATER BALANCE MODEL

The main objective of the water balance modelling component as part of the baseline phase of this study is to quantify the available water within the study basin in both space and time. During subsequent phases of this study, the configured water balance model will be used as an analytical tool to assess the hydrological impacts of development interventions and management options, which can then be translated into relevant social, environmental and economic indicators to inform scenario evaluation. A two-step modelling approach was used. Firstly, a rainfall-runoff model was calibrated against observed stream flows at selected flow gauging stations in the basin. Secondly, the calibrated rainfall-runoff model was used to generate long-term monthly flows at various key locations within the basin. The modelling procedure involved seven sequential tasks, 1) Evaluation of flow records, 2) Delineation of model subcatchments, 3) Pre-processing of climate data, 4) Quantification of existing water demands and identification of existing water resources infrastructure, 5) Calibration of the rainfall-runoff model, 6) Configuration and validation of the water balance model, 7) Simulation of long-term flow sequences and conducting a water balance, 8) Using the calibrated rainfall runoff model in conjunction with the validated MIKE HYDRO Basin model, long-term flow sequences were simulated at key locations across the basin. The simulation period, which extended from 1905 to 2014, was dictated by the length of the catchment rainfall files. Figure 2-13 displays a schematic representation of the simulated water balance in the study basin, and provides information on the mean annual runoff volumes along main rivers, in key tributaries, and at spill locations and inter-catchment links along the floodplains.

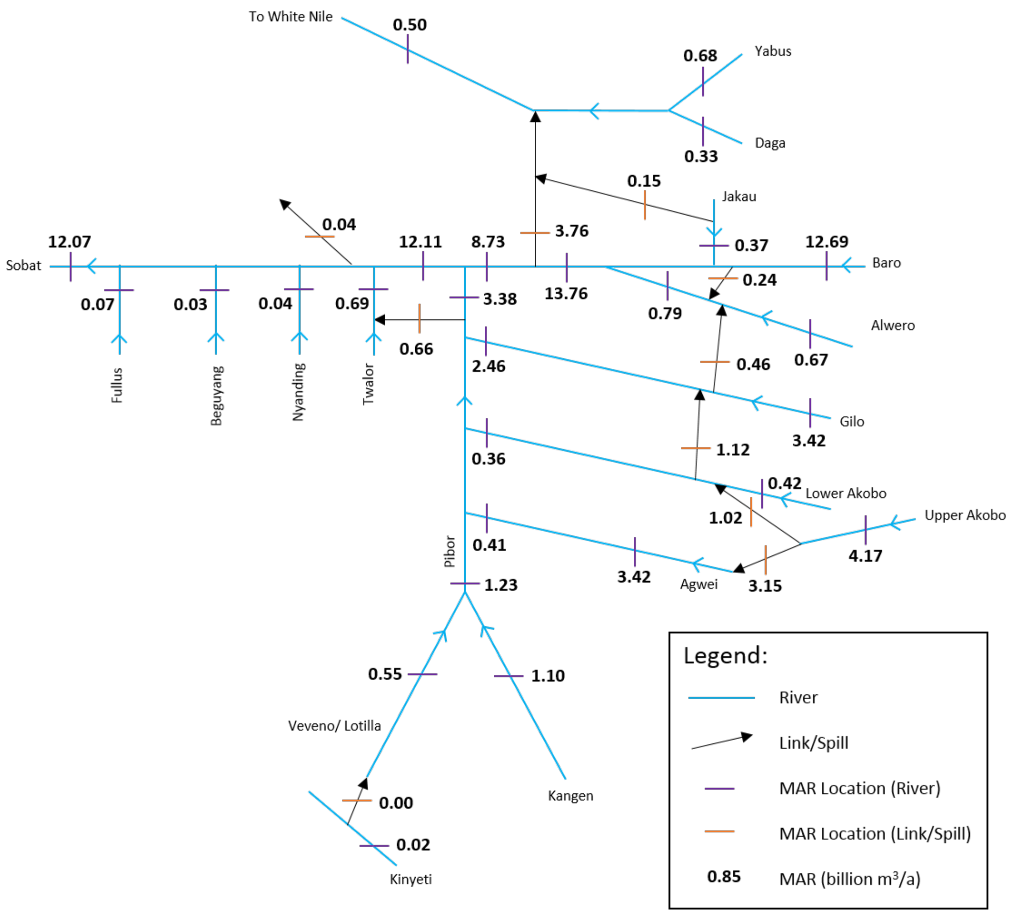



*Figure 2-13: Water balance of the Baro-Akobo-Sobat basin*

# PART 2: DEVELOPMENT POTENTIALS

## INTRODUCTION

Identification of the potential developments in the Baro-Akobo-Sobat basin serves three related purposes:

- The potential developments are based on needs and potentials identified for the different sectors. This has been particularly important to define the key water related opportunities in part 3 of this report. Identification of these opportunities was then integrated with the key issues and challenges to all propose strategic objectives to be discussed during the baseline workshop.
- The potential developments will be part of development and managelent scenarios which will be screened through the multicriteria analysis in order to propose medium and long term projects that will help achieve the desired vision for the basin, agreed during the baseline workshop.
- The identification of the seven short term projects proposed in a separate report is based on the potential developments identified in this report.

## SUMMARY OF THE MAIN FINDINGS PER SECTOR

The key findings per sector are illustrated on the map hereafter. The map identifies the existing development projects in the basin and the projects proposed as part of this study. Some of these projects have been selected as part of the short term projects.

## OPPORTUNITY TO DEVELOP MULTIPURPOSE PROJECTS

It is widely recognised that multipurpose projects usually cost more that single sector oriented projects. However, if well designed and implemented, the projects can generate higher incomes and thus have a more significant impact on poverty reduction and development of the economy.

The projects proposed in this report are mostly single sector oriented. They aim at representing the numerous development opportunities in the basin but it should be stressed that these projects can often be turned into multipurpose projects. This exercise has been realised in the concept note for the short term projects (separate report): the proposed infrastructure or development plans have been designed in such a way that it/they can be shared by a number of development sectors (potable water supply, livestock watering, small scale irrigation, fisheries, hydropower, etc.).

# PART 3: KEY ISSUES AND OBECTIVES FOR THE BARO-AKOBO-BASIN

## INTRODUCTION

The purpose of this Part of the overall Baseline, Development Potentials, Key Issues and Objectives Report is to move forward from an appreciation of the key issues and development potential within the BAS basin towards the development of a vision and the strategic objectives that will underpin the IWRDM Plan.

This section of the overall report starts with a rapid overview of the key issues, challenges, cause and impacts and then summarised the key water-related opportunities that can support development within the basin. It is understanding of these two opposing aspects that leads to the development of the vision. The vison is a picture of a future state of what the basin will look like after implementation of the IWRDMPlan.

## KEY ISSUES, CHALLENGES, CAUSES AND IMPACTS

A key aim of the baseline work has been to understand the status of the basin from a number of perspectives, and to appreciate the relayed issues and challenges. The issues are grouped into environmental, socio-economic and institutional issues. The issues of availability of water is also relevant but this can be considered as something that cuts across environmental, social and institutional areas. Similarly, “technical issues” can be seen as cross-cutting in nature.

### Bio-physical environment: Key issues identified

The key issues identified have been identified as follows:

- Stress on Wetlands
- Loss of biodiversity
- Unsustainable hunting of wildlife
- Loss of natural forest
- Soil erosion
- Scattered settlements
- Poor agriculture extension and poor credit facilities
- Flood and drought
- Lack of peace and security
- Poor physical and social infrastructure
- Climate change
- Lack of knowledge

## Socio-economic environment: key issues identified

The key issues identified are summarized as follows:

- Poverty and Food Insecurity
- Low level of well-being
- Lack of peace and security
- Low level of provision of social services
- Vulnerable groups
- Gender inequality
- Scattered settlements
- Poor agriculture extension and poor credit facilities
- Recurrence of various forms, intensity, duration and impacts of conflicts
- Potential for influx of people
- Risks
- Flood and drought
- Land security/land tenure issues
- Basin population dynamics place heavy pressure on natural resources
- Climate change
- Weak institutions, poor coordination and cooperation among existing institutions

## Institutional Aspects: key issues identified

- Transboundary Cooperative framework
- Security and instability
- Lack of capacity/ experience in (MPP) project implementation
- Capacity of local government institutions and Water Users
- Lack of inter-sector coordination and cooperation
- Planning based on limited consultation
- Inadequate water resources data/monitoring
- Land security/land tenure issues

## Development of water resources in the basin: current situation

The status of development of water resources in the basin has been presented in Part 1 of the baseline. This assessment is the basis for the understanding of the status of development in the basin. A summary is provided in the main report.

## Key water-related Opportunities

Refer to the maps of development potentials presented earlier.

# VISION AND STRATEGIC OBJECTIVES FOR THE BASIN

## Vision

A visioning exercise was carried out at the Baseline Workshop in April 2016, at which the draft version of this report (including the preceding text) was presented. As a first step, time was put over to the workshopping of a potential vision for the basin in 2042 and associated strategic objectives. Three groups, each with representation from Ethiopia, Sudan, South Sudan and ENTRO worked on the tasks of drawing up a vision and associated strategic objectives.

Although the wording of the visions were different, there was general consensus on the key elements of the vision. The key elements of the future status of the basin and its inhabitants, as identified by the groups, can be summarised as follows:

- Sustainable development and management
- Security (in terms of peace, certainty);
- Prosperous (wellbeing);
- Connectivity (integration);
- Co-existence.

The following vision of the basin in 2042 is provisionally proposed:

***"A sustainably managed and developed BAS river sub-basin with prosperous, connected, peacefully and mutually co-existing societies."***

This vision has been taken onto the ongoing work on the SSEA and IWRDMPlan development.

## Strategic objectives

As part of the visioning exercise already introduced above, there was a stakeholder-driven effort to derive the draft strategic objectives that would be required to lead towards realisation of the vision. The same three groups that worked on the vision also came up with suggestions for the strategic objectives and then these were discussed in a plenary session. The following draft strategic objectives were developed based on the stakeholder discussions and the need to develop a coherent and logical set of objectives, the realisation of which will ensure that the vision becomes a reality.

- To contribute to food security, livelihood enhancement, poverty reduction and the protection and conservation of biological resources through stakeholder-driven management of wetlands, watersheds and other important natural resources;
- Taking into account the comparative advantages of the different parts of the sub-basin to sustainably develop water resources for hydropower, irrigation, water supply and sanitation and other sectors with the dual aims of reducing poverty within the sub-basin and generating revenue;
- To ensure transboundary and inter/intra sectoral cooperation and benefit sharing with a view to minimizing resource-based conflicts through optimized management and use of water and associated resources;
- To manage water resources so that disasters associated with flood and drought can be prevented and/or mitigated;
- To enhance human and institutional capacities for sustainable management of the water, land, ecosystems and related resources.

The importance of the strategic objectives cannot be overstated. In view of the fact that SSEA is a stakeholder-driven process, the agreed strategic objectives provide consensus on key issue areas and challenges.

# PREAMBLE

The main purposes of the Baseline, Development Potentials, Key issues and Objectives report are i) to ensure that the required information is available to build the SSEA and ii) is to reach consensus on the vision and strategic objectives required to develop water resources in the Baro-Akobo-Sobat sub-basin. For greater clarity, this report has been divided in three parts:

- **Part 1: Baseline Study**

  The baseline study aims at providing a clear view on the current situation in the basin in terms of bio-physical, socio-economic and legal/institutional environments. This situational analysis, has been combined with a review of the ongoing initiatives to develop water resources uses in the basin.

  Another major component of the baseline study has been to set up a water balance model to quantify the available water within the study basin in both space and time.This model will then be used to assess the impacts of the proposed developments.

  The key output of Part 1 is to identify the key issues, challenges, causes and impacts related to water resources in the basin.

- **Part 2: Potential developments in the Baro-Akobo-Sobat sub-basin**

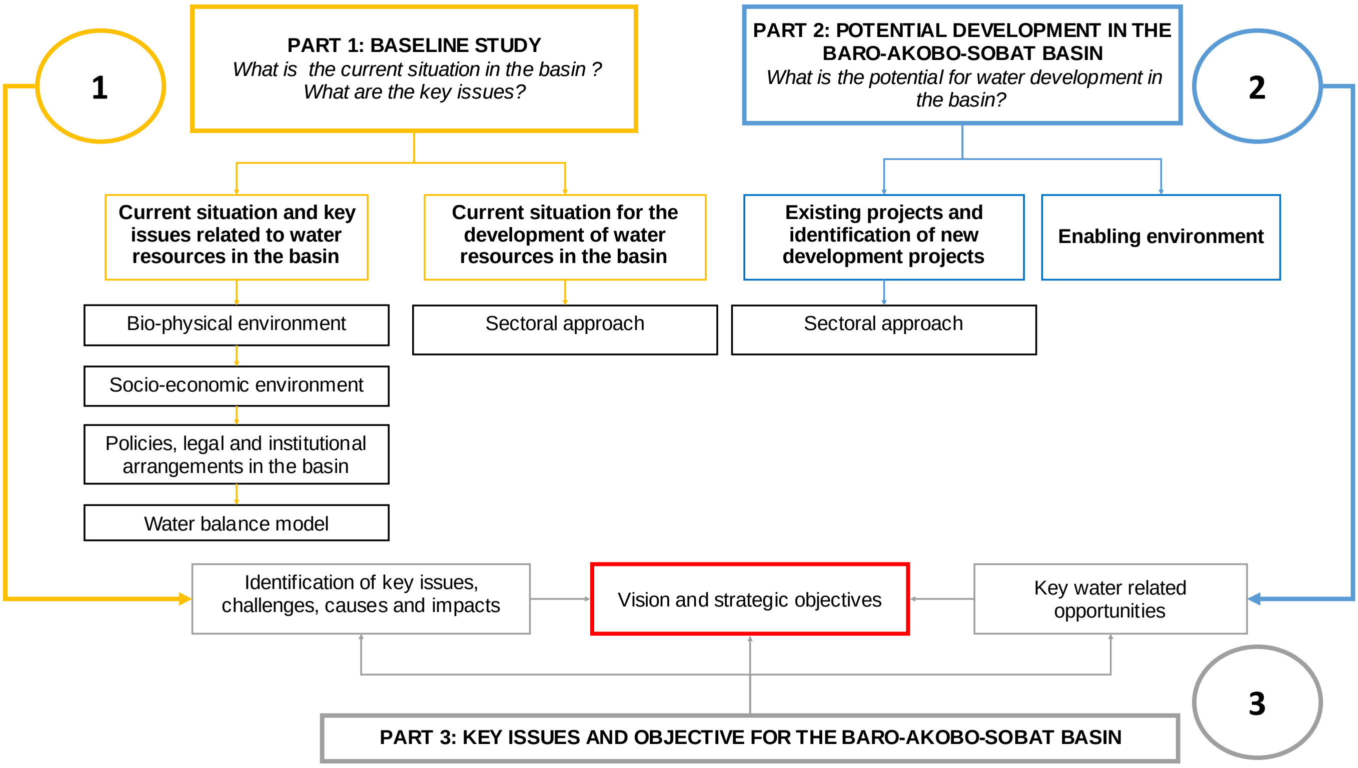
  A sectoral approach has been developed to list the existing development projects and identify new projects. It must be noted that a high level of consultation, at various levels, has been an essential component to identify the potential developments in the basin.

  The key output of Part 2 is to identify the water related opportunities in the basin.

- **Part 3: Summary of the findings – key issues and objectives for the Baro-Akobo-Sobat sub-basin**

  Part 3 aims at integrating the information from Parts 1 and 2 in order to propose a vision and strategic objectives for the basin. It should be noted that the vision and strategic objectives for the basin must be agreed and shared by the key stakeholders in the basin to ensure that the proposed IWRDMP will be implemented. This will be one of the objectives of the baseline workshop.

*Objectives of the Baseline, Development Potentials, Key issues and Objectives report and links between the three parts*



# PART 1: BASELINE STUDY

# 1. INTRODUCTION

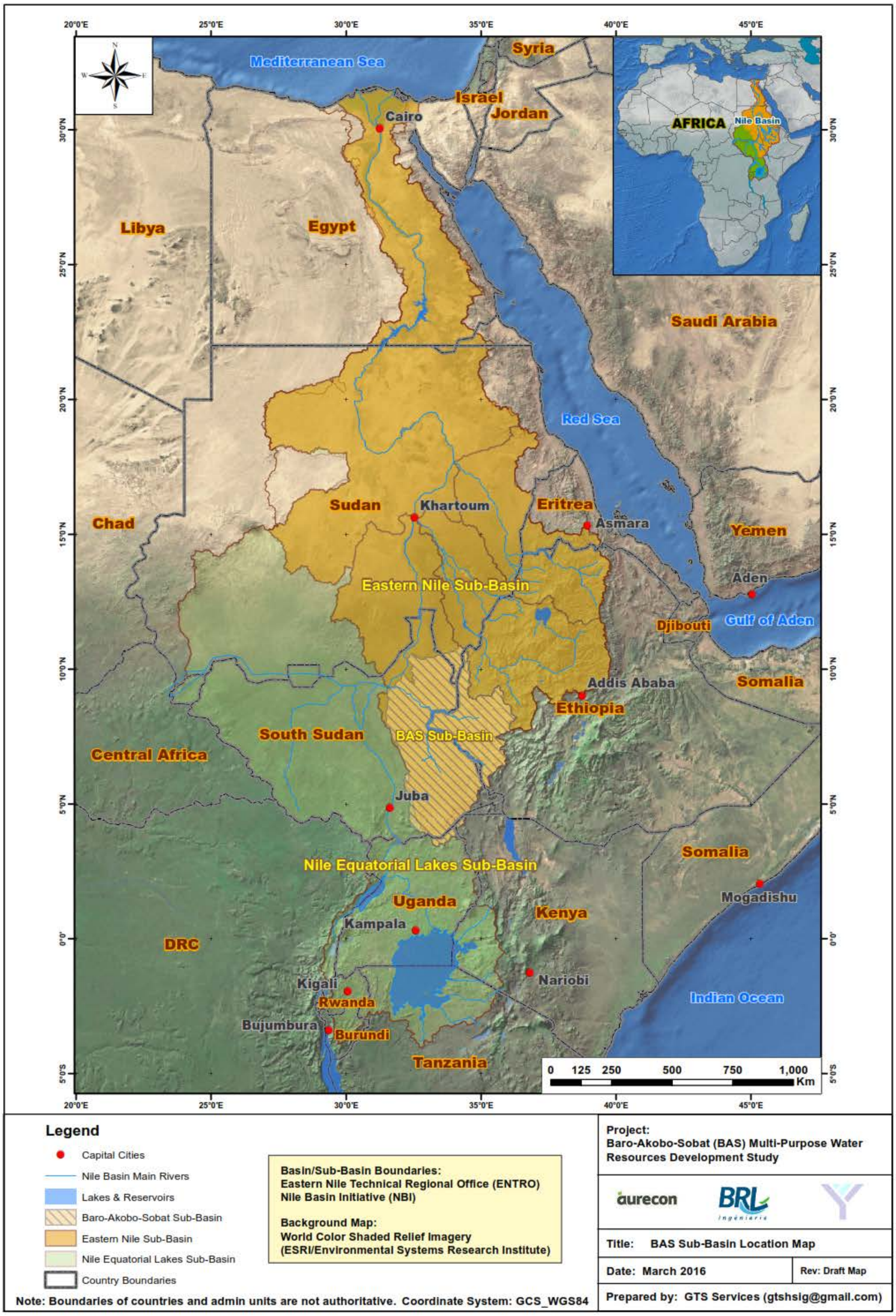
## 1.1 OVERVIEW OF THE STUDY AND PREVIOUS ACTIVITIES

The objective of the consultancy services is to assist ENTRO in preparing an Integrated Water Resources Development and Management Plan (IWRDMP) based on a Strategic Social and Environmental Assessment (SSEA), and further develop investment packages for cooperative development in the Baro-Akobo-Sobat sub-basin. There are a number of specific objectives:

- Preparation of a participatory strategic social and environmental assessment (SSEA) of the sub-basin to facilitate identification of investment options that take into account social, environmental, economic and institutional considerations.
- Formulation of an Integrated Water Resources Development and Management Plan (IWRDMP) informed by the SSEA to identify sustainable investments and provide a sound framework for long term development and management of water resources.
- Identification and preparation of a feasibility study, in a participatory and consultative manner with relevant basin stakeholders, for short-term investment ready projects.
- Identification with participation and engagement of relevant stakeholders in the sub-basin, medium and long-term projects and initiate project preparation activities.
- Provision of an objective and effective framework for stakeholder consultation and engagement in cooperative development and management of water resources of the Baro-Akobo-Sobat sub-basin, and support to ENTRO in mobilizing funds for the implementation of the prepared projects.

It is important to stress the fact that the title of this project is Baro-Akobo-Sobat Multipurpose Water Resources Development Study. As such, it is clearly stated in the terms of reference that “the Consultant shall develop a priority sequence of the multipurpose water resources development projects” as part of the IWRDMPlan.

*Figure 1-1: Location of the Baro-Akobo-Sobat sub-basin within the Eastern Nile Sub-Basin*



## 1.2 COMPONENTS AND MAIN STEPS OF THE STUDY

Without including the Inception Report, which is cross-cutting, the study comprises 4 components.

- Component 1 is the largest of the study components and will see the production of several deliverables. It runs for the duration of the study and culminates in the production of the Integrated Water resources Development and Management Plan (IWRDMP). The main steps can be summarised as follows:
  - Scoping of work for the baseline phase. This step has been completed
  - Establishment of a baseline, including the identification of potential development interventions (identified and otherwise). This is covered by this report (Parts A and B of the overall Baseline, Development potential and Issues and Objectives Report).
  - Understanding of issues, challenges and opportunities. This is covered by this report (Part C of the overall Baseline, Development potential and Issues and Objectives Report
  - Development of a Vision for the basin and associated strategic objectives. Work on this will be undertaken at the Baseline workshop planned for April 2016 and will involve inputs from stakeholders
  - Screening of development and management options through a SSEA developed as part of the study. A draft SSEA framework has been prepared and will be presented at the Baseline workshop planned for April 2016
  - Stakeholder-driven development of an Integrated Water Resources Development and Management Plan (IWRMDP) with multipurpose projects and enabling and cross-cutting interventions that support implementation of the Plan. Work on this part of the component will proceed following the Baseline workshop planned for April 2016.

- Component 2 echoes one of the core aims of Eastern Nile Subsidiary Action Program (ENSAP) of the NBI – the aim of initiating concrete joint investments and action on the ground. While a sound IWRDMPlan is essential for sustainable development, past experience has shown that there is a need to demonstrate that implementation of the IWRDMP should be seen to be starting as soon as possible after the end of this study, the concept of fast-tracking. Some of the short-term actions should be of the type that can be replicated elsewhere in the basin as the IWRDMP is rolled out. The following steps are envisaged:
  - Development of a **Concept Note** covering at least 7 potential projects. This will provide the basis for discussions at Baseline workshop planned for April 2016. The aim will be to **agree on 3 or 4 projects for final screening**
  - Screening of projects and selection of 3 projects for proceeding further.
  - Project preparation for 3 short-term projects
  - Climate proofing

- Component 3 comprises the identification and profiling of medium and long-term projects. This activity will follow directly on from the development of strategic actions and will be in line with the strategic objectives. Medium to long-term projects are seen as mainly large infrastructure projects that will require a significant amount of preparation and associated cost. In general the projects will be:
  - Regional in nature and/or transboundary in scope
  - Offer win-win benefits to the Eastern Nile countries
  - Contribute to improvement of access to drinking water and improved sanitation
  - Enhance food and energy security and reduce poverty
  - Promote peace and stability
  - Promote health and security

The steps to be followed include:

- Comprehensive analysis of candidate projects which will make use of a multi-criteria analysis to take into account social, environmental, economic and institutional aspects.
- Compilation of terms of reference (ToR), comprising ToR for feasibility studies and ToR for Environmental and Social Impact Assessments (ESIA) of three medium to long term projects
- Roadmap for project preparation, which will include i) a list of tasks to be carried out to ensure the project preparation and its funding, ii) institutional arrangements, iii) organizational setup of the project management, iv) communication and consultation plan, v) resource mobilization plan and vi) the schedule.
- Training needs assessment which will cover ENTRO and the organizations that will be responsible for implementation will be carried out.
- Preparation of a comprehensive Training Plan covering all aspects of project implementation

- Component 4 concerns the provision of Project Implementation Support. The inclusion of a participative approach is a central part of IWRM. Stakeholder consultation will play a key role throughout the course of this study and as important, beyond this study into implementation. Ensuring that adequate support is in place will be achieved through the:
  - Stakeholder Consultation Plan and the
  - Stakeholder Communication Plan

  Drafts of these documents have been finalised.

## 1.3 OBJECTIVES OF THE BASELINE

### 1.3.1 Overview

According to the terms of reference, the objective of this task is to enable comprehensive description of the baseline conditions (e.g. water quality, hydrology, fisheries, navigation, wetlands, eco-tourism, etc.). It is required that the baseline data/information covers an extensive and comprehensive list of thematic and sectoral areas. However, it is clear that having in mind how this information is to be used, for what purpose, is an important part of understanding the objectives of the baseline. As stated in the Scoping Report, the previous output for this study (December 2015), the main aims of the Baseline are to collect and analyse the information that will allow the “key issues and potentials related to water resources development and management in the river basin” to be determined.”

It is important to note that this study has a clear focus on the identification and development of projects. At the same time, this development of projects (large and small) has to take place within a coherent strategic framework for the management and development of water and related natutal resources basinwide. For this reason the baseline has been carried out at two levels:

- **Basinwide (BAS)** (and to a certain extent the **whole Eastern Nile/Nile** in order to take downstream impacts of identified projects, and especially cumulative impacts of a combination of projects, into account). This is especially necessary for:
  - water resources especially surface water,
  - the environment (existing and potential issues are both basinwide and localized),
  - Certain policy, strategic and institutional aspects (some are quite high level related to sectoral development, water resources and environmental management, socio-economic issues/aspects such as poverty alleviation etc.),

- **“Project” level.** The level of detail that is required at this level is too detailed to be assessed/collected at the basin-wide level. Our approach to the baseline has taken into account the fact that interventions can be:
  - the development of already identified projects (from masterplans, existing studies etc)
  - as a result of identifying a **need** and/or a **potential.** For example there may be a specific need for development (or a type(s) of development in a specific part of the basin) or there may be a specific potential for a certain type of development (irrigable land, hydropower potential etc)

The baseline/issues/objectives/potential has therefore been focused on these two areas.

## 1.3.2 The Baseline and the SSEA

### *1.3.2.1 Overview*

One of the main objectives of the baseline is to inform the Strategic Social and Environmental Assessment. In parallel with the baseline, work has been progressing on development of the SSEA framework. The aim of this framework is to provide a tool that can be used to assess the social and environmental impacts, positive and negative, of different water resources development and management futures. Clearly, looking into possible future development and management scenarios and making comparisons, requires a clear evaluation of the current situation, the baseline. At the heart of the SSEA framework are sets of criteria and indicators which have to be carefully designed so that they can be evaluated both for the baseline situation and changes to the baseline in the future. This is why it has been so important to work on the baseline and SSEA framework in parallel and to ensure that the information needed to populate the SSEA framework is collected, if possible, during the baseline

More specifically, for the SSEA, the baseline provides information concerning:

- Key environmental and social priorities to be integrated into the IWRDMP design and objectives;
- The existing institutional mechanisms in place ;
- The potential linkages between the intended activities of the IWRDMP and environmental and social resources;
- The potential for intended activities to cause impacts on sensitive environmental components and vulnerable social groups.

### 1.3.3 AFDB guidelines

Integrated safeguards system guidance materials, AfDB, 2014 give some information on what is expected for baseline or situation definition or analysis for an SSEA. An excerpt is provided in the adjacent box. It echoes the role that baseline has to play in the building of a framework for determining the environmental and social baseline and also that it will be used for the assessment of different options. The importance of understanding the institutional and policy situation and of an appropriate institutional framework in place for implementation is highlighted.

**AfDB Guidelines: Situation or Baseline Definition**

"The preparation of a situation analysis or baseline for a SESA will depend greatly on the nature of the programme-based operations (PBO) and its intended downstream activities or investments. It is likely that the relevant baseline will be in part a **general situation assessment of overall environmental and social conditions** relevant to the PBO's focus area, and in part **a framework for determining the environmental and social baseline for specific downstream activities**……."

"The objective of a policy relevant situation assessment is to **identify the key environmental and social issues associated with** a policy area, sector or region so as to inform the **assessment of different options**. This does not need to be as detailed as a project level baseline study and can be based mainly on secondary sources and expert opinion.

It is important that the SESA also takes account of the "**political economy**" of a proposed PBO and the key elements of the **institutional context** in which it will be implemented. The political economy is relevant to the political feasibility of the options to be covered in the SESA, taking account of prevailing incentives and interests that may pose challenges for alternative policy or sector options. The institutional context includes the formal legal and regulatory framework governing environmental and social issues.".

### 1.3.4 Central role of water resources modelling

Water resources modelling will play a central role in informing the SSEA. Many of the impacts, both positive and negative, will be related to changes in the spatial and temporal availability of water resources around the basin that may result from resources development and management practices. Many of indicators of the SSEA will be directly or indirectly related to water resources and as such their calculation is dependent on outputs of the water resources modelling work. For this reason, it has been necessary during the baseline, not only to collect the required data for setting up the model, but actually to make the models operational. In lines with the terms of reference, which require that in "parallel to baseline development studies, the Consultant shall develop a water balance model", which "shall simulate the water balance[1] on at least monthly basis all along major rivers of the sub-basin and until the Aswan reservoir". Because of the nature of the basin, with its extensive floodplains of which the functioning is not well understood, this has been a challenging task. Nevertheless, if the SSEA is to be partly built on an understanding of the impacts of development on the status of water resources around the basin, it is absolutely essential. As stated in the terms of reference, the model should permit the "assessment of the impacts of the development options on the water resources balance."

### 1.3.5 The Baseline and short-term projects

Another important activity that has been carried out in parallel with the baseline work, has been the compilation of the a Concept Note on potential short-term projects. Three of these projects will be fast-tracked so that implementation can start happening soon after the end of this consultancy. The baseline work has allowed the team to get an overview of needs and potential and to focus in on a number potential interventions. The baseline has allowed the team to home on some areas with the potential of multipurpose development in the short-term.

[1] Water resources, water uses, natural losses on Baro, Akobo, Sobat and if required White Nile till Aswan reservoir.

## 1.4 ORGANIZATION OF THIS PART OF THE REPORT

This Part 1 of the report is one of a three parts overall report. Its objectives have already been presented in the previous section of the report.

Including this Section, Part 1 of the report, henceforth referred to as “the report” comprises seven main sections as follows:

- This Section, Section 1 has been aimed at providing the reader with a brief introduction to the study and some insight into the objectives of both the overall study and of this baseline phase. The overview of the study and progress provided is very brief. If further details are required, reference should be made to the Inception Report and the Scoping Report.
- Section 2 is brief and only has the aim of presenting and discussing the spatial and temporal limits of the study. In most cases these limits are the same as the hydrographical limits of the BAS, but in some instances, it is necessary to go far beyond these limits.
- Section 3 is one of the two core chapters of the report and presents the detail of the physical and biological environments of the basin. It is important to stress that since water is the focus of this study, the presentation of the physical environment focuses on water and related resources. The physiography is presented mainly as it relates and is relevant for water resources, both surface and underground. There is a major annex to the report (Annex 1) providing further detail on the Physical Environment. This includes a detailed assessment (Annex 1-D) of groundwater which often is unduly overlooked in this type of transboundary basin-wide study.

  In a similar approach the biological environment is also presented with a water focus. The linkages with the physical environment are clear. Understanding the way in which wetlands function, for example, is a critical part of understanding both parts of the biophysical environment.

  In the final part of the section the main issues and challenges are highlighted
- Section 4 is the other core chapter of the report and presents the socio-economic environment. In view of the acknowledged need to bring development to this basin, which lags behind development when compared to other areas in both countries, understanding the socio-economic issues is fundamentally important. In addition to an analysis of demographics and social structure, particular attention has been paid to issues related to conflicts and security, which are highly relevant for the basin.
- Section 5 presents an overview of the policy, legal and institutional arrangements that may be relevant ultimately for implementation of the plan, and as with Chapters 3 and 4 concludes with an identification of the key issues and challenges.
- Section 6 essentially relates to the dependence on water resources of the various sectors. The presentation has been split into an assessment of economic, service and cross-cutting sectors.
- The final section of the report present the water balance model. This is where water resources and the demands placed on them are brought together. The main objective of the water balance modelling component at the baseline stage is to quantify the available water within the study basin in both space and time. During subsequent phases of this study, the configured water balance model will be used as an analytical tool to assess the hydrological impacts of development interventions and management options, which can then be translated into relevant social, environmental and economic indicators to inform scenario evaluation.

# 2. DETERMINATION OF SPATIAL AND TEMPORAL BOUNDARIES

## 2.1 INTRODUCTION

The study area is understood as the Baro-Akobo-Sobat sub-basin. A basin is generally understood as a hydrographic or surface water resources concept and often as the overall unit (with its sub-catchments as sub-units) for the application of Integrated Water Resources Management (IWRM). From a spatial point of view, this has been the definition used in this study and is discussed in Section 2.2. However, it is important to recognize that the development and management of water and related natural resources cannot take place in isolation of other parts of the countries in which the basin is situated. There are many examples of when influences outside of the basin's hydrographic limits have to be taken into account (see Section 2.3).

## 2.2 HYDROGRAPHIC LIMITS OF THE BARO-AKOBO-SOBAT SUB-BASIN

The Baro-Akobo-Sobat sub-basin is one of the four sub-basins of the Eastern Nile (see Figure 2-1).

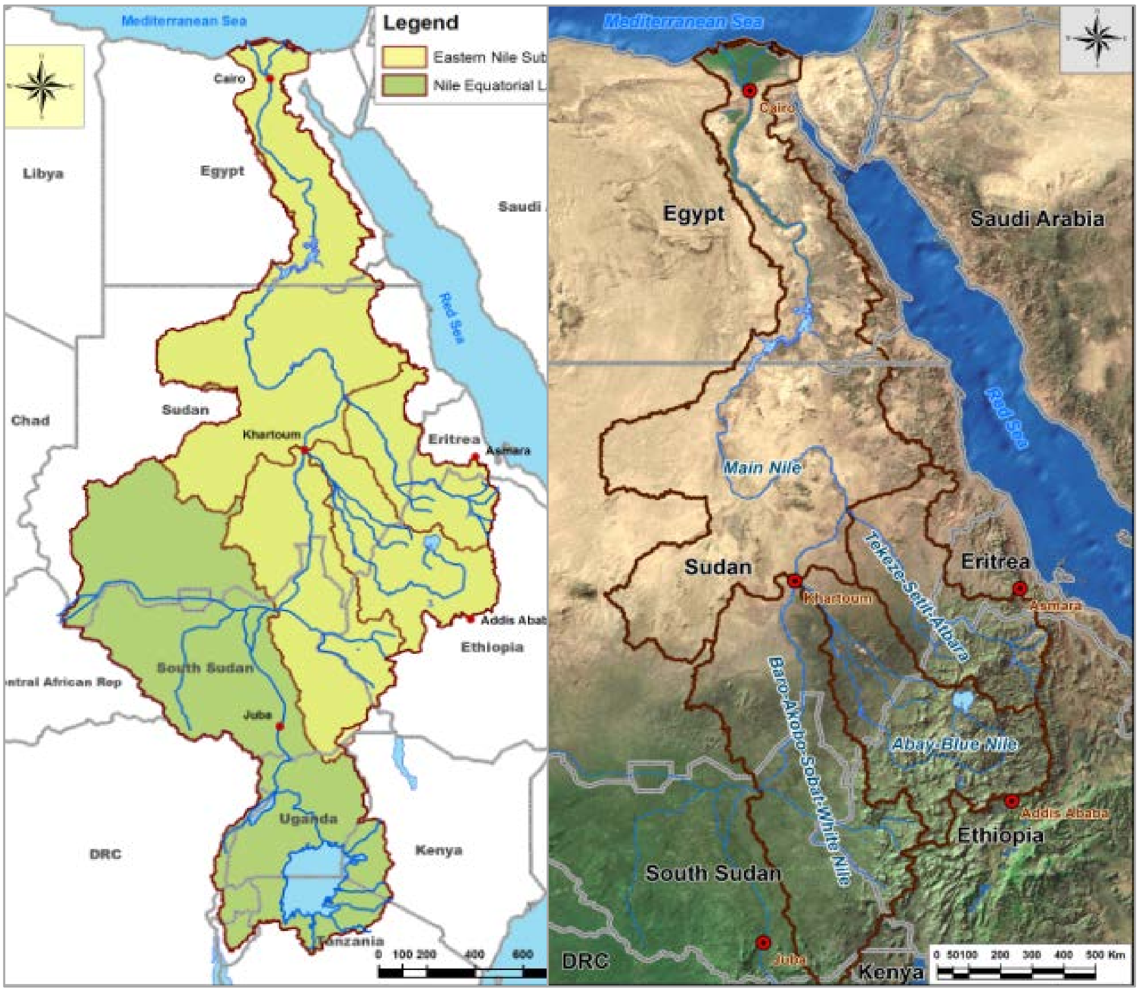



*Figure 2-1: Eastern Nile sub-basin as part of the overall Nile Basin (left) and the four sub-basins of the Eastern Nile (right). Source: ENTRO 2015*

## EXISTING BASIN LIMITS

In fact, the BAS sub-catchment is only a part of the BAS-White Nile sub-basin and is often studied as part of this overall sub-basin. This was the case, for example, in the recently completed ENTRO study, “Multisectoral Investment Opportunity Analysis”. The limits shown in Figure 2-2 are those used in the MSIOA study. The divide between the BAS and the White Nile was not indicated in maps produced in the MSIOA study.

During the scoping and baseline phases of this study, an in-depth analysis of all the available maps, satellite imagery and other remotely sensed information was carried out for a wide range of applications. One of the purposes was to accurately define the limits of the Baro-Akobo-Sobat sub-basin and its own sub-basins since some discrepancies between what had been used in the past and what was found in this analysis were observed.

The existing basin limits are indicated in red in Figure 2-2.

## PROPOSED BASIN BOUNDARY

As already indicated above, the existing basin boundary does not include any separation between the BAS and the White Nile. Defining this northern boundary of the BAS was one of the aims of this exercise. In addition, the detailed analysis of a range of satellite imagery (both free and purchased for the purpose of this study) and other remotely sensed products, showed that parts of the western boundary of the BAS were not correct and that a significant tributary draining into the Badingilo Wetlands is currently omitted from the basin. Understanding the interaction between stream flows and wetland storage is an important part of the hydrological modelling exercise so this type of omission has to be corrected.

It is important to stress that during high flood conditions, the limits of the basin (between the BAS and White Nile) become unclear in some places. This is evident in several of the very flat areas where there are exchanges between the BAS and the White Nile. This should not be seen as a problem but should be kept in mind. During the high flood part of the season, for example when the *Machar marshes* are at their fullest, there will be movement to and from the BAS across the delineated boundary.

While flow channels can be clearly seen in the various maps and on the various satellite images analysed, flow can move into two different directions depending on where areas flood first. This is why the catchment boundary will inevitably cross some of these streams/flow channels. In order to decide where this point is the dry season conditions are generally analysed since these represent the natural flow direction (slope) of the stream.

The proposed revised basin boundary is shown in black in Figure 2-2. Where the black basin limit is coincident with the red limit, this means that no revision is proposed in this area.

No changes are proposed for the southern and eastern limits of the BAS sub-basin. These limits are generally well-defined by distinct topographical feature. The revisions are shown on Figure 2-2 as A to C. these are briefly discussed in the following paragraphs.

- Inclusion of the Kinyeti River (A): During meetings with stakeholders and experts in South Sudan it was understood that the Kinyeti River, which takes its source in the Imatong Mountains is considered as a tributary of the Pibor River and hence part of the BAS. The river was also visited during a field visit to the area in May 2015. Close analysis of the available mapping and imagery indeed indicates that the Kinyeti River is an important source of water for the Badingilo Wetlands. These wetlands are already correctly included in the existing BAS boundary. Outflow from the Badingilo Wetlands joins the Pibor River. The Kinyeti River is now included.

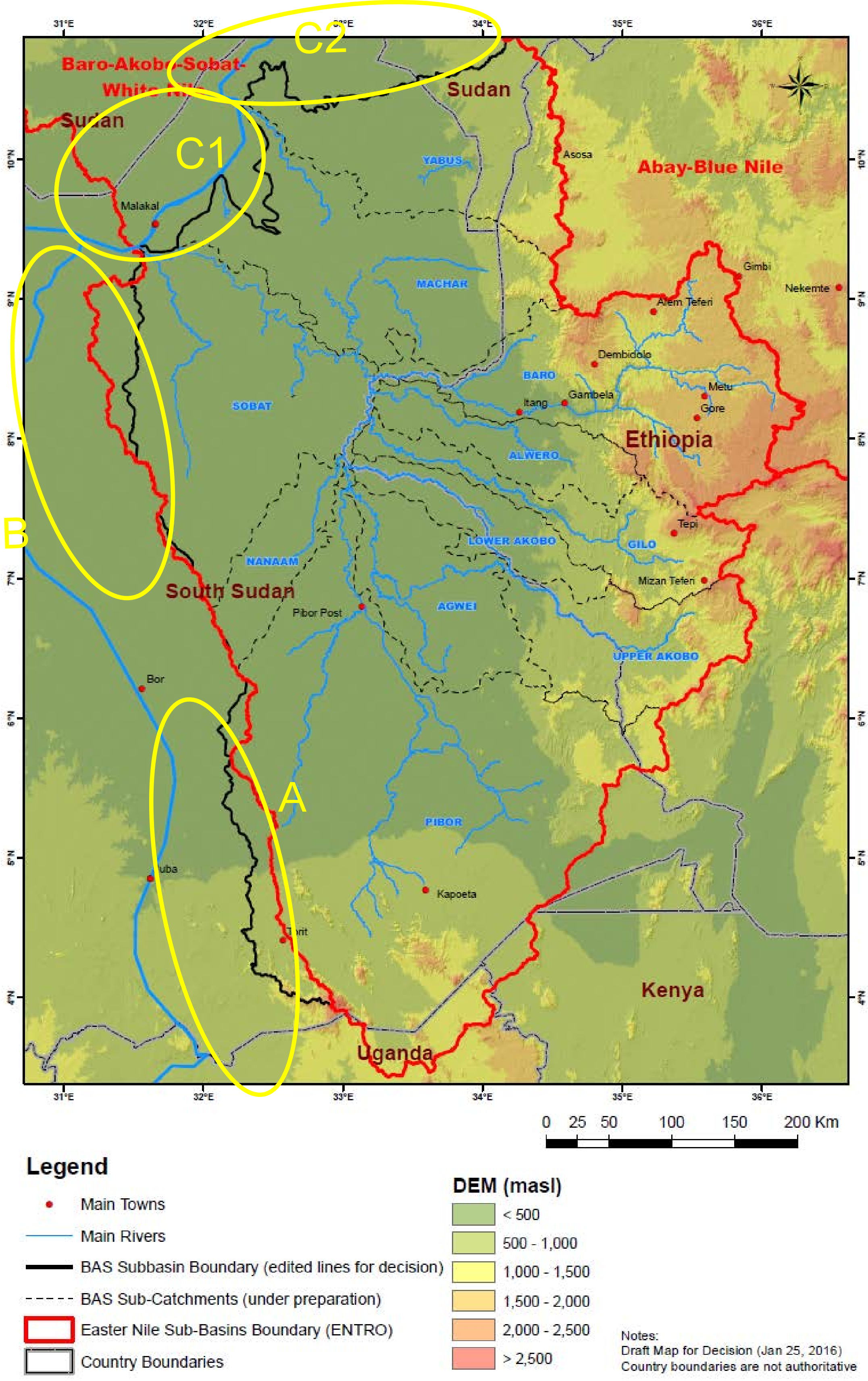



*Figure 2-2: Comparison of existing and proposed basin limits*

- Western limits (B): The western limits of the BAS basin are very flat. This complicates the delineation of the boundary between the BAS. The simple application of a digital elevations model (DEM) is not sufficient. Through the analysis of all available information the boundary has been modified. The analysis showed that some stream which had been shown to be part of the BAS, are in fact part of the White Nile.
- Northern limits; divide between BAS and White Nile (C1 and C2 on Figure 2): On Figure 2-2 the northern limits of the BAS basin have been divided into two parts. C1 shows the divide between the BAS and the small streams that flow directly into the White Nile. It is also in this reach that a minor outflow from the Machar marshes may occur, probably only during years when the level of the marshes is exceptionally high. The magnitude and frequency of this possible outflow is not known. The main outflow from the Machar marshes is the Khor Adar.

  The northern boundary of the BAS basin is delineated eastwards from the confluence of the Khor Adar and separates the streams that flow towards Machar marshes and those which flow generally north-westwards towards the White Nile. The areas is very flat and this delineation is difficult to define precisely. Indeed there is some limited exchange of water across this divide depending on the relative water levels during the wet season. The boundary is somewhat artificial and underlines the fact that the BAS and White Nile should be studied in conjunction with each other where possible.

## 2.3 BEYOND THE HYDROGRAPHIC BASINS LIMITS

Beyond the hydrographic basins limits, emphasis has been put on integrating in a regional perspective the existing and proposed developments, notably for the following:

- Exports for commercial agriculture
- Regional and national policies and institutions
- Hydropower generation within the basin for linkage with national and regional grids
- Transport links and access to markets
- Influence of administrative and commercial centres outside of the basin

## 2.4 TEMPORAL BOUNDARIES

The planning horizon for the IWRDMP has been taken as 25 years. Within this time frame “short-term” is taken as up to 5 years, “medium term” as 5 to 15 years and “long-term” as 15-25 and beyond.

# 3. BIO-PHYSICAL ENVIRONMENT: CURRENT SITUATION AND KEY ISSUES

## 3.1 INTRODUCTION

This section of the report presents the detail of the physical and biological environments of the basin. It is important to stress that since water is the focus of this study, the presentation of the physical environment (Section 3.2) focuses on water and related resources. The physiography is presented mainly as it relates and is relevant for water resources, both surface and underground. Further details are provided in Annex 1 to the report:

- Annex 1-A: Longitudinal River Profiles and Top Channel Widths
- Annex 1-D: Potential Sources of Water Pollution
- Annex 1-C: Analysis of Sediment Yield
- Annex 1-D: Groundwater; Baseline Report

In a similar approach the biological environment (Section 3.3) is also presented with a water focus. Annex 2 provides the detailed baseline report for the Biological Environment.

## 3.2 PHYSICAL ENVIRONMENT

### 3.2.1 Physiography

#### *3.2.1.1 Topography*

In Ethiopia, the Baro-Akobo-Sobat sub-basin can be divided into two generalised landscape units, namely the western lowlands and the eastern highlands. The western lowlands, often referred to as the Gambella Plains, comprise gently sloping hills or flat plains with elevations between 400 masl in the west and 450 masl at Gambella at the start of the foothills. A well-defined north-south escarpment constitutes the transition between the lowlands and the highland plateaus. The eastern highlands are characterised by undulating and rolling plateau, mostly between 1600 masl and 2100 masl, with isolated mountain peaks close to 3000 masl.

In the South Sudan part of the basin, the southern part of the Pibor sub-basin is characterised by a series of steep hills and mountains stretching north-eastwards along the Ugandan border, and reaching heights of 3180 masl on Mount Kinyeti in the Imatong Mountains. The Didinga Hills to the east of the Imatong Mountains is another upland area with elevations as high as 2000 masl, while the Boma Plateau along the eastern border of the Pibor catchment is characterised by elevations above 1200 masl. These mountainous areas merge into a zone with lower slopes before becoming flat clay, gently sloping plains stretching northwards toward the Sobat River.

On the northern side of the Baro and Sobat rivers in South Sudan, the topography is flat and dominated by the extensive *Machar marshes*, which is fed by spills from the Baro and Sobat Rivers, direct rainfall and runoff from rivers draining the highlands along the Ethiopian border. The topography of the basin is shown in Figure 3-1.

### 3.2.1.2 River network and sub-basins

The Baro-Akobo-Sobat sub-basin can be delinated into 10 primary sub-basins as shown in Figure 3-1. These include the Baro, Alwero, Gilo, Upper Akobo, Lower Akobo, Agwei, Pibor, Nanaam, Sobat and Machar sub-basins. The Lotigapi sub-basin along the most southern part of the study area, constitutes an endorheic area, straddling the Kenya-South Sudan border.

*Figure 3-1: Topography of the Baro-Akobo-Sobat Sub-basin*

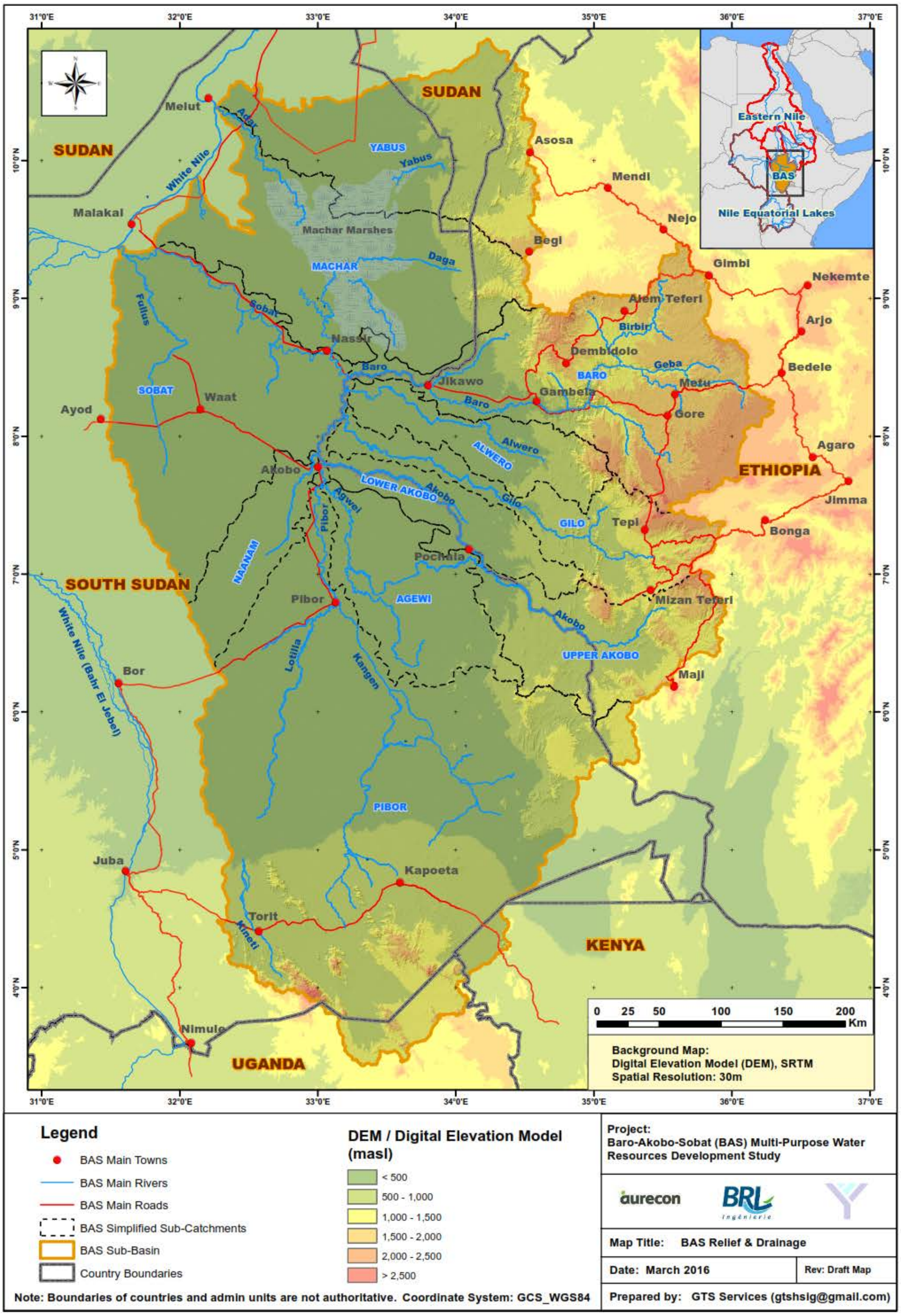
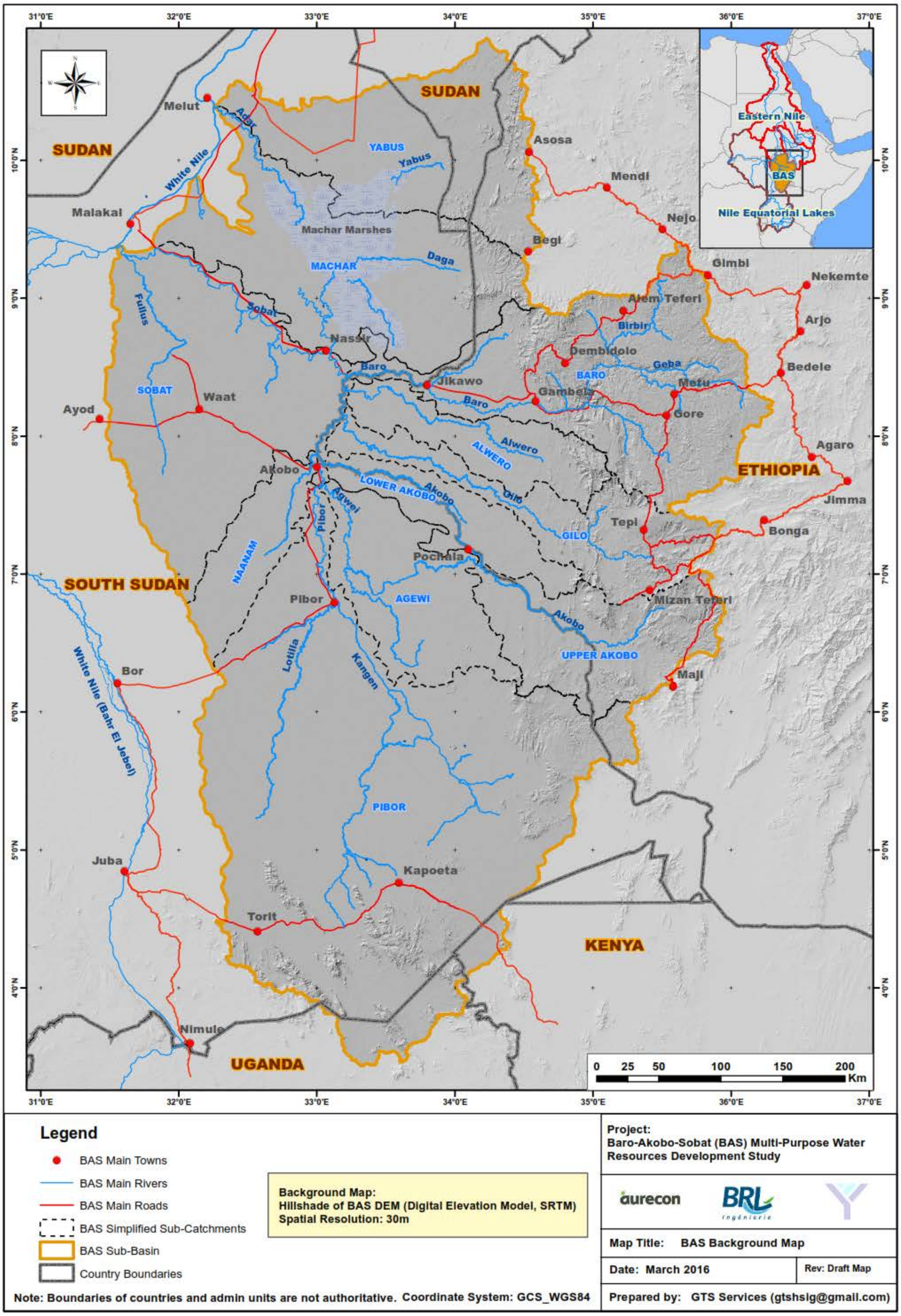


*Figure 3-2: Primary sub-basins of the Baro-Akobo-Sobat Sub-basin*



The total area of the Baro-Akobo-Sobat Sub-basin as defined for this study is 254 061 km$^2$. Individual sub-catchment areas are listed in Table 3-1.

*Table 3-1: Sub-catchment areas*

| Sub-basin | Area (km$^2$) |
|---|---|
| Baro | 31,234 |
| Alwero | 7,368 |
| Gilo | 12,081 |
| Upper Akobo | 14,980 |
| Agwei | 14,388 |
| Lower Akobo | 7,920 |
| Pibor | 77,309 |
| Nanaam | 7,403 |
| Sobat | 34,625 |
| Machar | 46,753 |
| TOTAL | 254,061 |

The Baro River and its main tributaries (Birbir, Geba, Sor, Gumero and Genji), the Gilo River with its tributaries (Gecheb, Bitun, Beg), and the Akobo River originate from the south-western part of the Ethiopian Plateau and then flow westward where they eventually join the Pibor River flowing from the south. As these rivers enter the low-lying plains, they disperse through small channels in some areas or spill into floodplains and wetlands and even across into adjacent catchments during high flow events. The spills are supplemented by significant rainfall directly onto the plains.

Downstream of Gambella and Itang, the Baro River is joined by the Jokau stream from the north. Along the same reach, the Baro River bifurcates into the Adura River to the south, which joins the Baro River again upstream of its confluence with the Pibor River. Along this reach, the Baro River also spills its banks towards the Alwero River to its south, which later on joins the Baro River. Downstream of the Jokau confluence, the Baro River discharges significant water volumes through the Khor Machar and by means of overbank spills to the *Machar marshes* during the high flood season. The *Machar marshes*, which has a maximum area of approximately 8 000 km2, lies to the north of the main channel of the Baro River and receives water from direct rainfall, over-bank spills from the Baro River, and from local runoff via the “eastern torrents”, including the Yabus and Daga rivers which originate on the Ethiopian escarpment. In the rainy season these wetlands expand to cover a large area east of Malakal and north of the Baro River. Small amounts of water from the *Machar marshes* occasionally enter the White Nile northeast of Malakal through the Khor Adar.

The upper area of the Pibor catchment is an area of rapid runoff where streams debouch off the Basement Complex Hills and mountains from Eastern Equatoria State. Flows are seasonal and highly variable, sediment loads are high and gradients very steep. Rivers in these areas include the Kinyeti River. Below these streams on the footslopes, gradients rapidly decrease and coarse sediment is deposited forming well defined valley floodplains and seasonal wetlands (see Section 3.3) characterised by significant evaporation losses. The Pibor River, which flows in a northerly direction, drains a number of ephemeral streams from this region. The river accumulates flow from mainly three tributaries viz. the Viveno, Lotila and Kangen, which join at Pibor Post. Further downstream, the Nanaam River joins the Pibor from the western side, while the Agwei, lower Akobo and Gilo rivers join from the east. During high flows, the lower Pibor spills westwards to the Twalor a south bank tributary of the Sobat. The Pibor River becomes braided on the plains to create wide floodplains.

After the Pibor-Baro confluence, the river is known as the Sobat River to its outlet to the White Nile at Hillet Doleib, shortly upstream of Malakal. The River forms a defined channel through grassy plains with numerous back swamps and is joined by the Thul, Nyanding and Fullus ephemeral streams from the south. Occasionally, the lower Sobat River overtops its northern bank, from where water flows to the White Nile via the Khor Wal.

In the Ethiopian highlands, the catchments are covered with dense forests. However, agriculture and settlements in these areas are causing rapid clearing of the forest areas. In the lowland areas, the catchments are characterised by grassy swamp plains.

The Baro River is the steepest river in the basin, with a hydraulically steep gradient (river slope greater than 1%) over approximately 45% of its length and gradients as high as 10% in some of the upstream reaches. The other rivers in the basin have gentler slopes. The upper Akobo and Gilo rivers have hydraulically steep gradients over about 20% of their lengths. The other rivers generally have much gentler slopes. The rivers follow a trend where in the upper catchment (gradients greater than 1%) they widen gradually as more tributaries join the rivers, and further downstream widen even further once the gradient becomes more gradual. Along the lower floodplain areas, the channel profile and width also seems to be affected by spills and links between the various channels during high flood conditions and tends to be narrower in some areas due to the drier climate.

Longitudinal profiles of the main rivers in the basin are included as Annex 1-A.

## 3.2.2 Climate and climate change

### *3.2.2.1 Introduction*

The climate of the Baro-Akobo-Sobat Sub-basin varies between the Ethiopian highlands in the east, the mountainous areas in the south and the extensive floodplains in the central, northern and eastern parts of the sub-basin.

### *3.2.2.2 Temperature*

Figure 3-5 and Figure 3-5 display the variation in average maximum and minimum daily temperature across the basin and shows that the temperature difference between the high-lying and low-lying areas is pronounced. The average maximum daily temperature on the highlands is 20°C and the average minimum daily temperature is about 11°C. In the lowlands, the average daily maximum temperature goes up to 33°C with a minimum of 21°C.

From Figure 3-3, which shows the mean monthly maximum and minimum temperatures at four locations across the basin, it is evident that the months between November and April are characterized by higher temperatures, while the period from May to September has lower temperatures, mainly as a result of cloud cover and rainfall. The temperature variability over the year is not very significant.

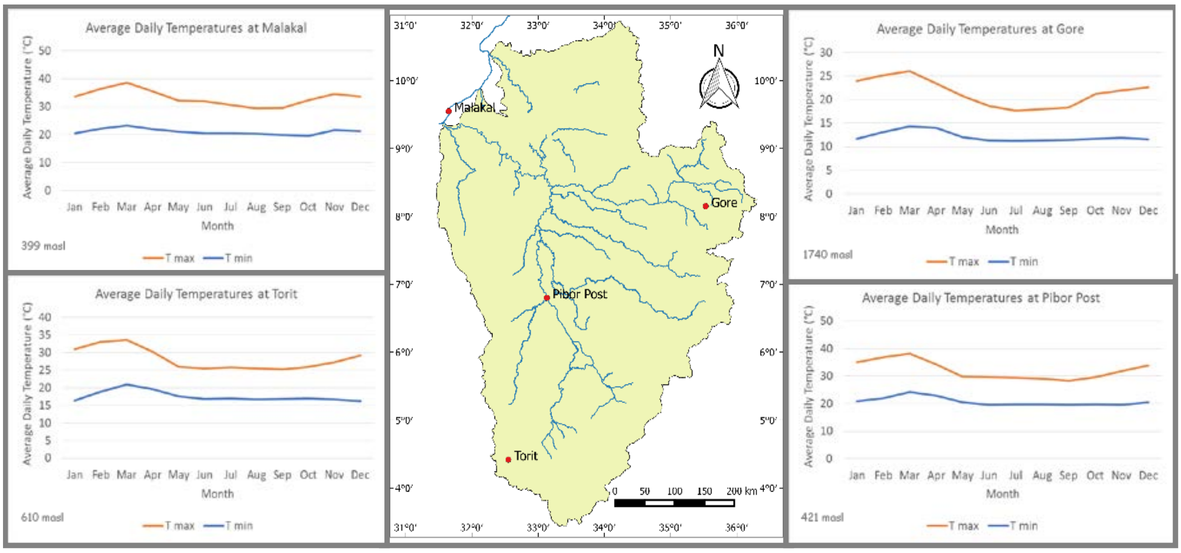



*Figure 3-3: Monthly temperature variation at four locations across the basin*

*Figure 3-4: Average daily maximum temperatures across the basin*

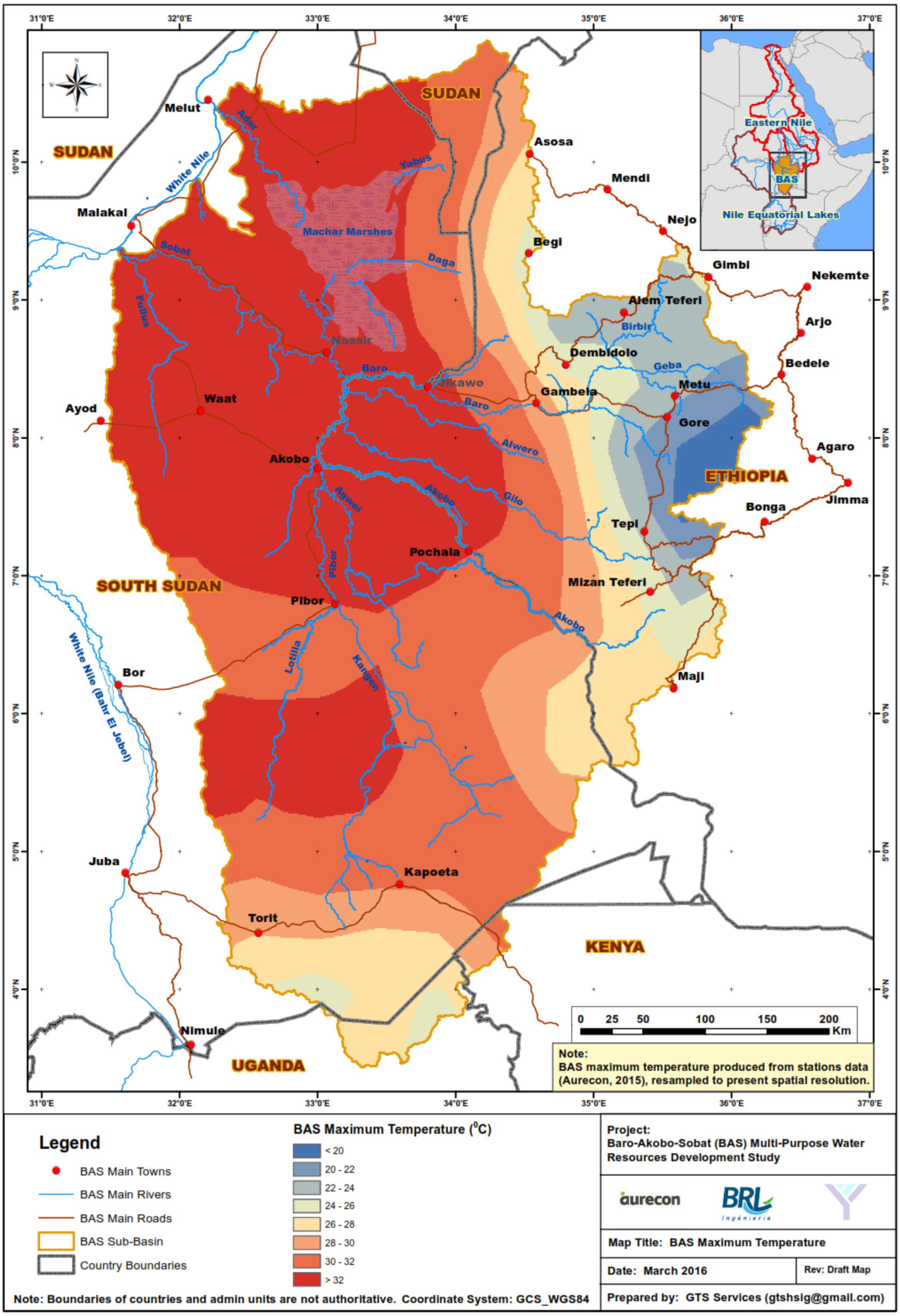
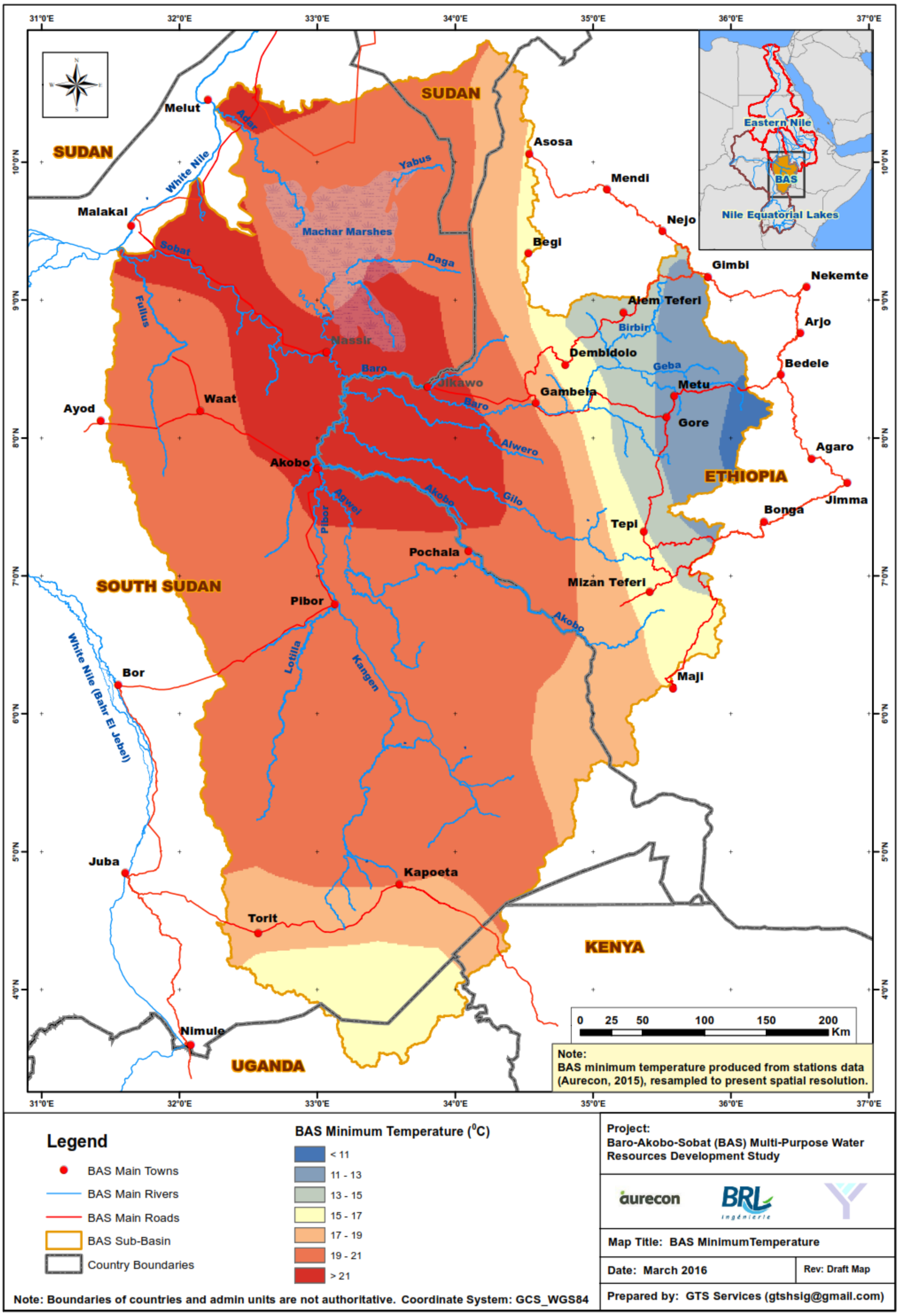


*Figure 3-5: Average daily minimum temperatures across the basin*



### 3.2.2.3 Rainfall

The Baro-Akobo-Sobat Sub-basin is characterised by distinct wet and dry seasons. During summer, the influence of the Inter Tropical Convergence Zone causes intense rainfall. The spatial variation of precipitation across the basin is also considerable due to the range of elevations. The rainfall varies across the basin from more than 2000 mm/a in the high altitude regions of the Ethiopian Highlands to about 1000 mm/a at Gambella in the lowland regions and less than 800 mm/a at Malakal. The mean annual precipitation across the basin is shown in Figure 3-6.

Across the basin, July and August are typically the wettest months, although September can also still have significant rainfall (see Figure 3-7). In the eastern highlands and Gambella Plains, the rainfall is concentrated between May and September, with about 80% to 90% of the rainfall occurring during these months. Towards the southern part of the basin, the rainfall season tends to be slightly longer, extending from April to October. Figure 3-7 also provides an indication of the inter-annual variability of rainfall.

*Figure 3-6: Mean Annual Precipitation over the Baro-Akobo-Sobat sub-basin*

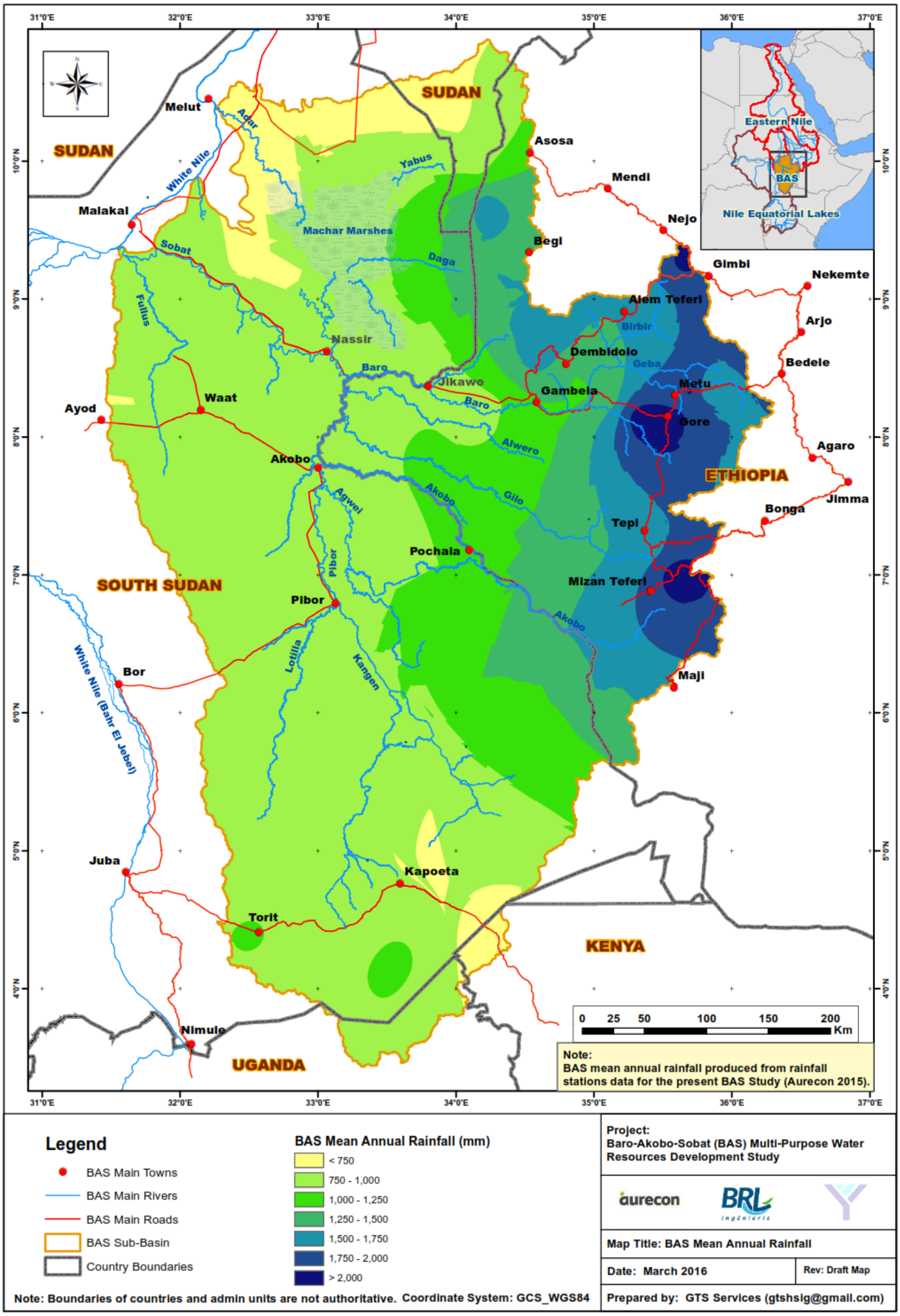



*Figure 3-7: Monthly and annual rainfall patterns at five stations across the basin*

### 3.2.2.4 Evaporation

The spatial and temporal patterns of evaporation across the Baro-Akobo-Sobat sub-basin correlate well with temperature, while there is also a strong inverse correlation with elevation. Figure 3-9 shows the variation of mean annual evaporation (Penman-Monteith) across the basin, with high evaporation in the western and northern parts of the basin, and lower evaporation in the Ethiopian highlands. Potential evapotranspiration varies from less than 1400 mm in the Ethiopian highlands to 1500 mm at Gambella and more than 1900 mm towards the White Nile (reference ET0 – FAO Penman Monteith).

The average monthly evaporation at four stations across the basin are shown in Figure 3-8. Evaporation is highest between the months of December and April, and lowest between June and September.

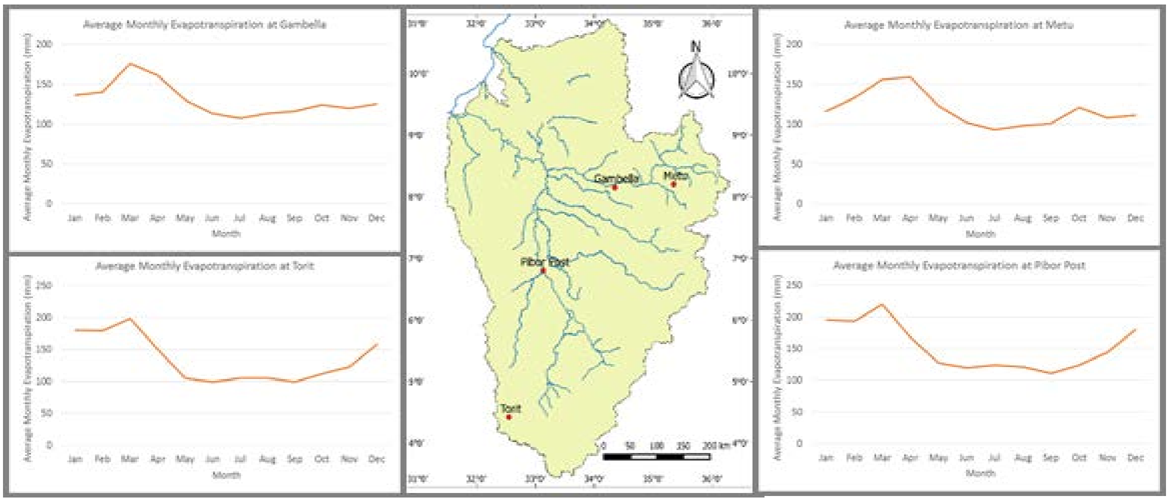
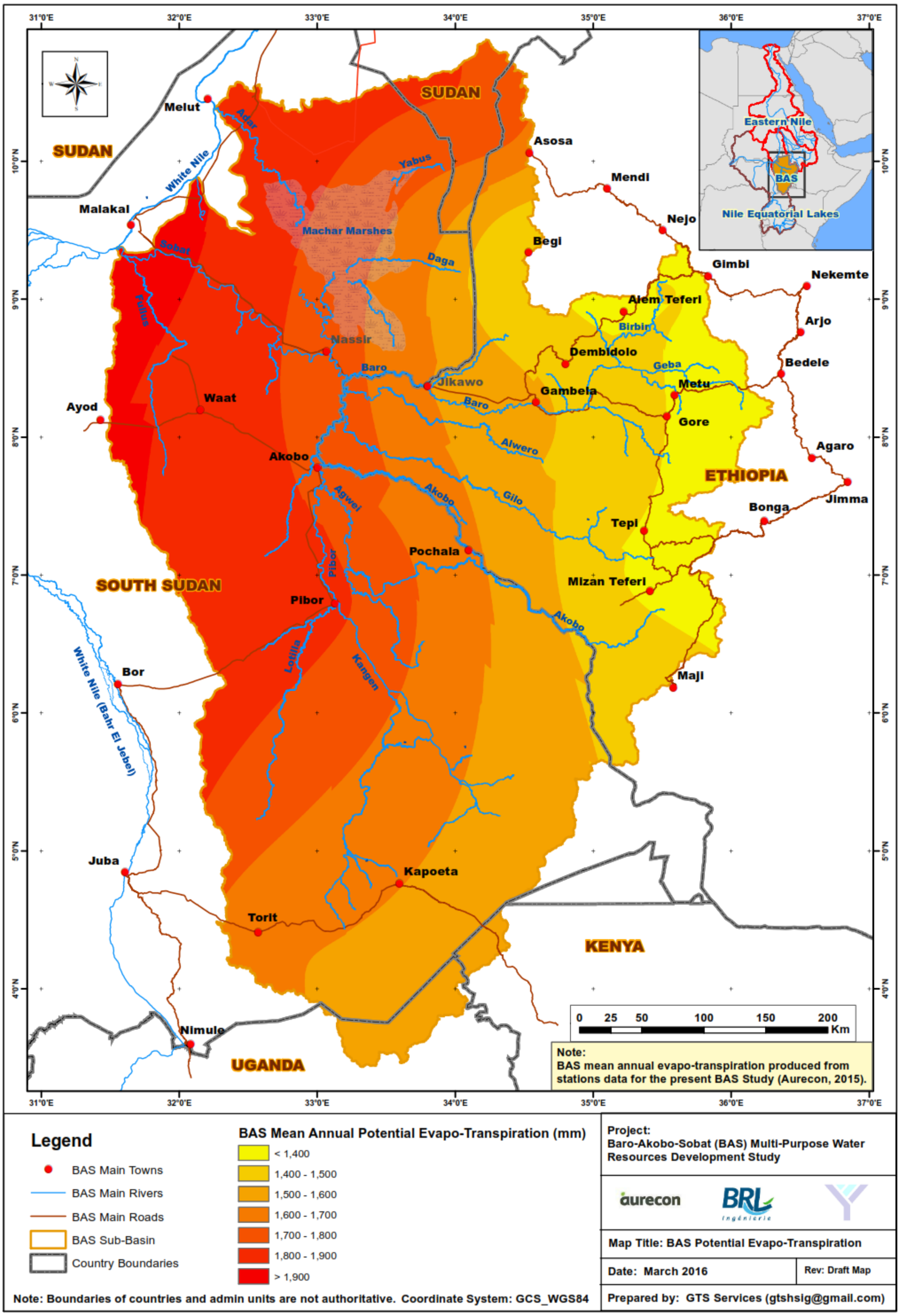



*Figure 3-8: Monthly potential evapotranspiration at four stations across the basin*

*Figure 3-9: BAS mean annual evapotranspiration*



### 3.2.2.5 Climate change

Both temperature and precipitation changes can have a significant impact on the water resources of a catchment and the potential for water resources development in support of sustainable social and economic development. Given these possible risks, it is important to take into account potential climate change impacts in the Baro-Akobo-Sobat Sub-basin, particularly given that countries such as Ethiopia and South Sudan are considered to be amongst the most vulnerable to potential climate change risks.

The IPCC Fifth Assessment Report (AR5) indicates significant increases in temperature across the Baro-Akobo-Sobat basin by the end of this century, particularly under the higher emissions scenario (RCP8.5). However, the report provides no certainty on the projected precipitation changes. Kassa (2013) considered the potential impacts of climate change over the Baro-Akobo-Sobat sub-basin using a global circulation model (CGCM3.1) as well as a regional climate model (REMO), both downscaled using statistical downscaling methods. The results showed:

- A general incremental increasing trend of annual maximum temperature. The projected trend change also appears to increase with decreasing altitude in the basin. (Figure 3-10).
- A general increase in mean annual precipitation across all stations up to 22% by 2050 except for a potential slight reduction in the MAP for the Metu and Bure stations (Figure 3-11). No significant trend with altitude was observed.

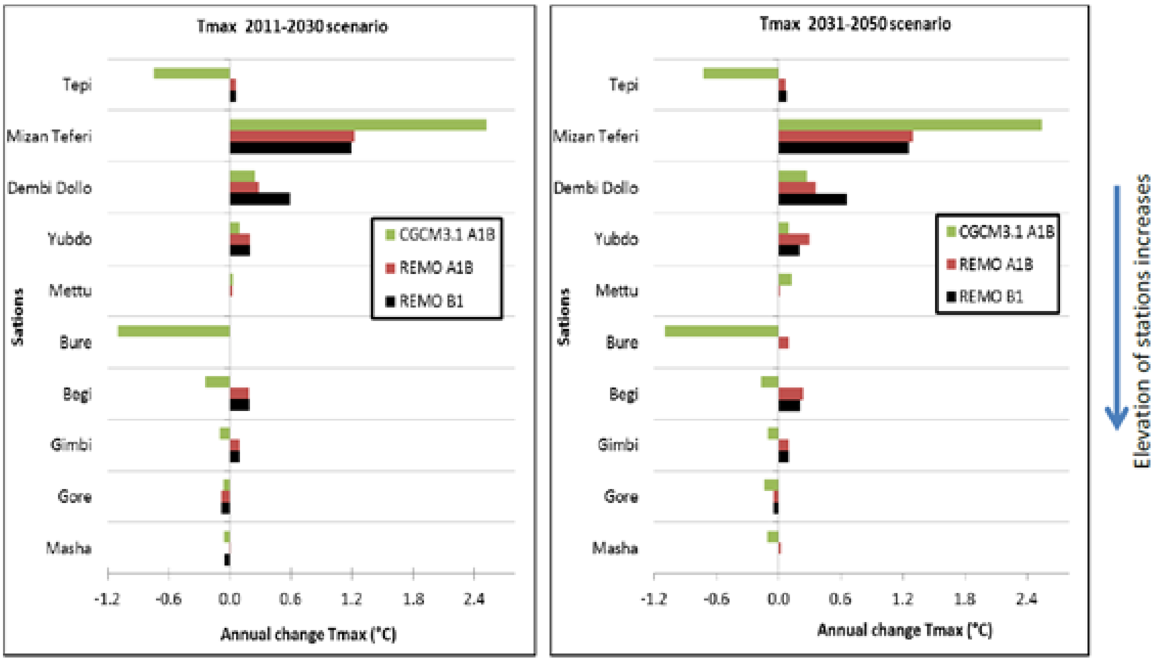



*Figure 3-10: Projected change in annual maximum temperature from base period for stations in the Baro-Akobo-Sobat sub-basin.*

*Source: Kassa, 2013*

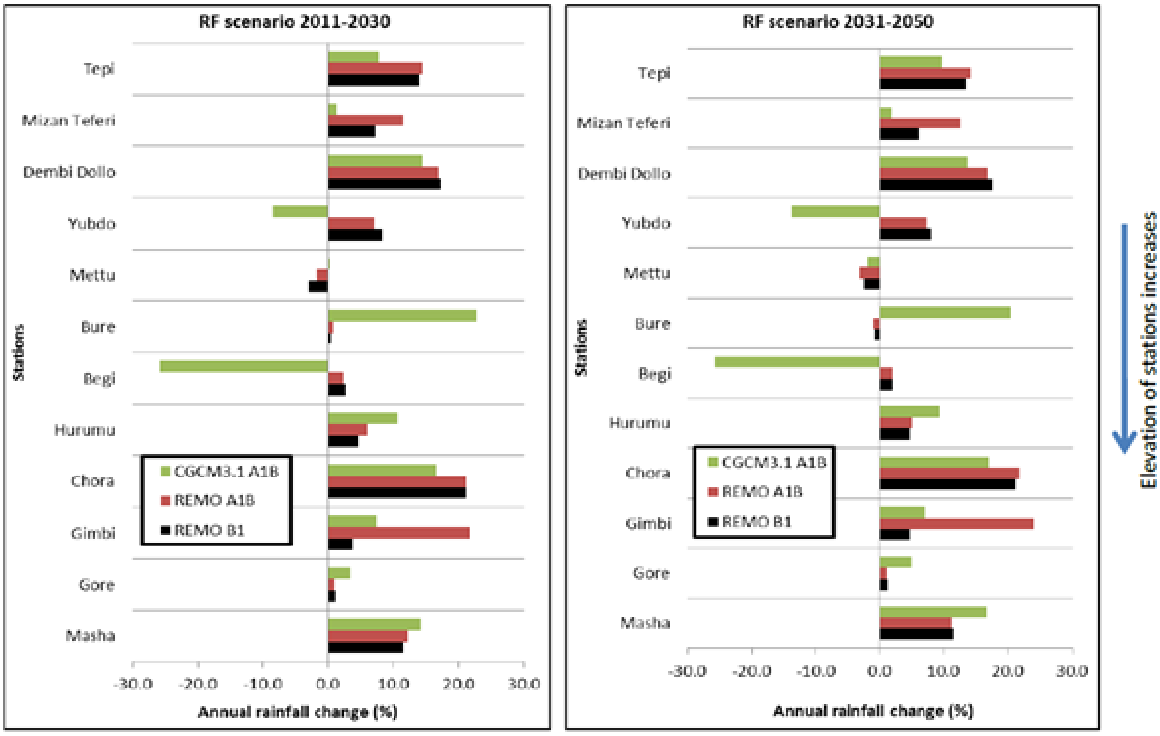



*Figure 3-11: Projected percentage change in mean annual rainfall in the Baro-Akobo-Sobat sub-basin from base period (Kassa, 2014)*

## 3.2.3 Surface Water

### 3.2.3.1 Introduction

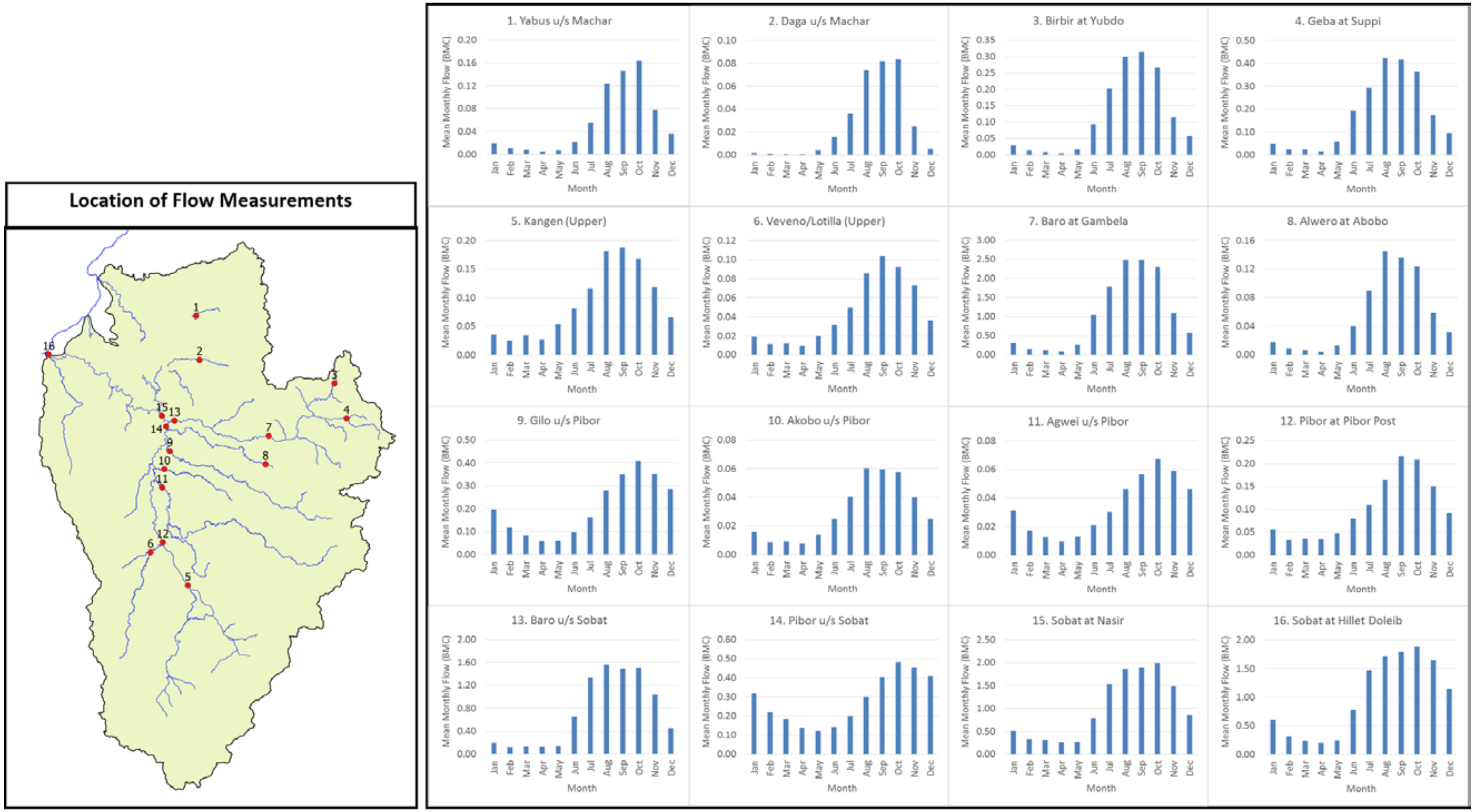
A critical component related to the development of the Baro-Akobo-Sobat sub-basin concerns the potential impacts of development interventions and management options on the surface water regime in the basin, both in terms of quantity and spatial and temporal impacts. Impacts related to surface water could have social, economic and environmental consequences linked to water availability during the dry season, drought, recession agriculture, flood risk, ecological stress, water quality, hydropower generation, fish and food production and irrigation, inundation of floodplains and marsh areas and flow seasonality.

The mean annual outflow of the Baro-Akobo-Sobat sub-basin into the White Nile of 12.07 billion $m^3/a$ for the period from 1905 to 2014 as determined during this study (see Section 7) contributes about half of the flow of the White Nile at Malakal and about a sixth of the flow of the Main Nile at Aswan. The Baro-Akobo-Sobat sub-basin has distinct hydrological regions, with most of the runoff being generated in the mountainous, high rainfall areas of the Ethiopian Highlands. Due to overbank spillage and evaporation, significant amounts of water which enter the Gambella Plains, the *Machar marshes* and the wetlands and swamps in the southern and central parts of the Pibor sub-basin are lossed by means of infiltration, evaporation and evapotranspiration.

### 3.2.3.2 Streamflow

In terms of flow volume, the Baro River constitutes the main river in the basin. Using the hydrological model which was developed as part of this study to simulate long-term flow sequences at key locations across the basin for the period 1905 to 2014 (see Section 7), at Gambella, the Baro River has a mean annual flow of about 12.69 billion $m^3$/a. Downstream of Gambella, this volume gets significantly reduced as the Baro River frequently overtops its banks during the wet season with spills onto the Gambella floodplains and also to the *Machar marshes*, while the river receives some inflow from the Alwero River. At is confluence with the Pibor River, the mean annual flow of the Baro River has reduced to 8.73 billion $m^3$/a. The Gilo, Akobo and Agwei rivers discharge in total about 8.00 billion $m^3$/a from the highlands. However, by the time these rivers join the Pibor River, their flow contribution has reduced to about 3 billion $m^3$/a due to floodplain storage and evaporation and infiltration losses. Although the Pibor catchment is significantly larger than the catchments draining the Ethiopian highlands, the Pibor's mean annual flow at Pibor Post upstream of its eastern tributary confluences, is only about 1.23 billion $m^3$/a. This is due to the fact that a significant portion of the runoff (about 25%) that is generated in the upper mountainous part of the Pibor Basin disappears into swamps and wetlands along the Pibor tributaries such as the Kinyeti, Kangen, Veveno and Lotilla rivers. Furthermore, the gradient of the Pibor catchment is flat, which results in a relatively low runoff coefficient. During high flows in the lower Pibor River, some of the flow finds its way to the Sobat River via the Khor Twalor to the west of the lower Pibor River. The Sobat River downstream of the Pibor-Baro confluence receives occasional inflows from its south bank tributaries (Fullus, Thul and Nyanding).

Figure 3-12 displays the seasonal flow patterns at key locations in the major rivers within the basin and also provides information on the mean annual flow at each location. It is evident that low flows occur between January and May, while high flows occur from September to October. Along the lower Sobat River, due to attenuation in the floodplains, the seasonal flow pattern is less pronounced. The major rivers in the basin are perennial, although some of the smaller tributaries e.g. the Yabus and Daga and the Sobat and upper Pibor tributaries are seasonal.




| Mean Annual Runoff in BCM | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 Yabus u/s Machar | 0.68 | 5 Kangen (Upper) | 1.10 | 9 Gilo u/s Pibor | 2.46 | 13 Baro u/s Sobat | 8.73 |
| 2 Daga u/s Machar | 0.33 | 6 Veveno/Lotilla (Upper) | 0.55 | 10 Akobo u/s Pibor | 0.36 | 14 Pibor u/s Sobat | 3.38 |
| 3 Birbir at Yubdo | 1.42 | 7 Baro at Gambela | 12.69 | 11 Agwei u/s Pibor | 0.41 | 15 Sobat at Nasir | 12.11 |
| 4 Geba at Suppi | 2.13 | 8 Alwero at Abobo | 0.67 | 12 Pibor at Pibor Post | 1.23 | 16 Sobat at Hillet Doleib | 12.07 |

*Figure 3-12: Hydrology of the Baro-Akobo-Sobat sub-basin*

### 3.2.4 Groundwater

#### 3.2.4.1 Groundwater potential

The groundwater supply potential for the entire study area has not previously been determined. For this reason, a new approach to quantifying the groundwater resources was developed. The approach involved collating, checking and sorting existing data, extrapolating data to areas without data, developing a system to group and rank similar groundwater areas and finally developing an approach to quantify these areas. The final products are two maps, one that provides a qualitative assessment (Figure 3-13) and the other that provides a quantitative assessment of the groundwater potential of the study area (Figure 3-14). Three yield options were assessed and Option 2 which has yields falling between Option 1 and Option 3 is considered the 'best estimate' at this stage, and is presented in Figure 3-14. A detailed description of the methodology can be found in Annex 1-D.

*Figure 3-13: BAS regional groundwater availability*

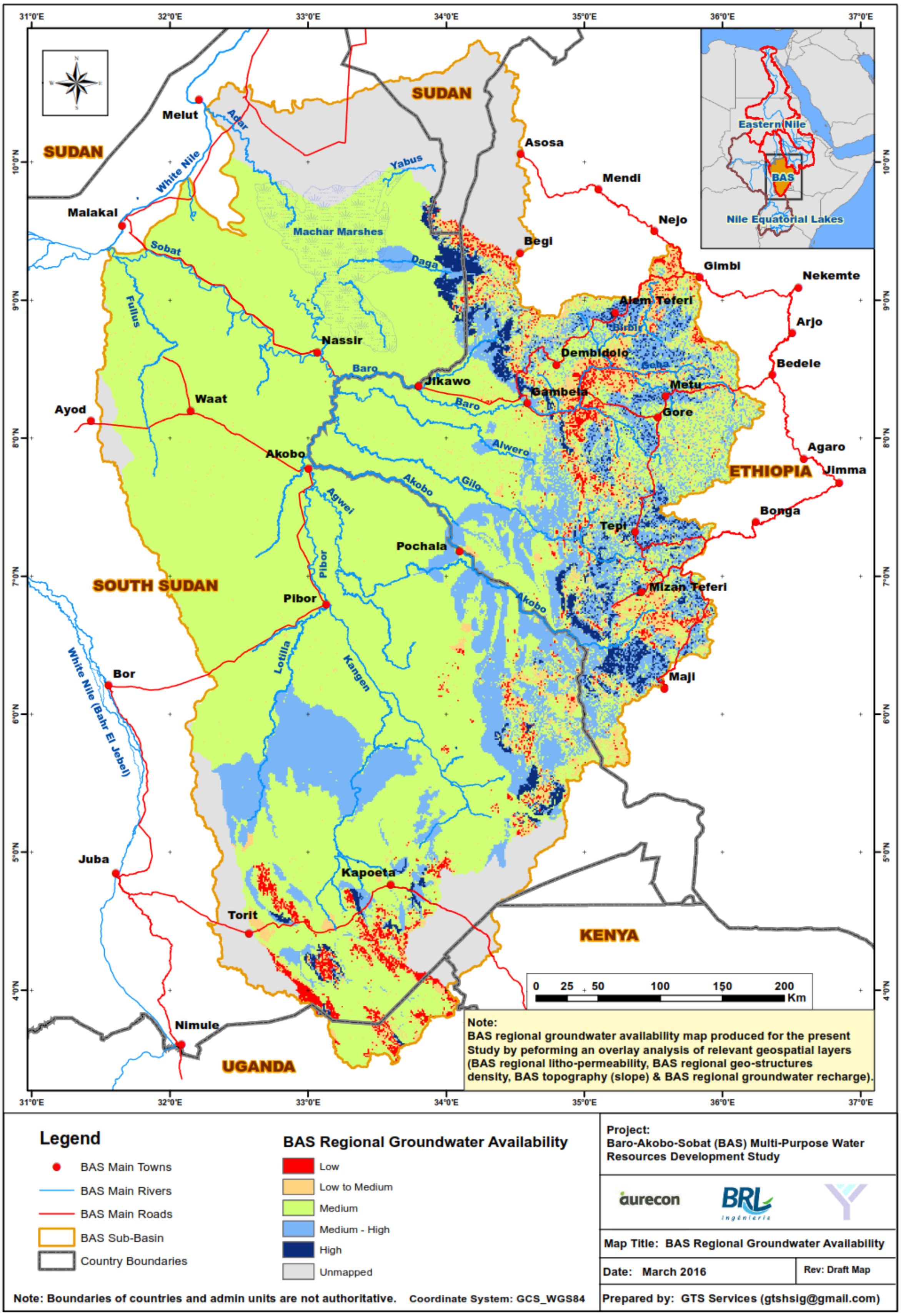
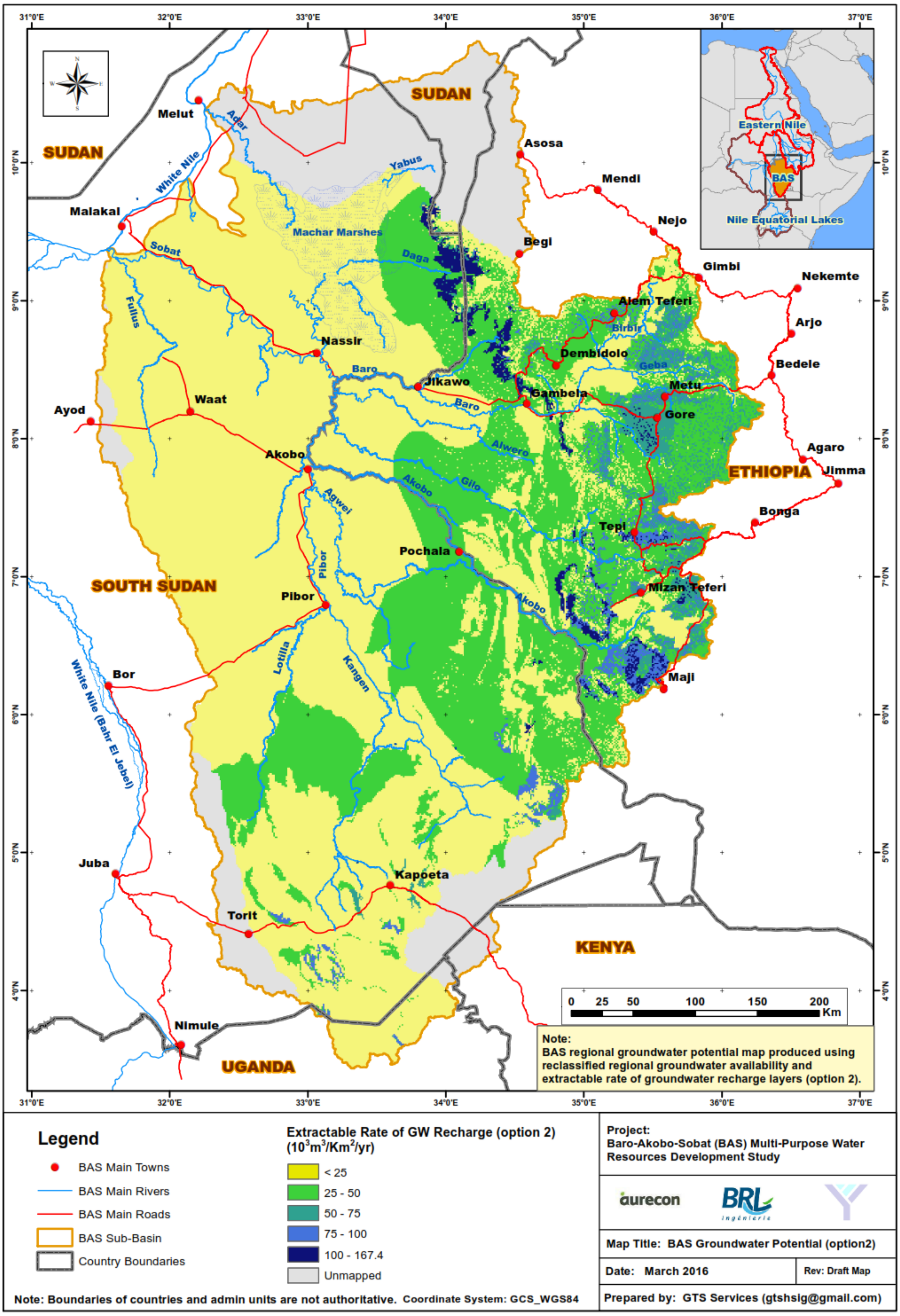


*Figure 3-14: BAS regional groundwater potential*



Since groundwater is so widely used in the sub-basin, and in many cases it is the sole water source, water supply problems are often attributed to the lack of groundwater, and comments like “boreholes are drying up” or “boreholes can’t give enough water” are frequently made. These two comments raise two questions: i) Are boreholes drying up? And ii) Are borehole yields insufficient.

The answer to the first question, is that the groundwater resources in the sub-basin are under-utilized, and in many cases, the lack of supply comes from infrastructure/conveyance problems, like pumps not working or poorly working due to lack of maintenance, or leaking pipelines, reservoirs, etc. In some cases, boreholes may have collapsed, and are now shallower than originally drilled, and possibly no longer reach the water table. In these cases, by simply measuring the depth of the boreholes and groundwater levels, it could be established whether the boreholes have in fact collapsed or dried up. Experience throughout Africa shows that in most cases, except for areas where the demand from individual boreholes has increased significantly or after extended droughts, the groundwater resource is reliable – it’s the infrastructure that frequently is not.

The answer to the second question is that the borehole yields in many parts of the sub-basin are low. Newly drilled boreholes may also be dry if the most favourable drilling sites were not located. I.e. the strata have low permeabilities and cannot supply enough water to meet the demand from a single or a few boreholes. In these areas, groundwater is available (and even a “dry” borehole will produce a water level if left a few days), but several boreholes, located in the right places, are required to meet the demand.

#### *3.2.4.2 Groundwater quality*

Water quality variations over the project area are complex as a result of different physical and geochemical processes that take place due primarily to the diversity in the geology. The spatial coverage of data is also limited and primarily dependent on localised surveys of individual projects. The available literature indicate that generally groundwater quality is good throughout the study area. The water is generally “fresh” (low salinity) and suitable for most uses. There are, however, localized exceptions such as high salinity due to mineralization arising from more reactive rock types, and from contamination due to urbanization. Contamination is greatest in areas with highly permeable unconsolidated sediments, and where water is drawn from hand-dug wells and unprotected springs.

##### UPPER BARO AKOBO

Except very few fault controlled springs which are reported to show high mineralization (TDS 2230mg/l), all analyses indicate fresh groundwater with Total Dissolved Solids (TDS) less than 600mg/l. This is due to the favorable hydrogeological setting of the region in that it gets rapid flushing by the prevailing high rainfall and short distance from the recharge areas. The TDS of the springs on Ethiopian highlands were plotted with graduated symbol (Figure 3-15). Except for few highly mineralized samples, most of the springs have TDS less than 500 mg/l.

##### GAMBELLA PLAIN

The groundwater is slightly saline to fresh; its TDS is not higher than 1000 mg/l and in most cases it lies between 200 and 600 mg/l. Its pH is generally neutral with values varying between 6.5 to 8.4. There are however strips of areas where iron concentrations are high (up to 89 mg/l), and its use for potable water supply is not possible without treatment. Examples of such areas are in the Jikawo-Baro interfluves along the Baro River, a strip east of the Gambella Plain in the Baro-Alwero interfluvial area, and at Gog, which is in the Alwero-Gilo interfluves. In these areas manganese and copper concentrations are also relatively high and would have to be (mostly) removed prior to domestic water supply.

In terms its suitability for irrigation, the groundwater is classified as a low salinity hazard with Sodium Adsorption Ratios (SAR) of 0.1 to 6.13.

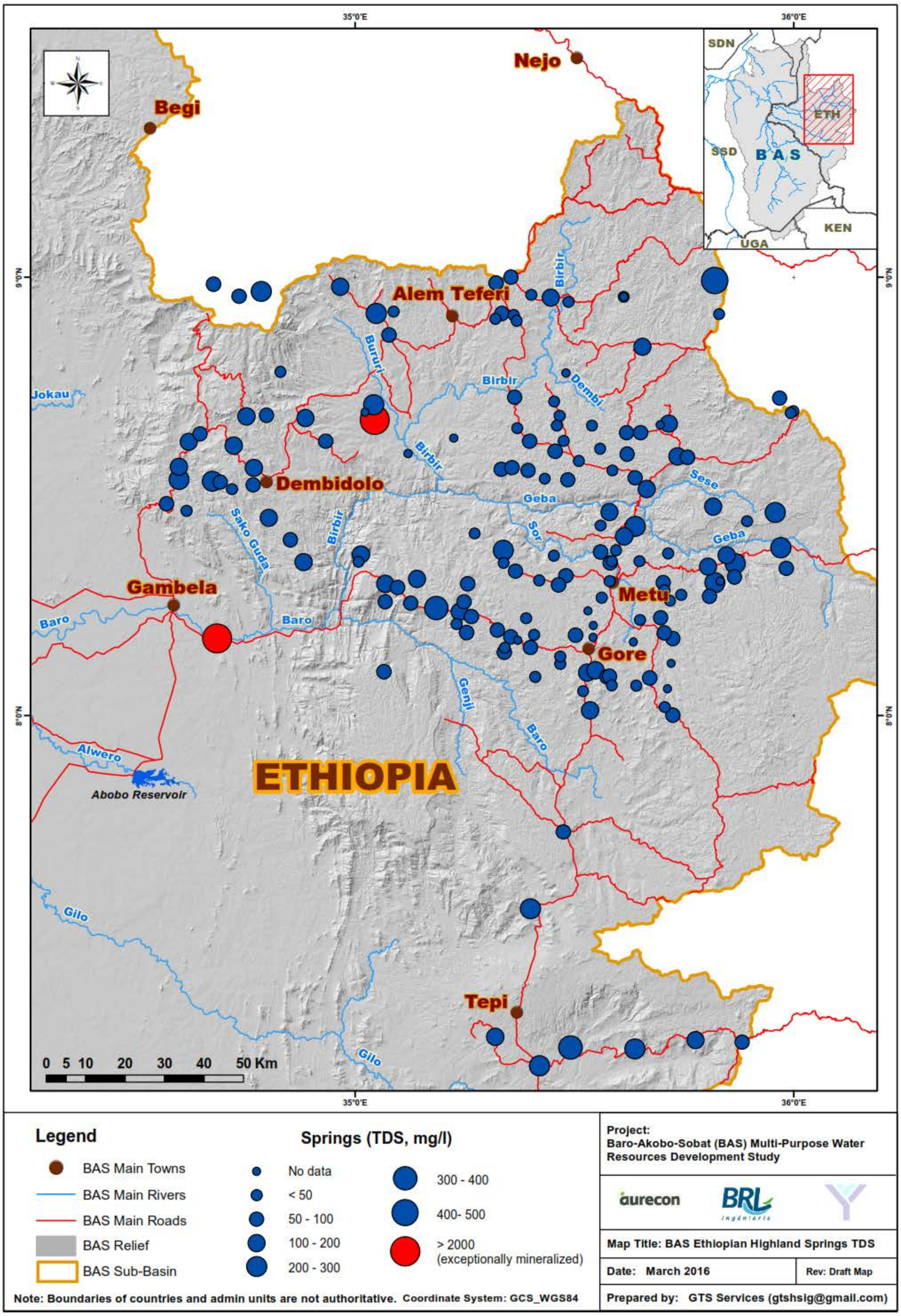
The quality of the artesian water from the Alwero Formation is fresh with TDS values of 300 mg/l and the water is neutral with a pH of ~7. Because of the confined nature of the aquifer, it is well protected from contamination.

### SOUTH SUDAN

Two dominant aquifer systems are present:

- Umm Ruwaba Formation: The bulk of South Sudan groundwater resources are found within this formation which is characterized by unconsolidated sands, clays and gravels with low to high permeability. Generally, groundwater quality is considered suitable for raw water supply, however, the salinity does vary considerably from 100 to over 5000 mg/l (fresh to brakish, rarely saline). Elevated concentrations of iron and manganese have been noted.
- Some boreholes in the Bor town area have been abandoned due to water quality problems. This is quite likely due to contamination rather than poor natural groundwater quality. The groundwater is considered to have low salinity, variable pH and moderate hardness, but with with elevated nitrate. Elevated nitrate and total coliforms are signs of contamination and are encountered especially in the shallow aquifers.

*Figure 3-15: Spring TDS values on the Ethiopian side of the study area.*



The basement complex: The Basement Complex rocks form an extensive hydrogeological unit in South Sudan covering one third of the country. It includes parts of the Eastern Equatoria region in the southern part of the project area (including the Torit area). Groundwater occurs in fractures and fault zones and may be recharged directly from rainfall. Water quality is generally considered good with low salinity.

There are areas however with elevated salinity, and not all wells are operating in Torit due to reported salinity problems and other factors. The groundwater is said to be of variable quality, being fresh to brackish, however no analytical information could be found on water quality (physiochemical or microbiological).

**SALINE GROUNDWATER ZONES**

Salinity levels exceeding allowable limits have been reported in Jonglei and Unity States of South Sudan. While higher concentrations of fluoride, sulphate and nitrates have been observed in a few states, overgrazing and deforestation has also affected water resource quality by increasing the turbidity and siltation in water structures.

In the Northern part of the study area, within the Jonglei State, an area with brackish groundwater TDS 1500 – 5000 mg/l is recorded.

Areas of elevated salinity may also coincide with oil exploration sites in Unity State. It is recommended that groundwater be monitored and that the impact of effluent from waste stabilization and oxidation ponds around Juba, west of the present project boundary, be assessed.

#### *3.2.4.3 Existing groundwater use*

The water point records were evaluated as indicators of groundwater use from different source types. Water points collected include springs, hand dug wells, boreholes and limited water harvesting, hafir and spring catchment points (Figure 3-16). A relatively large number of boreholes have been drilled within the South Sudan part of the study area while concentrations of springs exist in the highland part of the Baro Akobo Basin of Ethiopia The density of hand dug wells may indicate the potential of shallow groundwater which is expected in the recent alluvial deposits close to river channels. Except where the resource base is limited in terms of its availability or water quality, groundwater is mostly the preferred source of water supply for rural as well as urban centres.

Groundwater abstraction from all groundwater sources was estimated to be in the range of 3.4 $Mm^3$/year for the upper Baro Akobo part of the study area (ARDCO-GEOSEV, 1995). This is comprised of springs (2.0 $Mm^3$/year), hand dug wells (0.675$Mm^3$/year) and drilled wells (0.66 Mm3/year). In total, this yield is equivalent to an abstraction of groundwater from about 10 boreholes at a rate of about 10.5 l/s from the entire mapped study area.

This information shows (together with borehole depth data) that groundwater use is very low and mostly limited to abstraction from springs and shallow aquifer systems. There is, however, a significant potential in certain areas for utilising high-yielding, deeper aquifer systems.

There are no known large scale development works in the basin using groundwater such as for irrigation purposes. In the Baro Akobo highland part of the project area, 22 boreholes, 68 hand dug wells and 42 springs were recorded as sources of domestic water supply in the ARDCO-GEOSERV (1995) inventory.

Similarly, the boreholes data retrieved from South Sudan for the Jonglei, Eastern Equatoria and upper Nile states provide regional information on the status of groundwater development and drilling practices. Though the information contained is not complete, 1642, 305 and 73 boreholes data records have been registered in the Eastern Equatoria, Jonglei and Upper Nile states respectively ; and of these, 1343 of them fall within the present study area. From the data with records and at a regional scale, it is evident that the wells drilled are shallow mostly in the range of 30 – 100m and their yields are low in the range of less than 0.01 to 5 l/s.

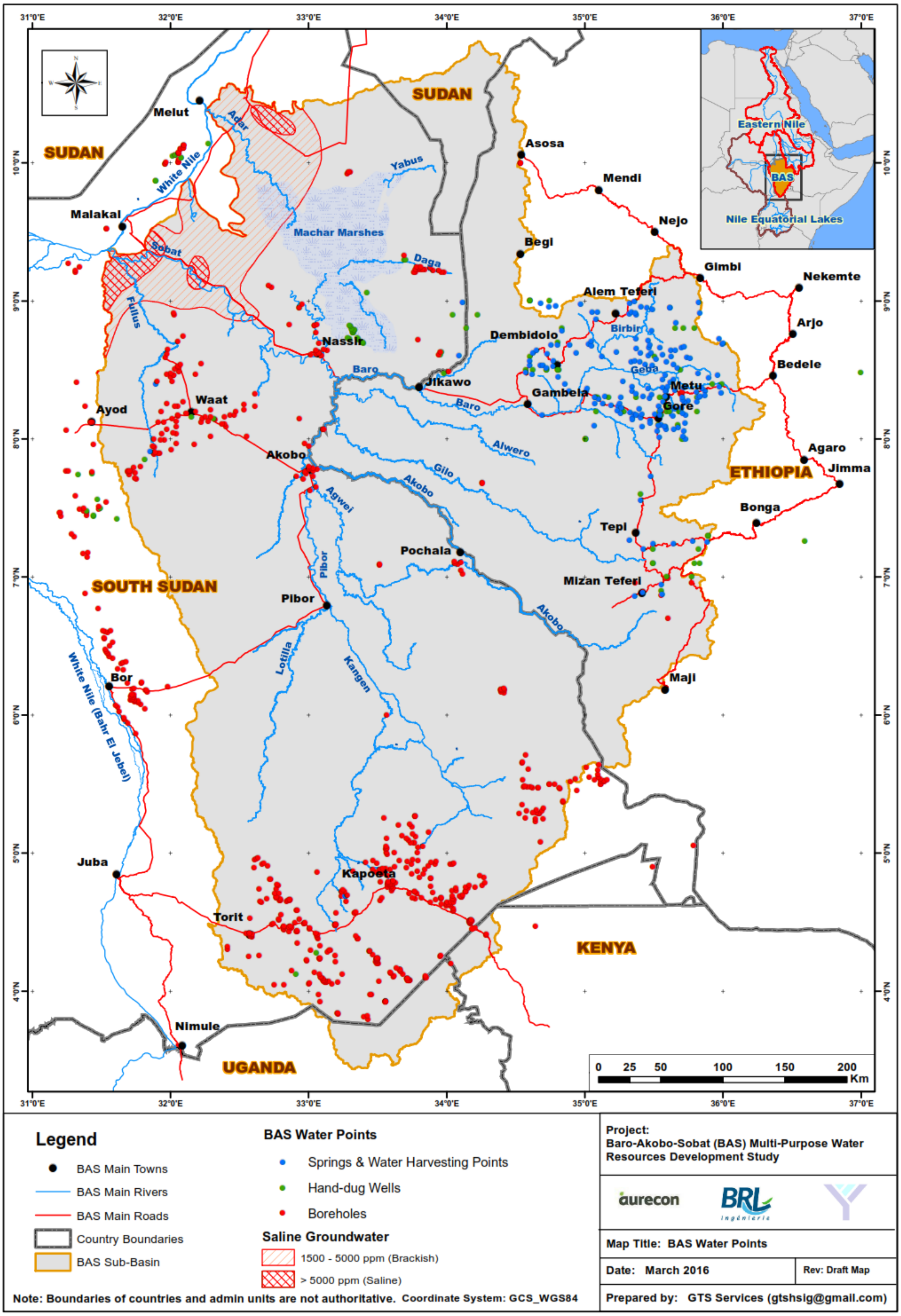
For the Sobat part of the study area, it is evident that groundwater significantly supports water supplies for the towns of Bor and Torit, together with other centres. However, this practice is confronted with problems such as wells becoming dry, saline or polluted and this has resulted in abandoning many of them and shifting to surface water. It must be noted that in many parts of Africa, boreholes and wells have been reported as “dry” when actually the pumps or conveyance infrastructure is faulty. It is not known whether the reportedly dry wells in the study area are indeed dry or whether this is the term commonly used when people cannot draw water from a well, irrespective of the reason.

Bor town, located on the banks of the Bahr el Jebel River (Nile), uses treated surface water. There are about 55 domestic water supply boreholes in the town, some of which are apparently abandoned due to being dry, saline or contaminated. Drilling records suggests that prior to 2008 most boreholes were drilled to a depth of less than 40m. Since 2008 borehole depths increased to around 80 m. This may suggest over-use of the resource, but there could be numerous other reasons why boreholes were drilled deeper (e.g. better equipment may have made it easier to drill). Yields are said to be ‘moderate’ to ‘good’ although no quantitative data is available.

Torit is located on the northern bank of the Kinyeti River, and like Bore, uses treated surface water. Of the 98 boreholes that have been located in the town, some 19 were reportedly abandoned or disused due to being dry, saline or equipment failures. Borehole yields are low, and most are relatively shallow (less than 40 m prior to 2007/8).

All in all the data shows that currently groundwater use is limited to waters found at shallow and medium depths. As demand increases, for example for irrigation use, the option of drilling into deeper aquifers that could provide large yields should be explored.

*Figure 3-16: BAS water points*



### 3.2.4.4 Boreholes water supply potential

#### NUMBER OF PEOPLE THAT CAN BE SUPPLIED WITH DIFFERENT PUMPS

The number of people that can be served at various abstraction rates and the number of boreholes required is shown in Figure 3-17. Furthermore, a borehole equipped with a hand pump can serve about 200 people if operated for 12 hours a day (this equates to each person having around 3 minutes to fill a 20 L container, or continuous abstraction at 0.1 L/s). The higher-yielding solar pumps can yield around 80 $m^3$/day (although this varies with pumping head and pump type), and this can supply 4 000 people/day on average (e.g. average of 2 L/s x 12 hours/day). A diesel or electric powered pump supplying 5 L/s can supply around 10 000 people/day using a 12-hour pumping cycle.

Figure 3-17 shows, for example, that 5 boreholes equipped with hand pumps can supply around1000 people, but if the borehole yields were sufficient to support solar, diesel or electric pumps, then up to around 30 000 people could be supplied with solar pumps and more than 50 000 people could be supplied with diesel or electric pumps.


*Figure 3-17: The number of boreholes required to serve various population sizes*

#### AREAS WITH GREATER GROUNDWATER DEVELOPMENT POTENTIAL

The statement from the TAMS-LGL (1997) report "There is some groundwater development potential in effectively all areas of the Baro-Akobo Basin" could equally apply to the entire study area (the BAS Basin), as all areas have enough groundwater resources to meet small-scale rural domestic and livestock requirements. However there are 4 main aquifer types that can potentially provide more water than merely the basic requirements for scattered rural settlements; these are:

i. Fractured Basement Complex rocks
ii. Porous and permeable unconsolidated sediments
iii. Fractured basalts, and in particular the Gog Formation basalts.
iv. Permeable sandstone of the Alwero Formation.

All four aquifer types appear to be underutilised and all can possibly be developed to meet domestic, livestock and irrigation requirements, although for irrigation purposes, prime areas in these aquifers would need to be located.

In essence, groundwater can meet the needs of all rural villages (including pastoralists), small towns and most medium-sized towns. In some areas it can also meet the requirements of main cities. The populations associated with these terms are those used by TAMS-ULG (1997), and are shown in Table 3-2 (just the upper population values are given). Table 3-2 also shows the pumping supply options that could be used to meet these demands.

*Table 3-2: Number of boreholes and pumps required to meet domestic water demands (at 20 L/p/day)*

| Settlement | Population | Hand Pump | Solar Pump | Diesel/Electric Pump |
|---|---|---|---|---|
| Villages | 1 000 | 5 | 2 | 1 |
| Small towns | 4 000 | - | 6 | 1 |
| Medium towns | 10 000 | - | - | 1 |
| Main cities | >10 000 | - | - | >1 |

### THE HIGH-POTENTIAL BUT POORLY UNDERSTOOD ALWERO FORMATION

There is one major area of uncertainty in the study area and additional knowledge on this could open up development opportunities for people in both western Ethiopia and southern South Sudan. This is the Alwero Formation sand/sandstone aquifer. This aquifer was assessed in 1990 (Selkhozpromexport, 1990) but no further development appears to have happened since then. Six boreholes were drilled into this confined aquifer in the Gambella Plains, and after testing them, the recommended combined production yield was 50 L/s (or around 8 L/s on average of continuous supply).

Besides the high yields, the water quality was also found to be very good (TDS around 300 mg/l). By all accounts, the water should be suitable for domestic and irrigation use. Being a confined aquifer, the water is unlikely to be contaminated with micro-organisms, and therefore for bulk domestic supplies would possibly require no treatment, although chlorination is recommended due to possible contamination in the conveyance infrastructure.

The aquifer has not been mapped and thus its geographic extent in the sub-surface is not known, but it is expected to stretch from the eastern parts of the Gambella Plains in Ethiopia to the west, into South Sudan; and it’s northern and southern boundaries are likewise, not known. In order to establish the potential yield from this aquifer, a hypothetical wellfield was modelled using the aquifer parameters obtained during the 1990 study (Selkhozpromexport, 1990). The model used was designed by Murray, et al (2012) and showed that if the Alwero Fm does have regional aquifer parameters similar to those found by Selkhozpromexport (1990), and if natural recharge can replenish the aquifer during the rainfall season, then it is possible to abstract around 5 500 m3/day from a 8-borehole wellfield that occupies a 4 km by 4 km space on the ground.

### 3.2.4.5 Groundwater management

Managing groundwater for water supply purposes should have three main functions. The first should be to ensure that the aquifer is used optimally. This means that it should not be overpumped as that would negatively impact on its long-term sustainable yield or on the environment. It also means that if the aquifer is being under-utilised, this will become known. The second main reason is to ensure that the water quality in the aquifer is not negatively affected. This may be as a result of high abstraction from the aquifer, or from poor groundwater protection (from latrines, animal enclosures, etc). The third main reason is to optimise borehole pumping rates so that the pumping equipment operates efficiently. An additional function, which is usually captured in the first two points, is to ensure that environmental integrity is maintained. This may mean abstracting groundwater at a rate lower that the aquifer's sustainable yield in order to maintain spring flows.

The management system needs to include data collection, data capture and data analysis, and this must inform operational changes.

At this stage it is assumed that very little groundwater management, if any, takes place in the study area. All proposed projects will need to incorporate the necessary monitoring and management tasks mentioned above. In addition to this, and in order to obtain more information on the aquifers recommended for demonstration projects, additional monitoring boreholes should be installed. These boreholes will enable the hydrogeologist who analyses the data to establish if there is any regional effect of large-scale groundwater abstraction, and this will help in managing the wellfields and it will help in designing future wellfields and groundwater development projects.

To improve the current groundwater management status, following measures should be undertaken:

- Capacitate the sector institutions for proper monitoring, management, development and utilization of groundwater resources.
- License and control groundwater development and use practices.
- Prepare detailed and exhaustive studies to map and determine the available resource in a reliable and more accurate way.
- Develop groundwater management plans at local and regional levels.
- Establish proper metering and monitoring systems for sustainable use of the resource including applications of modern technologies.
- Give appropriate emphasis on groundwater development technological issues and operation and maintenance requirements.
- Establish applicable environmental protection regulation in relation to groundwater resources protection.

#### 3.2.4.6 Possible development projects

Groundwater can probably meet the demand for domestic water in most areas. However, siting specific locations for boreholes would require more detailed assessments. The limiting factor from a groundwater perspective is the number of boreholes or wells that would be required to meet a specific demand and not the reliability of the resource itself. In low-permeability areas a number of boreholes may be required, but in the areas with high permeability, a few boreholes should meet the requirements for most domestic use. There are, however, specific areas where the water quality may be the limiting factor. In such areas, additional treatment, besides chlorination, is required.

Urban centers should be supplied from deep boreholes or large diametre wells sunk into properly protected aquifers. Rural settings can be supplied from shallow wells, protected springs or hand dug wells depending on their respective demands. In most case, well yields of 0.2 to 1 l/s could meet the demand for rural villages if good construction and sanitary protections are provided.

In this project, priority areas of the Akobo and Jore woredas, and the Kapoeta area, were identified as possible sites for groundwater development projects that would target the needs of both human and livestock requirements.

**Livestock water supplies** can be integrated with domestic supplies or developed independently depending on the local conditions and requirements. Like domestic supplies, it is quite likely that all areas can be supplied with groundwater.

At this stage it appears as if no groundwater-based irrigation projects exist in the study area. The ARDCO GEOSERV (1995) study mentioned that “the potential for high rate of groundwater production for irrigation is not considered feasible throughout most of the project area”. While this certainly holds for the low-permeability areas where hand dug wells are prevalent, it probably does not hold for the prime aquifers that are yet to be exploited such as the Alwero Formation aquifer described above.

The following areas were identified as prospective groundwater development areas with production capacities in the range of 1.5 l/s to 20 l/s (TAMS,1996):

- Itang vicinity (50 km west of Gambella)
- Vicinities of Jikaro-Baro
- Vicinities of Baro-Alwero
- Vicinities of Alwero-Gilo
- Vicinities of Gilo-Akobo

## 3.2.5 Water Quality and sedimentation

### 3.2.5.1 Water quality

There is no form of regular water quality monitoring in both the Ethiopian and South Sudan parts of the Baro-Akobo-Sobat sub-basin. Intermittent monitoring efforts seem to focus on quality control at the location of water supply schemes only. Surface and groundwater quality data have been collected on an ad hoc basis for various studies but these have not been collated into a central database that is accessible to water resources managers and to consultants alike. The ENTRO One System Inventory report (ENTRO, 2007) concluded that water quality in the Baro-Akobo-Sobat sub-basin was not threatened.

Merid (2005) undertook a high level assessment of water quality in the Ethiopian part of the Baro-Akobo-Sobat sub-basin The results were interpreted and evaluated within the context of guidelines and standards pertaining to Ethiopia and are summarised below:

- Turbidity, suspended sediments and colour: Turbidity in water is caused by the presence of suspended material, with soil and silt particles constituting the major part in most natural waters. The colour of water may be due to the presence of coloured organic matter such as humic acids, metals such as iron and manganese, or the presence of highly coloured industrial wastewater. About 85% of the Nile River annual flow for downstream countries (Sudan and Egypt) comes from the Ethiopian Highlands via the Blue Nile, Atbara River and Sobat River. Similar to many other rivers of Ethiopia maximum concentration of 342 TCU (True Color Unit) and 65 FTU (Formazin Turbidity Unit) were detected at Dabena in Bedele. This high concentration of the raw water quality was due to high suspended solids and presence of dissolved iron (1.05 mg/l) and manganese (0.5 mg/l) concentrations.
- Iron and Manganese: Iron, the essential element required for the formation of hemoglobin and other proteins and enzymes in the body is released naturally into the aquatic environment from weathering and leaching of sulfide ores and igneous, sedimentary and metamorphic rocks. The presence of high iron (1.05 mg/l) and manganese (0.5 mg/l) concentrations in drinking water poses predominantly aesthetic problems. Five samples for iron and 2 samples for manganese exceed the Guideline Value for Drinking Water Quality.
- pH and SAR: The pH value between 6 and 8 is acceptable for aquatic species and almost for drinking water supply purposes. The low salinity and Sodium Adsorption Ratio (SAR, less than 10) value indicated that the water was ideally suited for irrigation purposes (Selkhozpromexport, 1990).
- TDS (Total Dissolved Unit) and EC (Electrical Conductivity): Based on the hardness, TDS and EC measured the sampled water can be characterized as very soft, less saline and low mineral water, suitable for domestic water supply requirements and the maintenance of aquatic ecosystem health.
- Nitrates and Nitrites: Municipal and industrial discharges, decomposition of sewage wastes, leachate from waste disposal dumps, sanitary landfills and soil leaching in areas where inorganic nitrate fertilizers are used contribute nitrates to rivers and lakes. It was concluded that the low nitrate (10mg/l) and nitrite (0.4mg/l) concentrations indicated that the surface waters were largely free from above mentioned pollutants (Merid, 2005).
- Waterborne diseases: ENTRO (2007) identified malaria as a major concern that was increasing as it was difficult to control. Other water related diseases included Schistosomiasis, Typhoid, Diarrhoea, Helminthiasis, Leshimaniasis, and Onch ocerchiasis. Outbreaks appeared to be associated with the seasonal flooding of the low-lying areas.

The National Nile Basin Water Quality Monitoring Baseline Report for Sudan (NBI, 2005) states that there are no routine monitoring points in the South Sudan part of the Baro-Akobo-Sobat sub-basin, and the only regular sampling point is on the White Nile at Malakal.

Although water quality is not yet a problem in the Baro-Akobo-Sobat system, there are worrying signs of impacts that could, cumulatively, start to have a negative impact on water users in the basin. These include localised impacts of solid waste and wastewater impacts from urban and rural settlements, oil exploration and extraction in the *Machar marches* and its potential impacts on water pollution and flow diversion, deforestation in the Ethiopian highlands and the impacts on sediment loads in the rivers draining the highlands, the general poor state of flow and water quality monitoring in the basin which is a prerequisite for management decision making, artisanal gold mining in the highlands and the impacts on sediment loads and trace metal pollution, and invasive aquatic weeds starting to impede navigation and impacting on the dissolved oxygen concentrations in the water. Potential pollution from specific sources in the basin are described in more detail in Annex 1-B.

It is recommended that routine flow and water quality monitoring be implemented as recommended by the current NBI Hydromet Project (NBI, 2014) in order to improve the water quality knowledge base in the Baro-Akobo-Sobat sub-basin and to provide a platform for the early identification and investigation of potential water quality problems in the sub-basin.

#### 3.2.5.2 Sedimentation

A major issue in all of the Baro-Akobo-Sobat sub-basin concerns suspended solid loads in surface waters as a result of erosion. The high sediment loads in the rivers are the results of high topographic slopes, high intensity rainfall patterns, poor farming practices and deforestation due to population pressure and commercial exploitation of wood resources. Trampling of water courses when semi-pastoralists move closer to the river for grazing their cattle in the dry season is a further source of sediments. When the rainy season commences and water levels rise again, resuspension of the fine dust particles in the trampled areas occurs.

*There is no sediment database available in the basin and available data are too limited to deduce any meaningful sediment yield-discharge relationships. Consequently, the SHETRAN model (Ewen et al.,* *2000) was used to develop a sediment yield map for the basin.*

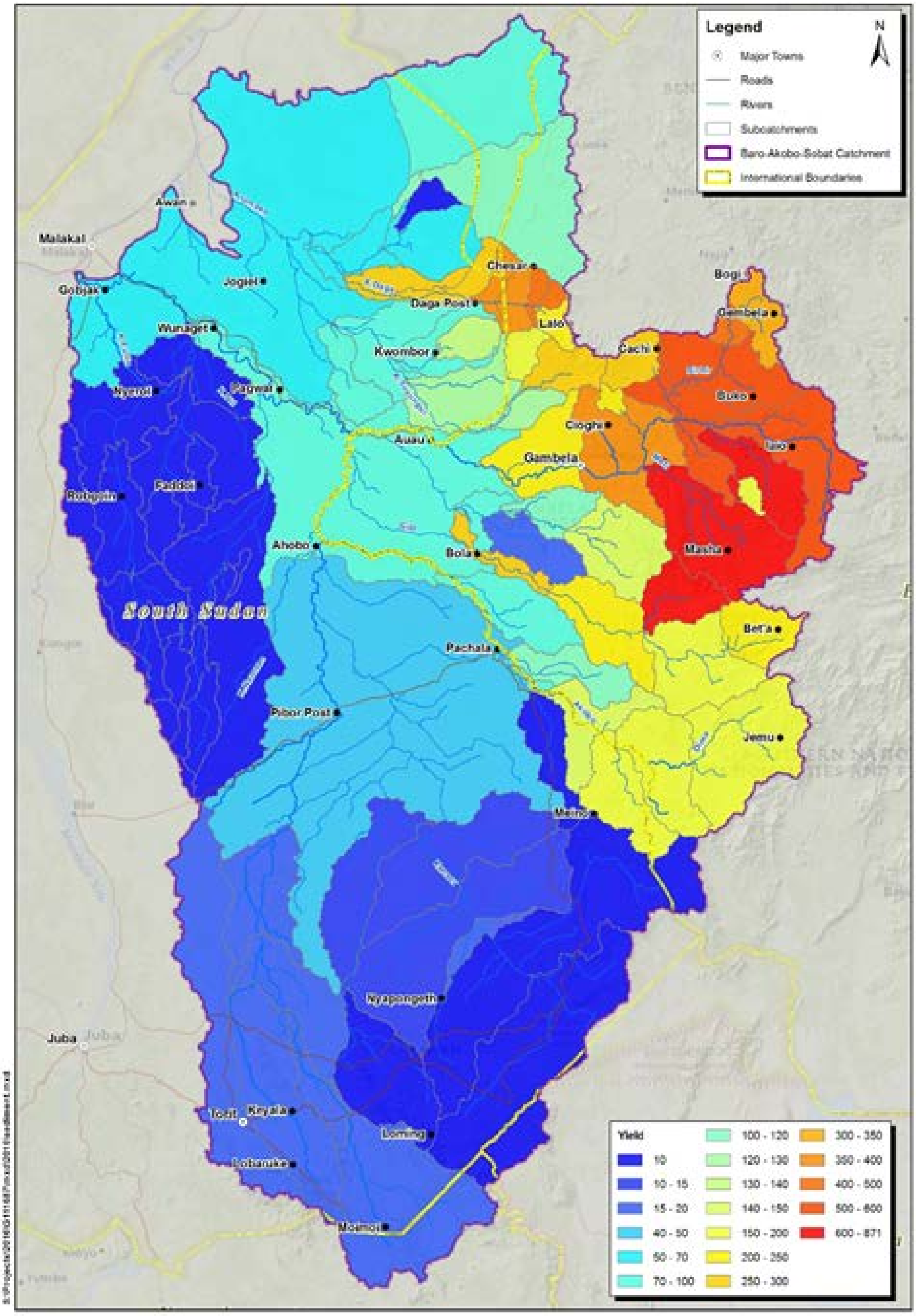


Figure 3-18 shows the cumulative sediment yield in t/km2/a at any location in the basin by taking into consideration soil erodibility and sediment transport. The sediment yield map shows that cumulative sediment yield is very high (above 800 t/km2/a) in the upper Baro River catchment. However, this reduces to between 200 t/km2/a and 400 t/km2/a in the foothill zones. Within the lower part of the catchment, due to less erosion and significant deposition, cumulative sediment yields are typically below 100 t/km$^2$/a. A detailed description of the SHETRAN model configuration and application to the Baro-Akobo-Sobat sub-basin is included under Annex 1-C.

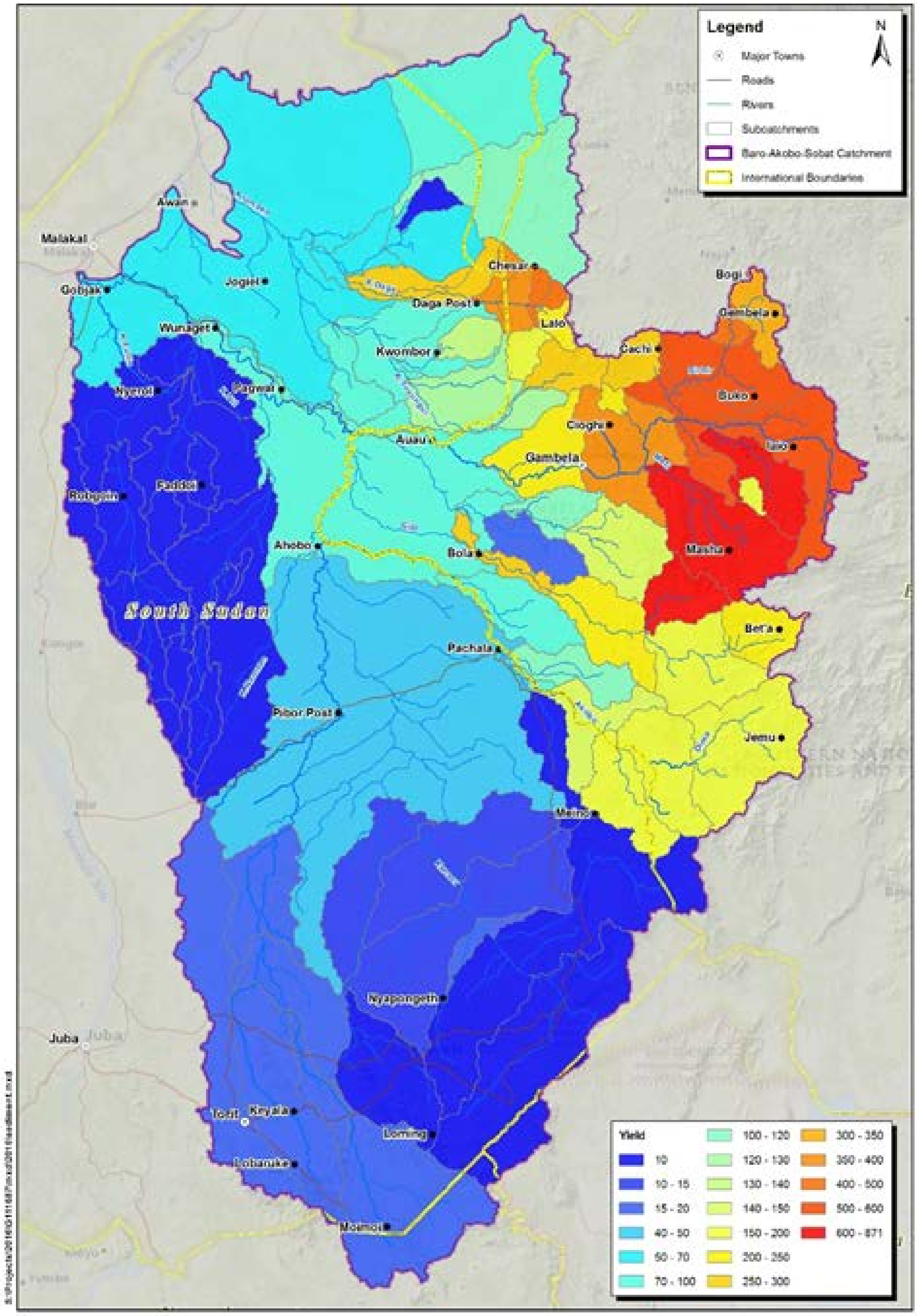



*Figure 3-18: Cumulative sediment yield in the basin in t/km$^2$/a*

## 3.2.6 Floods and droughts

### 3.2.6.1 Floods

The Gambella Plains to the west of Gambella flood almost every year. This flooding is mainly caused by the limited conveyance capacity of the mild sloping Baro, Alwero, Gilo and Akobo rivers upstream of their confluence with the Pibor River, which is exacerbated by the backwater effects from the Pibor and Sobat Rivers, direct heavy rainfall over the flood plains and deforestation in the upper catchment areas, which increases the flood runoff response and flood volumes and also leads to excessive sedimentation. Aerial surveys during previous flood events has shown that the flooded area can be extensive e.g. during the extreme flood in 1988, an area close to 10,000 km$^2$ was inundated along the Gambella Plain during October and November. Apart from the seasonal flooding along the plains, there are also occasional flash floods, especially in the southern and south-western parts of the basin in South Sudan. Apart from the almost annual floods, extreme floods in the region have occurred in 1934, 1946, 1962, 1996, 2007, 2010 and 2014. Flooding events have also been reported in Jonglei State in 2016.

The areas within the plains that are subject to regular flooding are mainly used as pastures and for recession agriculture. Furthermore, many people in the Gambella region live along the river banks which make them susceptible to flooding. Structures within the floodplain include cattle enclosures, isolated tukuls and several large villages, especially along the Baro River. During the 1988 flood, a significant portion of Gambella and almost the entire town of Itang were flooded with severe socio-economic impacts due to administrative buildings, houses, hotels, the power station and roads being inundated in Gambella. In South Sudan, especially in Upper Nile State, Jonglei and Eastern Equatoria State, the reported damages encompasse loss of lives, loss of crops, flooding of refugees camps, hindered access to many areas during the rainy season because road become then flooded.

*Figure 3-19: Flood in the Upper Nile State in 2011*

*Source: (FloodList, 2014)*

Although the flooding has severe negative impacts due to loss of life, structural damage to infrastructure, displacement, health risks and water logging of pastures and crops, the annual floods also support recession agriculture and provide fertile pastures to support the extensive cattle farming in the area.

Selkhozpromexport (1990) estimated the extent and duration of flooded and waterlogged areas along the Gambella Plain for different flood recurrence intervals as summarised in Table 3-3.

*Table 3-3: Extent and periods of inundation in the Gambella Plain*

| Flood recurrence interval (years) | Fully flooded lands | | Waterlogged lands | | Total area ($km^2$) |
|---|---|---|---|---|---|
| | Duration (months) | Area ($km^2$) | Duration (months) | Area ($km^2$) | |
| **2** | 2 to 3 | 800 | 3 to 4 | 1 930 | 2 730 |
| **10** | 2 to 3 | 3 600 | 3 to 4 | 5 650 | 9 250 |
| **50** | 3 to 4 | 9 720 | - | 972 | 9 720 |

*(Selkhozpromexport, 1990)*

The study also indicated the expected limits of the 1 in 2 year and 1 in 10 year floods. Areas along the Baro (near Jokau), Alwero, Gilo and Akobo Rivers where flooding is caused by the limited conveyance capacity can be clearly seen in Figure 3-20.

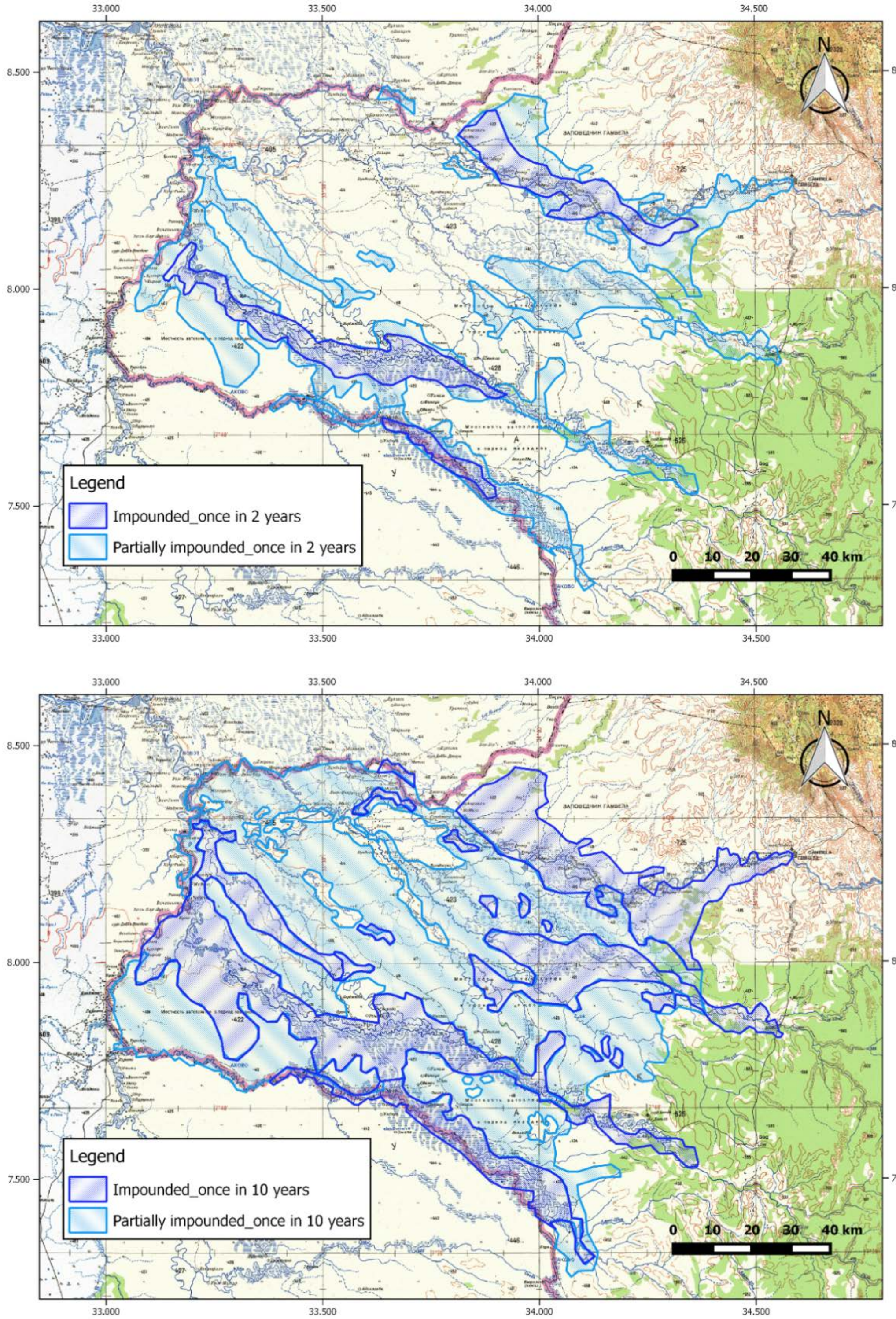



*Figure 3-20: Extent of flooding in the Gambella Plain under different recurrence intervals*

*(Selkhozpromexport, 1990)*

The flood season in the upper part of the Gambella Plain typically extends from July to October. However, due to the spills onto the floodplains and the associated ponding and attenuation, the flood season along the lower part of the Plain can last up to November and even December. Figure 3-20 shows the progression and extent of inundation in the Gambella Plains and *Machar marshes* for the period July to Dec 2007.

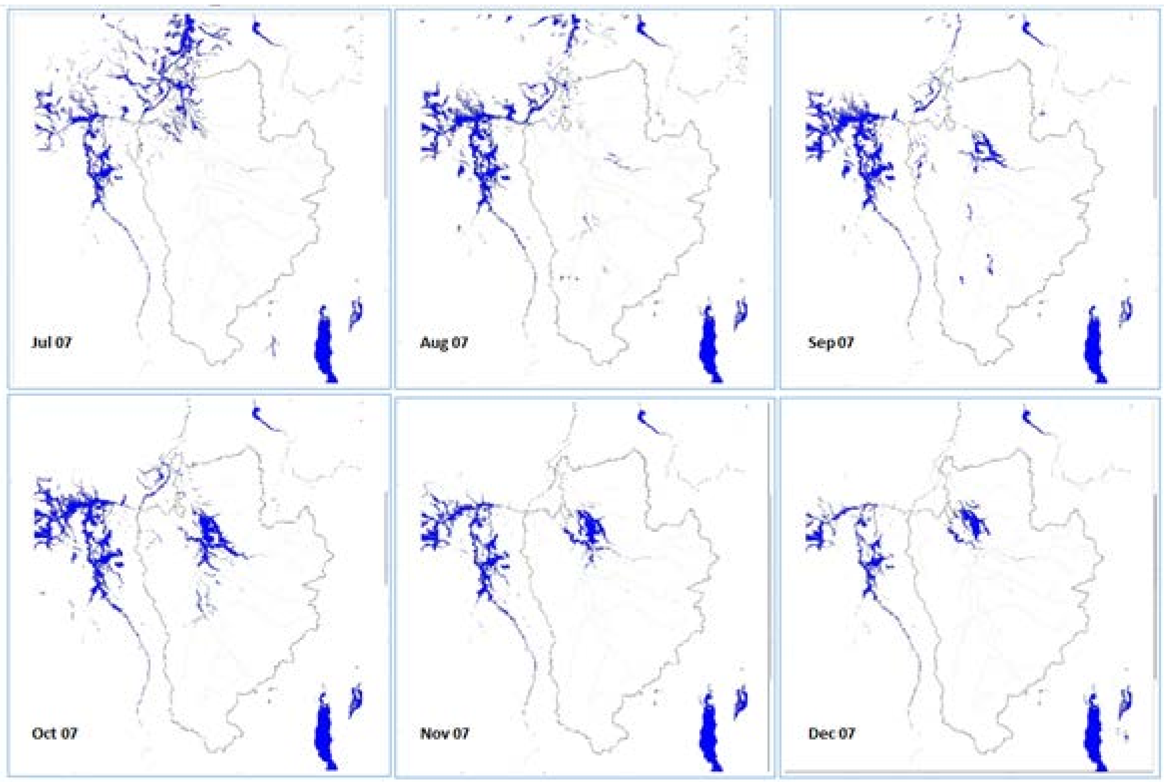



*Figure 3-21: Flood progression in the Gambella Plains and Machar Marshes during the 2007 floods*
*(Miolane et al., 2015)*

ENTRO's Flood Preparedness and Early Warning project (FPEW) was launched in 2007 and has been providing assistance to national, regional and local authorities in various regions, including Gambella, through early warnings and capacity building for preparedness. The project enhances regional collaboration and improves national capacity in mitigation, forecasting, early warning, emergency preparedness, and response to floods. Typical early warning information include rainfall forecasts and expected flood extents and inundation levels

Flood protection measures along the Gambella Plain should ideally involve a combination of structural measures (e.g. dikes or upstream flood attenuation dams) and non-structural measures aimed at reducing the impacts of flooding in vulnerable areas. It is imperative that flood protection works are constructed to adequately protect future developments within the Gambella Plain such as commercial agriculture schemes, from flooding, and that the cost of these protective measures are included in the economic and financial evaluation of these schemes.

### 3.2.6.2 Droughts

Drought is a natural phenomenon over which humans have little control. Droughts may be categorised as meteorological, agricultural and hydrological. Meteorological droughts are triggered by a prolonged period of less than average precipitation. Agricultural droughts refer to low levels of soil moisture due to lack of or unseasonal rainfall or insufficient water for irrigation. Hydrological droughts refer to surface and groundwater reserves being depleted. In recent years, a fourth category (socio-economic drought) has also emerged referring to the case where the demand for an economic good exceeds supply as a result of a weather-related shortfall in water supply.

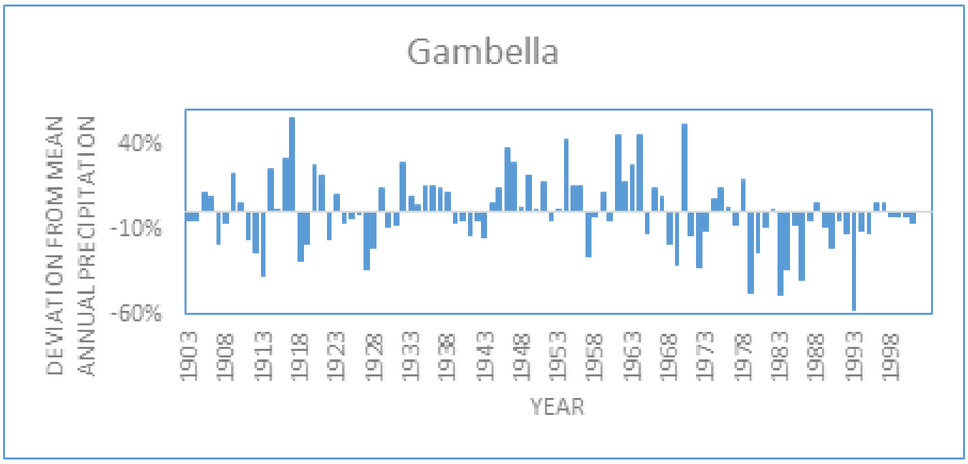
The potential impacts of droughts are many and varied and have environmental, agricultural, health, economic and social consequences. The effect varies according to vulnerability. It affects humanity in a number of ways including loss of life, crop failures and food shortages which may lead to famine in many regions, malnutrition, health issues and mass migration in search of food and water. It also causes damage to infrastructure and the environment and is regarded as a major cause of land degradation, aridity and desertification. The impacts of droughts are witnessed at a range of geographical scales: Individual families or communities may lose their livelihoods and source of water, leading to acute food shortages and health issues; At a different scale, a country's economy may be severely impacted. During times of drought, water-related diseases are rampant. Surface water sources such as springs and ponds dry up. Remaining water sources are heavily contaminated by environmental waste, such as human and animal excreta, while stagnant water serves as a breeding place for mosquitoes. In times of drought, there is often not enough water available for people to bathe regularly. As a result, community members, especially children, suffer from scabies and eye infections. During these times, in an effort to conserve water, hand-washing after defecation or before eating is rarely practised. Diarrheal and water-related diseases are among the principle causes of death in young children.

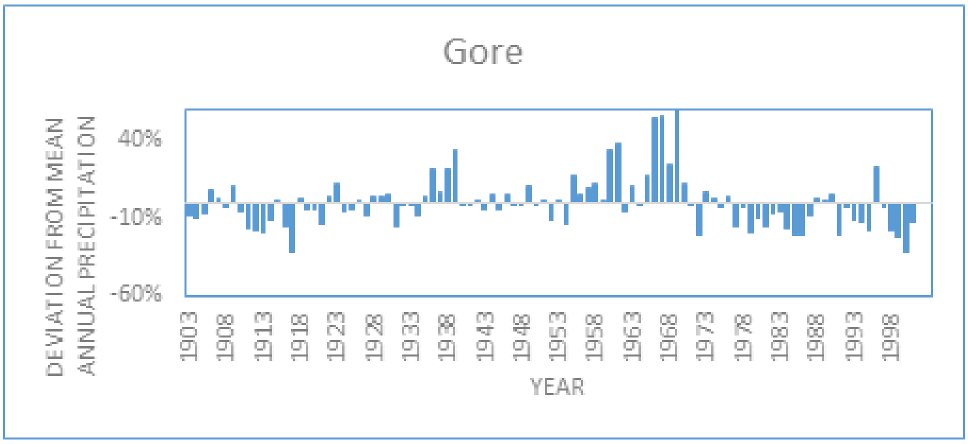
Within the Baro-Akobo-Sobat sub-basin, the main livelihoods systems include pastoralism, farming and ex-pastoralism – those who have dropped out of pastoralism and now survive on petty income-earning activities. Subsistence farmers and pastoralists have attempted to build resilience to meteorological droughts by selecting crops that are more sturdy to survive in stressed climatic conditions or by migrating to areas less affected by droughts. However, this causes social and political tensions.

The spatial variation of rainfall in the Baro-Akobo-Sobat sub-basin is considerable due to the significant variation in elevation across the basin. High altitudes (above 2000 masl) are characterised by high moisture and longer wet periods than the lower lying areas (less than 500 masl). On the Gambella Plain, only about six years in ten have a dependable rainfall of at least four months, which is required to support good yields of most annual crops (ENTRO, 2014).

Figure 3-22 for example, highlights the increased variability in annual rainfall at Gambella on the floodplain vs Gore in the highlands. Zaroug, et al. (2014) have shown that there is a strong correlation between droughts in Ethiopia and the El Nino events, which allows droughts to be predicted with some lead time.

*Figure 3-22: Annual rainfall variability at Gambella and Gore*




In addition to the increase in inter-annual rainfall variability, Figure 3-23 shows a decreasing trend over the last 100 years based on annual rainfall at Gambella.

*Figure 3-23: Decreasing trend in annual rainfall at Gambella*

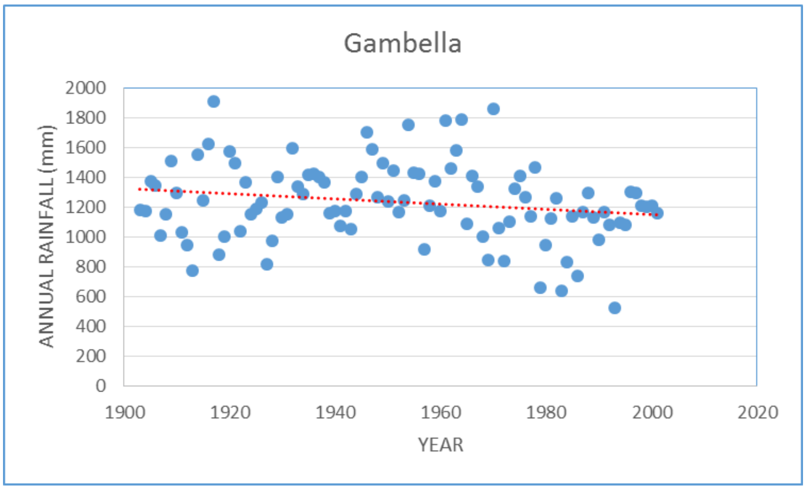
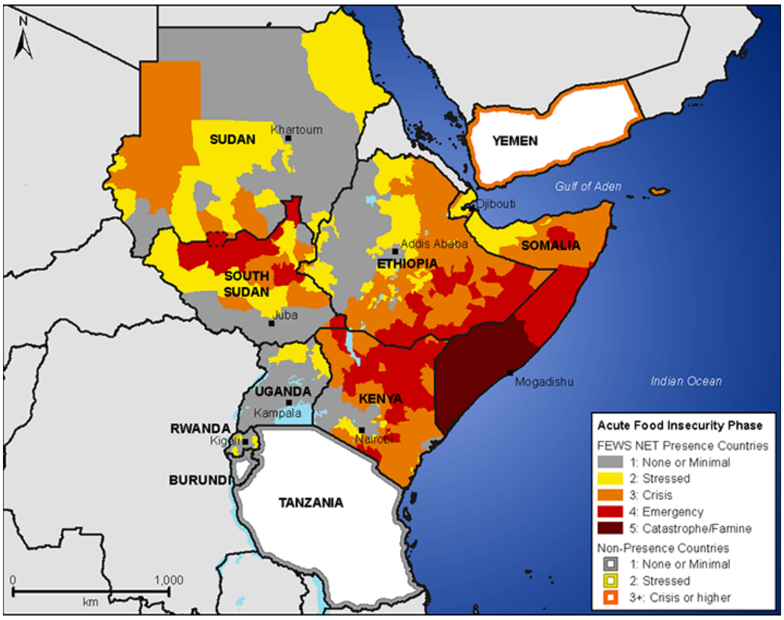


Figure 3-24 depicts the extent of the severe drought (between July 2011 and mid-2012) which affected the entire East Africa region including large parts of the Baro-Akobo-Sobat sub-basin. Said to be the worst in 60 years, the drought caused a severe food crisis that threatened the livelihood of 9.5 million people.

*Figure 3-24: East Africa food insecurity linked to drought (2011-2012)*




South Sudan and Ethiopia, including the Baro-Akobo-Sobat sub-basin, have experienced recurring droughts followed by food shortages and famines over the last fifty years. Droughts occurred in 1965, 1969, 1972/3, 1980, 1983/4, 1987, 1989, 1990, 1991, 1997, 2000, 2003, 2006, 2008, 2009, 2011 and 2015. Drought response in Ethiopia is regulated by the government's 1993 National Policy for Disaster Prevention, Preparedness and Management. According to this policy, each woreda is tasked with preparing drought contingency plans. In 'normal' times, the focus is on investing in structural development and building local resilience. This entails investment in fodder production, pasture development and water supplies. However, in practice, these plans lack implementation. The Ministry of Humanitarian Affairs and Disaster Management of the Government of South Sudan is responsible for disaster preparedness and response.

# 3.3 BIOLOGICAL ENVIRONMENT

## 3.3.1 Flora and Fauna, Land use, and biodiversity features of biophysical areas

### 3.3.1.1 Delineation of Biophysical areas

During the scoping phase, the following observation has been made: landuse patterns, ecoregion limits of the BAS, and as a consequence, environmental and social features, challenges and potentials identified in the sub-basin are strongly related to relief features of the BAS sub-basin.

In the following sections, the baseline information concerning environmental features of the BAS is organized by biophysical areas. Biophysical areas are delineated using the biotic and abiotic features of the environment. This should allow a better understanding of the BAS environment functionalities and their interlinkages with water resources and uses compared to a thematic approach. The four sections discussing the biophysical areas are the following (refer to Figure 3-25 for more information on the biophysical areas delineation):

1. Highlands

   Located between 1,800 and 3,000 masl, highlands are part of the **Ethiopian montane grasslands and woodlands** ecoregion, mainly covered by dense forest and subsistence agriculture. For a small area located in South Sudan, highands are also part of the **East African Montane Forest ecoregion.**

2. Escarpments

   Characterized by very steep slopes, located between 1,100 and 1,800 masl - part of the **Ethiopian Montane woodland** ecoregion, mainly covered by forest, montane pastures and subsistence agriculture

3. Foothills / Piedmonts

   Situated between 700 and 1,100 masl, foothills and piedmonts are part of the **eastern block of East Sudanian Savanna** and **Northern Accacia Commiphora Bushland and Thickets** ecoregions which are mainly covered by shrubs, dry savannas and Woodlands.

4. Floodplains and wetlands

   Situated between 370 and 700 masl, floodplains and wetlands are part of the **Saharan flooded grassland** ecoregion

The biophysical areas are described following the ecoregions found in the sub-basin. According to the WWF, an ecoregion is a "large unit of land or water containing a geographically distinct assemblage of species, natural communities, and environmental conditions". The ecoregions classification should not be confused with the livelihood zones classification which is used many times in the report. Ecoregions are a reference classification used to study biodiversity conservation issues as the classification is made using flora and fauna criteria. This classification is different from the classification with agro-ecological zones which is particularly of use for the social analysis and to study economic sectors later in the report. Locations of the ecoregions are given in Table 3-4.

Several delineations for ecoregions exist, they put emphasis on different criteria and serve different purposes. Ecoregions in this report were defined according to the delineation from the WWF (867 terrestrial ecoregions). This is particularly usefull to study the biological environment in the sub-basin. These ecoregions were defined using numerous references which can be found with a complete description of the ecoregions on the website of the WWF (*http://wwf.panda.org/about_our_earth/ecoregions/ecoregion_list/).*

Table 3-4: Main features of the ecoregions in the BAS sub-basin

| Ecoregion | Code | Biome/Global ecoregion | Location within the sub-basin | Status WWF |
|---|---|---|---|---|
| Ethiopian montane grasslands and woodlands | AT1007 | Montane grasslands and shrublands | Ethiopian highlands, above 1,800 masl | Critical Endangered |
| East African Montane Forest ecoregion | AT0108 | Tropical and Subtropical Moist Broadleaf Forests | Mt. Kinyeti in the Imatong Mountains | Critical Endangered |
| Ethiopian Montane woodland | AT0112 | Tropical and Subtropical Moist Broadleaf Forests | Ethiopian escarpments, between 1,100 and 1,800 masl | Critical Endangered |
| East Sudanian Savanna | AT0705 | Tropical and Subtropical Grasslands, Savannas and Shrublands | West of the Ethiopian part of the sub-basin and East of the South Sudan part of the sub-basin (between 700 and 1,100 masl) | Critical Endangered |
| Northern Accacia Commiphora Bushland and Thickets | AT0711 | Tropical and Subtropical Grasslands, Savannas and Shrublands | Extreme South-West of the Ethiopian part of the sub-basin and South of the South Sudan part of the sub-basin (between 700 and 1,100 masl) | Information not available |
| Saharan flooded grassland | AT0905 | Flooded Grasslands and Savannas | West of the sub-basin, mostly in South Sudan (below 700 masl) | Vulnerable |

Figure 3-25: Simplified schematic of the BAS relief and related proposed biophysical areas

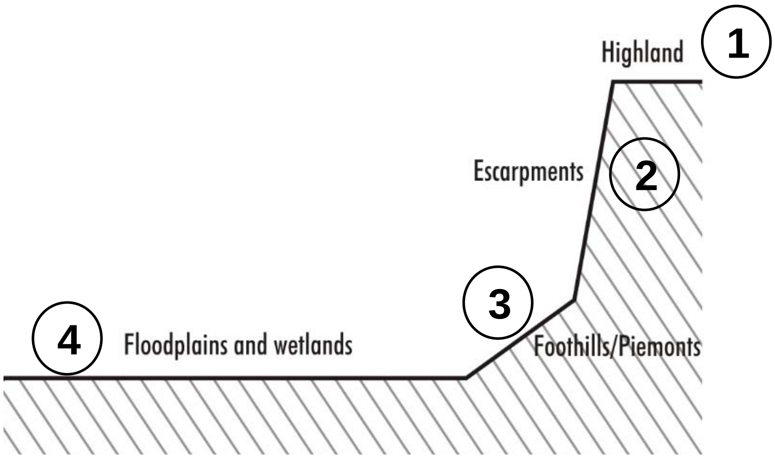



Table 3-5: Distribution of the BAS biophysical area

| Biophysical area of the BAS | Surface area (km2) | % of the BAS |
|---|---|---|
| Escarpments | 57439 | 22% |
| Highlands | 13956 | 5% |
| Piedmont / FootHills | 65563 | 25% |
| Flood plain and plain | 125668 | 48% |
| Total basin | 262626 | 100% |

*Figure 3-26: Relief of the BAS and biophysical areas*

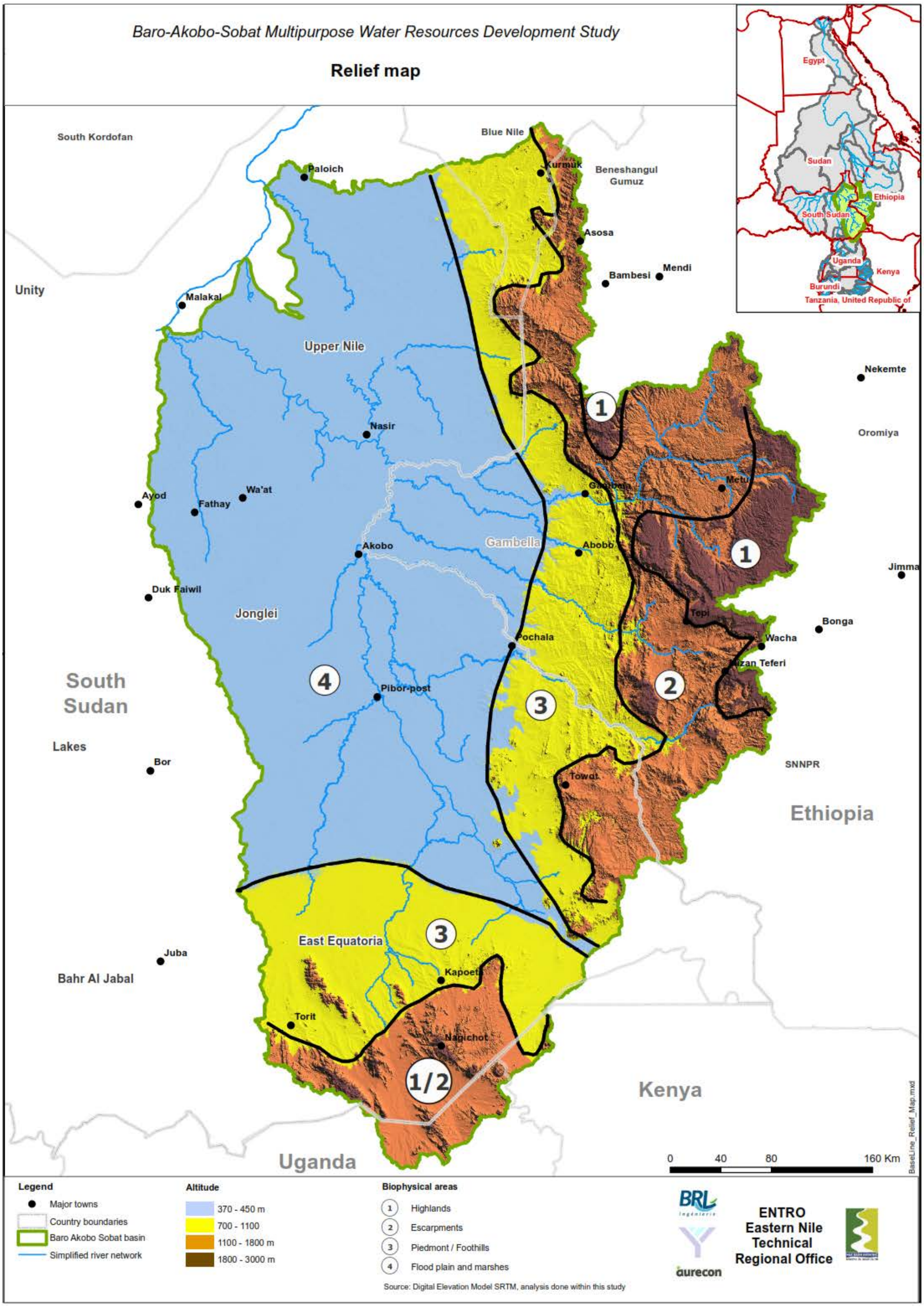


*Figure 3-27: Eco-regions of the BAS and biophysical areas*

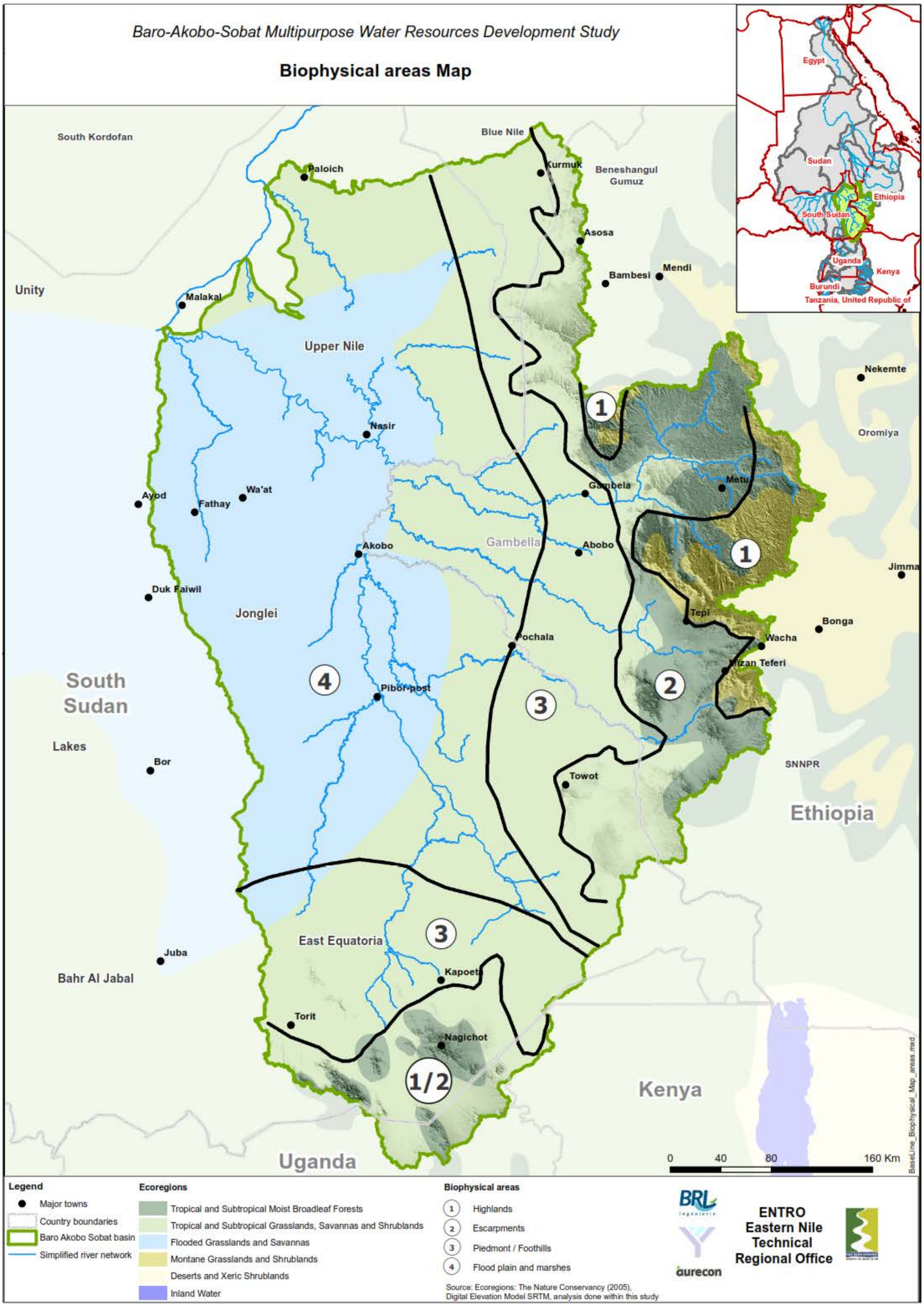
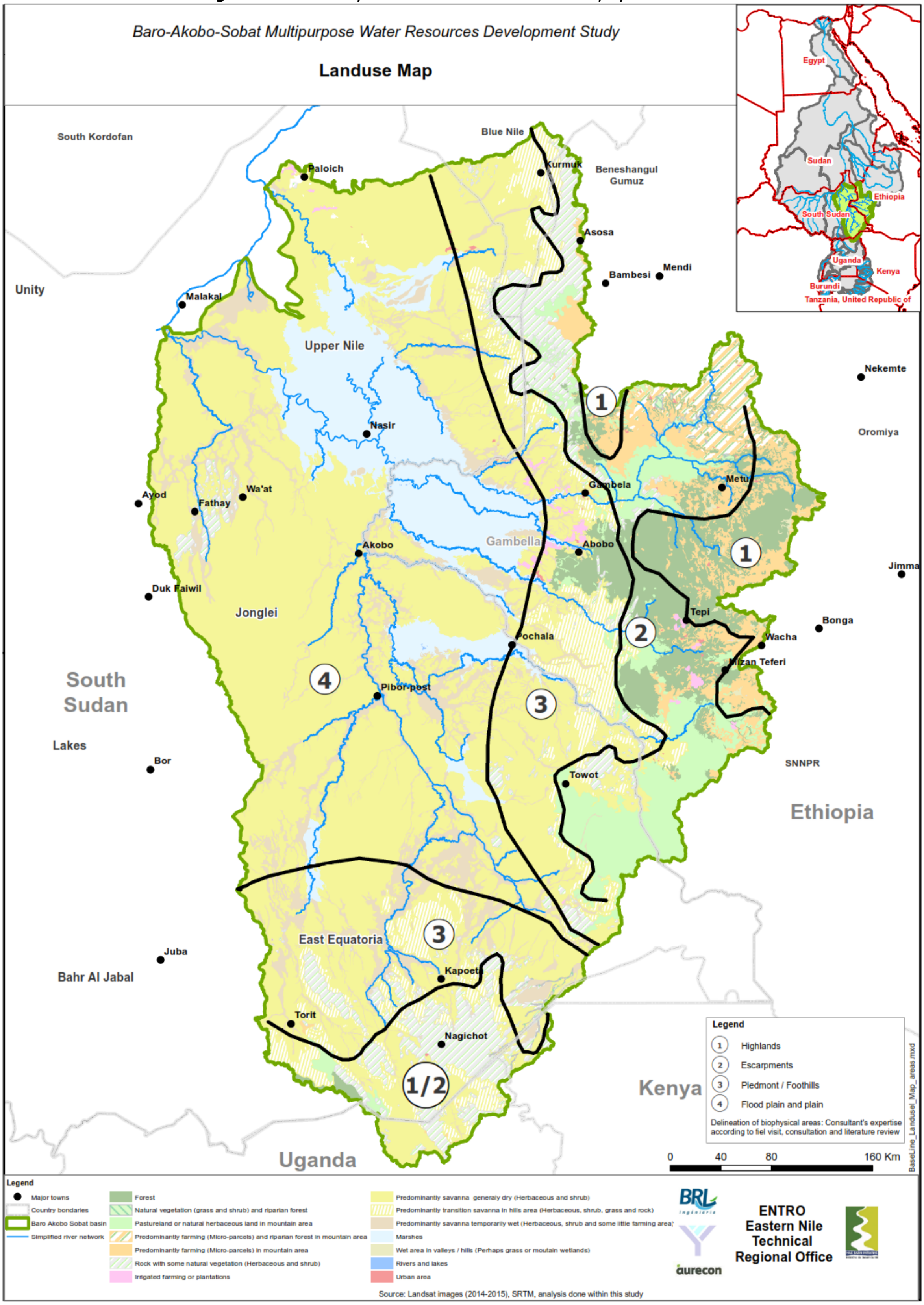


*Figure 3-28: Ecosystems of the BAS and biophysical areas*



### 3.3.1.2 Highlands

#### 3.3.1.2.1 Highlands: general features

Highlands are mainly situated in the eastern part and to a lesser extent in the southern part of the basin at an elevation varying from around 1,800 masl to 3,000 masl (Mont Kinyeti in the Imatong mountains reaches up to 3,187 masl). It is characterized by an undulating to rolling plateau, steeply incised by the major rivers with isolated high mountains such as Mount Tulu Welwel and Seccia (ENTRO, 2007a) .These mountains areas are characterised by very high rainfall (from 2000 to 2500 mm per year) and moderate evapotranspiration compared to floodplains. The rainy season lasts from May to October.

These highlands are the source areas for significant rivers such as the Baro, Alwero, Gilo, Akobo and Kinyeti and the population density is very high (refer to section 4.4).

As stated above, highlands of the BAS sub-basin are part of:

- The **Ethiopian montane grasslands and woodlands** ecoregion (Ethiopian highlands above 1,800 masl)
- The **East African Montane Forests** ecoregion (South Sudan highlands, Imatong mountains)

#### 3.3.1.2.2 Highlands: ecosystems and vegetation

The original vegetation of the BAS highlands was probably a mixture of closed forest (Friis, 1992 in Burgess et al., 2004). Currently, the highland areas are still largely covered with forest, even if forests have been severely encroached by agriculture. Elsewhere in the ecoregion (outside the BAS), these forests have almost disappeared. These remnant forest areas in the highlands are playing a crucial role in regulating river flows. In highly populated areas steep slopes and mountain tops are being farmed. The figure below shows the vegetation distribution in the BAS highlands:

*Table 3-6: Distribution of main vegetation types in the BAS highlands*

| Vegetation type | Surface area (km2) | % of the Higlands biophysical area |
|---|---|---|
| Forest | 7975 | 57% |
| Predominantly farming (Micro-parcels) in mountain area | 4904 | 35% |
| Predominantly farming (Micro-parcels) and riparian forest in mountain area | 407 | 3% |
| Pastureland or natural herbaceous land in mountain area | 363 | 3% |
| Wet area in valleys / hills (Perhaps grass or moutain wetlands) | 227 | 2% |
| Urban area | 34 | 0,2% |
| Rock with some natural vegetation (Herbaceous and shrub) | 19 | 0,1% |

*Source: this study*

The main highlands ecosystems are described in the following sections.

### HIGHLANDS FOREST ECOSYSTEMS

Ethiopian highlands

In the Ethiopian highlands, forest ecosystems include the following characteristic species: Albizzia gummifera, Syzygium guinnennense, Allophyllus abyssinicus, Schefflera abyssinica, Draceaena afromontana, Celtis africana, Chionanthus mildbraedii, Erythrococca trichogyne, Olea welwitschii, Vepris dainelli, Grewia ferruginea, Cyathea manniana, Croton macrostachyus, Phonix reclinata, Sapium ellepticum, Pouteria adolfifriedericii, Draceaena steudneri, Schefflera volkensii, Milletia ferruginea, Macaranga capensis, Psychotria orophila and Ficus spp. Undergrowth in the high forest areas of Ethiopian highlands of the basin also consists of coffee Arabica, Aframomum corrorima and Piper capense, which are economically important products of the forest.

South Sudan highlands

In the South Sudan highlands, the climax vegetation found between 1,500 and 2,600 masl in the Imatong Mountain is closed evergreen forest with *Podocarpus milanjianus*, *Olea hochstetteri and Syzygium spp*. dominant over a shrubby understorey. Regret of *Acacia xiphocarpa* occupies large areas of old cultivation sites (ENTRO, 2007a). Between 2,600 and 3,000 masl *Podocarpus milanjianus* again forms the climax vegetation, but is less mixed with other species, apart from a little *Olea hochstetteri*. This zone includes large areas of mountain meadow dominated by the sedge *Bulbostyles atrosanguineus*. The *bamboo Arundinaria* alpina is also found. Much of the ground is wet or swampy because of the combination of high rainfall and low potential evapo-transpiration. Above 3,000 masl, ferns, *Erica arborea* and *Myrica salicifolia* are dominant. Many species of herbs occur (ENTRO, 2007a).

*Figure 3-29: Typical vegetation found in the BAS highlands*

Riverine forest along Baro river at the road from Masha-Gore

Corrorima (*Aframomum corrorima)*

Timiz (*Piper capense*)

Coffee Arabica

*Source: this study*

### HIGHLANDS WETLANDS ECOSYSTEMS

Even if highlands wetlands could not be mapped within the scope of this study, many small wetlands are reported in the literature. EPA (2003b) in ENTRO (2014) estimated the total area of wetlands to be about 1.5% of the total land area of the highland plateau. In the Kafa zone for example, wetlands represent the Afro-tropical Highlands wetland type of Ethiopia. They constitute swamps, marshes, forested wetland areas, peat swamps, and riverine wetlands and cover around 50, 000 ha (EWNRA, 2008).

The wetland flora of the highland plateau hosts commonly *Cyperus latifiolius, Leersia hexandra*, and *Panicum hymeniochilum*. In pristine wetlands *Guizotia scarba*, *Phyllanthus boehmii* and *Snowdenia petitiana* are more commonly found and cultivated wetlands at the end of the rainy season and *Anagallis serpens, Cyperus brevifolius, Fuirena stricta* and *Hygrophila auriclata* are more common in degraded wetlands and cultivated wetlands during the dry season (ENSAP-ENTRO, 2012 in ENTRO, 2014).

*Figure 3-30: Highland wetlands of the BAS*

*Source: (EWNRA, 2008)*

## *3.3.1.2.3 Highlands: distinctive biodiversity features and wildlife*

Highlands are biologically rich and severely threatened. Their distinctive biodiversity features can be listed as follows:

- They are endowed with a high level of endemism, including:
  - a high number of endemic plants,
  - covering an important part of the South and Central Ethiopian Highlands endemic bird areas;
  - at least ten amphibians endemic or near endemic (Burgess et al., 2004)
- They host the last important remnant forest of the Ethiopian Upper Montane Forests, Woodlands, Bushlands and Grasslands ecoregion and the last important forest area in Ethiopia.
  - The cloud forests of the basin have international importance for their ecology, biodiversity and economy (due to significant contribution on the world market of coffee) (NABU, 2011).
  - Three forest areas have therefore been designated as Biosphere reserves in the basin (Yayu, Kafa, and Sheka).
  - Wildlife species in the Ethiopian Highlands include *Colobus and Vervet Monkeys, Tree Squirrel, Lion, Leopard, Antelopes, Buffalo, Elephant, Porcupine, Aardvark, Wart Hog and Forest Pig* (waterhog) (ENTRO, 2014).

### 3.3.1.2.4 Main threats to the BAS highlands ecosystems

#### GLOBAL THREATS TO THE BAS HIGHLANDS

The Ethiopian Montane grasslands and woodlands ecoregion as a whole is severely threatened (classified critical/endangered by the WWF). In the highlands, the high population density and the related widespread practice of subsistence farming, the huge demand for land for farming and for natural products are the predominant reasons for the widespread loss of vegetation (Burgess et al., 2004). In some areas, the population density reaches up to 1,000 inhabitants per $km^2$ (NABU, 2011)

The East African Montane Forest ecoregion is also classified as critical. This ecoregion does not form a continuous area but is constituted of several patches of forests in South Sudan, Kenya, Tanzania and Uganda which makes this ecoregion endangered. In South Sudan, three major patches are found in the Imatong mountains. Even if the population density is not currently high in the Imatong mountains, these forests do not cover a large area and are threatened by deforestation.

#### SPECIFIC THREATS TO HIGHLANDS FOREST ECOSYSTEMS

As stated above, high population density rates in the Ethiopian part of the sub-basin makes this area more subject to deforestation than the South Sudan highland forests.

The highland areas of the basin were formerly covered with high forest. But these days, with population increase and expansion of farming into the forest cover, natural forest has significantly depleted. Only small portion has got remnant intact forests in the Ethiopian part of the sub-basin. Annual average deforestation rate is expected to be around 1.2 - 1.6 % (Sutcliffe, 2009 in ENTRO, 2014).

According to NABU (2007), the recent estimated rate of loss of highland forests reaches 80,000 - 200,000 ha/year in the Kafa region. If this rate remains constant in the future, the area covered with natural forest will have completely disappeared within 10 years (NABU, 2007).

NABU (2011) lists the following main drivers of deforestation and forest degradation in Kafa as follows:

- “Agriculture expansion: The conversion of forest land to agriculture is at first a way to increase the productivity. This can be mainly observed at forest borders, were farmers systematically clear the understorey (mostly initiated by forest grazing) and thereafter slash and burn the area. The harvested wood is used as an additional income (fire wood, or charcoal) or for the own consumption.
- Resettlement: If labor cannot support livelihood sufficiently, it results in a widespread illegal/uncontrolled use and conversion of forest land. It was observed, that dynamic forest perforation patches with unstable shape and size were settled by people without permission.
- Concessions (coffee): Large scale coffee investment (coffee investment area) is supported by the government. Due to the site requirements of Coffee plants, the upper storey of forest is thinned while the understorey is systematically removed. This practice decreases the biodiversity of the forest tremendously. Furthermore, the capability to store carbon is minimized. Local communities are banned for all purposes of forest use.
- Property rights: The unsecure defined allocation of property rights and the land tenure system in Ethiopia can be addressed as one of the main drivers for forest loss.
- Unsustainable use of forest resource: Legal and illegal forest use is increasing since customary user rights have been replaced by state sanctioned rights. Missing technical assistance in sustainable forestry and missing resource use (of plantations) from governmental side lead to illegal and unmanaged use of wood resource.”

### SPECIFIC THREATS RELATED TO HIGHLAND WETLANDS ECOSYSTEMS

Wetlands ecosystems have been studied in the Ethiopian part of the sub-basin. There is no information regarding wetlands in the South Sudan highlands. Several studies undertaken by EWRP (Emergency Wetlands Reserve Program), Wetland Action (WA) and EWNRA (Ethio Wetlands and Natural Resources Association) in Western Oromiya Region, mainly in Jimma, Western and Eastern Wollega and Illubabor zones, revealed that wetlands have been drained for growing food crops for more than a century (Hailu A, 2006).

Highland wetlands also support other important uses for local communities. For example, wetlands uses and beneficiaries in Illubator are shown in the figure here after.

*Figure 3-31:Wetlands uses and beneficiaries of highlands wetlands in Illubator*

| Uses | Estimate of Households Benefiting |
|---|---|
| Social/ceremonial use of reeds | 100% (including urban dwellers) |
| Thatching reeds | 85% (for house construction) |
| Thatching reeds for granary roofing | >50% |
| Temporary crop guarding huts of reeds | 30% |
| Domestic water from springs | 50% |
| Craft materials | 5% |
| Medicinal plants | 100% |
| Dry season grazing | >30% |
| Water for stock | >30% |
| Cultivation | 10% |

*Source: (Afework, 2001)*

These various uses, when not properly managed, can contribute to wetlands degradation.

*Figure 3-32: Brick making in highland wetlands*

*Source: (EWNRA, 2008).*

### 3.3.1.3 Escarpments

#### 3.3.1.3.1 Escarpments: general features

Escarpments are generally situated between 1,100 and 1,800 masl. These areas are characterised by very steep slopes (much more important than in the highlands and foothills). The Escarpment area in the basin is a transition zone between highland and lowland areas. Some parts are also flatter like the Boma Plateau, situated between 1,100 and 1,300 masl. The Ethiopian Montane woodlands surround the highlands ecosystems described in the previous section. In South Sudan, escarpments are part of the East African Montane Forest ecoregion.

Rainfall can reach 2,300 mm per annum, from May to October. Ancient Precambrian basement rocks form the substrate of the forests and woodlands and bushlands in deep river valley (Burgess et al., 2004).

*Figure 3-33: Typical landscapes of BAS escarpments (left : Ethiopia; right: South Sudan)*

*Source: This study*

#### 3.3.1.3.2 Escarpments: ecosystems and vegetation

The area supports East African evergreen and semi-evergreen forests, woodlands, and shrublands. Moister sites in southwest forest patches are dominated by tall trees, chiefly *Aningeria* and other Sapotaceae, species of Moraceae, and species of *Olea* (Burgess et al., 2004).

*Figure 3-34: Woody grass land at the escarpment of Gambella Region (left) and Savanna forest of the Boma Plateau (right)*

*Source: this study (left) and (USAID, 2007b)*

Transitional forests occur between 500 and 1,500 masl in Illubator and Kefa and have rainfall close to 2,000 mm per annum. These transitional forests change to Afromontane forests at approximately 1,500 masl altitude in the southwest, where the rainfall is between 700 and 1,500 mm (Friis, 1992 in Burgess et al., 2004). *Coffea Arabica* is the dominant natural understory shrub and wild coffee is harvested.

*Figure 3-35: Imatong lowland forest*

*Source: Safaris, 2016*

In the Akobo catchment around Bench-Maji and Sheka zones, edible roots like Taro and Enset are common and support livelihood of people. These edible roots are drought-resistant and help to soil conservation.

*Figure 3-36: Taro at Kafa (left) and Enset at Sheka (right)*

*Source: this study*

*Figure 3-37: Distribution of the main vegetation types in the BAS Escarpments*

| Vegetation type | Surface area (km2) | % of the Escarpments biophysical area |
|---|---|---|
| Pastureland or natural herbaceous land in mountain area | 14237,6 | 24,8% |
| Rock with some natural vegetation (Herbaceous and shrub) | 12603,4 | 21,9% |
| Forest | 7704,3 | 13,4% |
| Predominantly savanna generally dry (Herbaceous and shrub) | 6457,2 | 11,2% |
| Predominantly farming (Micro-parcels) in mountain area | 5845,0 | 10,2% |
| Predominantly transition savanna in hills area (Herbaceous, shrub, grass and rock) | 5371,0 | 9,4% |
| Predominantly farming (Micro-parcels) and riparian forest in mountain area | 3786,7 | 6,6% |
| Predominantly savanna temporarily wet (Herbaceous, shrub and some little farming area) | 422,4 | 0,7% |
| Natural vegetation (grass and shrub) and riparian forest | 404,7 | 0,7% |
| Irrigated farming or plantations | 228,8 | 0,4% |
| Wet area in valleys / hills (Perhaps grass or mountain wetlands) | 149,3 | 0,3% |
| Urban area | 109,5 | 0,2% |
| Water surfaces | 2,1 | 0,0% |
| Total | 57439 | 100% |

*Source: this study*

### 3.3.1.3.3 Escarpments: distinctive biodiversity features and wildlife

The Ethiopian Montane woodland ecoregion, like the Ethiopian montane grasslands and woodlands ecoregion from the BAS highlands, is part of the Afromontane archipelago-like regional center of endemism It supports a variety of forest types with associated bushland and woodland habitats and consequently have high species richness and endemic species (Friis, 1992 in Burgess et al., 2004). For example, the Mejang area is characterized by:

- A rich biodiversity: about 550 species of plants, 130 birds, 33 mammals and 20 species of Amphibians and Reptiles.
- Many rare and endemic species that are found in the area; e.g. 27 endemic plants, 3 endemic amphibians,
- Endemic plants, three of them are endangered: Aframomum zambesiacum subsp. Puberulum, Rinorea friisii, and Scadoxus nutans (MELCA, 2014).

*Coffea Arabica* comes naturally in the escarpments, contrary to higher areas, where it has been transplanted (ENTRO, 2014).

Yalden (1996) in Burgess et al. (2004) draws attention to the poverty of forest mammal fauna in the southwestern Ethiopian part of this ecoregion.

#### 3.3.1.3.4 Main threats to the BAS escarpments ecosystems

For the time being, there is no significant pressure and human encroachment in the very steep parts of this area. They are covered with woody grass land and are used for grazing and wildlife habitat. This is why the escarpments host the largest areas of natural forests found in the Ethiopian montane woodland ecoregion. However, with the development of access roads and the increasing demand for fuel wood and charcoal, people could start exploitation of fuel wood and charcoal that would deplete woodland and cause degradation.

In accessible parts of the escarpments, all natural habitats are highly threatened because they have been reduced to small patches and are severely fragmented. Little habitat remains in its natural state, except in rocky ravines and other inaccessible areas. Agriculture is the main threat, coupled with exploitation of trees for fuelwood and timber. In many areas poor agricultural methods and overgrazing have resulted in intense soil erosion.

According to MELCA (2014), specific causes of deforestation in the Mejang area are identified as follows:

- Expansion of coffee plantation,
- Settlements and Agricultural expansion,
- Logging,
- Fire,
- Local wood consumption.

These causes are also valid for escarpments in other areas of the sub-basin in Ethiopia and South Sudan (especially for agricultural expansion, logging, fire and local wood consumption).

**PROTECTION MEASURES IN THE ETHIOPIAN PART OF THE SUB-BASIN**

As already mentioned, recent biosphere reserves on both highlands and escarpments have been created in the Ethiopian part of the sub-basin:

- Government of Ethiopia has adopted biosphere reserve approach for the first time in 2010 by creating the Yayu Coffee Forest in Oromia and the Kafa in SNNP regional states;
- The neighboring Sheka Forest has also become the third biosphere reserve in 2012 initiated and supported by MELCA Ethiopia (MELCA, 2014).

National Forest Priority Areas theoretically cover the entire forests areas of the BAS ethiopian highlands, escarpments and Foothills but do not provide effective protection and are not known at local level (NABU, 2011).

**PROTECTION MEASURES IN THE SOUTH SUDAN PART OF THE SUB-BASIN**

In South Sudan, the Imatong mountains form a large forest reserve but effective protection of the area has been impended by the security situation in the country.

### 3.3.1.4 Foothills / Piedmonts

#### 3.3.1.4.1 Foothills: general features

Foothills or Piedmonts are situated between 700 and 1,100 masl. They form a transition area between escarpments, characterized by very steep slopes and flood plains which are extremely flat. The rainy season lasts from April to September. The foothill areas are part of the eastern block of **East Sudanian Savanna ecoregion** in Ethiopia and southern part of the sub-basin and **Northern Accacia Commiphora Bushland an Thicket ecoregion** in the southern part of South Sudan. Both ecoregions belong to the Tropical and Subtropical Grasslands, Savannas, shrublands and Woodlands Biome. They are mainly covered by shrubs, dry savannas and Woodlands.

*Figure 3-38: Typical landscapes of BAS Foothills / Piedmonts (left : Ethiopia; right: South Sudan)*

*Source: This study*

#### 3.3.1.4.2 Foothills: ecosystems and vegetation

In the foothills area, the vegetation is undifferentiated woodland with trees that are mainly deciduous in the dry season, with and understory of grasses, shrubs, and herbs. Typical trees found in these areas are: Combretum and Terminalia species, *anogeissus leiocarpus, Boswellia papyrifera, Lanea schimperi, and Stereospermum kunthianum*. The solid-stemmed *bamboo Oxytenanthera abyssinica* is prominent in the western river valleys of Ethiopia. Dominant grasses include tall species of *Hyparrhenia, Cymbopogon, Echinochloa, Sorghum, and Pennisetum* (Tilahun et al., 1996 in Burgess et al., 2004).

*Figure 3-39: Lowland bamboo (left) and lowland woody grasslands (right) along Guba-Torit road*

*Source: This study*

*Table 3-7: Distribution of main vegetation types in the BAS Foothills*

| Vegetation type | Surface area (km2) | % of the Foothills biophysical area |
|---|---|---|
| Predominantly savanna generally dry (Herbaceous and shrub) | 34 029 | 52% |
| Predominantly transition savanna in hills area (Herbaceous, shrub, grass and rock) | 13 699 | 21% |
| Predominantly savanna temporarily wet (Herbaceous, shrub and some little farming area) | 8 381 | 13% |
| Rock with some natural vegetation (Herbaceous and shrub) | 4 179 | 6% |
| Forest | 2 128 | 3% |
| Pastureland or natural herbaceous land in mountain area | 1 439 | 2% |
| Marshes | 1 028 | 2% |
| Irrigated farming or plantations | 382 | 1% |
| Natural vegetation (grass and shrub) and riparian forest | 141 | 0,2% |
| Urban area | 81 | 0,1% |
| Predominantly farming (Micro-parcels) in mountain area | 51 | 0,1% |
| Water surfaces | 24 | 0,0% |
| Total | 65 563 | 100% |

*Source: this study*

### *3.3.1.4.3 Foothills: distinctive biodiversity features and wildlife*

The East Sudanian Savanna and Northern Accacia Commiphora Bushland and Thickets ecoregions have low rates of faunal endemism, with only one strictly endemic mammal, two strictly endemic reptiles and five bird species for the Easte Sudanian Savana ecoregion. However, this is an important area for endemic plants.

Threatened mammal species include elephants (*Loxodonta Africana*), wild dog (*Lycaon pictus*), cheetah (*Acinonyc jubatus*), and lion (*Panthera leo*). The roan antelope's (*Hippotradus equinus*) can also be found.

### *3.3.1.4.4 Main threats to the BAS Foothill ecosystems*

According to Burgess et al. (2004), the original wooded savanna habitat has been significantly reduced. The main treats to foothill ecosystems are:

- seasonal shifting of cultivation,
- overgrazing by livestock,
- cutting of trees and bushes for wood,
- burning of woody materials for charcoal,
- and uncontrolled wild fires.

The main threats to the species come from overgrazing, poaching and overhunting for meat.

Climate change consists of an additional threat while it exacerbates the above quoted impacts of human activities. Ability of the ecosystem to recover from overuse can indeed be reduced when there is little rainfall.

### 3.3.1.5 Flood Plains and wetlands

#### 3.3.1.5.1 Flood plains and wetlands: general features

This biophysical area covers more than the half of the BAS.

The Floodplains and wetlands biophysical area is situated between 370 and 700 masl. It consists of very flat clay plains that stretch from northwards South Sudan foothills and westwards from Ethiopia foothills to the Sobat river. These plains have very gentle slopes between 0,01 and 0,012% (ENTRO, 2007a).

The rainfall reaches between 600 and 800 mm/year, falling between April and September during the hot season when temperatures average 30-33°C, dropping to an average of 18°C in the cooler season (Burgess et al., 2004). Mean annual evaporation is from 1600 to 1900 mm/year (ENTRO, 2007a).

Vertisols have developed in the waterlogged conditions over these nutrient poor sediments, although fluvisols and patches of luvisols can be found along the river courses.

This biophysical area is included in the two following ecoregions:

- The East Sudanian Savanna ecoregion, which belongs to the Tropical and Subtropical Grasslands, Savannas, Shrublands, and Woodlands biome (also largely present in the foothills / piedmonts biophysical area),
- The Saharan Flooded Grasslands ecoregion, which consists of Flooded Grasslands and Savannas.

*Figure 3-40: Typical landscapes of BAS floodplains and wetlands (left: Ethiopia; right: South Sudan)*

*Source: This study*

#### 3.3.1.5.2 Floodplains and wetlands: ecosystems and vegetation

The floodplain ecosystem supports a variety of plant species ranging from those adapted to wet environments, under water during several months in a year, to those adapted to drier environments, occasionally flooding or only by rainfall. Moving from the center of the swamps, the ecological zones grade from the open water and submerged vegetation of a river-lake, to floating fringe wetlands, to seasonally flooded grasslands, to rain-fed wetlands, and finally to floodplains woodlands (Hickley, 1987 in Burgess N. & al, 2004). *Cyperus papyrus* is dominant at riversides and in the wettest swamps. *Phragmites* and *Typha* swamps are extensive behind the papyrus stands, and there is an abundance of submerged macrophytes in the open waterbodies.

Seasonal floodplains, up to 25 km wide, are found on both sides of the main swamps. Wild rice (*Oryza longistaminata*) and *Echinochola pyramidalis* grasslands dominate the seasonally inundated floodplains. Wild rice support a flooded period from 5 to 9 months, whereas *Echinochola pyramidalis* is inundated during less than 3 to 4 months in a year. The seasonally river-flooded grassland forms the '*Toich*', which yields dry season grazing areas important to the Nuer and Dinka agro-pastoralists. Yield is affected by the duration, timing and intensity of the flood (ENTRO, 2007a), varying from 1 ton/ha when non inundated to 7 ton/ha when inundated.

Beyond the floodplain, Echinochloa haploclada, Sporobolus pyramidalis and Hyparrhenia rufa grasslands cover the rain-fed wetlands. Mixed woodlands of Accacia seyal, Ziziphus mauritiana, Combretum fragans, and Balanites aegyptica border the floodplain ecosystem (Denny, 1991 in Burgess & al., 2004). Riparian forests species include: Celtis kraussiana, Ficus sycomorus, Mimusops kummel, Tamarindus indica, Maytenus senegalensis, Kigelia aethiopum, Syzygium guineense and Acacia spp (ENTRO, 2007a).

*Table 3-8: Distribution of the main vegetation types in the BAS wetlands*

| Vegetation type | Surface area (km2) | % of the Foothills biophysical area |
|---|---|---|
| Marshes | 25799 | 21% |
| Predominantly savanna temporarily wet (Herbaceous, shrub and some little farming area) | 16813 | 13% |
| Predominantly savanna generally dry (Herbaceous and shrub) | 81206 | 65% |
| Pastureland or natural herbaceous land in mountain area | 34 | 0,0% |
| Rock with some natural vegetation (Herbaceous and shrub) | 1133 | 0,9% |
| Predominantly transition savanna in hills area (Herbaceous, shrub, grass and rock) | 166 | 0,1% |
| Water surfaces | 60 | 0,0% |
| Irrigated farming or plantations | 229 | 0,2% |
| Urban area | 54 | 0,0% |
| Petroleum domain | 125 | 0,1% |
| Total | 125668 | 100% |

*Source: this study*

### *3.3.1.5.3 Flood plains and wetlands: distinctive biodiversity features and wildlife*

The BAS hosts **one of the most important mammal migration of the world** (USAID, 2010b). The **main migratory species is the White-eared Kob** (Kobus kob leucotis). White-eared Kobs are endemic to the BAS since migration routes are nearly confined within the sub-basin limits. White-eared Kobs are listed as "least concerned" but faces increasing threats leading to population decline. The inclusion of the White-eared Kobs in the CMS (Convention on Migratory Species) Appendix 2 has been proposed in 2014 (CMS, 2014). White-eared Kob population estimations vary from one source to another. For example, the WCS-HoA (2010) suggests that the total number of White-eared Kobs is as high as 753 000; USAID (2010) estimates the total population at 1.2 million. According to some experts (Frost, 2014), this migration is the 2$^{nd}$ most important of Africa, after the Serengeti one. According to others, the White-eared Kob migration rivals that of the Common Wildebeest *(Connochaetes taurinus)* in the Serengeti ecosystem (Kingdon et al. 2013) or could be even more significant (HoA-REC, 2011).

Migration routes **are strongly correlated with hydrological patterns** (HoA-REC, 2011). Fryxell et al. (1988) have studied the relationship between seasonal migration of White-eared Kob and resources (food, water availability) and show that "seasonal migration by white-eared kob is linked to shifting distributions of critical resources".

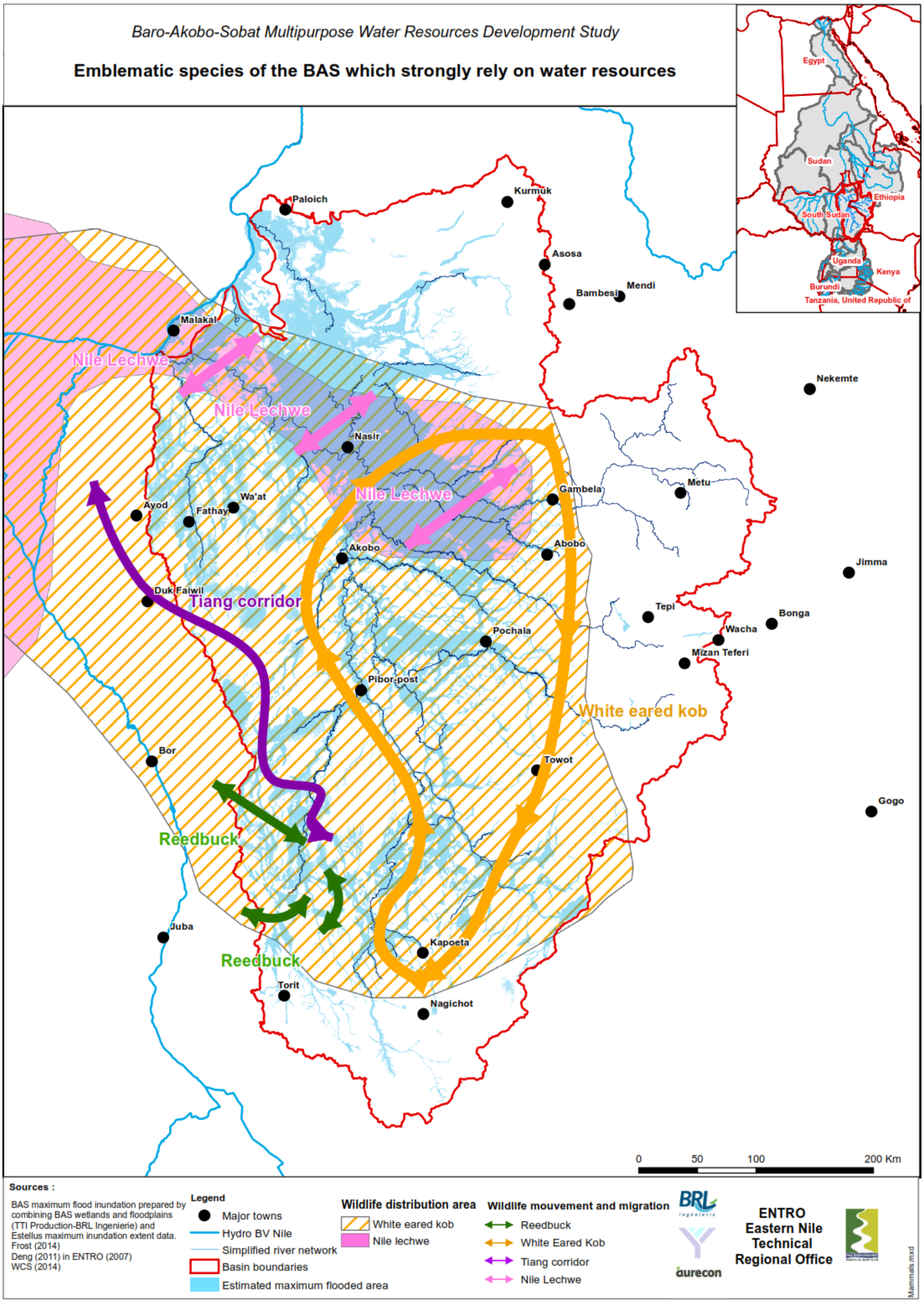
Apart from the White-eared Kob, the migration consists of Tiang, Mongalla gazelle and East African eland all followed by Lion, Jackal and Hyena. At the southern end of the migration they are joined by Zebra, Bright's Gazelle, Giraffe and Beeisa Oryx. There are also roan Antelope and Buffalo near the Ethiopian foothills (Frost, 2014).

*Figure 3-41 : White-eared Kob in floodplain grassland (left) and Nile lechwe (right)*

*Source: (Frost, W., 2014) (National geographic, 2015)*

The BAS hosts the **Nile lechwe endangered species** which is present only in the Sudd swamps, *Machar marshes* and in Gambella region (Frost, 2014; IUCN SSC Antelope Specialist Group , 2008; Kingdon et al., 2013). Nile lechwe's primary habitat is swamps and marshes which are subject to seasonal inundation (Kingdon et al., 2013). **Local patterns of flooding have the most significant influence on the species** (Kingdon et al., 2013). Indeed, the Nile lechwe depends on the open area between floodwaters and drier ground, moving up and down the flood tide lines following the seasons (Frost, 2014). Nile Lechwe population seems to be reduced to a very low density (Kingdon et al., 2013; Frost, 2014).

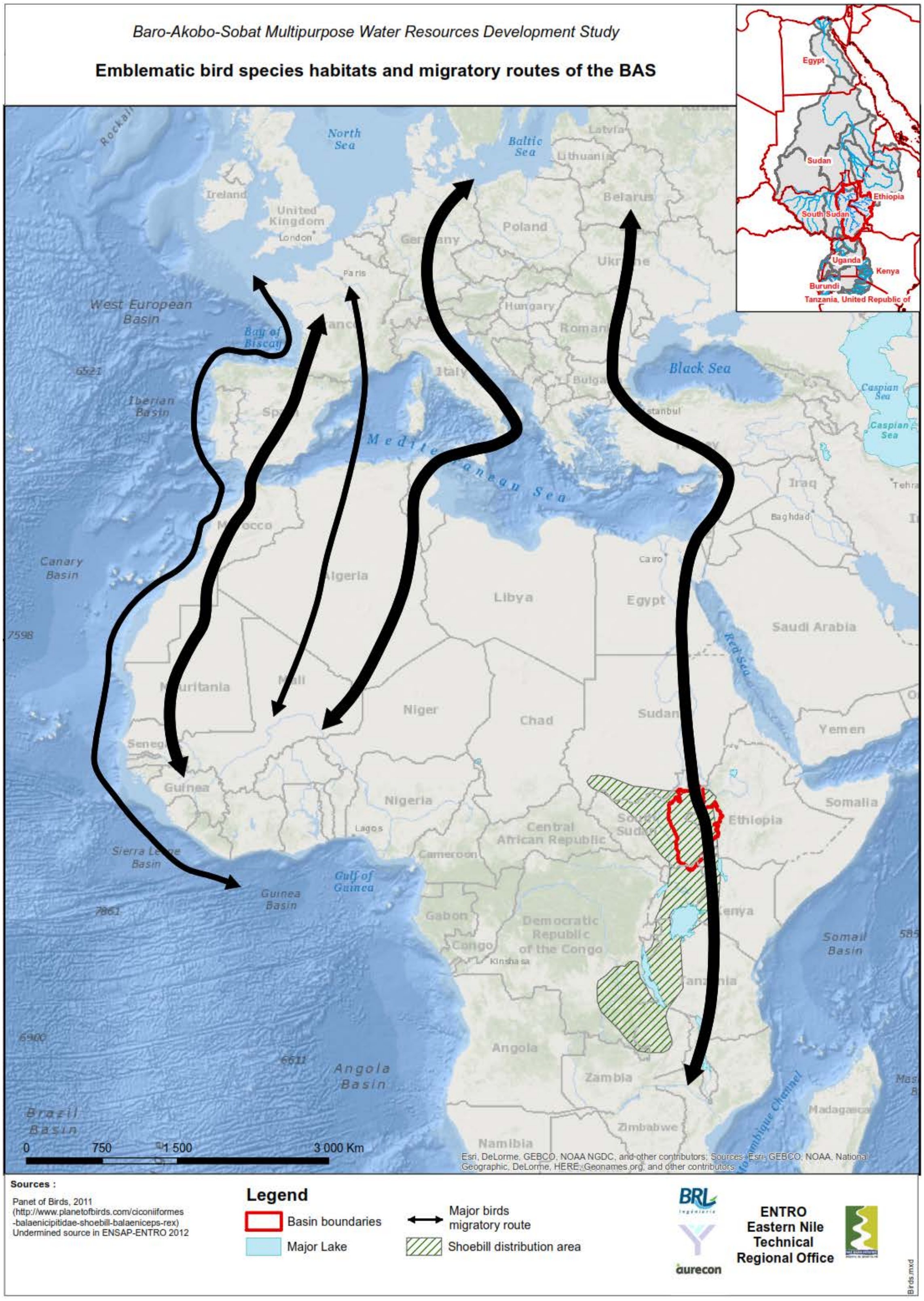
*Figure 3-42: Emblematic mammal species habitats and migratory routes of the BAS*




The BAS is situated on the major birds migratory routes between Africa and Europe and hosts an important population and diversity of birds (ENSAP-ENTRO, 2012) with more than 2.5 million using the floodplains of the Sudd annually, mainly migratory species moving between Europe and Africa (Robertson, 2001 in Burgess & al, 2004).

These wetlands also support the largest population of shoebill (*Balaeniceps rex*) in the world, estimated to be around 6,400 individuals (Robertson, 2001 in Burgess & al, 2004). The area is also a stronghold for the great white pelican (*Pelecanus onocrotalus*), ferruginous duck (*Aythya nyroca*) (Robertson, 2001 in Burgess & al, 2004), and black-cowed crane (*Balearica pavonina*) (Newton, 1996 in Burgess & al, 2004).

*Figure 3-43: Emblematic bird species habitats and migratory routes of the BAS*



Werner's garter snake (*Elapsoidea laticincta*) is a near-endemic snake, but other amphibians and reptiles are unremarkable (Burgess & al, 2004).

The basin waters and wetlands host a **high diversity of fish** (from around 90 to more than 100 species depending on sources) (ENTRO, 2007a). The main species found in the basin are *Lates niloticus* (Nile perch), and *Polypterus bichir* (Nile bichir), *Bagrus spp*., *Heterotis niloticus*, Clarias gariepinus, *Distichodus sp.,Gymnarchus niloticus, Barbus spp., Synodontis spp., ydrocynus sp., Citharinus sp.and Tilapia nilotica* (ENTRO, 2007a)

The BAS water bodies also support **various Malacofauna species**, including 13 gastropod species, (from which only one, *Gabbiella schweinfurthi* may be endemic) and 11 bivalve species (from which only the *iridinid Chambardia marnoi* is likely distinctive and confined to this part of the Nil). Near the mouth of the Sobat, large zones were invaded by the big bivalve, *Etheria elliptica*. The colonies of these mollusks provided a habitat for a rich fauna of Ephemeroptera and Trichoptera. The genera Amphipsyche, Cheumatopsyche, Aethaloptera and Ecnomis predominated (ENSAP-ENTRO, 2012).

The **benthos of the Sobat River is similar to that of the White Nile**. The clayey bottom of the bed was sparsely populated by Chironomidae (*Polypedilum sp., Clinotanypus sp., Stictochironomus sp., Cryptochironomus sp.*) and Trichoptera. The total biomass of the benthos in the middle of the river was about 0.2 g m-2 (ENSAP-ENTRO, 2012).

### 3.3.1.5.4 Main threats to the BAS Floodplains and wetlands ecosystems

#### SPECIFIC THREATS CONCERNING WILDLIFE

The main threats to the mammal migrating species come from overgrazing, poaching and overhunting for meat.

Frost (2014) and Kingdon et al. (2013) estimate that the survival of the Nile lechwe Ethiopian population seems highly precarious and the South Sudan one threatened. The main reported threats are the increased human pressure in the form of hunting / poaching; habitat degradation by domestic livestock, especially when large numbers of cattle penetrate the area during the dry season; impacts of oil exploration on water quality and current inadequate conservation measures.

Some population estimates of emblematic migratory species of the BAS are summarized in the tables below:

*Table 3-9: Population estimates of emblematic species of the BAS in the area*

| Date | Area investigated | Observation/ estimation | Species | Source |
|---|---|---|---|---|
| 2007 | South Sudan | 4,291 | Nile lechwe | Frost (2014) quoting the aerial survey carried out by WCS |
| 1983 | South Sudan and Ethiopia | 30,000 – 40,000 | Nile lechwe | Aerial survey of Mefit-Babtie (1983) in Kingdon (2013) |
| 1988 | Machar | 900 | Nile lechwe | Hillman & Fryxell (1988) in Kingdon (2013) |
| 2007 | Boma National park<br>Lotilla plains<br>Jonglei area | 700,000<br>46,000<br>12,000 | White-eared Kob | Fay et al (2007) in Kingdom et al (2013) |
| 1980-1983 | Boma National park | 800,000 | White-eared Kob | Fryxell & Sinclair (1988) |
| Early 1980s | Boma ecosystem | Nearly 1 million | White-eared Kob | Fryxell (1985), Hillman & Fryxell (1988) in Kingdom et al (2013) |
| 2009-2010 | Gambella National Park<br>Upper Akobo | 203,181<br>51,962 | White-eared Kob | TFCI (2010) |

| Date | Area investigated | Observation/ estimation | Species | Source |
|---|---|---|---|---|
| 2010 | Sudan's Boma-Jonglei Landscape | 1.2 million | white-eared kob, tiang, Mongalla gazelle, and reedbuck | USAID (2010) |
| 2001 | Not specified | 753,000 | White-eared Kob | WCS (2001) |

*Source: this study – compilation from various sources*

*Table 3-10: Recent wildlife population estimates from EWCA 2015 aerial survey in Gambella National Park*

| Specie | Scientific name | Individuals observed (n) | Population Estimate (Ŷ) |
|---|---|---|---|
| White eared kob | *Kobus kob leucotis* | 29,458 | 399,299 |
| Giraffe | *Giraffa cameleopardalis* | 33 | 447 |
| Buffalo | *Syncerus caffer* | 887 | 12,023 |
| Roan Antelope | *Hippotragus equinus* | 40 | 542 |
| Tiang | *Damaliscus lunatus* | 39 | 529 |
| Hartebeest | *Acelaphusbushel apuslelwel* | 16 | 217 |
| Waterbuck | *Kobus ellipsiprymnus* | 5 | 68 |
| Nile lechwe | *Kobus megaceros* | 28 | 192 |
| Shoebill stork | *Baleaniceps rex* | 26 | 34 |

*Source: (EWCA, 2015) b*

In South Sudan, the Jonglei canal is also detrimental to wildlife in the BAS sub-basin (according to stakeholders' consultations). It indeed blocks the annual movement of the tiang southwest to their wet season grazing area, and many thousands are shot as they try to find crossing points (Burgess & al., 2004).

In Ethiopia, the recent and planned development of huge mechanized farms in Gambella could become an important threat to wildlife migration and habitat. According to Pearce (2011), canal and roads have been constructed, land has been cleared, 55,000 ha have already been planted, including 35,000 ha of rice, 10,000 ha of maize, and 10,000 hectares of sorghum and 20,000 hectares of oil palm and sugar cane should be added soon within the original boundaries of Gambella national park. These original boundaries have been revised in order to make way for new agricultural concessions.

*Figure 3-44: Earth clearing before plantation of irrigated rice in Gambella (left) and farming in the original boundaries of Gambella national park (right)*

*Source : left : (Pearce, 2011) and right : (Gebresenbet F., et al., 2013)*

### OIL EXPLOITATION

Oil extraction and exploration is limited to the South Sudan part of the basin, in Upper Nile State where there are 3 oil fields in activity: Paloch, Gumry and Adar Yale. Water quality issues have been reported to several NGOs by the local communities (Bonn International Center for Conversion, 2013; Cordaid, 2014). These communities usually rely on surface water for drinkable water and to provide water for the livestock. They have reported to the NGOs that they cannot use surface water anymore because of the pollution and noticed abnormal loss of livestock that they ascribe to oil contamination.

It should be noted that oil pollution can have adverse effects on surface water but also on groundwater and on the soils (polluted by oil residues).

### POOR SANITATION AND WASTE MANAGEMENT

Increased population density in the upper catchment areas and in the main towns of the basin, combined with poor sanitation and waste management can lead to local water quality problems.

*Figure 3-45: Washing and sewage discharge in the Kinyeti river (left) and untreated water for the Torit market (right)*

*Source: (MWRI, 2012)*

### SILTATION OF THE RIVERS

During a field mission to *Machar marshes* conducted in November and December 2012, siltation has been identified as an important issue.

Sand dunes and deposits in the Machar mouth have been observed and reported by local inhabitants on the Machar mouth, along the Khor Machar, on the Zure River / Adura river, and on the Baro river and its major spills and bifurcations. These deposits occurred in less than 10 years period and could have already important socio-economics, and environmental impacts. Erosion of the upper parts of the catchment seems to be the cause of the observed downstream siltation (ENTRO, 2012b).

### INVASIVE SPECIES IN WATERBODIES

Water hyacinth was observed during the site visit in Baro River below the Baro bridge at Gambella town. It is also mentioned during the discussion with South Sudan Transport office as a barrier for boat movement in Sobat River.

Water hyacinth (*Eichhornia crassipes*) is considered one of the world's worst weeds invading lakes, reservoirs, ponds, canals, and rivers due to its numerous adverse effects:

- Creates impenetrable barriers and obstructing various uses of water,
- Leads to complete blockage of navigation and fish migratory routes,
- Hinders irrigation by impeding water flow, by clogging irrigation pumps, and by interfering with weirs. Increased water loss through evapo-transpiration,
- Provides a breeding ground for disease vectors such as mosquitoes and the vector snails of schistosomiasis,
- Leads to depleting oxygen to aquatic communities, resulting in lack of phytoplankton which alters the composition of invertebrate communities, ultimately affecting fisheries,
- Destroys native plants and wildlife habitat (Rezene, 2014).

*Figure 3-46: Floating Water hyacinth observed in Baro River below the Baro bridge at Gambella town (letft) luxurious growth of water hyacinth at Koka Reservoir in Ethiopia (right)*

*Source: This study (left), (Rezene, 2014) (right)*

## 3.3.2 Summary of the biological environment

### *3.3.2.1 Main ecosystem services provided by the BAS ecosystems*

#### *3.3.2.1.1 The BAS natural resources are the main sources of livelihood for the major part of the BAS population*

In each biophysical areas of the basin, communities strongly rely on natural resources for food resources, construction material, fuel, coffee and timber production.

**DOMESTIC WATER USE AND FOOD RESOURCES**

Wetlands are vital for domestic water use when several rivers have dried up.

An important part of highland wetlands have been drained and are used for cultivation. In some parts of the lowlands of the basin, recession agriculture occur. In western Ethiopia, the production from wetlands has been estimated to contribute up to 50 – 60% of the household's food security where wetland areas are large enough. The importance of wetland production for farmers lies in the fact that the wetlands can be harvested at the end of the dry season, when other food supplies are becoming exhausted (Hailu A, 2006).

Floodplains and wetlands are key resources for livestock in the dry season since they provide high quality grass and water for cattle grazing and watering (Denny, 1991 in Burgess & al, 2004). In areas where there are no wetlands or where rivers are ephemeral, farmers move their cattle in search of water every day (Afework, 2001). The **main valuable plants for grazing are flooded grasslands** such as :

- Oryza which provides high quality grazing for much of the year even into the dry season and yield only 1 ton/ha when not flooded to 7 ton/ha when deeply flooded for a long period;
- Echinochloa pyramidalis which also grows even during the dry season and is thus a year-round pasture (ENTRO, 2007a),

whereas main rain-fed grasslands provide less quality grass and do not last during the dry season.

According to Hailu (2006), it “would be no exaggeration to claim that the survival of the country's livestock is directly linked to the abundance of wetlands”.

Waterbodies and other wetlands provide important fish resources. For example, only for the Gambella region, the current fish production of the region has been estimated at about 380 tons/year and the fish production potential of the region should range from 15,417-17,308 tons/year according to the MoA (2010). According to Hailu (2006), fish is the main source of protein for Agnuak communities, who live along the banks of the Baro and Gillo Rivers. Fishing is undertaken by men whereas women are heavily involved with fish processing and preservation.

In the southern part of the basin, wildlife also provide sources of proteins and commercial bush meat a source of income.

Afromontane natural forests also provide a variety of food products such as honey, spices, palm, wildfruits (Asseffa, 2007). In the Akobo catchment around Bench-Maji and Sheka zones, edible roots like Taro and Enset are common and support livelihood of people. These edible roots are drought resistance and also help to soil conservation. Consultations also revealed that Sheka people make the livelihood majorly from the wild honey they produced in the forest. They have customary forest management associated with beekeeping which is called Kobbo in local language. It is forest management in which members of the community own part of the forest to use it only for hanging beehives and collecting of spices, which doesn't deter the sustainable existence of the species.

Some floodplain grasslands plants like Oryza can also be used as a crop at the end of the dry season when other sources of food become rare.

The sale of wildcoffee, growing under Afromontane highland and lowland Ethiopian forests is also an important source of subsistence for the local communities (NABU, 2015).

Medicinal plants are also found especially in highland wetlands (Afework, 2001).

### CONSTRUCTION MATERIALS

Sedges (carex) found in the BAS wetlands are widely used for thatching. For example, in Western Oromia sedges prime importance is for thatching local houses (*tukuls*), among a variety of uses for the local communities, especially where other suitable materials are not available or are too expensive. In Illubabor Zone it is estimated that an estimated 85% of the local households use sedges or *cheffe* for roofing their houses or *Tukuls* (Hailu A, 2006; fework, 2001).

Bamboo forest are also used for construction in western and southern part of the basin.

Brick making is also reported in Oromia wetlands (EWNRA, 2008) and in South Sudan.

### ENERGY

Charcoal is considered as the main source of fuel used in the BAS urban centers and play an important role in forest and bushland degradation.

### TIMBER

Afromontane highlands and lowlands forests offer large old high quality wood from *Daniellia oliveri* and *Khaya senegalensis* trees for instance.

Asseffa (2007) has estimated that households from Sheka forests generate about 44% of their income from forest and forest products.

### 3.3.2.1.2 Head catchments remnant forests and wetlands provide climate, flow and siltation regulation

Head catchments wetlands and forests are known to play an important role in flood regulation, micro-climate regulation and erosion control. The extent of these services vary depending on local climatic, topographic and vegetation characteristics. The biophysical characteristics of the basin, the percentage of forest cover on the head catchments and the regional importance of the forest area (over 20% of Ethiopia's forest cover are located in the basin (FAO, 2010 in Institute of Biodiversity Conservation, 2012) make these services particularly important in the basin.

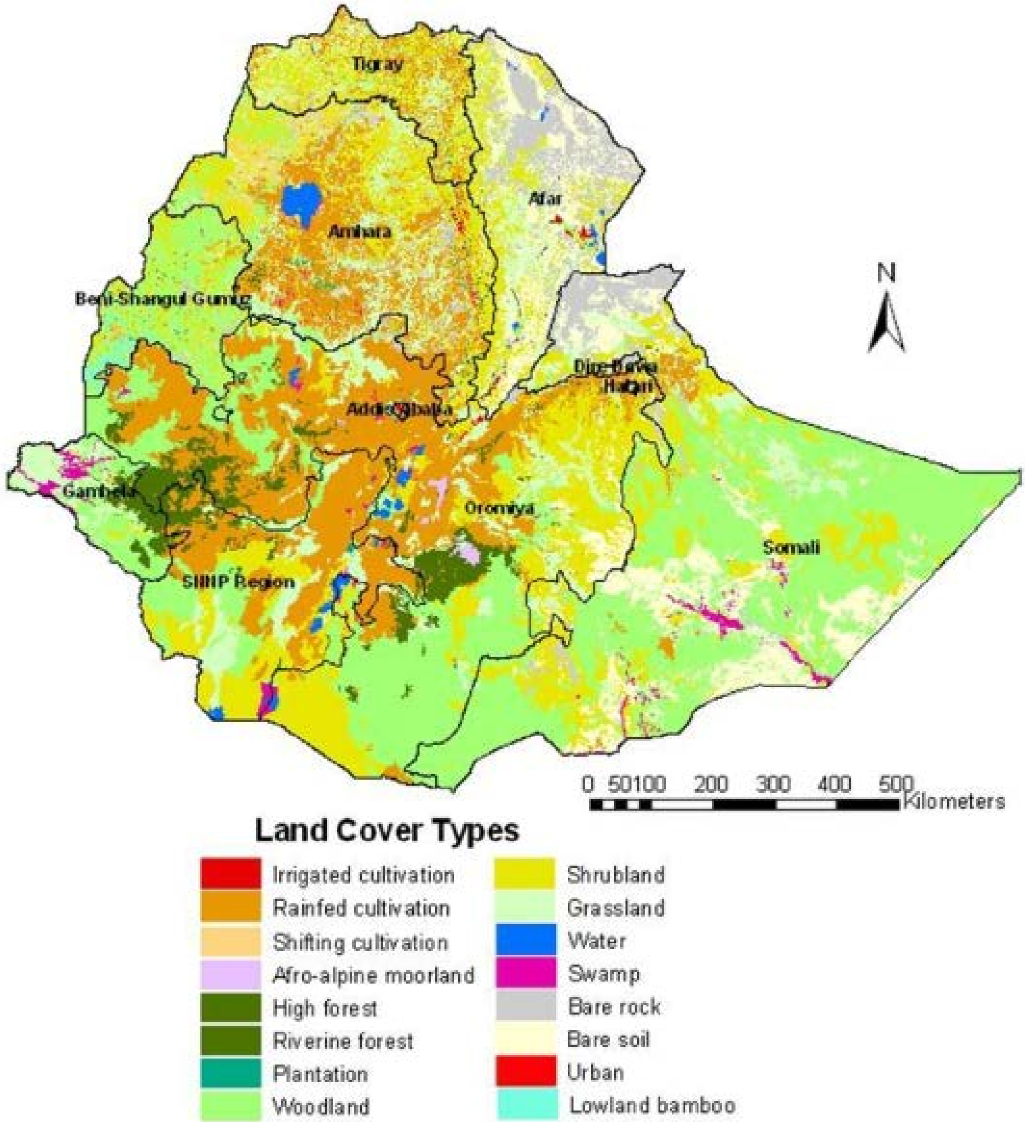



*Figure 3-47: Dominant land cover types in Ethiopia, showing the importance of the BAS forests*

*Source: (WBISPP, 2014) in (Institute of Biodiversity Conservation, 2012)*

Hailu (2006) reports that before deforestation and wetland drainage intensified in the Highlands around Illubabor, there was no history of flooding in the neighbouring Gambella Township. However, with increased deforestation and extensive drainage of wetlands, flooding has become a major threat to Gambella Township leading to dikes construction.

Local experts in Majang zone revealed that some streams which were permanent some years back have now become seasonal as a result of deforestation and land use change and therefore stress the importance to protect the remnant forest cover of the upper catchment and promote reforestation works on degraded areas.

At the scale of the basin, highlands and escarpments forests also play a critical role in carbon sequestration. The following figure illustrates impacts of deforestation on carbon sequestration and emission:

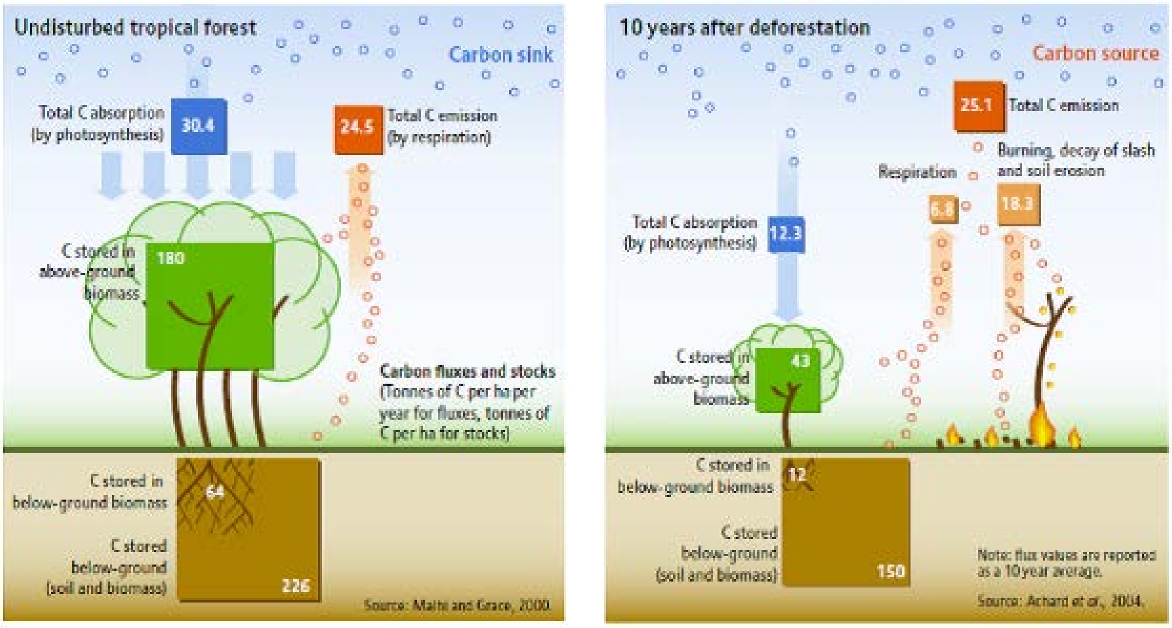



*Figure 3-48: Deforestation's impacts on carbon sequestration and emission*

*Source: (UNEP, 2009) in (EWCA, 2015)*

### *3.3.2.1.3 The BAS ecosystems offer habitats for a rich biodiversity of flora and fauna*

The BAS ecosystems support habitats hosting a rich flora and fauna, characterised by a high rate of endemism in the mountain and large endangered and threatened herds of mammals in the plains (refer to section 3.3.1 of Annex 2).

### *3.3.2.1.4 Flood patterns influence wildlife habitats and play a critical role in their migration*

According to Kingdon et al. (2013), the local patterns of flooding have the most influence on the Nile lechwe, more than the differences between dry and wet seasons.

The flood extent influences directly the availability of resources (grass and water) on which antelopes rely, consisting in an important driver in the migration (Fryxell, 1991; Fryxell, et al. 1988).

Birds habitats are also directly linked to flood recession areas (Zwarts, 2012).

Apart from wildlife, the entire socio-economic organization and livelihood of the plains depend on floodplains and wetlands seasonal variations.

#### *3.3.2.1.5 Rich biodiversity and pristine landscapes offer a huge opportunity for tourism development*

The variety of ecosystems of the BAS, its quite pristine character in an important part of the basin, the importance of the mammal and bird migration offer a huge potential for natural-resources based tourism.

Wildlife experts consider that the mammal migration of the BAS is equal to the Massai Mara – Serengeti one. The total annual numbers of visitors to this transboundary protected areas vary from 300,000 to 400,000. This is more than the current most visited national park of Ethiopia (Nechisar national park) and offer interesting perspectives for complementary sources of income for communities and for the two countries.

### *3.3.2.2 Synthesis of environmental specificities of the BAS*

The BAS is one of the hot biodiversity spots in Africa:

- The presence of vast wetlands, flood plains, lakes, perennial rivers, high forest areas, wood and grass lands make the area rich in biodiversity.
- It hosts largest remaining forests of Ethiopia, including the few remaining intact primary Afromontane, Evergreen Forest Ecosystem, which supports a unique floral and arboreal primate species and natural or wild coffee genetic resource as well as rich bird species diversity.
- It supports one of the largest migration of mammals (total estimated at 1.2 million individuals) and bird in Africa – at least equivalent to the Massai Mara – Serengeti migration, which habitats and migratory routes mostly relies on water resources seasonal variations and flood extent and duration.
- It is endowed with quite preserved beautiful landscape.

Its population strongly rely on natural resources for domestic water, food resources, construction material, medicinal plants and sources of income.

Natural resources of the BAS provide other high value ecosystems services such as:

- Rainfall and moisture regulation by natural and open forests,
- Flow regulation and erosion control,
- Carbon sequestration,
- High potential for ecotourism.

Therefore the function of the BAS ecosystems is “reckoned as vital as it serves mainly to the maintenance of the biodiversity, of its watershed values, the environmental services it renders and of its economic values both at local, basin and global levels” (Berhan, 2008).

The existing threats on the BAS ecoystems, including deforestation and forest degradation as well as highland and lowland wetland encroachment and degradation reduce the capacity of these ecosystems to provide the same level of services.

The current level of protection is very low but ongoing initiatives are promising.

## 3.4 BIOPHYSICAL ENVIRONMENT OF THE BAS BASIN: IDENTIFICATION OF THE KEY ISSUES AND CHALLENGES

The BAS key socio-environmental constraints identified during stakeholders' consultations and literature review are described below:

### 3.4.1 Stress on Wetlands

In the marshes of BAS (*Machar marshes* and others), water stagnates and is exposed to a high evaporation rate. However, the evaporated water is not lost from the system as it is partly recycled in the form of rain and contributes to an increase of the air moisture index, which results in a reduction of evaporation in the dry season (Mohamed et al., 2005). Plans to reduce the inflow of rivers water into these wetlands by abstracting or regulating water at pick rivers flow would reduce the size and function of these wetlands and is expected to have a negative impact on the climate , ecosystem and social fabrics of the basin. Unless adequate care is taken, a dramatic impact is to be expected on wildlife, livestock and fish resources. The dry season food supply for wildlife and livestock will decrease due to reduced flooding, and wet season spawning areas for many fish species will also decrease.

Within the plateau area of the upper sub-basin there are many small permanent and semi-permanent wetlands, mostly occupied by *Cyperus latifolius*. These are mostly found in the upper reaches of the Sor, and Gabba rivers. These account for approximately 2% of the land area but they are becoming increasingly important as land pressures in the cleared area outside the forest increases. Management of wetlands for sustainable cultivation, when drainage is involved, is not easy and there has been extensive and, in some areas, complete, loss of wetlands in the southwest highlands of Ethiopia. The impacts of the loss of wetlands or their transformation for farming are considerable and are also distributed in different ways across the communities. Women and the poor are especially seriously affected when wetland cultivation leads to the loss of safe spring water for domestic use and the loss of plant materials for craft and domestic use. Similar losses are linked to wetland degradation, but in addition the typically richer cultivators lose out.

The main driving forces for wetland drainage cultivation are seasonal food shortages caused by grain storage problems and expansion of coffee plantation on previously cereals growing farm lands. More recently, there has been a growing demand from urban areas for cereals and vegetables which are grown in wetlands. Urban growth has been associated with the growth of the coffee-based economy and there has been some response by farmers close to urban centres to grow crops in response to these market opportunities. Resettlement in Ethiopia after the 1984 famine also led to the increased use of wetlands in some areas of Illubabor where the integrated resettlement approach was used. Local communities asked to host resettlers allocated them land which was not in use or not of prime quality, and in some cases, this included wetlands. Settlers were also encouraged to cultivate wetlands for an early maize harvest as they did not have root crops which help local farmers fill the hungry season food gap.

In the mid / late1980s, the NGO MFM developed a programme, in Illubabor, which sought to reduce the pressure for forest clearance by developing rural livelihoods in the areas outside the forest. One element in this was wetland drainage for vegetable cultivation. Although this element of the programme was closed by the late 1990s, it showed communities some of the possibilities, as well as some of the problems, that could be encountered in wetlands and provided a stimulus to further wetland drainage. Since the early 1990s there has been Wetland Task Forces in the south-west highlands of Ethiopia including parts of the upper Baro-Akobo sub-basin. In years when food shortages are severe in other parts of the country, the Task Forces set communities targets for additional wetland drainage and cultivation and regularly visit communities to ensure these are achieved. In some cases they are also requiring farmers to extend the drainage period and undertake double cropping in the wetlands.

### 3.4.2 Loss of Biodiversity

Biodiversity Conservation in Ethiopia has been given attention since long ago. The first National Park was established in the fifteenth century. King Zera' Ya'ekob (1434–1468) designated Menagesha-Suba Forest Area as one of the "crown forests" of the country. He ordered the area to be planted with seedlings of indigenous junipers from Wef-Washa Forest, located between Ankober and Debre Sina, and established Menagesha-Suba Park as the country's first protected area (PA).

The first recognized legislation on wildlife conservation in Ethiopia was passed in October 1908 by Emperor Menelik II (1888–1912), who decreed that elephant hunting should be regulated. Further legislation was passed in 1944 to regulate hunting of wildlife by ensuring that certain species were not overhunted. This early legislation demonstrates awareness of the limits of wildlife resources and the dangers people posed to them ( Governance for Effective and Efficient Conservation in Ethiopia, by Fikirte Gebresenbet, et al).

Currently, there are many designated protected areas of land including National Parks, Wildlife Reserves, Priority Forests, Biosphere Reserves and Community Conservation Areas in Ethiopia. These do not only act as biodiversity 'banks', but also provide important spiritual places and centres for traditional ecological knowledge. These protected areas can also have a direct economic benefit; bringing in revenues from tourism and carbon trading.

However, the challenge is that Ethiopia's protected areas are increasingly degraded. Land is being converted for subsistence and commercial agriculture, timber use, fuel wood and construction, protected grasslands used for livestock grazing. The loss of forests and other protected land is underpinned by a growing population, unsustainable natural resource management, poor enforcement of existing legislation, uncertain land tenure and very low public awareness of the impact of climate change and the importance of biodiversity and ecosystems.

### 3.4.3 Loss of Natural forest

The dominant environmental change in the Baro-Akobo sub-basin is the loss of forest cover which is most marked in the southern and eastern part of the upper sub-basin where the main areas of forest remain. The FAO Forest Resources Assessment (FAO, 2010) estimates the annual loss for forests and other wooded land in South Sudan at 277,630 hectares.

Analysis by the WBISPP (Woody Biomass Inventory and Strategic Planning Project) in the high forest areas of Ethiopia (Dima, Godere, Gog, Akobo and Gambella woredas) has estimated the rates of deforestation caused by expanding population was 2.23% per annum. Annual destruction of the woody biomass from the high forest areas for agricultural expansion in the Ethiopian side of the BAS basin was estimated at about 4,287 ha per annum in 1995. This will increase exponentially and it is estimated that Gambella Regional State could lose 32% of its high forest resources between 1990 and 2020. Some 68 per cent of the loss will occur in Godere and Dima woredas. These woredas are also exhibiting the fastest rate of decrease of forest.

The rate of deforestation is determined by the national and foreign demand for tree products. It is likely that deforestation (without significant improvement of protection) will increase at least proportionally with the number of national consumers, but probably much faster with the increasing number of consumers as a result of immigration, natural population growth and the extension of the market (e.g. to Kenya, Uganda and Sudan) due to the reduction of transport barriers.

The factors playing an important role in deforestation are :

- Clearing for cultivation: The most important factor responsible for total forest clearing in BAS basin is cultivation. The average small scale farming household in the basin uses 0.4 to 1 hectares of land for the cultivation of subsistence crops. Currently, the total area under cultivation in low laying areas of the basin is still low. However, it may be expected that the cultivated area will increase proportionally with the increasing population and, in the longer term when agricultural mechanization becomes more common, even more. In Gambella area, mechanized farm is already booming. When the security situation improves, in South Sudan, mechanized agriculture is expected to expand at a fast rate. A survey of land-based investments (Deng, 2011) indicates that, from 2007 to 2010, foreign companies, governments and individuals have sought or acquired at least 2.64 million hectares (26,400 km$^2$) of land for agricultural projects, biofuel and forestry sectors in South Sudan. Private investment projects in agriculture may help the basin's economy forward, but if social and environmental aspects are not taken into account, social and environmental costs may be very high. This is particularly the case with mechanized agriculture, which does not contribute much to employment.

*Figure 3-49: Clearing of wood land for the expansion of farm in Torit State, south Sudan*


*Source: This study*

- Clearing for roads and settlements: To create space for roads, settlements and other social and economic infrastructure, forested areas are often to be cleared. The area cleared is usually larger than the area occupied by the structures themselves. Moreover, the impact of human presence and land use associated with roads and settlements usually reaches much further than the original area cleared. Continuous use of forest products by people and passing livestock results in an impact gradient in a wide zone along and around such areas, which may stretch over a distance of up to 5 km or more away from roads and settlements (Deodatus, 1998 in UNDP, 2011). Currently, roads are being constructed at various areas where there were no road previously. These roads will open up vast areas in the basin that were previously isolated. Road construction will have a positive influence on the economy of these areas, but at the same time pressure on their resources and natural environment will increase considerably.

- Charcoal burning: The main fuel used in urban centres of the BAS basin is charcoal. In South Sudan, many returnees burn wood to make charcoal to generate income, because no license is needed and simple tools are required. Moreover, the forest belongs 'to nobody.' The production of charcoal requires large quantities of wood and likely contributes significantly to deforestation. The situation of charcoal production is similar in all the parts of the basin and considered to be one of the main causes of deforestation and land degradation. Large quantities of charcoal are also exported. Based on some monthly figures on charcoal exportation from the Renk County in Upper Nile State to Sudan, it is estimated that now annually in the order of 60,000 bags of charcoal are exported from Renk County, representing 2,700 hectares of deforested land (Upper Nile State Ministry of Finance in (UNDP, 2011). This estimate is based on an extrapolation of the annual fluctuations in charcoal production due to seasonality. Since more charcoal may have been exported unregistered or illegally, the real figure is expected to be much higher. The development of hydropower could play a significant role to cope with deforestation.

*Figure 3-50: Charcoal making at Sheka zone of Ethiopia (left) and Charcoal ready for sell at Torit area in South Sudan (right)*

Source: this study

*Table 3-11: Number of bags of charcoal taxed for exportation to northern Sudan in Upper Nile during the first months of 2011*

| Months | Bags of Charcoal taxed for exported |
|---|---|
| January | 3,118 |
| February | Unknown |
| March | 7,596 |
| April | 3605 |
| May | 432 |

Source: Upper Nile State Ministry of Finance in (UNDP, 2011)

- Brick making in South Sudan: In the past, houses were made of sun-dried bricks. Nowadays more and more baked bricks are used. Brick bakers interviewed in the basin produced 120,000 bricks in one cycle, which are sold for 0.25 South Sudan Pounds per piece (UNEP, 2007 in UNDP, 2011). One brick-baking cycle uses 8 cubic metres of firewood. Building the kiln takes 7-14 days, baking 7 days and taking the bricks out another 7-8 days. In Upper Nile brick makers produced between 80,000 and 160,000 bricks per kiln using one truck load of wood for large kilns and a half a truck load for small kilns. One brick-baking cycle was half a month, which means that the presence of one kiln accounts for the utilization of an average of 18 truckloads of firewood per year.
- Construction and fire wood: The demand for construction and fire wood has increased due to the construction of new settlements and population growth. For timber, higher quality wood of larger older trees (Daniellia oliveri, Khaya senegalensis) is exploited. If taken in large quantities, important elements of the vegetation are removed, which impacts vegetation structure and may increase erosion (UNEP, 2007 in UNDP, 2011)

*Figure 3-51: Wood collected for sell at Sheka zone near Tepi (left) and Fuel Wood collected along the Tepi-Meti road (right)*

Source: this study

- Livestock grazing/browsing: Livestock in the basin, particularly cattle, sheep and goats, consume grass and trees. Grazing is sustainable as long as the re-growth capacity of the vegetation matches the level of use. If the off-take by livestock is too high or if other factors of degradation (e.g. fire, clearing for different purposes, low rainfall, drop of water table) interact with grazing, the vegetation will degrade, which means that open tree savannas may fragment and on the long run they turn into grasslands or deserts (Miehe, 2010 in UNDP, 2011). The impact of livestock grazing is less visible and more difficult to quantify than that of clearing for agriculture and cutting for charcoal, fuel wood or construction. The most important contribution of livestock to deforestation is the removal of seedlings, which eliminates the capacity of the forest to regenerate.
- Fires: Bush fire is one of the factors for the degradation of forest. It may originate from a number of causes:
  - Farmers use fire to remove vegetation for cultivation; sometimes they lose control and wildfires result;
  - Pastoralists use fire to remove dry grass cover and to stimulate re-growth of perennial grasses (green flush);
  - Hunters use fire to chase animals hidden in the vegetation;
  - On some occasions natural fires occur due to thunderstorms, but this is actually rare since thunderstorms mainly occur in the wet season and they are accompanied by rain.

  Fires destroy seeds, tree seedlings, rhizomes of perennial grasses and organic contents of the soil. Areas frequently devastated by fires lose tree re-growth and perennial grasses. Annual grasses, which have less nutritious value for livestock, gain an advantage from fire, since their seeds may survive in the subsoil or recolonize burned areas by dispersion through wind or herbivores.
- Population Growth and Resettlement: Population growth is in the order of 2.8% in the rural areas of the upper sub-basin. This growth is mostly due to natural increase, but there has been a long history, when permitted, of spontaneous migration of people in search of land or economic opportunities associated with the coffee economy, as well as planned resettlement from famine affected areas.
- Forest Land Allocation for State Farms and Investors: The process of forest land allocation for the estate farming in Ethiopia accelerated during the Derg government (1974-1991) as the road infrastructure in this area was improved. This period saw the establishment of the 8,000 ha coffee estate at Bebeka, to the west of Mizan Teferi and established another state farm for coffee near Tepi covering around 5,000 ha. In the lower basin the state farm at Abobo was also established partly in woodland. Since the change of government in 1991, and the introduction of the free market, forest land has been allocated to investors on long leases for estate agriculture. This has mostly been done in SNNPRS where a rather favourable attitude to investors exists, compared to that in Oromiya where more stringent EIA procedures have been applied. The new estates are mostly in Sheka Zone, near Masha, along the road from Tepi to Gore, but also west of Mizan Teferi. Recent land allocation for investors become more common in Gambella region. In all cases, the estates have been established in areas of high forest and, experience shows that when options exist for using secondary / thinned forest within the allocated area, investors prefer the high forest.

*Figure 3-52: Wushwush tea plantation at Kafa*

*Source: This study*

### 3.4.4 Soil Erosion

Soil erosion is a serious problem, which occurs particularly on sloping areas with coarse soil texture and poor vegetation cover. Factors accelerating erosion are deforestation for cultivation, over-grazing, wildfire and other activities responsible for the clearing of the land's natural ground cover. The major consequences of erosion are loss of soil quality which impacts natural vegetation and productivity in agriculture, and the siltation of rivers, lakes, dams and irrigation canals. Water erosion is more prominent in the highlands of the BAS basin due to higher human pressure, more sloping land and/ or generally coarser soil types compared to the landscapes dominated by the floodplains in the low laying areas of the basin.

### 3.4.5 Scattered settlement

The settlement pattern of the communities are mainly rural and are scattered along the river banks increasing susceptibility to flooding and reducing accessibility limiting access to basic social services and retarding development initiatives.

### 3.4.6 Poor Agriculture Extension and Poor Credit Facilities

Agricultural extension programs were not designed to address the complex socio cultural farming systems and agro – climatic conditions of the basin. Lack of or no rural credit facilities, agricultural input supply and market facilities, inadequate linkage between research – extension farmers and cooperatives, prevalence of livestock diseases and crop pests, inadequate market infrastructure and marketing information system, higher humidity and traditional farming techniques (hand tillage) are among the constraints limiting agricultural productivity in the basin. This leads to important loss of soil and to deforestation as a response to rapidly decreasing yields and increasing demand.

### 3.4.7 Encroachment into protected areas

In general, land-use change in the BAS basin is causing the extensive destruction of natural resources. For instance, Gambella National Park in Ethiopia is the country's largest national park formerly covering an area of 5061 $km^2$, with a unique ecosystem and wildlife composition. Many recognize great potential for wildlife conservation in this park, but this potential has not yet been tapped as it is expected. The state and federal governments carve up the land for "small" and big investments. Recently, the government established huge tracts of commercial farms within the former park area. Two large Indian and Saudi commercial plantations, Karuturi (300,000 ha) and Saudi Star (100,000 ha), have started producing rice encroaching to the national park area. As a result of these activities, EWCA and the Park Administration organized a workshop in December 2010 with the objective of re-demarcating the borders of the park. As a result the park area has been re-demarcated and reduced from former 5061 $km^2$ to 4575 $km^2$.

### 3.4.8 Poverty, Poor physical and Social Infrastructure, Security issues

Poor physical and social infrastructure including communication (Poor access to health and education services inadequate technical/modern skills); Poor animal husbandry and animal health services; Poor market outlet, absence of roads and information, etc. are among the constraints of the basin development.

Also, unpredictable conflict between tribes and ethnic groups within the region and cross border conflict consist of additional obstacle for development and growth efforts exerted by the people. Over the last four years, pressure on natural resources such as land, food and shelter materials has increased due to the influx of refugee (and now IDP) populations in the area. Consequently, tensions between refugees and host communities have risen, frequently developing into violent conflict ( which in turn hinders the delivery of aid to both refugees and hosts, and affects the integration of refugees in the area). A specific study has shown that most important components of tension and dispute between refugees and neighbouring host community villages was in regards to natural resources and land, livestock and wood. Access to water was not found to be a prominent issue (REACH, 2016).

The combination of the above quoted factors, along with the persistence of poverty lead to high degree of dependency over the BAS natural resources and leads therefore to important pressures on them, especially in historic populated areas (highlands and escarpments) but also recently around refugees settlements (lowlands).

### 3.4.9 Unsustainable Hunting of Wildlife

The civil war and continuing insecurity has seen a proliferation of firearms among the communities in the South Sudan part of the basin. The proliferation of arms allows hunters to kill more wildlife with less effort. In the context of insecure tenure, wildlife has become an open access resource and well-armed hunters are rapidly depleting wildlife population. For long, food insecurity and local income had been the drivers toward wildlife hunting to supplement for inadequate animal protein especially during the wet season. It has also meant that conflicts over access to land and water have become appallingly violent in South Sudan, especially among the cattle keeping communities which in some occasion may also involve peasant. Lack of livelihood options for internally displaced people (IDP) and returning refugees in South Sudan has resulted in an overdependence on natural resources as a source of income, causing a rapid spread of unsustainable trade in bush meat across the basin. .

Livestock grazing pressure, access to water and the transmission of wildlife-livestock diseases (e.g., bovine tuberculosis, rabies, rinderpest, cooties) are important factors affecting local wildlife, livestock and human communities as well as natural resource management (USAID, 2010c).

# 4. SOCIO-ECONOMIC ENVIRONMENT: CURRENT SITUATION AND KEY ISSUES

## 4.1 INTRODUCTION

This chapter presents the main demographic and socio-economic features of the BAS basin, including the following dimensions:

- Population Dynamics – size, density, population of major towns, mobility (including migration, resettlement, internal displacement and refugees, and status of road network), linkages between population and environmental features
- Education and Health status
- Gender Relations
- Government and Administrative Framework
- Ethnic and Language groups
- Conflicts
- Humanitarian assistance
- Livelihoods
- Food security
- Poverty
- Markets

The final sections of this chapter present key issues, potentials and objectives related to the development of the BAS basin and identifies indicators that can be used to develop a monitoring framework for the demographic and socio-economic dimensions of the future development of the BAS basin.

## 4.2 CONCEPTUALIZING INTERRELATIONSHIPS

The following model[2] will be used to conceptualize the complex interrelationships between water resources and the social and economic domains of human life.

Each domain in the model in Figure 4-1 exhibits and is maintained by a number of key features and processes.

[2] Vulnerability Assessment of Water Resources Systems in the Eastern Nile Basin, Mohamed A. Hamouda ·Mohamed M. Nour El-Din Fawzia I. Moursy, published in Water Resource Management: 23 (2009)

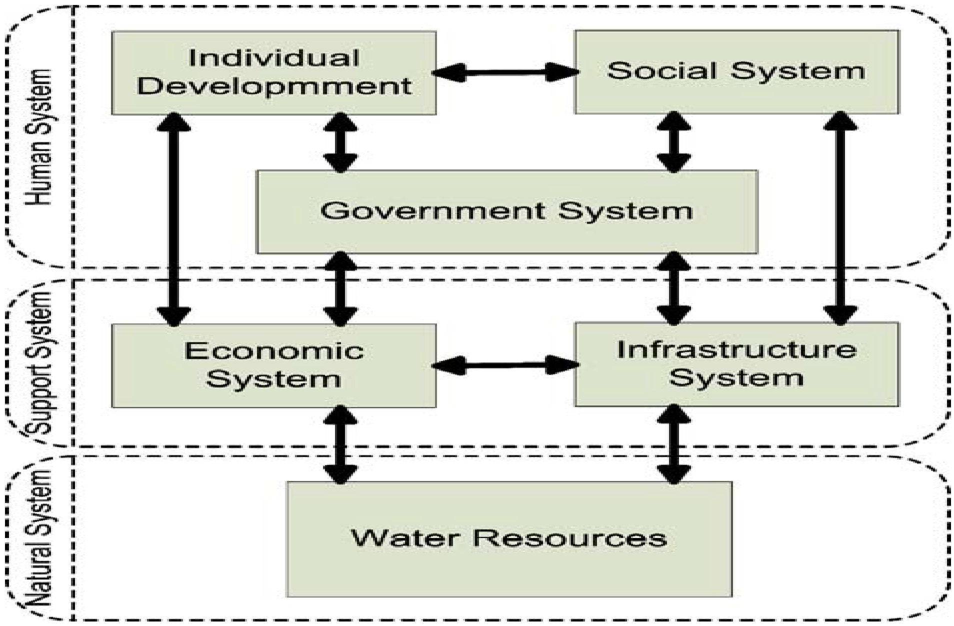



*Figure 4-1: Conceptual Model Linking Water Resources with Social and Economic Systems*

The focus of the present chapter is on the social system, which is functionally linked to the economic, government and individual development systems. The social system is a domain where government, economics and individual development systems merge, interact and are ”rationalized” and harmonized to form the foundations of a nation, society or social group.

Following are the defining characteristics of the systems that are relevant to the present chapter.

*Table 4-1: Characteristics of System Domains*

| System | Defining Characteristics |
|---|---|
| Social | Reproduction, identity, kinship roles, socialization of individuals, moral values |
| Economic | Production, labor, meeting survival needs, markets |
| Government | Control, power, legitimacy, national goals, regulation |
| Individual Development | Survival, needs, personal goals and attributes |

The concept of social vulnerability will be introduced as a composite variable composed of a combination of characteristics related to sensitivity and adaptability of domains or groups in the basin. The following table presents a typology of the components of vulnerability: sensitivity and adaptive capacity of social systems3.

*Table 4-2: Typology of Characteristics of Vulnerability*

| Sensitivity | Adaptability | |
|---|---|---|
| | High | Low |
| **High** | Responsive | High Vulnerability |
| **Low** | Resilient | Inflexible |

[3] Adapted from Ibid, 2009

This typology can be used to assess the social vulnerability of the basin as a whole, small areas parts of or social groups in the basin. However, to do so, it is necessary to identify proxy variables or indicators for use in our analysis. The indicators should be measurable or at least observable, and the methodology used to derive them should be transparent.

In the present chapter, the dimensions of population, education and health, ethnic groups, conflicts, livelihoods, humanitarian assistance, poverty and agricultural markets will be used to describe the socio-economic characteristics of the BAS basin**.**

## 4.3 DEMOGRAPHIC AND SOCIAL DRIVERS OF CHANGE

The main socio-economic drivers of change in the basin include the following:

- Population dynamics
  - Population density and growth rates
  - Migration, displacement and resettlement
- Government policies/actions
  - Ethnic relations
  - Allocation of land and other resources
- Conflicts
  - Interethnic
  - Political
- Food security
- Market forces
  - Linkages
  - Disruption

## 4.4 POPULATION DYNAMICS

### 4.4.1 Introduction

The human population in the basin exhibits both relatively static and dynamic characteristics. The population is in the western part of the basin in Jonglei and Upper Nile state in South Sudan and parts of Benishangul-Gumuz and Gambella regions in is highly dynamic, being affected by layered conflicts and resulting displacement that will be described in further detail below and in Annexes 3-A and 3-B.

### 4.4.2 Size and age composition

The current population in the basin is estimated to be around 5.7 million consisting of 2.6 million in the basin in South Sudan and 3,04 million in Ethiopia[4].

The basin's population is also overwhelmingly young, with almost half of the basin's population under 15 years old. Fertility and birth rates are also high, averaging 5 births per woman and a birth rate of over 40 per 1,000 population.

[4] This figure does not include the relatively small basin population in Kenya (Turkana), Uganda (Kidepo area) and in Sudan.

Overall, the total BAS population is deemed to double by 2041 and triple by 2056 according to both Ethiopian and South Sudan projections (see Table 4-4 below).

Population growth rates across the South Sudan part of the sub-basin are high, ranging from 4.4% per year in Eastern Equatoria State, 3.9% per year in the Upper Nile State to 3.3% per year in Jonglei State. If these growth rates continue, the population of the South Sudan part of the BAS sub-basin will more than double to 8.4 million by 2040. This growth in population will exacerbate pressure on the natural resources and infrastructure in the basin and can well increase the competition and conflicts over land, water and other natural resources.

Table 4-3 presents the population growth rates and densities in the Ethiopian area of the BAS sub-basin. The population density in the regions varies from 10 people per km² in Gambella to 70 people per km² in the parts of Oromia region.

*Table 4-3: Annual Population Growth Rate and Density in Regions in the BAS sub-basin in Ethiopia*

| Region | Growth Rate | | Population Density (per km$^2$) |
|---|---|---|---|
| | Rural | Urban | |
| Gambella | 2.71 | 10.3 | 10 |
| Oromia | 2.56 | 17.0 | 70 |
| SNNPR | 2.98 | 9.7 | 43 |
| Benishangul-Gumuz | 2.43 | 16.9 | 16 |

*Source: ENTRO (2009): One System Inventory.*

As a result, the future population of the BAS is expected to double by 2040 and almost triple by 2056. The current and future projected population is presented per sub-catchment of the Baro Akobo Sobat sub-basin in the table below.

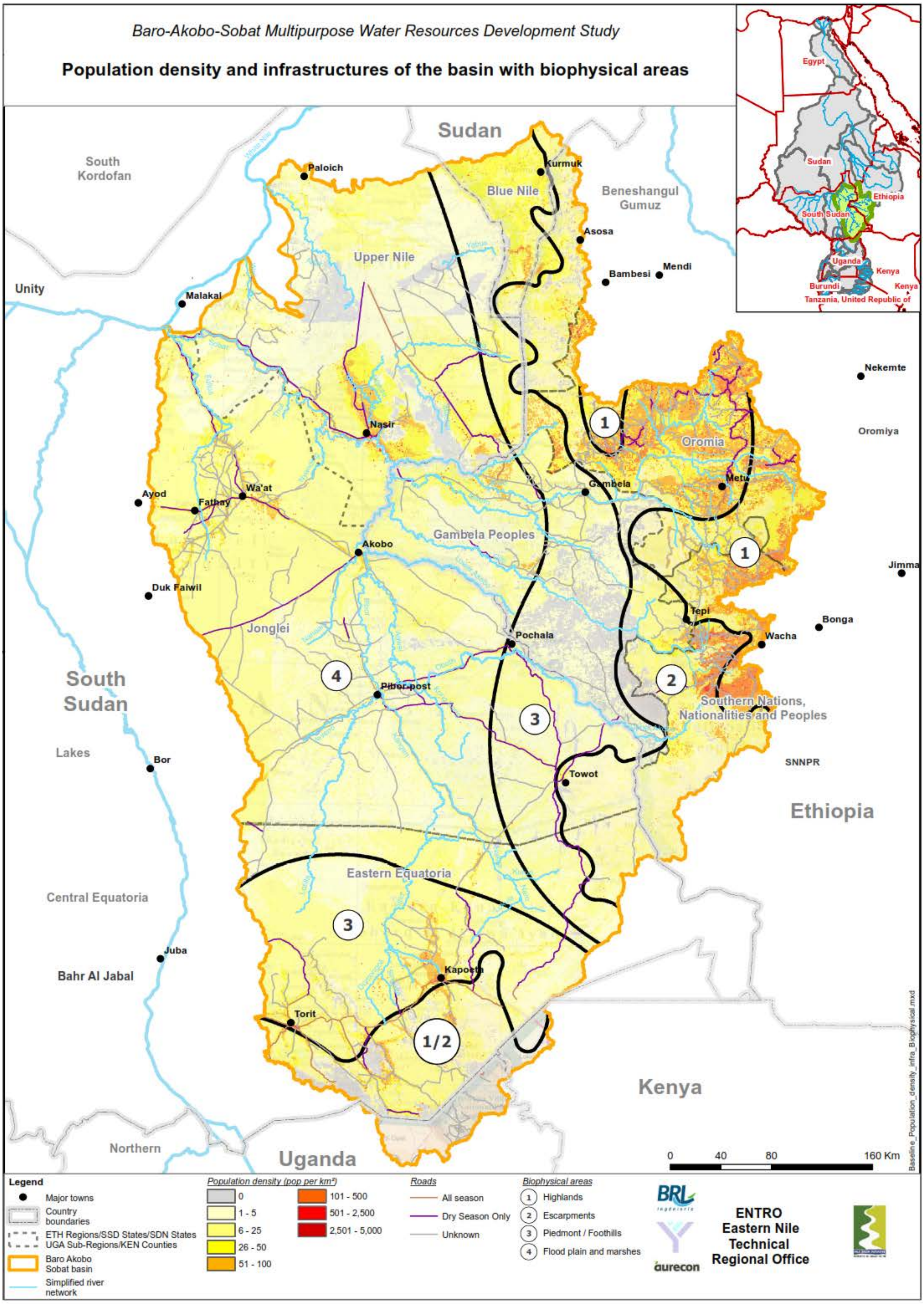
*Table 4-4: Projections for the total BAS sub-basin population*

| Sub-basin | Current population | 2041 projected population | 2056 projected population |
|---|---|---|---|
| Machar marshes | 880 322 | 1 607 229 | 2 345 506 |
| Birbir | 801 193 | 1 206 207 | 1 541 816 |
| Geba | 721 024 | 1 085 511 | 1 387 538 |
| Alw ero | 121 897 | 183 521 | 234 585 |
| Gilo | 403 745 | 607 843 | 776 967 |
| Low er Akobo | 82 294 | 144 469 | 204 930 |
| Agw ei | 197 019 | 390 831 | 592 370 |
| Upper Akobo | 355 279 | 571 063 | 765 494 |
| Upper Pibor East | 729 474 | 1 757 082 | 2 647 039 |
| Upper Pibor West | 338 551 | 838 170 | 1 270 385 |
| Low er Pibor | 154 185 | 299 575 | 449 526 |
| Sobat | 546 530 | 1 079 975 | 1 636 879 |
| Baro | 380 906 | 580 541 | 749 380 |
| **TOTAL BAS** | **5 712 421** | **10 352 016** | **14 602 415** |

## 4.4.3 Population distribution

The population is unevenly distributed across the basin, and its density within the basin shows considerable variation, as can be seen in Figure 4-2.

*Figure 4-2: Population density, main towns and infrastructures in the Baro-Akobo-Sobat sub-basin*



It can be seen that population density is generally higher in the eastern part of the basin toward the Ethiopian highlands, whereas with the exception of a few urban areas, the population density in the South Sudan part of the basin is generally low, varying from less than 1 per km$^2$ to around 60 per km$^2$, whereas in the Ethiopian part of the basin, population densities reach as high as 500 per km$^2$ in the eastern highlands in Oromia Region.

In the South Sudan part of the basin the highest densities of population are found along rivers, in particular the area along the Sobat River immediately north of the Gambella salient.

Under normal conditions, in areas that are largely rural and agrarian it can be expected that there would be a natural tendency for the population to move from areas of high population density to areas of lower density in search of new land for cultivation or grazing. However, in the present situation in the basin, conflicts and accompanying insecurity in the western part of the basin, primarily in South Sudan, inhibit such a movement.

The relatively sparsely populated area of the basin in southwestern Gambella Region along the border with South Sudan is attracting new settlers from the highlands to the east, primarily from Oromia and SNNP regions, which increases pressure on land and water resources as well as increasing tensions with the indigenous people in the receiving area. This is also the area where large areas of land are being leased to outside investors for agricultural development.

### 4.4.4 Population of major towns

Population of major towns of the basin is presented in the following table (please refer to Figure 4-2 which shows the location of the main towns):

*Table 4-5: Major towns in the BAS*

| Country | Region / State | Town over 30,000 inhabitants | Population |
|---|---|---|---|
| Ethiopia | Gambella | Gambella | 70,099 |
| | | Tepi | 19,231 |
| | Oromia | Metu | 44,296 |
| | SNNPR | Mïzan Teferi | 23,144 |
| | | Wacha | 23,528 |
| | Benishangul-Gumuz | Asossa | 49,145 |
| South Sudan | Upper Nile | Nasir | ? |
| | | Malakal (outside the BAS) | 139,400 |
| | Eastern Equatoria | Kapoeta | 7,000 |
| | | Torit | 20,050 |
| | Jonglei | Akobo | 1,000 |
| | | Pibor-post | 1,000 |
| Sudan | Blue Nile | Kurmuk | 110,815 |

*Sources: (1) CSA (2012) Projected Population for 2016 ; (2) CSA (2014) E Ethiopian's Rural Facilities and Services Atlas 2014 for SNNPR, Oromia, BG and Gabella Regions and Wikipedia*

## 4.4.5 Population mobility and the road network

### POPULATION MOBILITY

Population mobility includes migration, resettlement, internal displacement and refugees and can be voluntary, as in the case of permanent or temporary migration, or involuntary, as in the case of resettlement, eviction, political and inter-ethnic conflicts, or natural disasters.

The most common types of mobility in the basin are migration from the eastern highlands to the lowlands in Gambella Region and internal displacement due to ethnic and political conflicts. Over 250,000 people in the basin have been affected by internal displacement since the outbreak of political conflicts in South Sudan in December 2013.

The areas most affected by displacement due to political and ethnic conflicts are Jonglei and Upper Nile States in South Sudan and Gambella and parts of Benishangul-Gumuz regions in Ethiopia.

### ROAD NETWORK

Access to the BAS lowlands is problematic during the rainy season because roads become flooded. As shown in the Figure 4-2, only a small portion of the BAS road network is accessible all year long. This has a negative impact on development and also impede humanitarian aids to reach these areas.

It should be also noted that internal displacement also occur via the river network (see section 6.3.2 on navigation).

## 4.4.6 Linkages between population and environmental features

The carrying capacity “refers to the number of individuals who can be supported in a given area within natural resource limits, and without degrading the natural, social, cultural and economic environment for present and future generations. The carrying capacity for any given area is not fixed. It can be altered by technology and resource management practices, but mostly it is changed for the worse by pressures which accompany a population increase. A major symptom of reduction in carrying capacity is the reduction of bioproductivity.” (ENS Lyon, 2012a).

The most populated areas of the basin are located within the Ethiopian highlands and escarpments where the predominant land use is made of micro-parcels of farming (see orange areas in Figure 4-3) along with some pasture land (light green in Figure 4-3). From the map and from the literature, it is easy to understand that the expansion of this type of land use has been done to the detriment of the initial forest coverage. In these areas, inadequate agricultural praticies and massive land clearing lead to loss of soil which in turn lead to a reduction of the productivity. Gradual encroachment of cultivation into grazing lands is common in both highlands and mid-altitude areas. Many meadows in the flood plains have been converted into croplands. As a result, livestock population (and its high stocking density) and the intensity of cultivation are greater than the carrying capacity of the land, due to land degradation and low biomass production (RoE, 1993) (Mengistu, 2006).

Apart from the extremely high populated highlands, high population densities are also reported around main towns and settlements such as Torit, Kapoeata, Nassir, Wa’at, Fathay and along the road network (eg: between Wa’at and Akobo; from Nasir to the North). Around dense settlements, high stocking of livestock lead to overgrazing, encroachment of livestock into the crop fields of the sedentary farmers, intermittent conflicts over drinking water during the dry season and conflictual situation between herdsmen and the native population (Udo, 2006).

Within the forest areas of the BAS, the population density does not exceed 50 habitants per $km^2$ and can be very low, close to zero (See Figure 4-3). According to the same map, the population is also close to nil in the Pibor, Machar, Yabus, Daga, Adar floodplains. Even if these ecosystems face numerous threats, the current population density is deemed to be lower than their carrying capacity.

The semi-arid areas of the Upper Nile, Jonglei and Eastern Equatoria States are mainly covered by dry savannas and also show low population density, ranging from 1 to 25 inhabitants per $km^2$. In these areas, short growing season suit only fast maturing plants; limited rainfall, recurrent drought and shrub invasion indeed lead to low grass productivity (Mengistu, 2006), except in floodplain and wetlands areas. Even if almost inhabited, it appears that the population (mainly practicing nomadic pastoralism) has approached the carrying capacity of the environment during the dry season under the prevailing agricultural and animal production technologies because of the low range biomass and high stocking rates. This predisposes the grazing lands to overgrazing and soil degradation (Udo, 2006). Recurrent conflict between cultivators and herders, particularly in the arid zone, is an indicator of the degradation of resources as well as of the growth of human and livestock populations" (CBD, s.d.).

The global rise of temperature, expected in the BAS according to climate change projections is expected to further reduce livestock carrying capacity ((White et. al. (2006) in (International Resources Group, 2007)).

The above findings and the population projections (which indicate that the BAS population is suppose to double by 2041 and triple by 2056) stress the need to both develop the BAS, in order to reduce the overdependancy over natural resources and to better manage its natural resources in order to avoid their deterioration and the resulting reduction of carrying capacity.

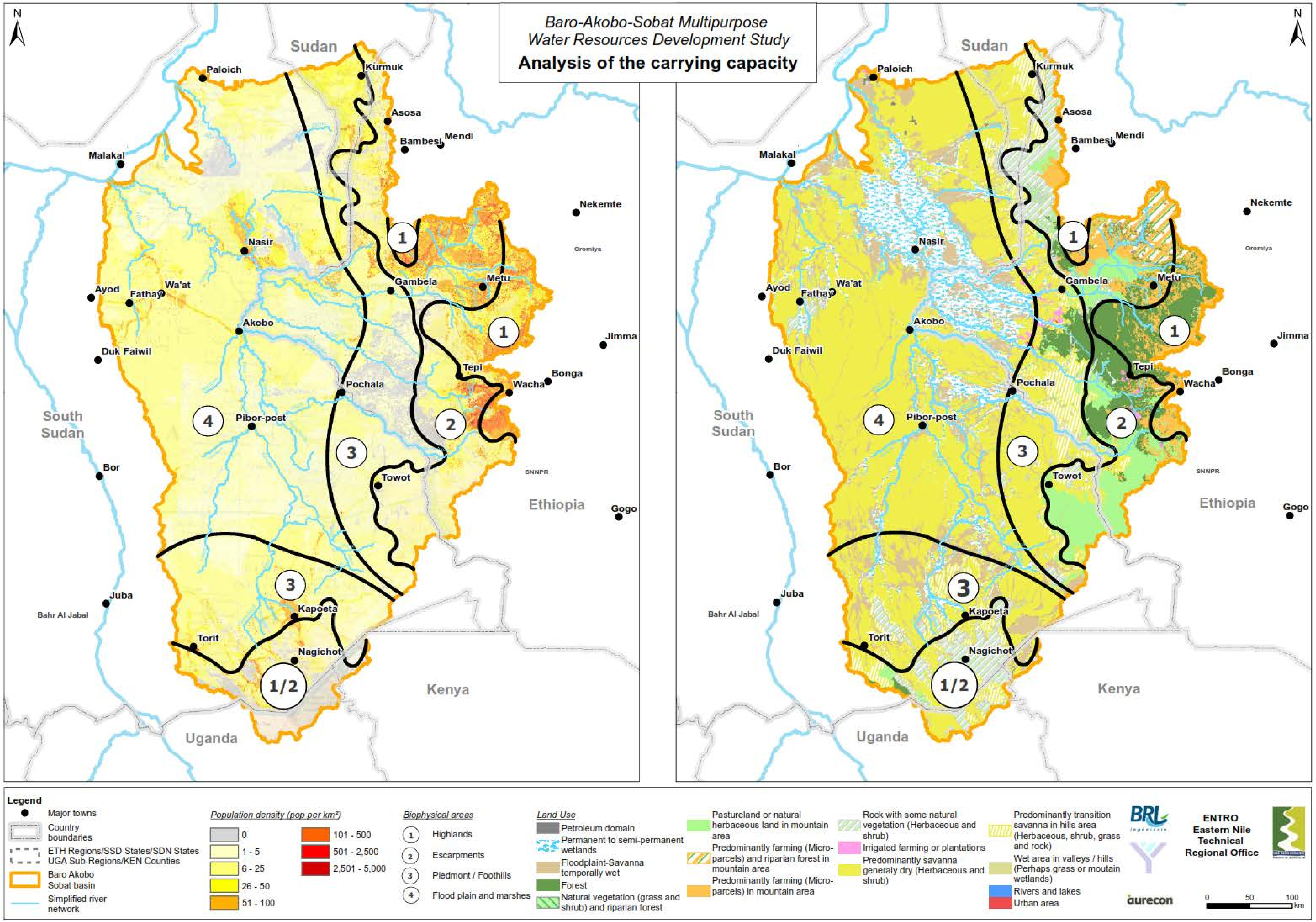



*Figure 4-3: Qualitative analysis of the resources carrying capacity of the BAS sub-basin*

## 4.5 EDUCATION AND HEALTH STATUS

### 4.5.1 Health status

The health status of a human population is important in determining the development potential of an area or group. An area or group that is suffering from a high burden of disease and debilitating conditions will not be able to respond to many opportunities for development and will spend scarce time and money on medical treatment and medicine.

The following table presents selected health indicators of two basin countries, Ethiopia and South Sudan.

*Table 4-6: Selected Health Indicators for Two Basin Countries*

| **Indicator** | **Country** | |
|---|---|---|
| | **Ethiopia** | **South Sudan** |
| Birth rate (per 1,000) | 38 (2014) | 46 (2011) |
| Death rate (per 1,000 pop) | 8.5 (2014) | 11 (2013) |
| Infant mortality (per 1,000 live births) | 55.77 | 99 (2006) |
| Total fertility (children/woman) | 5.23 (2014) | 4.9 (2014) |
| Life expectancy at birth | 60.75 (2014) | 54.0 (2014) |
| HIV/AIDs – adult prevalance rate | 1.3% (2012) | 2.6% (2013) |
| Access to improved water sources | Urban 96.8%<br>Rural 42.1%<br>Total 51% (2012) | Urban 67%<br>Rural 53%<br>Total 55% (2009) |
| Access to improved sanitation | Urban 27.4%<br>Rural 22.8%<br>Total 23.6% (2012) | Total 20% (2009) |
| Maternal mortality (per 1,000 live births) | 350 (2010) | 730 (2006) |
| Underweight children under 5 | 29.2% (2011) | N/A |
| Health expenditure (% of GDP) | 4.7 (2011) | 0.7 (2011) |

*Sources: WHO, 2012 and 2014, World Bank, World Development Indicators, and SSCCSE, Key Indicators for South Sudan, February 2011.*

The above table paints a generally bleak picture of the health status of the basin's population. The conditions shown in the above table are not amenable to rapid change or quick results and will require a concerted effort and considerable resources to improve. Particularly alarming are the high maternal mortality rates, especially in South Sudan, the high birth rates in both countries, and low life expectancy, especially in South Sudan, and access to improved sanitation facilities in both countries. A rare positive item is the relatively high health expenditure in Ethiopia as a percentage of the country's GDP.

#### 4.5.1.1 Health status in the South Sudan part of the sub-basin

The health situation in the BAS basin is characterized by high incidence of preventable diseases, childhood malnutrition, infant mortality and poor sanitary conditions. There is also low access to effective health care and medicines. The following tables show some common indicators of health status of the basin states in South Sudan.

*Table 4-7: Childhood Nutrition Status in Sub-basin States*

| Location | Low Weight for Age (%)[1] |
|---|---|
| Upper Nile | 24.2 |
| Jonglei | 29.3 |
| Eastern Equatoria | 29.2 |
| South Sudan | 27.6 |

*[1] Low weight for age is used as an indicator of the nutrition status of children in a population using a comparison with normal weights for each age group*

*Source: South Sudan - Household Health Survey, Final Report, National Bureau of Statistics, Ministry of Health, August 2013.*

Another commonly used indicator of the general health status of a population is the infant mortality rate. The infant mortality rate for the states in the BAS basin is shown in the following table.

*Table 4-8: Infant Mortality Rates* for Sub-basin States*

| Location | Infant Mortality Rate (IMR) |
|---|---|
| Upper Nile | 74 |
| Jonglei | 31 |
| Eastern Equatoria | 106 |
| South Sudan | 60 |

**Deaths in the first year of life per 1,000 live births*

*Source: South Sudan - Household Health Survey, Final Report, National Bureau of Statistics, Ministry of Health, August 2013.*

Another important indicator of general health conditions in a population is access to adequate sanitation. The following table shows access to improved sanitary facilities by households in the Sub-basin states.

*Table 4-9: Access to Sanitation in Basin States – South Sudan*

| Location | Improved Sanitation (%) | No toilet/open air (%) |
|---|---|---|
| Upper Nile | 7.8 | 71.5 |
| Jonglei | 6.2 | 70.7 |
| Eastern Equatoria | 4.5 | 74.7 |
| South Sudan | 7.0 | 64.1 |

*Source: South Sudan - Household Health Survey, Final Report, National Bureau of Statistics, Ministry of Health, August 2013.*

### MALARIA

Malaria is a leading cause of death of children under age five in South Sudan. From January to October 2015, more than 2.1 million cases of malaria were reported in health facilities in the country, resulting in more than 1,100 deaths. These figures include only deaths at health facilities, and the overall death rate from this disease is likely to be much higher.

Malaria also contributes to anemia in children and is a common cause of absenteeism from school and work. A rough indicator of measures in place to prevent of malaria is ownership of mosquito nets by households. The ownership of at least one mosquito net by households in the sub-basin states is shown in the following table:

*Table 4-10: Ownership of at least one Mosquito Net by Households in Basin States – South Sudan*

| Location | Households (%) |
|---|---|
| Upper Nile | 74.3 |
| Jonglei | 66.1 |
| Eastern Equatoria | 37.0 |
| South Sudan | 60.0 |

*Source: South Sudan - Household Health Survey, Final Report, National Bureau of Statistics, Ministry of Health, August 2013.*

Mortality in the sub-basin has been exacerbated by acute malnutrition and disease, with more than one in five counties surveyed (10 out of 46) having Crude Death Rates (CDR) above the threshold of 1 death per 10,000 people per day. There continue to be deaths from preventable diseases. Malaria is the largest cause of death, with more than 1,100 deaths due to the disease reported in health facilities from January to October 2015.

### 4.5.1.2 Health status in the Ethiopian part of the sub-basin

In Ethiopia diseases responsible for deaths and disability (i.e. disease burden) include malaria, prenatal and maternal death, acute respiratory infection, nutrition deficiency, diarrhea and HIV/AIDs. Communicable diseases are the main cause of mortality in the country that account for about 70% of the causes (WHO, 2013), followed by non-communicable diseases (20%) and injuries (10%)5.

The main health problems in the Sub-basin in Ethiopia are diseases which include tsetse, yellow fever, malaria, Onchocerciasis and Schistosomiasis. These diseases are major constraints to economic and social development in the sub-basin. In the future, there is a risk that many of these diseases are likely to increase as a result of development interventions such as irrigation, hydropower reservoirs, expansion of human settlements, and influx of people into the basin due to large-scale farm development and investments. There is a risk that malaria will become perennial instead of seasonal; and tsetse will increase with the increase in the livestock population and with the use of animal traction for crop production.

[5] Ethiopia: Health Profile (undated) http://www.who.int/gho/countries/eth.pdf?ua=1

## 4.5.2 Education and literacy

### *4.5.2.1 Education and literacy for the South Sudan part of the sub-basin*

#### LITERACY

Most of the population in the sub-basin has limited access to education and low literacy and educational attainment. The literacy rates for the states in the BAS sub-basin are shown below.

*Table 4.4: Literacy Rate in Sub-basin States (%)*

| Location | Literacy Rate[1] |
|---|---|
| Upper Nile | 50 |
| Jonglei | 19 |
| Eastern Equatoria | 18 |
| South Sudan | 28 |

*[1] Literacy is defined as the ability to read and write a simple text among people 15 years old and above*

#### EDUCATION

South Sudan has some of the lowest educational indicators in Sub-saharan Africa, with education of girls also being among the lowest. Only one girl in ten completes primary education, and girls comprise just a little over one-third of the secondary school population. Very few girls who complete primary education continue on to secondary school. There are many barriers (cultural, financial, poor infrastructure/quality) that prevent girls from going to and remaining in school. A girl child faces many barriers when she wants to go to school: her family may not be able to pay for her education, or may think education for girls is not important or necessary.

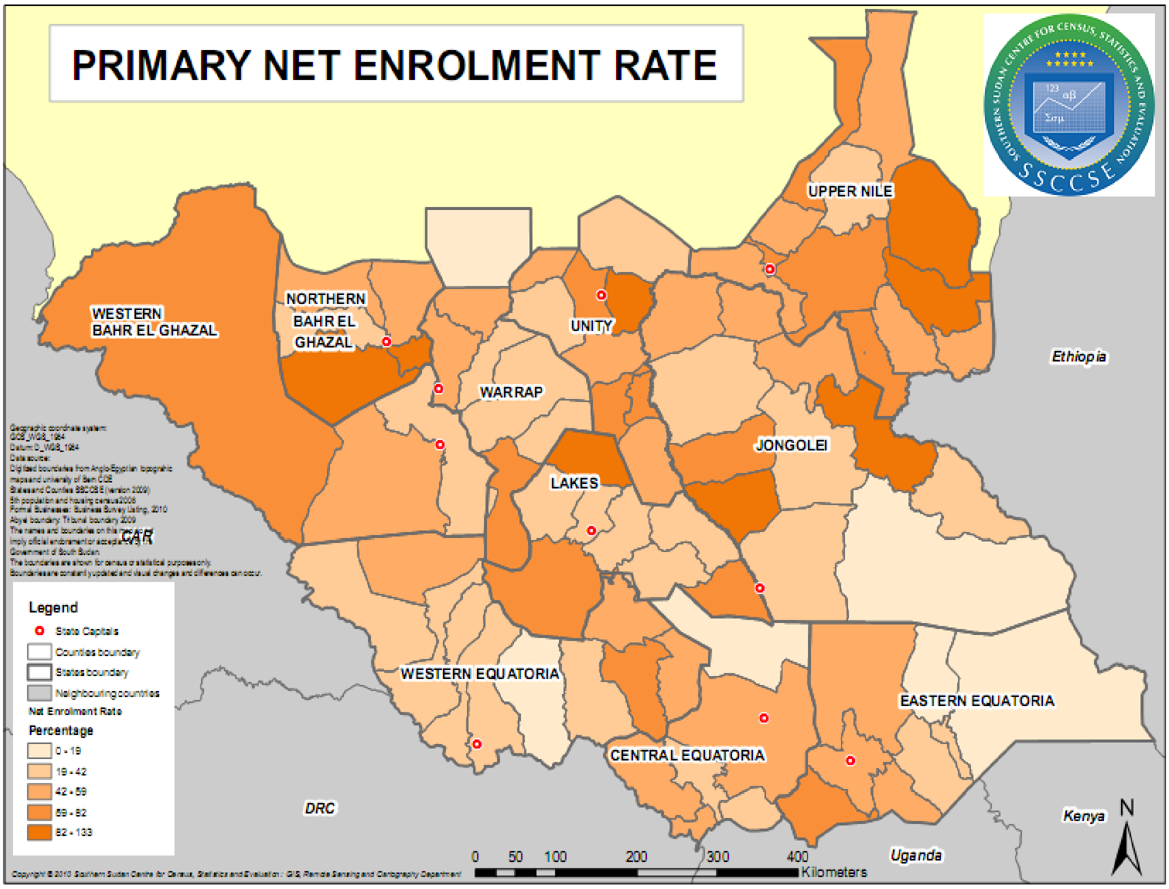
At primary level the distribution of girl and boy pupils is uneven, with girls comprising only 39% of the pupil population nationally in 2011, a pattern which can be assumed to apply to the BAS sub-basin as well.

While the number of students has increased, there has been very little change in gender parity. Some 70% of secondary school students in the country are male. The trend resembles that at the primary level, whereby boys have higher access to education than girls (MoGEI, 2012).

A main challenge to education in South Sudan is to eliminate barriers to girls' education and promote gender equality through and throughout the education system6. As shown in the map below, in the sub-basin states the Net enrolment Rate (NER) is highest (i.e. 82-129) in Upper Nile and lowest (below 20%) in Eastern Equatoria.

[6] http://www.girlseducationsouthsudan.org/about-girls-education-south-sudan.

*Figure 4-4: Primary Net Enrolment Rate in South Sudan*




Source: SSCCS, 2009

Most of the population in the sub-basin area has limited access to education. The primary school enrolment rates for males and females inr the states in the BAS sub-basin are shown below.

*Table 4.4 Primary School Enrolment Rates*

| Location | Primary School Enrolment (6-13 years) - % | |
|---|---|---|
| | Male | Female |
| Eastern Equatoria | 59.6 | 40.4 |
| Jonglei | 61.2 | 38.8 |
| Upper Nile | 56.7 | 43.3 |

Source: 2008 Census for South Sudan

Another indicator of access to education is the primary school attendance rate, which shows actual attendance and is therefore more accurate than the enrolment rate alone.

*Table 4-11: Primary School Attendance Rate in Sub-Basin States in South Sudan*

| Location | Primary School Attendance Rate (%) |
|---|---|
| Upper Nile | 50.0 |
| Jonglei | 27.0 |
| Eastern Equatoria | 27.0 |
| South Sudan | 37.0 |

The most common reasons given by parents for children not attending school were mostly attributed to poverty - no money to pay school fees (32%) and lack of schools or schools are very far (30%).

Education Facilities

South Sudan in general and the sub-basin in particular have an acute shortage of educational institutions and staff and resources to maintain them. Seventy-three percent of the population is illiterate according to the Southern Sudan Centre for Census, Statistics and Evaluation (2014) and nearly one in four civil servants lacks formal education.

In addition, a need exists for vocational and non-formal training to reintegrate thousands of ex-combatants and hundreds of thousands of newly arrived returnees into productive employment and to develop a labor force with the skills to support a growing economy, especially in the areas of construction, mechanics, plumbing and electrical work. In some cases, new returnees arrive in South Sudan with useful skill sets from work experience in Sudan, such as teaching, mechanics or construction. Making effective use of these human resources in the developing economy of South Sudan is a major challenge to making an enabling environment for development.

The significance of present education and literacy levels for the future development of the BAS sub-basin is the absence of a cadre of indigenous basin residents with the knowledge, skills, and experience with access to capital for investment in productive activities to drive development in the basin. In the absence of such an indigenous entrepreneural class, development is dependent on government, donors and relatively unknown external “investors”. Thus there is a high risk that development will depend on externally-driven forces and interests and capital for investment.

#### 4.5.2.2 Education and literacy for the Ethiopian part of the sub-basin

At country level, the literacy rate (for reading and writing in any language) was 53% for males and 36% for females (CSA and WB, 2013). The literacy rate in the Ethiopian part of the Basin is shown in Table A4.8 below. All areas in the basin have a low literacy level ranging from 18% in Benishangul-Gumuz to 29% in Gambella.

*Table 4-12: Adult Literacy Rate in the Ethiopian Part of the Sub-Basin (%)*

| Region | Literacy (>15 years of age) | | |
|---|---|---|---|
| | Male | Female | Average |
| Gambella | 38.6 | 10.5 | 29.3 |
| Oromia | 29.3 | 16.6 | 22.4 |
| SNNPR | 33.9 | 15.2 | 24.4 |
| Benishangu-Gumuz | 24.9 | 10.5 | 17.7 |

School enrolment in Ethiopia has increased in the last five years. Table 4-13 below presents the current situation and trends in the net enrollment rate (NER) for five years. As noted in the same table, NER increased by 3.3% in 2013/14 from the previous year and by 6.9% from 2009/10.

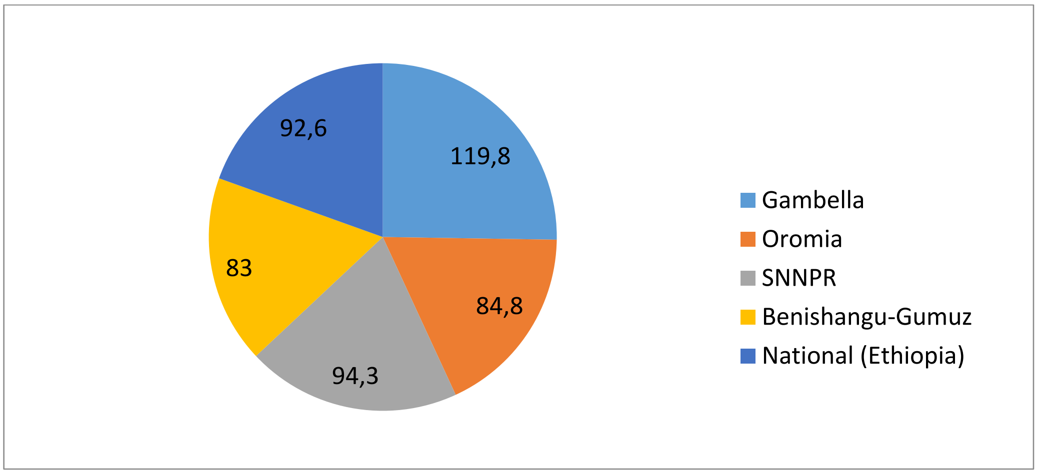
*Table 4-13: NER Trends at Primary Level (Grade 1-8)*

| Year | Boys | Girls | Total |
|---|---|---|---|
| 2002 EC (2009/10) | 83.7 | 80.5 | 82.1 |
| 2003 EC (2010/11) | 87.0 | 83.5 | 85.3 |
| 2004 EC (2011/12) | 86.8 | 83.9 | 85.4 |
| 2005 EC (2012/13) | 87.5 | 83.9 | 85.7 |
| 2006 EC (2013/14) | 95.1 | 90.1 | 92.6 |

***Source:** MoE (2015, June): Education Statistics Annual Abstract for 2006 EC (2013/2014GC)*

The Net Enrolment Rate (NER) by regions in the sub-basin is given in Figure 4-5 below. SNNPR and Gambella rank above the national average (92.6). The NER in Gambella region exceeded 100% which suggests that the education system should put more effort into this region to enhance the on-time participation of students in primary education.

*Figure 4-5: Net Enrolment Rate in the Sub-Basin Regions (Grades 1-8) (2013/14)*




***Source:*** *MoE (June 2015): Eucation Statistics Annual Abstract for 2006 EC (2013/2014GC) .*

As can be seen from Table 4-14, as of 2013/14 there were 1,919 Technical Vocational Education and Training (TVET) institutions in Ethiopia. Of this number, 1,350 were public owned, 538 private and 31 owned by NGOs. The number of trainees in 2013 were 404,041, of which 50.2% were males and 49.8% were females. There are 284 TVETs in the Ethiopian side of the sub-basin.

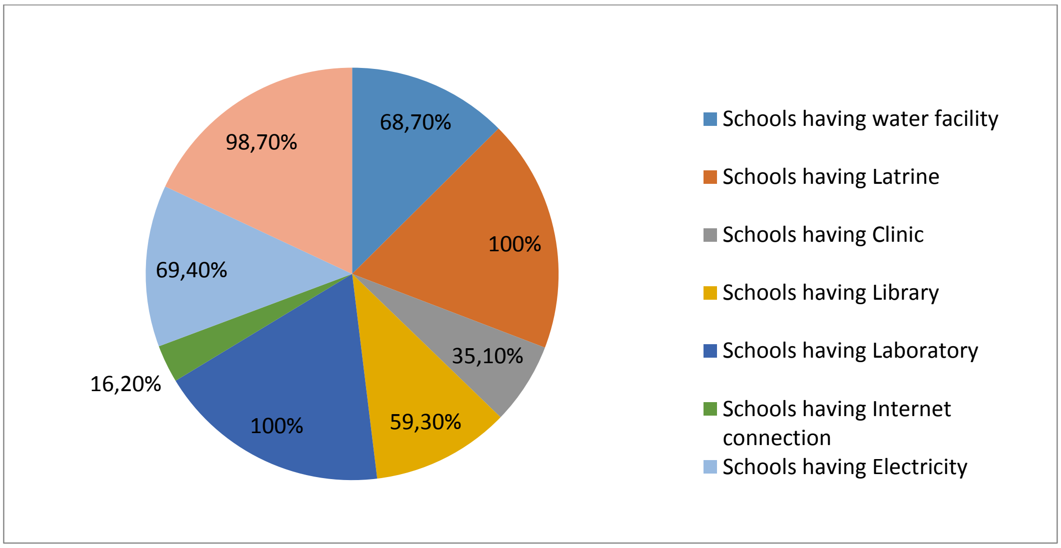
*Table 4-14: TVETs in Ethiopia and the Sub-Basin Regions (2013)*

| **Country and Sub-Basin Regions** | **Distribution of TVETs by Ownership and Basin Regions** |
|---|---|
| TVETs in Ethiopia | 1,919* |
| Public | 1,350 |
| Private | 538 |
| NGOs | 31 |
| TVETs in Regions in the Sub-basin | 284 |
| Oromia | 212 |
| Gambella | 3 |
| Behnisahgul_Gumuz | 4 |
| SNNP | 65 |

***Source****: MoE, 2014; MoE (2015, June ): Eucation Statistics Annual Abstract for 2006 EC (2013/2014GC).*
**The firgure includes TVETs from nine regions and from the two city adminisations.*

Figure 4-6 shows that almost all schools have facilities such as latrines, laboratories and TVs. About 69% of schools have water and electricity. Only 16.2% of secondary schools have internet connections, and about 59% have a library.

*Figure 4-6: Availability of Basic Facilities in Secondary Schools*




***Source:*** *Computed from Education Statistics Annual Abstract for 2006 EC (2013/2014GC), MOE, 2015.*

Recent surveys indicate that the literacy level was 60% for males and 43% for females in 2013-2014. For school-age population (7-18 years of age), about 36% of boys and 34% of girls were not in school. Primary and secondary enrollment rates were similar for both sexes. About 60% were enrolled in primary schools and the remainder (less than 4%) were enrolled in secondary school. (CSA and WB, 2015). Generally, literacy levels of the population are still low, both at national and sub-basin levels.

Issues and Indicators:

- Literacy level is still low in the country, as well as in the BAS sub-basin.
- Much of the school age population (about 36% of boys and 34% of girls) still remain out of school.
- On-time participation of students in primary education is low in Gambella and BG.
- Shortage of school facilities such as water supply, toilets, library, internet, etc.

## 4.6 GENDER RELATIONS AND GENDER INCLUSION

Within the broader context of social and economic inequality in the basin there is also a subset of inequality between the sexes. In most parts of the basin the female population is legally disenfranchised, socially limited and excluded from important economic activities and resources such as property as well as effective political representation. Conditions and opportunities vary among ethnic groups in the basin and between urban and rural areas, but there a number of common issues.

- **Equality in access to education** is still not a reality for many girls in the basin. Women are only half as likely (19%) to be as literate as men. Although the gap is narrowing with higher school enrolment for girls, it is still below the enrolment rates of males, particularly in secondary, vocational and higher education.
- **Access to employment** is limited in the formal public and private sectors by a combination of restrictive social norms and lack of formal educational qualifications and skills. Males are also the main beneficiaries of political patronage for government jobs.
- **Access to wealth**, measured in ownership of land, shelter, cattle or cash, is severely curtailed for women in the basin. Cattle are owned and controlled by males and represent a means of wealth and social status as well as valuable property for which girls can be exchanged in marriage through the bride price. Women have very few resources that confer social status and political power.
- **Inheritance rights** are limited for women. This results in disinherited widows (of whom there are inevitably very many) and divorcees, especially those from polygamous relationships, as well as their children. Without access to land, cattle or other forms of wealth, and with little prospect of remarrying outside their late husband’s family, widows or divorcees are marginalized and have few opportunities to improve their lives.

Opening up economic opportunities for women, especially the most marginalized, is critical for the rights and aspirations of future generations of South Sudan as well as the future of economic growth.

The following are proposed as indicators of gender inclusion and balance in the basin:

*Table 4-15: Gender-related Indicators*

| Indicator | Measure |
|---|---|
| Girls’ school enrolment/attainment | Enrolment rates/attainment levels |
| Adult female literacy | Literacy levels |
| Enrolment in vocational training courses | Enrolment rates |
| Women in paid jobs outside the home | Number employed |
| Births attended by trained midwives or in maternity wards | Number of attended births |
| Maternal mortality | Maternal mortality rate |
| Infant mortality | Infant mortality rate |
| Legal rights for women to inherit property and obtain custody of children | Laws enacted and enforced |
| Representation in government | % of women in elected office |

# 4.7 ETHNIC GROUPS

## 4.7.1 Introduction

The basin is home to over 150 ethnic groups and sub-groups who exhibit a wide range of cultures, values, norms and practices. They encompass nomadic pastoralists, agro-pastoralists, hunters and gatherers, sedentary farmers, gardeners, fishermen, traders, warriors, raiders and soldiers. Languages spoken by these groups are in most cases not mutually understandable, and bridge languages such as Arabic and English are necessary to communicate and conduct business across ethnic boundaries, In border areas and larger markets, trade languages based on Swahili, Amharic and other languages are widely used.

## 4.7.2 Characteristics of Main Ethnic Groups in the Basin

Ethnic groups in the basin will be presented by their location, starting with the ethnic groups living in regions in Ethiopia, followed by the main ethnic groups living in South Sudan.

### ETHIOPIA - OROMIA REGION

The major ethic groups in the region nclude Oromo (85%), Amhara (9.1%), and the remaining 5.9% are other ethic groups (CSA, 2007). Afan Oromo, presently written with Latin characters, is the official language (ONRS, 2011). The large majority in the part of the sub-basin in Oromia Region are Oromo people.

Oromo people occupy compact farming villages on the upland slopes and plateau of Halu Bure Woreda, Alledidu Woreda and Sale Nono Woreda, in the Illu-Ababora zone of Oromia Region. Their way of life revolves around subsistence agriculture, trading in local markets, animal husbandry (mainly keeping draught oxen), and the harvest of wild coffee from the forest (NORPLAN, 2006).

Oromos respect their elders and value social responsibility, helping others, bravery, and hard work. Knowledge of history and culture is admired. Oromos can count their family trees through ten generations or more. These values are expressed in *geerarsa* or *mirisa* (singing), storytelling, poems, and proverbs. *Geerarsa* is used to praise good behaviour and discourage inappropriate behaviour.

The Oromo regard harmony and solidarity as a virtue that can help create an indissoluble unity. The idea of Oromo unity incorporates harmony and solidarity between nature, God and human beings. The Oromo oral arts and belief systems emphasize that the existence of an individual is reliant on the stability and continuity of the society. It means that the right, value and attribute of an individual is driven from and shaped within the larger society. Yet personal initiatives and action may not be discouraged in so far as they do not violate the socio-cultural standards (Jeylan, 2006).

The Oromo have an indigenous calendar based on skilful readings of the astronomical configurations of the moon and the stars. They have also indigenous systems of resolving social, economic and political conflicts. They have used these systems to live in peaceful coexistence with neighbouring tribal and ethnic groups and to negotiate or redefine their relationships with them.

The *Gada* System is the most common among the largest Oromo ethnic groups. The Oromo have a well-developed age-based system grouping upon which the religious, political, economic and social life of the people is based. The *Gada* system organizes Oromo society into age groups and rotates leadership in egalitarian democracy every eight years and is most remarkable and unique.

The socio-political functions of the *Gada* system, a system of an age grade classes that succeed each other in assuming economic, political and social responsibilities. A complete *Gada* cycle consists of five age-grades. The authority held by the elders is derived from their position in the *Gada* system. According to *Gada*, those people who have entered the *Luba* group (individuals in the 40-48 age group) are considered to be elders.

Elders in the Oromo community form a dominant component of the customary mechanisms of conflict management. The *Lubas* (elders) settle disputes among groups and individuals and apply the laws dealing with the distribution of resources, criminal fines and punishment, protection of property, theft, etc. After *Luba*, men automatically retire from *Gada* and move into an advisory role known as *Yuba*. They receive a great deal of respect as wise experienced authorities and repositories of knowledge and law, but their decisions are no longer final as they had been before. At this point they turn their attention to private family businesses or religious activities, while their sons enter *Gada*, the public service (Junior Worldmark Encyclopedia of World Cultures, 1999)

The *Gada* system has always guided the religious, social, political, and economic life of the Oromo people. The institution is still functional in different parts of Oromia along with the modern administration system. In the *Gada* system, elders were responsible for teaching, resolving conflicts, and nurturing Oromo culture. Seniority is thus an important factor in Oromo relationships. The system helps to exercise democracy, participatory government and leadership.

For example, the Borana use their *Gada* leadership to avoid conflict over water resources. The wells are managed by a council of the clan group which includes a retired *hayyuu* (special counsellors or individuals who hold ritual authority to judge, the *Jallaba* (a local lineage of clan elder or special messenger, the *Abbaa Konfi* (trustee of each well), the *abbaa herregaa* (the coordinator of water use and maintenance) and other members of the traditional leadership (Jeylan, 2006).

### GAMBELLA REGION

The Nuer, Anywa, Mejeng, Amhara and Keffa ethnic groups form the largest socio-ethnic groups. The Nuer constitute 46.65%, Anywa 21.17%, Amhara 8.42%, Oromo 4.83%, Mejeng 4%, Kefficho 5.05%, and the rest are Kembata, Shekecho, Bench, Tigrians and others (CSA, 2008).

Nuers are predominantly cattle-breeders but they also cultivate flood recession maize and sorghum to supplement their diet of milk and blood, thus cattle are jointly owned by families. The Nuer are pastoralists and transhumance cultivators. They move from the banks of the rivers to the uplands and vice versa, depending on the seasons and the flooding of rivers. The rivers typically flood the plains from June through August, at which time the Nuer and their livestock move to live in the upper woodland areas and cultivate crops for this season. At the end of the floods in October/November, they return with their livestock to the banks of the rivers and stay there until May to herd their animals and cultivate crops on land enriched by the floods. For the Nuer the rivers are vital for their sustenance as well as the survival of their livestock (Desalegn, 2011).

The seasonal movements in “Nuerland” is mainly to find suitable grazing lands for the Nuer’s cattle, a practice directly threatened by the villagization process. As agro-pastoralists, the majority of Nuer have little experience living in sedentary settlements. Cattle are uniquely dependent on their livelihood strategy, ethnic identity, and cultural patterns. Nuer language is unique within the Gambella region, and cannot be understood by other ethnicities. The Nuer are also well-known for their unique cultural practices, including their ritual scarification (HRW, 2012).

The Nuer people belong to Nilotic ethnic group. The majority of Nuer are found in South Sudan but a significant number of Nuers are found in Gambella Region. They inhabit five woredas of the region and are the largest ethnic group consisting of more than 46% of the population in Gambella.

Until very recently, cattle have historically been of the highest symbolic, religious and economic value for the Nuer. Cattle are particularly important due to their role as bride wealth, where they are given by a husband’s lineage to his wife’s lineage. It is this exchange of cattle which ensures that the children will be considered to belong to the husband’s lineage and to his line of descent.

The Anywa live in dispersed settlements. They are dependent mainly on the cultivation of the land and crop production (maize, sorghum, sweet potato and groundnuts). They also supplement their income with fishing on riverbanks, with hunting as a source of meat, honey production, and access to a wide variety of forest resources and grasslands around them.

Cultivation is based on the use of hoe and other hand tools, and most of the time the produce is not sufficient for the needs of families the whole year round. Therefore, the period from January to May is known as the “hardship season”. April and May is the difficult and “hungry season” and during this period people may be reduced to starvation. During the scarcity of food, families depend on wild foods collected from the forests and to live through the hardship and hunger seasons. The Anywa eke out a precarious existence and depend greatly on the ecosystem and surrounding natural resources for their survival (Desalegn, 2011; UNCEF, 2006).

The Anuak are a Luo Nilotic Ewhic group. The Anuak in Ethiopia are the second largest ethnic group occupying most parts of Anuak zone of Gambella region. The Anuak share some cultural traits with the Nuer and the largest ethnic groups in the region have a mutual understanding. Cultural similarities exist between the Nuer and Anuak, but in a limited extent even though these tribes are both from Nilotic language group.

The Mejeng/Majang are found in southeastern Gambella bordering SNNPR. They are the third largest ethnic group accounted for 4% of the Gambella population. The Mejeng inhabit mainly in Godere and Mengesh woredas, a landscape of broad-leaved tropical rain forests. They live in scattered communities in the forests of Southwestern Ethiopia and are often interspersed with other ethnic groups. Their livelihood activities include slash and burn farming, hunting, fishing and bee keeping. They cultivate maize, sorghum, godere (cassava), taro, yams and pumpkins, spices, herbs and peppers, sesame, beans, peas and pulses. Their principal source of livelihood is bee-keeping. Mejeng families tend numerous hives, often more than fifty. They are particularly noted as honey producers for which the forest ecosystem is critical. Selling honey and clay pots provides their main - almost only - cash income. They also prepare a special drink made by boiling coffee leaves with a mixture of spices. While the Mejeng traditionally shifted their residence often, they have recently established permanent villages.

For all population groups the ecosystem provides a variety of essential resources, including wood for tools, grass for homesteads, wild food, medicinal and other useful plants, and access to water resources (NORPLAN, 2006; Desalegn, 2011).

The Opuo and Komo tribes are smaller in number compared to the major indigenous ethnic groups. The Opuo depend on sedentary cultivation for their livelihood, while the Komo depend on shifting cultivation (NORPLAN, 2006). These people depend heavily on the natural resources for their livelihoods. They cultivate a variety of crops using simple tools and practice shifting cultivation.

Settlers*:* Gambella region is one of the main regions where resettlement programs of the previous government took place. Many highlanders have settled in Gambella, Gog, Jor, Abobo and Godere woredas. Late in 1993, after the demise of the Derg, there were 13,000 settlers in Abobo Woreda with an unknown number in Godere Woreda. In addition, there have been large numbers of refugees settling in Gambella due to the civil war and other conflicts in Sudan (NORPLAN, 2006) and later in South Sudan. A critical issue is the relationship between indigenous people and recent settlers/migrants.

## BENISHANGUL-GUMUZ REGION

A small part of the BAS basin is included in this region, more specifically in the Asosa zone.

The region is home to diverse ethnic groups, of which five are indigenous. The indigenous ethnic groups according to size are Berta (26.7%), Gumuz (23.4%), Shinasha (7.0%), Mao (0.6%) and Komo (0.2%. Significant numbers of Amhara (22.2%), Oromo (12.8%) and others (7.1%) also live in the region. There are also significant numbers of settlers in the region from various parts of the country as a result of resettlement programs carried out by previous governments.

“Gumuzland” is endowed with vital natural resources such as abundant land with fertile soils, extensive forest and vegetation with diverse plant species that also serve as a habitat for wildlife, and ample perennial water resources. The Gumuz base their livelihood on these natural resources, deriving their livelihood from agriculture (cultivation of crops and rearing livestock), hunting and gathering wild food. Shifting cultivation alongside gathering wild forest food, raising livestock (mainly goats and chickens), hunting, fishing, collecting honey, handicrafts, and local market exchange are major elements of the Gumuz subsistence economy.

Agriculture accounts for about 93.2% of the people’s livelihood. Individuals also engage in income-generating activities to supplement food gaps. These activities include artisanal mining, sale of firewood and charcoal, day labor, pottery and similar activities.

The Gumuz have a special relationship to their land and the environment. They possess knowledge about their natural resources and environment based on observation and experience. Indigenous knowledge is important to the Gumuz system of natural resource management which can be best understood along with their traditional belief systems. The Gumuz hold that vital natural/land resources are sacred and that natural resources are a gift, blessing and creation of *Yamba* (the supreme deity), which is the source of all life and livelihoods to the past, present and future generations. *Yamba* endows the Gumuz with knowledge of proper use, management and a responsibility of passing the natural resources to the next generation. Different resources have their own *Missa* (poly-spirits) that ensure their proper use and management; violations result in severe punishments and retribution from the respective Missa (Woldesilassie, 2007).

The Berta are mostly Muslim and many speak fluent Arabic. They are very conservative in their religion and culture. Most of them speak Bertigna/Rutanigna - the indigenous language as well as Arabic, Amharic and Oromifa. They have traditional customs that are similar to those of their Nilo-Saharan neighbours. Ritual specialists called *neri*, who have healing and divination powers, still exist and can communicate with evil spirits (*shuman*).

Rainmaking rituals are also found among the Berta, as among other Nilo-Saharan and Nilotic communities. In their wedding ceremonies music is played by males with large calabash trumpets (*was'a*). The Berta decorate their faces with scarifications, usually three vertical lines on each cheek, which they consider to be symbols of God (each line is interpreted as the initial letter of Allah, the Arabic *alif*). The Berta are slash-and-burn agriculturalists. Their staple food is sorghum, with which they make porridge in ceramic vessels. Working parties play an important role in Berta society. When somebody needs to build a house or cultivate a field, he calls his neighbours for help and provides then with beer and food.

## Southern Nations, Nationalities and Peoples' Region (SNNPR)

There are some 56 ethnic groups living in SNNPR. These ethnic groups reside in their own administrative/geographical area (zones), special woredas or woredas having unique language, culture and other social values. More than 80 indigenous and non-indigenous languages are spoken in the SNNPR. Among them about 50 indigenous languages are spoken by different ethnic groups.

The ethnic composition of the population includes seven major languages (Sidamigna, Wolaytigna, Hadiyigna, Siltigna, Goffigna, Guragigna, and Kaffigna) which are widely spoken by 60.7% of the region's population. Sidamigna and Wolaytigna are the two major languages spoken by 17.3% and 11.1% of the total population, respectively. In urban areas, Amharic is spoken by 39.8% of the total urban population and followed by Wolaytigna and Hadiygna language spoken by 11.8 and 5.2% of the urban population, respectively (Aweke, 2011).

In SNNPR, Benchi Maji, Keffa and Shecka zones fall in the Ethiopian part of the basin. The seven largest ethnic groups in the Bench Maji Zone were the Bench (45.11%), the Me'en (21.36%), the Amhara (8.23%), the Kafficho (6.55%), the Dizi (5.17%), the  (4.21%), and the  (3.88%); all other ethnic groups made up 5.49% of the population. In Keffa Zone the four largest ethnic groups are the Kafficho (82.72%), the Bench (5.05%), the Amhara (3.67%), and the Oromo (3.5%). Other ethnic groups make up 5.09% of the population. The seven largest ethnic groups reported in Sheka zone were the Shakacho (32.41%), the Amhara (22.17%), the Kafficho (20.16%), the Oromo (7.39%), the Bench (5.23%), the Sheko (4.24%), and the Mejeng (1.73%); all other ethnic groups made up 6.67% of the population (CSA, 2007 Census).

The institution of *Sera* is operative among many ethnic groups on SNNPR. The *sera* institution has been operative in one form or another among, Gamo, Gofa and among Oromos in some localities. The institution of *Sera* has been operative among many ethnic groups, particularly in the SNNPR region (e.g. among Sidama, Gurage, Walaita, Kambata, Gamo, Gofa, and Hallaba) and as well as among Oromos in some localities. Traditionally, it is an ethical and moral code. It provides social security to members and provides a means of decision making through consensus. It obliges the individual to accommodate the majority, to seek harmony and consensus rather than an individual opinion and personalized justice.

*Sera* mainly relates to domestic communal life and traditionally is a means of consensus and consent over individualism. It also requires social collaboration and cooperation from its members, for example, when a house is built or a funeral is held. It regulates the contributions and obligations within the community

### 4.7.3 Main Ethnic Groups in South Sudan

The main ethnic groups in the part of the basin in South Sudan are the Dinka, Nuer, Bari, Shilluk, Lotuho, Toposa, and Murle.

The Dinka people in South Sudan are organized into several independent but interrelated patrilineal clans. They form the largest ethnic group in South Sudan, accounting for 35.8% of the population. They are predominately pastoral people, but also practice shifting cultivation, growing millet, maize and occasionally cotton.

The Nuer people live in both Ethiopia and South Sudan, and are pastoralists or, more accurately, agro-pastoralists. Nuers are predominantly cattle-breeders, but they also cultivate flood recession maize and sorghum to supplement their normal diet of milk and blood. Cattle are jointly owned by extended families.

The organization, culture, livelihoods and practices of the Nuer have been described above. In South Sudan, the Nuer live in the states of Upper Nile, Jonglei and Unity. They are the part of the Nilotic group and are the second largest group in South Sudan, making up 15.6% of the population.

The Bari people occupy the savanna lands of the White Nile Valley. The Bari number about 542,000 and are South Sudan's 4th largest ethnic group. They embrace a cattle culture; the components of a typical traditional Bari dowry are made up of live animals.

The Shilluk peoplebmainly live in Upper Nile State in South Sudan. The Shilluk are sedentary and practice rainfed cultivation of sorghum, maize, groundnuts, beans and tobacco near their villages. Shilluk people possess fewer cattle and depend less on cattle products. Thus, they are not obliged to migrate with the seasons. Fishing is an important component of their economy.

The Lotuho are primarily a pastoral people in South Sudan and are located in Eastern Equatoria State. Their religion is based on nature and ancestor worship. They cultivate gardens, and the group decides the boundaries of each person's garden. Certain areas are fallow (for up to 10 years in the mountains) and other areas open to cultivation (for up to 4 years in the plains), with fallow areas being used for grazing livestock. In recent times, the Lotuho and their neighbors, the Lopit, have been in conflict with the Murle people, who have traditionally raided their cattle and abducted their children.

The Toposa people primarily live in Eastern Equatoria. Traditionally they lived by herding cattle, sheep and goats, low-level warfare (mainly cattle raids against neighbors), and have always engaged in cattle raiding. They are mainly pastoralists, keeping cattle, camels, goats and sheep, but also cultivate some maize and sorghum.

The Murle people live primarily in the State of Jonglei in South Sudan as well as in neighboring regions of Ethiopia and practice a mix of traditional religion and Christianity. The Murle (like the Dinka and Nuer) have a tradition in which men can only marry when they pay a dowry of several dozen cows. Because of poverty in the area, the easiest way to obtain a bride is to steal cows from other tribes.

### 4.7.4 Implications of Ethnic Diversity for the Future development of the basin

The high degree of ethnic diversity found in the basin has a number of important implications for development objectives and potentials in the basin, among which are:

- Ethnic diversity coupled with population growth, depletion of natural resources and unequal political power and patronage creates the conditions for increasing tensions and conflicts in the basin.
- In Ethiopia, some areas in the basin such as Gambella and Behishangul Gumuz have recently been prioritized for development by the government, resulting in the influx of outsiders as investors and settlers which has increased tensions and conflicts with the existing ethnic groups in the area. In Oromia, the largest population in the basin, some of the federal government's development policies have been effectively opposed by local ethnically-based organizations.
- As long as ethnicity remains the primary, and in some cases, the sole identity for the largest number of people the basin, national governments will not be able to forge a common identity, sense of purpose and support for development priorities and programs, which are often seen as zero-sum games with few winners and many losers.
- Any relevant, effective and sustainable development effort should not be imposed from outside and should be planned in close consultation with local ethnic groups, respect their identities and livelihoods and obtain the consent of their representatives.

### 4.7.5 Ethnic-related Indicators

The following indicators are proposed to assess the role of ethnic factors in the future development of the basin.

*Table 4-16: Ethnic-related Indicators*

| Indicator | Measure |
|---|---|
| Interethnic incidents/cattle raids | Number and frequency |
| | Damage caused |
| Protests/clashes with governments | Number and frequency |
| Participatory planning | Consultations held |
| Political representation | Ethnicity of representatives by level of government |
| Patronage | Ethnicity of leadership positions in government |
| Economic empowerment | Ethnicity of recipients of contracts, licenses and land allocations |
| Balanced development | Programs and projects benefitting ethnic minorities |

## 4.8 CONFLICTS

Conflicts in the basin occur as interrelated and mutually reinforcing layers consisting of three main types of conflicts.

- Resource-based conflicts in South Sudan can be a consequence of oil exploration and extraction activities as oil have potential impacts on water quality. Another potential impact related to these activities results from the management, allocation and control over land and water resources.

  Resource allocation conflicts between national and state/regional governments and indigenous people over land allocation policies and practices. This includes allocation, leasing or sales of land to local and foreign investors, resettlement, and evictions. Governments in the basin are seen as misallocating land (and water) resources, appropriating land to which local farmers claim property or use rights, and where land lease contracts not transparent. Unclear land tenure and the lack of effective conflict resolution mechanisms make the situation high in the potential for conflicts.

- Historical pastoralist conflicts: cattle raids, communal clashes, revenge attacks and selective violence in the Jonglei and Upper Nile areas in South Sudan and in the Akobo area bordering Gambella in Ethiopia. The frequency and intensity of these conflicts has increased since independence, and there is no clear prospect for resolution in sight into a supporting and suggesting solution statements.

- Political conflicts in the basin take two forms. In the area of the basin in South Sudan, there are political rivalries between the President and former Vice President accompanied by armed conflicts, occurring in Jonglei and Upper Nile states. In the area of the basin in Ethiopia, the fault lines are between the national Government and Oromo people in Oromia region and the Anurak people in Gambella.

While the first two types of conflict are relatively stable, political conflicts are more sporadic and unpredictable in terms of frequency, intensity, damage and location where incidents occur.

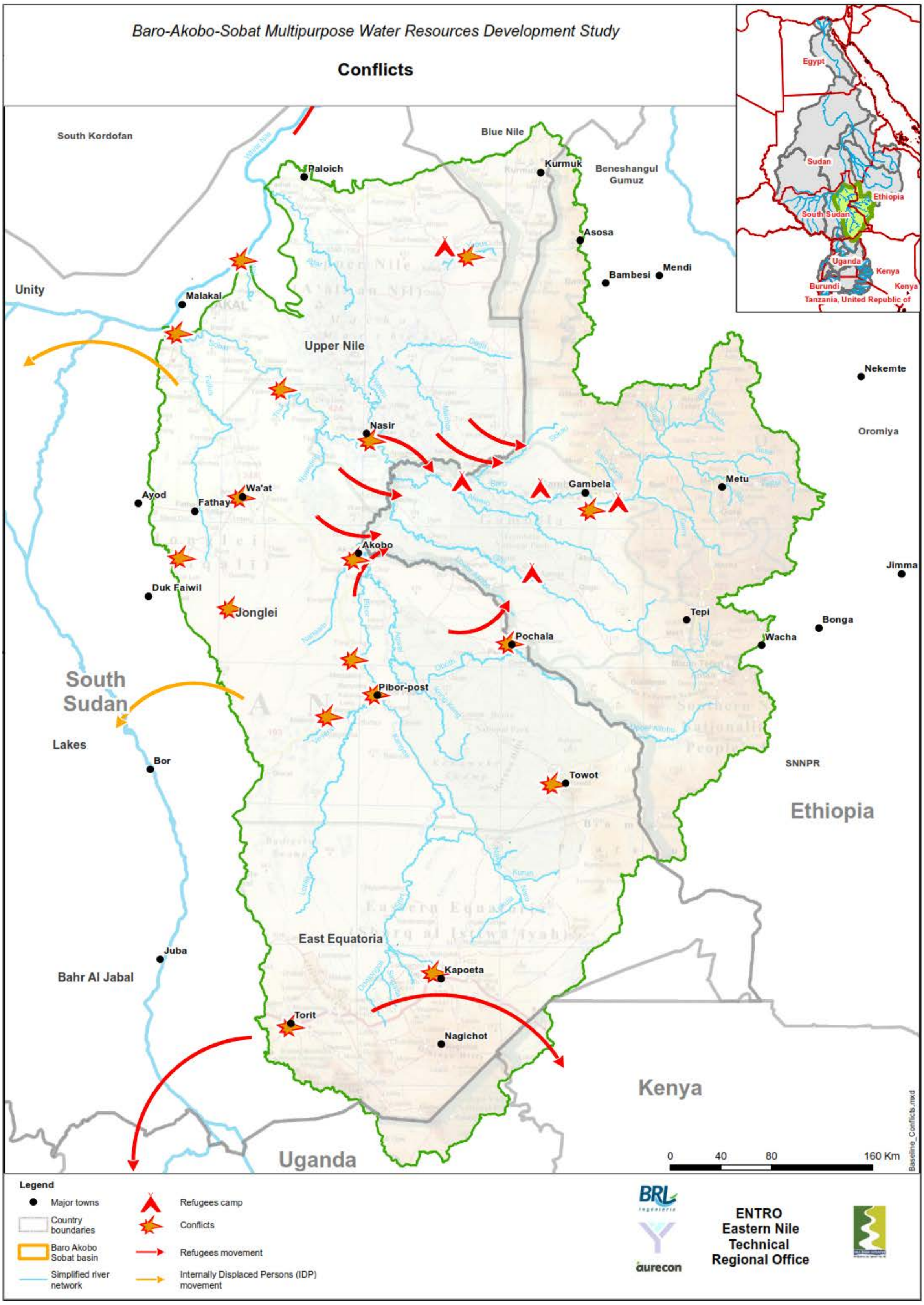
There are two areas in the basin that are especially vulnerable to the above conflicts; i.e. Jonglei and Gambella.

In the case of Gambella, the causes of present conflicts have accumulated due to a series of events occurring over several decades. Active conflicts are the result of a series of migrations and encroachments, including cross-border incursions, mainly for the purpose of cattle raiding. These conflicts are exacerbated by the Government's policy of allocating large tracts of land to outside investors for agricultural development and relocation of the local population.

Another source of tension in Gambella is between the local inhabitants and refugees from South Sudan who also compete for space, firewood, water and other resources. Increasing dependency on food aid with the arrival of the South Sudan refugees, accompanied by a host of international aid agencies provide humanitarian assistance. This also includes food aid, which contributes to the disruption of agricultural production and markets.

The breakdown of customary means of conflict resolution means that governance structures on managing and allocating land and water resources need to be strengthened and applied equitably if a fair distribution of resources and benefits is to be achieved. Legal and institutional frameworks to address issues such as land tenure, water rights and conflict resolution need to be developed and implemented in a consultative and transparent manner at all levels.

*Figure 4-7: Location of main conflicts and related refugees and IDP movements in the BAS*



## 4.9 HUMANITARIAN ASSISTANCE

Various forms of humanitarian assistance are a major feature of the basin and have been so for many years, dating back to the decades-long conflict between South Sudan and Sudan. This assistance is provided by such agencies and UNHCR, WFP, FAO, OCHA, UNICEF and many others. This assistance is wide-ranging, consisting of food aid, shelter in reception centers along the borders of South Sudan and in refugee camps in Gambella and Benishangul-Gumuz regions in Ethiopia, medical care, mother and child health and nutrition programs, water supply and sanitation, basic supplies and perhaps most importantly, protection and security.

At the end of February 2016, there were 268,352 registered refugees in South Sudan, of which 131, 871 were in Upper Nile State[7]. In the beginning of February 2016 there were 270,942 refugees from South Sudan in Gambella, of which 237,946 were in six camps and 33,026 were living with host communities (UNHCR, 2016). Some 180,000 of these refugees were under 18 years old. It is estimated that some 25,000 refugees from South Sudan are living in Benishangul-Gumuz Region in Ethiopia.

The number of displaced people and refugees and the volume of humanitarian assistance in the basin vary widely from month to month. The UN agencies publish publically available statistics both monthly and quarterly.

## 4.10 LIVELIHOODS

Security, resilience and adaptability of livelihoods are important aspects of vulnerability. There is a highly diverse and complex mix of livelihood systems in the basin as can be seen in the following table and map.

*Figure 4-8: Main Agricultural and Livelihood Systems in the Basin*

| MAIN CATEGORY | SCALE OF OPERATIONS | TENURE TYPE | MAIN COMPONENTS | LOCATION |
|---|---|---|---|---|
| RAINFED CROPPING | Small-scale Traditional; Sedentary | State land: Individual and communal use rights | Cropping (cereals, pulses, oil seeds) Cropping (Enset, roots, cereals, pulses) Small livestock holdings (communal grazing) | Ethiopia highlands |
| | Small-scale traditional; shifting | State land: Individual and communal use rights | Cropping (cereals, pulses) No livestock holdings (Tsetse infestation) | Ethiopia and South Sudan (Anuak, Shilluk) |
| | Small-scale traditional: Flood retreat | State land: Individual and communal use rights | Cropping (cereals, pulses) Small livestock holdings (Communal grazing) | Ethiopia and South Sudan: Lowlands |
| | Large-scale: mechanized | State land; medium term leases; private sector | Cropping (sorghum, cotton, sesame) | Ethiopia (Gambela) South Sudan Lowlands |
| IRRIGATED CROPPING | Small schemes in valley bottoms: Small scale operations (< 1.0ha) Gravity controlled water tables | State land: individual use rights: additional to rain-fed land | Cropping (cereals, vegetables) | Ethiopian Lowlands |
| | Small-scale: (<20 ha) Pump | Individual freehold state land: lease | Cropping: Sorghum, wheat, alfalfa | White Nile |
| | Large scheme: small-scale operations (<40 ha feddans) Gravity | State land: Individual long-term leases | Cropping: Cotton, sorghum, wheat,, small livestock holdings | Sudan: Gezira and Rahad schemes |
| | Large scheme: Large scale operations | State land: long-term leases | Cropping: Sugar | Sudan: Kenana schemes |
| LIVESTOCK | Small-scale: Extensive pastoral transhumant | Communal use (grazing, water) rights | Cattle, small ruminants | South Sudan (Toposa) |
| | Small-scale Extensive Agro-pastoral transhumant sedentary | State land: communal use (grazing, water) rights | Cattle, small ruminants, small scale cropping | South Sudan (Nuer, Shilluk, Murle) |

Source: One System Inventory, ENTRO, 2009

[7] Source, UNHCR, March 2016

The type and location of the main livelihood zones in the basin are shown in the following map.

*Figure 4-9: Livelihood zones in the basin*

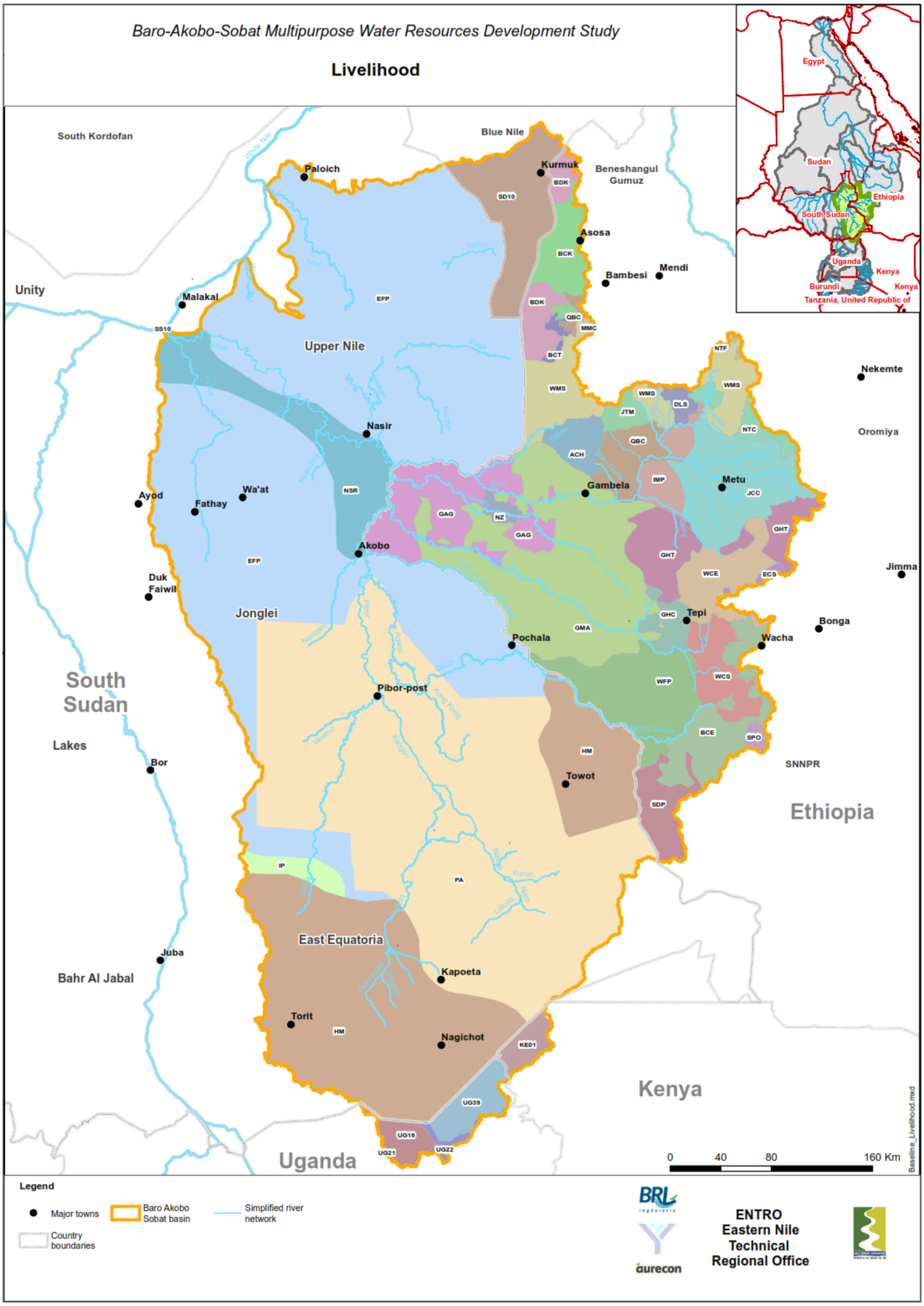


*Figure 4-10: Legend for livelihood zones*

**Kenya Livelihood Zones**

KE01 : Northwestern Pastoral Zone

**Sudan Livelihood Zones**

SD10 : Southeast Rainfed Semi-Mechanized Agriculture

**South Sudan Livelihood Zones**

EFP : Eastern Flood Plains

HM : Hills & Mountains

IP : Ironstone Plateau

NSR : Nile-Sobat Rivers

PA : Pastoral

**Uganda Livelihood Zones**

UG16 : North Kitgum Gulu Amuru West Nile Simsim Sorghum Livestock Zone

UG21 : South Kitgum Pader Abim Simsim Groundnuts Sorghum Cattle Zone

UG22 : NE sorghum Simsim Maize Livestock Zone

UG39 : National Park

**Ethiopia Livelihood Zones**

ACH : Anfilo Coffee Monoculture & Honey

BCE : Bench-Keffa Cereal & Enset

BCK : Central Kolla Sorghum, Maize & Millet

BCT : Midland Teff & Coffee

BDK : Western Dry Kolla Sorghum, Maize & Mining

DLS : Dale-Lalo Sorghum & Maize

ECS : Western Coffee & Spices - Eastern Sub-Zone

GAG : Gambella Agropastoral

GHC : Gambella Coffee, Honey & Cereal

GHT : Gera-Setema-Sale Forest Teff, Honey & Cattle

GMA : Gambella Mixed Agriculture

IMP : Illu-Wellega-Birbir Maize, Peppers & Sesame

JCC : Jimma-Illubabur Coffee, Cereals & Chat

JTM : Jimma-Yama Logi Teff & Maize

MMC : Mendi-Dabisu Maize, Sesame & Cattle

NTC : Nole-Meko-Diga Teff & Cattle

NTF : Nejo-Dilla Teff, Finger Millet & Nug

NZ : No Data

QBC : Keto-Begi Cereals & Cattle

SDP : Surma Agro-Pastoral

SPO : Salamago Pastoral

WCE Sheka Cereal and Enset

WCS : Western Coffee & Spices - Western Sub-Zone

WFP : Western Forest Products

WMS : Wellega Coffee, Maize & Sorghum

The large number and variation in livelihood characteristics are defining features of the basin, and present a complex and demanding challenge to development planners. Standard, top-down approaches to development planning are very likely to create more losers than winners. Therefore, a culturally sensitive and consultative approach is a necessary condition for a relevant, efficient and sustainable plan for managing water resources the basin.

Characteristics of the major livelihood zones in the basin are described in greater detail in Annex 3.

## 4.11 POVERTY

Poverty in the basin is both pervasive and deep, but is also differentially distributed across the basin. It is assumed that any future development and investment plan for the basin will have addressing and alleviating poverty as a central objective. The differential distribution of poverty in the basin states in South Sudan and basin regions in Ethiopia are shown in the table below.

*Table 4-17: Poverty Headcount Ratios8 in Basin Regions and States*

| South Sudan[1] | | Ethiopia[2] | |
|---|---|---|---|
| Location | Headcount (%) | Location | Headcount (%) |
| Upper Nile | 26.0 | Oromia | 28.7 |
| Jonglei | 48.0 | Gambella | 32.0 |
| Eastern Equatoria | 50.0 | SNNP | 29.6 |
| South Sudan | 50.6 | B. Gumuz | 28.9 |
| | | Ethiopia | 25.7 |

*Source, [1]World Bank, 2009; [2]World Bank, 2011*

It can be seen from the above data that poverty is unevenly distributed in the basin states and regions, with the basin regions in Ethiopia having generally lower poverty headcounts than the basin states in South Sudan and that the basin regions have a somewhat higher headcount than the national average. Gambella Region exhibits has a somewhat higher poverty headcount than the other basin regions.

In South Sudan, Upper Nile State has the lowest poverty headcount and one which is also significantly lower than the other two basin states, Jonglei and Eastern Equatoria, which are the poorest in the basin. Eastern Equatoria has a large arid pastoral area, which may account for its high poverty headcount. Upper Nile State has oil resources, which may account for its relatively low poverty level.

The above information suggests that the root causes of poverty in Jonglei and Eastern Equatoria states need to be further understood and addressed in future development programs and projects in the basin.

8 The proportion of a population below the 'poverty line'. The international poverty line is US$1.90 a day. Purchasing power and the value of goods consumed are considered in calculating the line.

## 4.12 AGRICULTURAL MARKETS

### 4.12.1 Introduction

This section focuses on the status of markets for agricultural produce in the basin, which are most critical for addressing the development objective of increasing food security in the basin.

### 4.12.2 Market structure and flows

The markets for agricultural produce in the basin are stratified into local, regional and international markets. The linkages between these levels and access are important to stimulate production, to connect urban demand with rural source of supply and to generate more cash income to farmers.

Market status and disruptions in the South Sudan part of the basin (Jonglei, Upper Nile and Eastern Equatoria states) are shown in the following map:

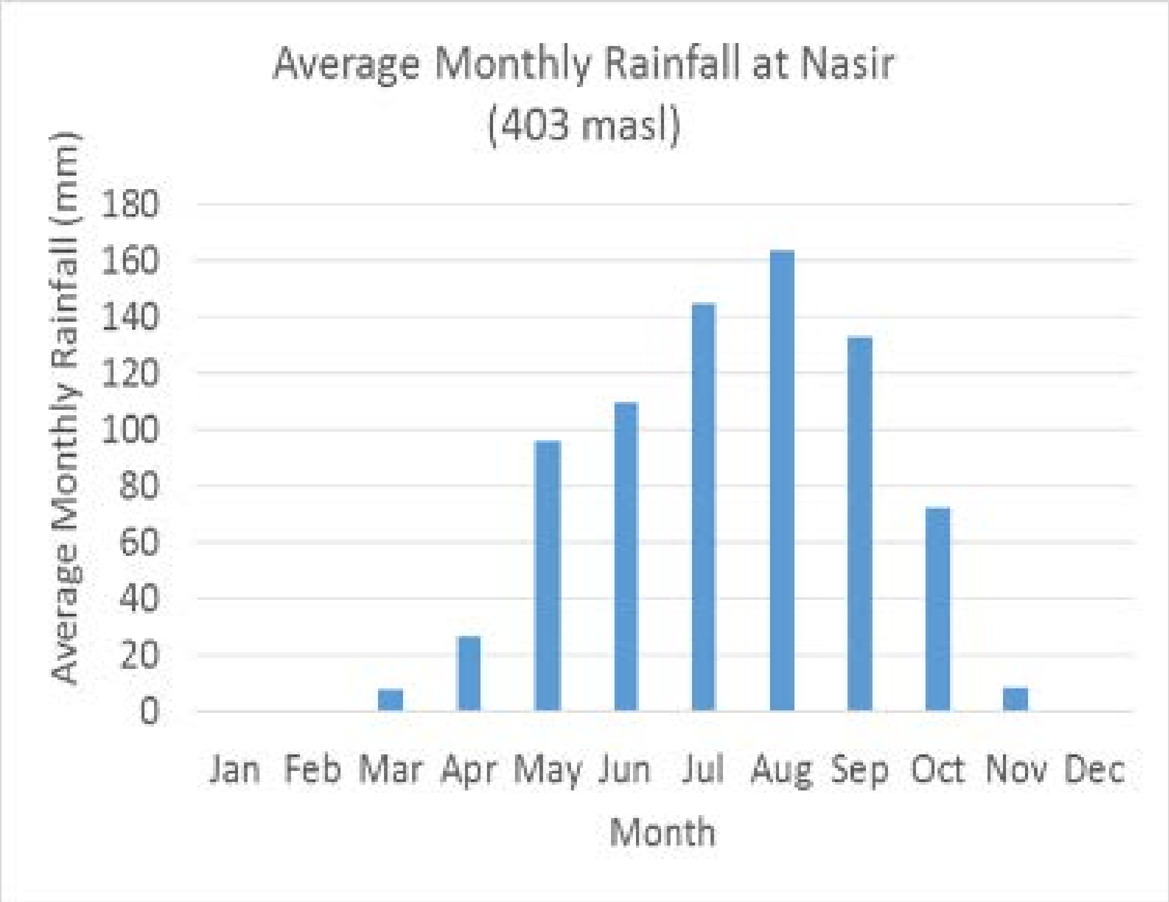



*Figure 4-11: Market functioning in South Sudan, March 2015*

# 4.13 AGRICULTURE AND FOOD SECURITY

## 4.13.1 Agriculture and food security in the South Sudan part of the sub-basin

### *4.13.1.1 Food Security, Agriculture and Investment Policies in South Sudan*

#### INTRODUCTION

Food security is one of the most important and frequently mentioned policy issues and goals of South Sudan's development efforts. It is the purpose of this section to describe the prevailing policy environment in the BAS sub-basin, with special reference to the official national food security and agricultural investment policies of the Republic of South Sudan (RoSS). Together, these policies form the enabling environment for present and future development of irrigation and in the BAS Sub-basin. It is worth noting that both countries experience periodic severe food deficits and depend on food imports and external and humanitarian assistance to bridge the food gap.

#### THE NATIONAL CONTEXT

The potential for agricultural growth in South Sudan is very high, with only about half of the some 82 million hectares of agricultural land being suitable for agricultural production currently exploited. The remaining half is composed of marginal arable land, forests and wetlands. Thus, the country has potential to produce surpluses of cereal and legume crops, and other valuable cash crops. The potential for irrigated agriculture is also substantial with the presence of the river Nile and the world's most extensive wetlands, the Sudd. This wetland, which includes several swamps and a number of river tributaries, provides a large irrigation capacity in six states (Eastern Equatoria, Central Equatoria, Lakes, Jonglei, Unity and Upper Nile).

However, cultivation is still mainly rain-fed. Irrigation would increase arable land and extend growing seasons, but irrigation facilities and technologies are limited and therefore the productive potential of water resources remains underutilized. Thus, despite having vast agricultural land, only 4.5 per cent of this land is cultivated.

A large proportion of the economically active population of South Sudan is engaged either directly or indirectly in smallholder subsistence agriculture or fisheries. According to the South Sudan National Census (2008), about 62%) of South Sudan are dependent on agricultural production for their livelihoods.

To attain sustainable food security, the country has to ensure that sufficient quantities of food are available through agricultural production and commercial imports. For most rural areas, low and/or variable agricultural production is still a key limiting factor in food and nutrition security. This has been characterized by varying but generally low cereal production due to several factors including limited inputs; unfavorable weather conditions (i.e. erratic rainfall and dry spells and floods); poor physical infrastructure for connectivity to markets; low agricultural extension services; lack of skills and knowledge development; low priority given to agriculture production; and ethnic conflicts, which have in most cases disrupted the farming activities.

Production of South Sudan's main staple crops, sorghum, maize and cassava, is mainly a subsistence activity. The area cultivated is limited in size, and crop production is predominantly done by traditional hand tools (malodas and hoes). Rain fed mechanized cereal production is practiced on a large scale in the Upper Nile counties of Renk, Manyo, Melut, Baliet, Fashoda and Malakal. National average area for cereal production is estimated at 0.9 ha per household, and sorghum constitutes 70% of the area planted.

Sorghum is the staple food crop for all the states in South Sudan except the greater Equatoria states. Maize is also estimated to be grown in 27% of the total area cultivated and popularly grown in the Greenbelt of the Equatoria states, along the Nile-Sobat River and in eastern Jonglei State bordering Ethiopia. Millet (Bulrush and Finger) and rice complete the remaining 3 per cent of the cereal areas cultivated. Other food crops produced in the country also include sweet potato, yams, sesame, groundnut, okra, cowpeas, green-gram, pumpkin, bambara nut and a wide variety of vegetables.

Coffee, tea, pineapples, sugar cane, tobacco and bananas can be grown in the country with great potential. In most cases, subsistence farmers tend to sell their surplus produce immediately after the harvest in order to settle accumulated debts, school fees and purchase other basic foodstuffs However, in South Sudan, this is hindered by poor road connectivity to markets and a lack of effective marketing information and linkages.

Agricultural produce from South Sudan is currently not regionally or globally competitive. The direct cost of production is around US$ 525 per acre, compared to an average US$ 325 per acre in developed agricultural economies (based on the same level of crop inputs). The capital cost of development on-site amounts to US$ 375 to US$ 400 per acre, compared to an average of US$ 225 to US$ 250 per acre in a developed agricultural economy. Transport costs, too, are among the most expensive in the world. Shipping a single 40ft container of agricultural equipment costs over $22,000 to clear and transport from the port of Mombasa to sites in South Sudan.

Low current output, alongside substantial production and transport costs, compounded by the impact of unscrupulous middlemen, are reflected in the exceptional prices South Sudan pay at market. A kilogram of maize costs US$ 10/kg, and a three-liter bottle of cooking oil US$ 16. In view of these dynamics, the urgent demand for affordable food in South Sudan and a desire by government to curb imports.[9]

### FOOD SECURITY AT SECTOR MINISTRIES

Food security figures prominently in the vision of GoSS and relevant ministries. MAFCRD's stated vision is; *Food security for all the people of the Republic of South Sudan, enjoying improved quality of life and environment,* while the vision of the Ministry of Animal Resources and Fisheries (MARF) is; *Productive livestock and fisheries sectors contributing 5% annually to improvement in food security, household income, job creation and the national Gross Domestic Product.*

### EXTERNAL ASSISTANCE

Food security is also a central theme in development and humanitarian assistance to South Sudan. GoSS receives external assistance to enhance food security from a number of development partners and humanitarian aid organizations such as the World Food Program, UNHCR, UNICEF and others. As part of their commitment to promote food security, FAO, USAID, the Netherlands, International Fertilizer Development Centre (IFDC) and Alliance for a Green Revolution for Africa (AGRA), among others, have agreed to provide assistance to South Sudan in the form of food aid and agricultural inputs**.**

The majority of food aid is received by the three conflict states, Upper Nile, Jonglei and Unity. Within these states, food aid importance is variable: it is the major provider of sorghum for 10-25 percent of households in Upper Nile State and 50-60 percent in Jonglei State. This situation is accompanied by a reduction in importance of markets as a source of sorghum – in Upper Nile State, the proportion of households sourcing sorghum from markets fell from 80-90 percent pre-conflict to 40-45 percent post-conflict.

[9] The above information is from; Development of Agriculture in South Sudan, African Development Bank, 2013

#### 4.13.1.2 Food Insecurity in the BAS Sub-basin

The distribution of food production and deficits varies widely across states in South Sudan. States in the Greater Equatoria region and Western Bahr el Ghazal have recently had production surpluses, while the rest of the states have deficits. The Greater Upper Nile States had the largest crop production deficits (-308,976 MT), mainly due to recent conflicts. The worsening and significantly higher deficits in the conflict-affected states of Upper Nile and Jonglei reflect the adverse impact of conflicts on agriculture production. Conflicts have displaced a large proportion of the population, resulting in missed field preparation and planting.

Because of food shortages, many households consume grains initially meant for planting, leading to still more missed field preparation and planting.

*Table 4-18: South Sudan - Estimated settled population, farming households and harvested cereal area in 2015*

| Location | Population mid-2015 | Households mid-2015 | Farming households | Farming households | Average cereal area | Total cereal area (ha) |
|---|---|---|---|---|---|---|
| Eastern Equatoria | 1 094 791 | 187 306 | 76 | 142 859 | 0.97 | 139 179 |
| Jonglei | 1545664 | 218240 | 29 | 64037 | 0.73 | 46499 |
| Upper Nile | 1 127 551 | 166 089 | 41 | 68 100 | 0.66 | 44 667 |

*Table 4-19: South Sudan - Estimated cereal harvested area, yield, production, consumption and balance (traditional sector) in 2015*

| Location | Cereal area 2015 (ha) | 2015 gross yield (ton/ha) | 2015 gross cereal production (tons) | 2015 net cereal production (tons) | Population mid-2016 | 2016 cereal req't (tons) | 2016 surplus/ deficit (tons) |
|---|---|---|---|---|---|---|---|
| Eastern Equatoria | 139 179 | 1.06 | 146 975 | 117 580 | 1 127 634 | 139 882 | 22 302 |
| Jonglei | 46 499 | 0.83 | 38 632 | 30 906 | 1 592 034 | 178 032 | 147 126 |
| Upper Nile | 44 667 | 0.75 | 33 563 | 26 850 | 1 161 378 | 101 161 | 74 311 |

Estimated food aid requirements in 2016 for the states in the BAS sib-basin are shown in the following table:

*Table 4-20: Estimated Food Aid Requirements in 2016*

| Location | Targeted Recipients* | Total (Tons) |
|---|---|---|
| Jonglei | 774,937 | 84,753 |
| Upper Nile | 554,428 | 71,016 |
| Eastern Equatoria | 108,249 | 5,974 |
| **TOTAL** | **1,437,614** | **161,743** |

**Includes children*

*Source: Special Report, FAO/WFP Crop and Food Security Assessment Mission to South Sudan, April 2016*

## POLICY RESPONSES

The Water Policy

The Water Policy was issued in November 2007 during the interim period of Comprehensive Peace Agreement (CPA). The Water Policy's overall goal is "to support social development and economic irrigation development in South Sudan growth by promoting efficient, equitable and sustainable development and use of available water resources, and effective delivery of water and sanitation services in Southern Sudan". The purpose and scope of the Water Policy is stipulated as "to provide a framework for optimal allocation of available water resources in South Sudan on an equitable and sustainable basis. The Policy remarks that "it is important to note that policy should be dynamic and continuously evolving" and therefore, periodically re-assessed to meet the future changing needs.

For the irrigation sector, the Water Policy states, "irrigation will form an important component of future strategies for achieving food security and agriculture-based economic growth" and "agriculture is expected to be the single biggest user of water in South Sudan in the future, and as demand for irrigation water grows there is need to establish policies and strategies to promote efficient and responsible water use and mitigate potential conflicts between competing water users". The Water Policy also proposes cost recovery through fees and levies charged to water users for services such as delivery of irrigation water, operation of dams/reservoirs.

## AGRICULTURE SECTOR POLICIES AND STRATEGIES

The Agriculture Sector Policy Framework (2012-2017) with its vision of "*Food security for all the people of the Republic of South Sudan, enjoying improved quality of life and environment*", addresses important issues, for example acceleration of food and agricultural production through commercial smallholder and large-scale agriculture, using mechanized and irrigation technology. The Framework sets policy guidelines, one of which states to promote sustainable irrigation infrastructure and flood management system to contribute to improved agricultural productivity and food security.

The Framework's implementation strategy is: 1) develop a National Irrigation and Drainage Policy and Strategy to ensure IWRM, 2) build institutional and human capacity in irrigation and drainage development, 3) support and promote private sector participation, 4) support and collaborate with GoSS in implementing the Water Policy and implementing water resource development activities, and 5) promote water harvesting technique in arid and semi-arid areas for increasing irrigated agriculture.

Discussions at the Workshop on Agriculture for Sustainable Food Security and Economic Growth in South Sudan held by RoSS in November 2012 provides points to be considered in irrigation development, which include the need for the building the capacity of smallholder farmers; the need to create a conducive environment for the private sector to invest in irrigated agriculture by securing land and water rights; and the need for both large-scale and small-scale agricultural development.

## FOOD SECURITY IN AGRICULTURE AND IRRIGATION MASTER PLANS

Achieving food security is a main pillar of the Comprehensive Agricultural Development Plan (CAMP), along with poverty reduction, economic growth and market development. Likewise, the overarching goal of the Irrigation Development Master Plan (IDMP) is "*to achieve sustainable irrigated agriculture and other productive uses, and to thereby improve food security and resilience; reduce poverty; and contribute to economic growth and development*". In the IDMP, a positive contribution to food security is one of the three selection criteria for investments in irrigated agriculture

Large-scale Investment in Agriculture

Large-scale farming requires access to land with unambiguous rights to profitably develop the land. Under the 2009 Land Act foreigners are not permitted to own land, but can lease land for a maximum of 99 years. Community lands may be allocated for investment purposes, but the investment must reflect an important interest for the community and contribute to the economic and social development of the local community. Land acquisition of 250 *fedans* or more (104 hectares) must be approved by state authorities.

There are several developments intended to promote investment in the agriculture sector. The most important development is GoSS's stated commitment to resolve land tenure issues. Part of the legal framework on land use and land governance, i.e. Land Act 2009, Local Government Act 2009 and Land Policy 2013, has been completed, and there is a defined land tenure system to govern and manage land without jeopardising local customary practices and use rights.

In 2013 South Sudan's cabinet adopted the Land Policy which attempts to address issues pertaining to land acquisition, use and management. The policy addresses post-war conflicts over land rights, informal settlements in cities and towns, as well as conflicts over access to land with pasture and water.

Another important development is the enactment of the Investment Promotion Act 2009[10], which shows that GoSS is interested in creating an investment friendly environment for both the public and private sectors. An investment certificate can be obtained in accordance with the Act. The Act elaborates the investment terms and conditions for the agriculture and forestry sectors. The conditions are; (i) increase in foreign exchange, either through import substitution or export, and (ii) production and utilization of domestic raw materials and adoption of value addition in the processing of local resources.

The text of the Investment Act states the following about the terms and conditions for obtaining and investment certificate:

1. Investment Certificate

   (1) The holder of an investment certificate shall be entitled to incentives and benefits under the Investment Promotion Act.

   (2) An applicant shall be entitled to an investment certificate if

      (a) the applicant satisfies the conditions of grant of a certificate of investment as shall be prescribed in the regulations; and

      (b) the investment and the activity related to the investment are lawful and beneficial to the people of South Sudan.

   (3) In determining whether an investment and the activity related to the investment are beneficial to South Sudan, the Authority shall consider the extent to which the investment or activity will contribute to the conditions specified below.

      (a) creation of employment for South Sudan;

      (b) acquisitions of new skills and or technology for South Sudan;

      (c) contribution to tax revenues or other Government revenues;

      (d) transfer of technology to South Sudan;

      (e) increase in foreign exchange, whether through exports or imports substitution;

      (f) production and utilization of domestic raw materials, supplies and services;

      (g) adoption of value addition in the processing of local, environmental, natural and agricultural resources using forward and backward linkages strategy;

      (h) development of information technology for utilization, promotion, development and implementation, information and communication technology;

[10] Investment Promotion Act, GOSS, 2009

(i) contribution to the socio-economic and cultural amenities of the local communities e.g. health centers, schools, feeder roads, water supply, sports, cultural events; and
(j) any other factors that the Authority considers beneficial to South Sudan.

Priority Areas for Investment

Investment in the following areas shall be deemed a priority of the Government of South Sudan.

- Agriculture: food and cash crops, farm mechanization, seeds and agricultural tools industry, livestock and dairy development; fisheries and fish processing and preservations, and apiculture (beekeeping).
- Agro-business, textiles, leather industries and food processing such as flour milling, oil pressing mills, sugar processing, fruits and vegetable canning, meat and fish processing, animal feeds and fertilizers, abattoirs and hides (value addition).

In implementing priority areas identified in the Act, the following types of projects in priority areas will be taken into consideration:

- Direct investment in the least developed areas of South Sudan.
- Import substitution and export promotions (surplus production).
- Integrated rural development.
- Employment creation to citizens.
- Promotion of scientific and technological advancement.
- Joint venture/partnership enterprises where South Sudan citizens have at least 30% stake.
- Reinvestment of at least 20% of aftertax profits in South Sudan.

Environment-friendly Investment

- Notwithstanding any other provision or rule, and subject to the provisions of this directive, any company investing in South Sudan shall observe and implement environment friendly corporate rules and regulations for the following purposes
  - preservation of the top soil, surface and subterranean water, and river bank flora and fauna and ecosystem biodiversity;
  - redemption or repairing the land to the natural position after use or expiry of mining activities;
  - responsible solid waste management and disposal of trash, waste, toxic substances in landfills or recycling facilities, composing/decomposing sites;
  - responsible management of noise, clean air, clean water (ponds, rivers, streams and swamps/wetlands).
- Liability**:** Any investor who fails to design and implement environmentally friendly rules and regulations shall be guilty of an offense and liable of fines, payment of damages or remove or clean waste where applicable in accordance with the law.

In priority areas, the following types of projects in priority areas shall be taken into consideration.

- Direct investment in the least developed areas of South Sudan.
- Import substitution and export promotions (surplus production).
- Integrated rural development
- Employment creation for citizens of South Sudan
- Promotions of scientific and technological advancement

## LONG-TERM AGRICULTURE LEASEES – TWO CASE STUDIES[11]

Next, two cases of recent long-term agricultural leases to foreign investors in South Sudan will be presented, Concord Agriculture and Nile Trading and Development, Inc.

### Concord Agriculture

While the efforts of local and international advocacy groups raise awareness, it is necessary to distinguish between cases of land grabbing and cases of real change through responsible investment in sustainable agricultural businesses and related infrastructure.

Concord Agriculture is an agri-business operating in Unity State, South Sudan. The project is developing 250,000 acres of land to help improve food security and create socio-economic benefits to the surrounding communities. No ESIA or water resources assessment were carried out by Concord, nor were any required by GoSS.

The project, based in Unity State, is established on land obtained under a 25-year lease granted by the Government of South Sudan in 2009, ensuring land ownership is retained by the host country. Concord is obligated to fulfill specific requirements under the contract to ensure the investment is beneficial to the local community and to the host country. Concord plans to cultivate crops such as wheat, sorghum and maize, all of it for local consumption.

Concord is undertaking large-scale farming using its global experience to support improving food security while ensuring that smallholders and pastoralist migrants have access to land and resources as well as employment opportunities. Concord cites as additional benefits reduced dependence on aid and humanitarian assistance by introducing management and technical innovations through a partnership with responsible private capital.

Citadel Capital, Egypt’s largest private equity firm, has invested US$ 25 million in the project, which makes it one of the largest investors in South Sudan outside the oil industry. With the need to transfer knowledge to South Sudan staff and build critical infrastructure, Concord will only reach commercial viability in years, not months. This shows that generating long-term returns through long-term investing that leaves the communities in which we do business better than we found them. The goal of any business is to make a profit, but also to support South Sudan to address its development challenges.

In 2007 Citadel Capital launched the Wafra Fund to invest in agriculture in Sudan, in which the company's holdings have since increased to three distinct sites and companies. In South Sudan, Wafra acquired a 25-year lease on 105,000 ha through its subsidiary, Concord, previously known as the Sudanese Egyptian Agricultural Crops Company (SEAC). The land was community land which, according to the 2009 Land Act, is to be state-recognized, but the area was nonetheless treated as state-owned and the lease was negotiated directly with the state government; entirely without involvement of the local people. The annual US$125,000 in rent is paid directly to the state government.

The company is reinvesting a part of its profits in the community, by community consultation on local priorities to address and improve local livelihoods. Concord plans to only cultivate 120,000 acres of its 250,000 acre site, which will be developed to respect the rights of the Fallata pastoralists, enabling them to maintain their annual migration routes and preserve critical bio-diversity.

Concord's full-time workforce has a 25% local component, which is higher than other similar projects in South Sudan. Concord would prefer to hire local staff rather than foreign staff given the large difference in costs. This is a challenge due to the limited local talent pool with the required skills, an issue that is addressed by skills and knowledge transfer to build local capacity to work productively on the project.

[11] Information for the two case studies presented here has been obtained from the archives of the Oakland Institute and various online media sources.

Although Concord asserts that it will prioritize sale of its produce in local markets in the short to medium term, its clear priority is to make a profit from its operations. With no export restrictions in its investment agreement, Concord can export as much as they like, even in times of increased food insecurity in the country.

Land grabbing, is the acquisition of large tracts of land by domestic and foreign companies for commercial purposes is not confined to Equatori. Citadel Capital and Al Ain Wildlife's acquisition of lands in Western Upper Nile and Jonglei states should perhaps put this myth to rest. Like Mukaya Payam deal, these two deals were done at the back of the affected communities. For instance, the Murle community in Jonglei Boma national Park area and citizens of Pariang and Guit County were deliberately and systematically marginalize and excluded in the negotiations/

Nile Trading and Development, Inc.Brief on the land investment deal of Nile Trading & Development, Inc. - Emerging Protest

The largest land deal in South Sudan to date was negotiated between a Dallas, Texas-based firm, Nile Trading and Development Inc. (NTD) and Mukaya Payam Cooperative in March 2008. Brief on the land investment deal of Nile Trading & Development, Inc.contract The NTD's 49-year lease of 600,000 hectares - nearly 1.5 million acres, with a possibility of almost 1 million acres more - for USD 25,000, including unencumbered rights to exploit natural resources in the leased land, including water resources, and the:

- Right to develop, produce and exploit timber/forestry resources on the leased land, including, without limitation, the harvesting of current tree growth, the planting and harvesting of hardwood trees, and the development of wood-based industries;
- Right to trade and profit from any resulting carbon credits from timber on the leased land;
- Right to engage in agricultural activities, including the cultivation of biofuel crops (jatropha plant and palm oil trees);
- Right to explore, develop, mine, produce and/or exploit petroleum, natural gas, and other hydrocarbon resources for both local and export markets, as well as other minerals, and may also engage in power generation activities on the leased land;
- Right to sublease any portion or all of the leased land or to sublicense any right to undertake activities on the leased land to third parties.3

In addition, the Cooperative agrees to not oppose the undertaking of any such activities by NTD on the leased land and to cooperate with the company in any efforts to obtain more concessions from the government of South Sudan.

According to the terms of the Lease, the Cooperative leased to NTD 600,000 hectares (with the possibility of additional hectarage in the future) in order to:

- Develop, produce and exploit timber/forestry resources on the leased land, including, without limitation, the harvesting of current tree growth, the planting and harvesting of megafolia-paulownia, palm oil trees and other hardwood trees and the development of wood-based industries; and
- Engage in agricultural activities, including, without limitation, the cultivation of palm oil trees and biodiesel plants such as jatropha. To trade any carbon credits that result from the timber on the leased land and NTD's activities on the leased land – so that NTD could reinvest a significant portion of the profits in the Cooperative, Central Equatoria State, and elsewhere in SouthSudan.

The community of Mukaya Payam in Lainya County, Central Equatoria State (CES), became aware of the deal and mobilized a protest against it. The traditional and senior government leaders including county authorities launched a joint protest in July 2011, rejecting the lease to American investors. Watch Hon. Robert Isaiah Lomude Moses of the South Sudan Parliament speak on land grabs

In early August, a committee comprised of the Payam Parliamentarians in the CES Legislative Assembly, Payam Chiefs, and senior government officials at the state level traveled to Juba to voice their concerns to the state governor and the President of the Republic of South Sudan, H.E Salva Kiir.

The message said: "We the chiefs, elders, religious leaders, and the youth of Mukaya Payam unanimously with strong terms condemn, disavow, or deny the land lease agreement reached on 11 March 2008 between the two parties." Read the community's complete letter

The response of President Kiir to the community was: "*This issue has to be addressed according to your will. You are the government and you have powers*." The final outcome of this issue is not yet known[12].

## CONCLUSIONS

The preceding description of the context, policy and other instruments reveals that there are a number of unresolved unresolved issues regarding how to best address food security in South Sudan.

- Even though there is near universal agreement in policy pronouncements of the central importance of addressing food security as one of the highest development priorities in South Sudan, strategies and plans differ, and what happens on the ground is, as always, considerably more complex.
- Most policies, strategies and plans state that both small and large-scale irrigation should be developed in a balanced manner. However, in reality preference is often given to large- scale projects which promise quick results, higher productivity, employment  and incomes, while small-scale irrigation projects are neglected and deserve more attention in plans to develop agriculture and improve food security in the country.
- For large-scale agricultural projects to succeed, clear titles to large tracts of land over long periods of time, with accompanying water rights and access to domestic and export markets are necessary conditions.
- Long-term agricultural leases to external investors are often problematic due to lack of due diligence in planning, in assessing environmental and social impacts, understanding and respecting local cultures, water resource assessments which include downstream impacts, consultations with and consent from local communities, and compliance with the terms and conditions of their leases.

[12] Oakland Institute, Understanding Land Investment Deals in Africa, Nile Trading and Development, Inc., in South Sudan Land Deal Brief, June 2011

## 4.13.2 Agriculture and food security in the Ethiopian part of the sub-basin

### AGRICULTURAL SECTOR POLICY

Agricultural Development Led Industrialization (ADLI) has been a central pillar of economic policy since 1990s. After the completion of Plan for Accelerated and Sustained Development to End Poverty (PASDEP), the first Five Year Growth and Transformation Plan (GTP I) has been launched. Now the country has been launched the GTP II. In the agricultural sector, Ethiopia has a comprehensive and consistent set of policies and strategies, which reflects the importance of the sector in the Nation's development aspirations.

### AGRICULTURAL SECTOR POLICY AND INVESTMENT FRAMEWORK

Ethiopia's Agricultural Sector Policy and Investment Framework (PIF) is a sectoral national policy applicable for the period of 2010-2020. Its main objective is to sustainably increase rural incomes and national food security producing more, selling more, nurturing the environment, eliminating hunger and protecting the vulnerable against shocks. Four main themes, each with its own strategic objective, are identified within the above overall objective. These are:

- achieve a sustainable increase in agricultural productivity and production;
- accelerate agricultural commercialization and agro-industrial development;
- reduce degradation and improve productivity of natural resources; and
- achieve universal food security and protect vulnerable households from natural disasters (MoAR, 2010)

### AGRICULTURE AND RURAL DEVELOPMENT ISSUES

Increasing productivity in smallholder agriculture is Government's top priority, recognizing the importance of the smallholder sub-sector, the high prevalence of rural poverty and the large productivity gap. Productivity enhancement however, must be complemented by efforts to help farmers graduate from purely subsistence farming to semi-commercial status practicing farming as a business and to adopt more sustainable natural resource management practices in order to arrest and reverse environmental degradation.

The goal of the PIF is to "contribute to Ethiopia's achievement of middle income status by 2020". The development objective aim is to "sustainably increase rural incomes and national food security". This objective embodies the concepts of producing more, selling more, nurturing the environment, eliminating hunger and protecting the vulnerable against shocks; all of which are embodied in various national policy instruments, and are expressed in terms of four main themes, each with its own strategic objective as shown below:

*Table 4-21: strategic objectives of the Ethiopian Agricultural Sector Policy and Investment Framework for 2010-2020*

| Thematic Area | Strategic Objectives (SOs) |
|---|---|
| • Productivity and Production | • SO1: To achieve a sustainable increase in agricultural productivity and production. |
| • Rural Commercialisation | • SO2: To accelerate agricultural commercialisation and agro-industrial development. |
| • Natural Resource Management | • SO3: To reduce degradation and improve productivity of natural resources. |
| • Disaster Risk Management and Food Security | • SO4: To achieve universal food security and protect vulnerable households from natural disasters. |

***Source:*** *MoAR (2010): Ethiopian Agricultural Sector Policy and Investment Framework (PIF) for 2010-2020. Draft Final.*

### FOOD SECURITY STRATEGY IN ETHIOPIA

The food Security strategy of Ethiopia was issued in 1996. The strategy adopted three basic pillars. These are to

- Increase availability of food through increased domestic production.
- Ensure access to food for food deficit households
- Strengthen emergency response capabilities

Generally the focus of the strategy is on increase productivity and production thereby ensuring access to foods by all households. Also response capacity, which is nowadays conceptualized as resilience building has been also emphasized in the strategy. In order to meet the main objectives of the stagey, Ethiopia has adopted the food security program which is as described below.

### FOOD SECURITY PROGRAM

The overall objective of the Country's Food Security Program (FSP) is to achieve food security for chronic and transitory food insecure households in rural Ethiopia. To this end, the Program has four components: (i) the Productive Safety Net Program (PSNP), which provides transfers to meet household consumption and protect assets, and builds community assets through public works; (ii) the Household Asset Building Program (HABP) which provides credit and extension services; (iii) the Complementary Community Investment Program (CCIP) which undertakes community infrastructure investments in food insecure Woredas; and (iv) the water-centered Voluntary Resettlement Program (RP) which provides transfers, credit and infrastructure for re-settled households. The raising of households to the level of food security that these components aim to achieve is commonly described as graduation.

## 4.13.3 Response to floods and droughts

While some flooding is seasonal and even expected and welcomed by local farmers, in the event of extreme flooding or prolonged droughts, whose location, frequency, duration and extent can vary widely, residents employ a number of coping mechanisms including, but not limited to the following:

- Increased reliance on extended family, clan members and friends for food, shelter, money and other needs
- Reduction in the number, size and content of meals
- Increased consumption of wild foods, bush meat and forest products
- Sale of livestock and other assets to raise cash
- Reliance on food aid/humanitarian assistance
- Begging in the local community or nearby towns
- Relocation to a safer area/resettlement or permanent migration to towns as a last resort

# 4.14 ENERGY

## 4.14.1 Energy in the South Sudan part of the sub-basin

### INTRODUCTION

Current energy needs in South Sudan are predominantly met by biomass, consisting of the burning of charcoal, wood, grass, cow dung and agricultural residues. According to the National Baseline Household Survey in 2012, over 96% of the population use firewood or charcoal as the primary fuel for cooking (which typically constitutes 90% of the energy used in a rural household).

The energy needs in South Sudan are predominantly met by biomass, consisting of the burning of charcoal, wood, grass, cow dung, agriculture residues, etc. According to the National Baseline Household Survey, over 96% of the population use firewood or charcoal as the primary fuel for cooking (which typically constitutes 90% of the energy used in a rural household). An average household in South Sudan burns about 3 tons of woody biomass per year for cooking, emitting nearly 2 tons of carbon dioxide equivalent per year, as cooking is done mainly using three-stone open fires. Only about 1% of the population of the country has access to grid electricity. Most of these consumers are in Juba, with the remaining in Wau and Malakal.

Almost all households in rural areas and small towns cook with firewood or charcoal, the vast majority using charcoal. In urban low-income areas households spend 10-15% of their average monthly household income on charcoal. Firewood is the most used source for lighting used by 35% of population. Grass (15%) and kerosene lamps (13%) are the second and third most used source for lighting. Some 27% of the population has no source of lighting.

The fuel mainly used for cooking in rural areas in the sub-basin is firewood collected from forests and bushes, mainly by women and children, sometimes as far as 6 km away. Large tracts of unutilized bush land that is used as a source of firewood and charcoal are a common feature of the sub-basin. The following table shows the sources of energy for the sub-basin states in South Sudan.

*Table 4.4: Main Fuel Sources for sub-basin states in South Sudan*

| Source/Location | Upper Nile | Jonglei | Eastern Equatoria |
|---|---|---|---|
| Firewood | 63.2 | 92.0 | 94.1 |
| Charcoal | 21.5 | 3.5 | 5.7 |
| Grass | 13.9 | 4.4 | 0.0 |

*Source: National Baseline Household Survey, 2009*

The available electricity networks are three isolated distribution systems located in Juba, Wau and Malakal totaling about 15 km of 11 kV lines plus some electrified commercial centres and industries. In and near the sub-basin there is a 8.0 MW distribution system in Malakal and a 0.88 MW system in Kapoeta.

Installed capacity for the entire country is about 30 MW, of which about 22 MW is currently operational. The total number of customers connected to the network is about 22,000. Per capita electricity consumption in South Sudan is about 1-3 kWh, the lowest compared to neighboring countries. The average per capita electricity consumption in Sub–Saharan Africa is about 80 kWh. The current demand for electricity is estimated to be 300 MW, which is expected to rise to over 1,400 MW by 2030.

Since February 2013, the available generation capacity has been adversely affected by the lack of fuel and spare parts for the thermal power plants as a result of austerity measures following the oil shutdown shortly after independence and reduction of oil revenues from Sudan as well as lower prices for oil on international markets.

The Ministry of Electricity and Dams (MED) has drafted a national electricity policy that prioritizes the use of indigenous energy resources, mainly crude oil and hydropower, to supply power to new industries and households.

The power sector in South Sudan is highly subsidized The total number of customers connected to the electricity network is 22,000 which includes 1,500 customers of NRECA/USAID trained cooperatives in towns of Yei, Wau and Malakal. These who are connected to the grid have to pay a high cost for the service, the average tariff being US$ 0.22/kWh. This price is not cost reflective, as the production cost is around USD 0.70/kWh.. It is important to note that the big customers mainly the Government institutions, military barracks, airport, hospitals do not pay their electricity bills.

There is a solar PV for water pumping to supply water to 55,000 people in Akobo, Jonglei state, in northeastern South Sudan, near the Ethiopian border. The project was financed by the International Committee of the Red Cross (ICRC) to supply water to displaced people.

### RENEWABLE ENERGY

The BAS sub-basin has a potential for renewable energy to generate electricity, including small-scale and large scale hydropower, solar photovoltaic, and wind, biomass, geothermal and waste-to-energy. The share of renewable energy in the national generation mix is very low at present. However, a number of hydro projects are in pipeline including large scale, mini and micro hydro projects as the country is rich in hydropower resources.

Biomass energy remains the most used renewable energy in South Sudan and the situationis likely to remain so for the coming decades. Biomass fired power plant could be anoption for increasing generation capacity in the future.

### POWER SECTOR STRATEGY AND PLAN

The national electrification strategy prioritizes the use of indigenous resources, namely oil and hydropower to provide electric power for basic services and to meet the increasing development needs of the country.

The Strategic Plan 2013-2016 (GoSS, 2012) focuses on grid-based expansion to 48,000 customers (all 10 state capitals will be electrified) from 22,000 customers, investment in expansion of thermal generation capacity to 96 MW, as well as the expansion of distribution networks. The SSDP also includes plans to import 140 MW power from Sudan via a 220 kV interconnector line.

The Power Sector Development Action Plan for the coming ten years contains six key components:

i. To meet existing and projected demand for power, undertake a major program of expansion in generation capacity from the current 30 MW (22 MW available) to about 580 MW by 2025;
ii. Extend the national transmission and distribution grid to link all ten state capitals and link the South Sudan grid to those of Ethiopia, Kenya and Uganda;
iii. Expand access to electricity to provide 75% of urban households with access to electricity from the national grid by 2025, compared with only 1% at present;
iv. Complete a major restructuring of the SSEC to convert it into a financially sound state enterprise that has the capacity to enter into contracts with private suppliers of electric power;
v. Strengthen the enabling environment for private investment in power generation and attract private investors to operate as independent power producers (IPPs) within South Sudan;
vi. and Strengthen existing regulatory arrangements for the electricity sector.

It remains to be seen how and to what extent this strategy and plan will be implemented and the time frame for realizing its ambitious targets. In any case, its implementation will require a large injection of external assistance, and its impact in rural areas of the sub-basin in South Sudan are likely to take a long time to be realized. In the meantime, the vast majority of the rural population in the sub-basin will continue to rely on biomass for their fuel and energy needs.

## 4.14.2 Energy in the Ethiopian part of the sub-basin

### POWER GENERATION

Ethiopia has a considerable renewable energy endowment, with an abundant hydropower potential, solar and geothermal, as well fossil fuels. Hydropower constitutes almost 92.5% of the total energy mix and thermal energy comprise of 7%. Despite the huge potential to exploit renewable; historically only a very small portion has been developed owing to lack of financial resources amongst other factors.

Currently, Ethiopia has around 2,000 MW of installed power generating capacity, out of which 1,980 MW (99%) is generated from hydropower plants. The remaining 12 MW (0.6%) and 8 MW (0.4%) comes from thermal and geothermal sources respectively. With the coming five years the electricity generating capacity is expected to reach 10,000 MW from the current level of 2,000 MW thereby, the electricity coverage of the country will be 75%.

### ENERGY POLICY AND STRATEGY

The Energy Policy was published in February 2013 as a policy document previous to the Energy Proclamation. It recognizes that Energy is critical for economic development and its objectives are among others to:

- Develop and utilize the country's energy resources on the basis of Ethiopia's overall development strategy priority along with the introduction of energy conservation and efficiency strategy.
- Raise efficiency of the energy sector and develop the necessary institutional and manpower capabilities by introducing appropriate incentive measures, to undertake energy development programs.

The energy policy places high emphasis on hydropower resource development and encourages energy mix with renewable such as solar, wind and geothermal to be developed given their cost competitiveness. Currently, hydropower, diesel and geothermal systems account for 88%, 11% and 1%, respectively of total electricity generation in the country.

i. Energy Proclamation No. 810/2013

The Energy proclamation was enacted on 19th November 2013, and proclaimed on 27th January 2014. It replaces the Electricity Proclamation No. 86/1997. It main impact in the energy sector is that it contains the regulatory frameworks for “economic and technical regulation” of the energy sector and EE&C. It also created the Ethiopian Energy Authority (EEA) as a regulatory institution with the mandate to promote competitiveness in the energy sector; ensure efficient, reliable, fair, economical, and safe electricity supply; and promote and implement EE&C programs. The EEA should therefore as a matter of priority:

- develop a strategic plan to design and implement energy efficiency measures;
- develop the human and institutional capacities at the federal and regions levels;
- develop minimum energy efficiency standards, and a labeling and consumers information program;
- promote EE research, development & demonstration centers;
- build testing facilities for energy performance;
- enforce mandatory energy saving targets setting;

iii. Strategy for Energy Efficiency

The Energy Efficient Strategy (EES) is intended to serve as a roadmap for implementing the energy efficiency policy as established in the Ethiopian Energy Proclamation. Ethiopia from 2015 until 2045, the EES contains short (1-5 years), medium (5-10 years), and long (10-20 years) term actions designed to enhance the implementation of the policies and goals. The specific activities contained in the EES will foster policy reforms, energy conservation and energy efficiency and Education and Awareness. The EES contemplates an Institutional Organization and two specific strategies:

- Component 0: Institutional Organization
- Component I: Energy Conservation & Energy Efficiency
- Component II: Education and Awareness

With the implementation of these strategies Ethiopia expects to reduce in 2025, 10% of its overall energy intensity compared to 2015 values.

## ENERGY SOURCES FOR HOUSEHOLDS

In rural Ethiopia, 85% of the population use biomass energy sources and share of these sources about 99%. The biomass source comprises firewood (90.7%), animal dung crop residues and others (8.1%) and charcoal (0.2%). All these energy sources are used for cooking, baking, heating, lightening etc. As seen from the table below, the main sources of energy in the Ethiopian part of the BAS Sub-basin are firewood (56%), animal dung (16%), charcoal (8%). While 6% of the households used kerosene, only less than 1% of households use electricity and gas.

*Table 4-4: Household Sources of Energy by Region and Rural-urban Areas*

| Source of energy | Households by source of Energy in the Ethiopian Part of the BAS Sub-basin | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | BG | | Gambella | | Oromia | | SNNPR | | Total | |
| | Rural | Urban | Rural | Urban | Rural | Urban | Rural | Urban | Number | % |
| Electricity | 261 | 771 | 534 | 553 | 17,250 | 39,971 | 4,478 | 12,233 | 76,051 | 0.5 |
| Gas | 63 | 51 | 15 | 59 | 3,965 | 5,015 | 1,090 | 2,069 | 12,327 | 0.1 |
| Kerosene | 2,438 | 2,018 | 943 | 462 | 352,971 | 274,084 | 92,294 | 74,358 | 799,568 | 6.0 |
| Charcoal | 8,238 | 15,280 | 1,967 | 10,917 | 258,683 | 525,466 | 49,638 | 163,256 | 1,033,445 | 7.6 |
| Firewood | 126,711 | 22,789 | 36,922 | 14,013 | 4,050,002 | 661,508 | 2,359,888 | 272,271 | 7,544,104 | 55.7 |
| Dung | 8,724 | 2,084 | 5,260 | 575 | 1,446,270 | 197,077 | 458,404 | 21,165 | 2,139,559 | 15.8 |
| Bio-gas | 241 | 80 | 218 | 233 | 16,022 | 2,256 | 9,290 | 1,889 | 30,229 | 0.2 |
| Other | 33,746 | 3,712 | 13,013 | 3,594 | 1,081,063 | 99,704 | 625,553 | 52,710 | 1,913,095 | 14.1 |
| Total | 180,422 | 46,785 | 58,872 | 30,406 | 7,226,226 | 1,805,081 | 3,600,635 | 599,951 | 13,548,378 | 100 |

*Source: CSA, 2007 Population and Housing Census*

The energy sources and energy use pattern in Ethiopia parts of the Sub-basin are also very much similar to that of the sources recorded at the national level. The energy use pattern both at the national and sub-basin levels shows predominance of traditional energy sources that have implications for environment, land degradation, indoor pollution, deforestation, climate change and loss of soil fertility (Alemu, et al, 2008; Yonas, et al., 2013), and Getamsay, 2013:4. Therefore, supplying modern energy (e.g. electricity) is an important aspect not only for economic development and domestic energy supply for households, but also for relieving pressure on natural resources and sustainable use of environment. This suggest the need for harnessing the potential of hydropower in the Sub-basin for generating modern energy to the local economy and the household energy sources.

## 4.15 WATER SECURITY

Water security should be understood as the nexus between the availability, accessibility and use of water. The concept is defined as ‘availability of, and access to water in sufficient quantity and quality to meet livelihood needs of all households throughout the year.

There is currently no water stress or water security index available at the scale of the BAS. A qualitative approach has therefore been specifically developed by connecting previous biophysical and social findings (sections 3.2; 3.3 and 4) in the map below.

The population density is used as a proxy indicator for households water uses. Even if not represented here (because of inadequate data[13]), the livestock distribution (refer to Figure 6-2) can also be used as a complementary proxy indicator for households water uses.

Average dry season flow of main rivers and groundwater availability are used as proxy indicators for surface and groundwater availability respectively. Wetlands are also shown on the map since they also consist of precious water points during the dry season.

Permanent rivers and wetlands, boreholes, springs and existing water storage facilities (dams and reservoirs, hafir) are used as proxy indicators for water accessibility.

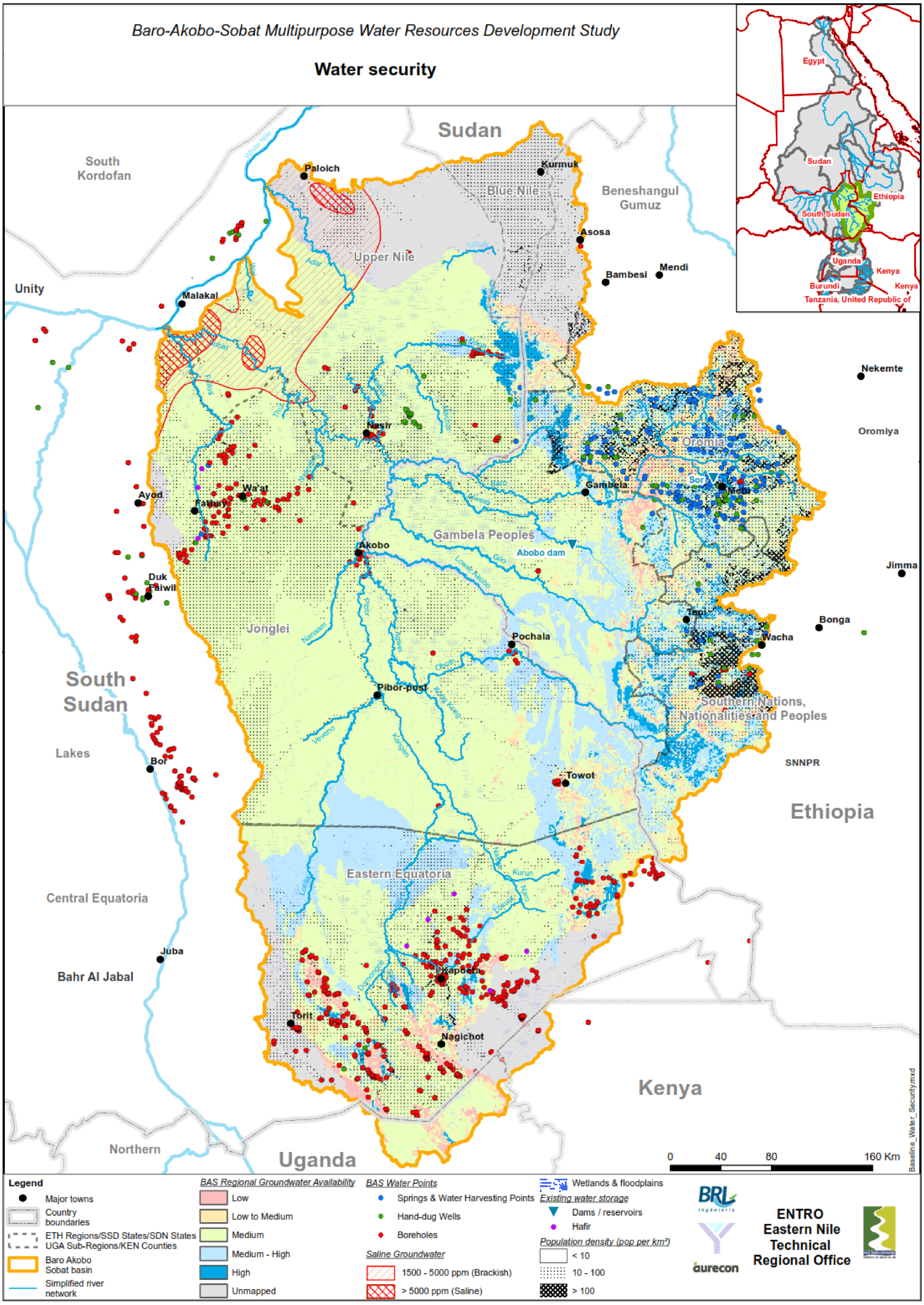
From the map next page, it can be seen that few areas of the BAS sub-basin should theoretically beexposed to water stress since only few locations of the basin are exposed to both high population density and low groundwater availability. These are mainly located in the upper parts of Birbir, Geba, Gilo and Akobo catchments. In addition, the north-western part of the BAS could be exposed to water stress because of the presence of saline groundwater.

However, while most of the BAS should theoretically[14] benefit from sufficient surface and / or groundwater, even throughout the dry season, water facilities such as boreholes or storage infrastructures are confined in certain areas, leaving entire parts of the basin without any reliable water points. In the lowland areas, this encourages people and livestock to migrate annualy in the search for permanent rivers and wetlands.

[13] Livestock density is only available at administrative level (states for South Sudan and Zones for Ethiopia) whose scale is not relevant compared to data about water availability.

[14] from the point of view of the water availability

*Figure 4-12: Qualitative water security assessment*



As a result, water security issues are mainly due to the following constraints:

- Drying up of the secondary river network in the lowland areas of the BAS (but could be compensate by groundwater development);
- Lack of water storage facilities: the only existing reservoir is the Abobo dam. Around 10 haffirs are reported in the BAS.
- Unsufficient groundwater development / lack of boreholes: entire areas reputed to lack surface water but with potential moderate groundwater do not have any boreholes. In addition, since less productive aquifers require more boreholes, dense populated areas with low ground water availability could also lack of water because of unsufficient boreholes.
- Deficit in water infrastructures operationality: technical erros in the design, which result in siltation and significant reduction of the water storage capacity are reported in the Haffir of the BAS. In addition, numerous cases of boreholes collapsing or inadequate pumping capacities.
- Local water quality issues, such as feacal contamination and saline groundwater.

*Figure 4-13: Dry season mean monthly flow of the BAS main rivers*

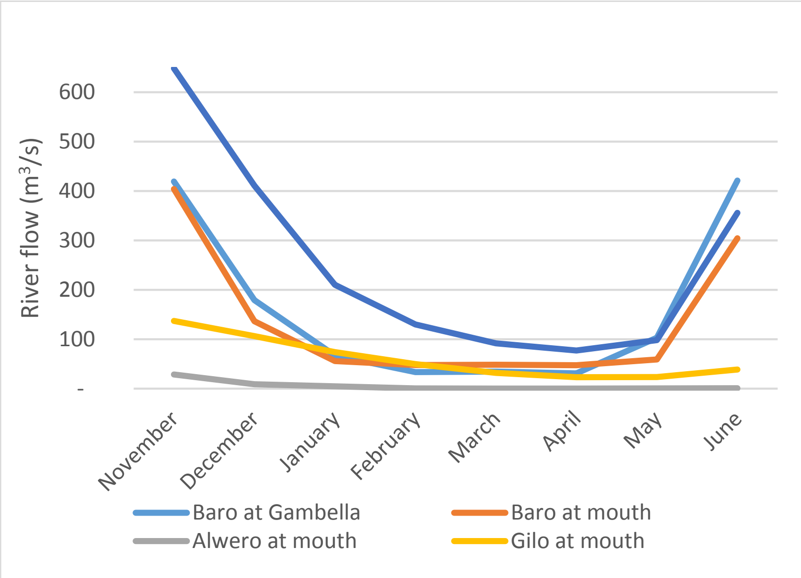



*Figure 14: Siltation at community-dug ponds in the BAS sub-basin (Eastern Equatoria State)*

Source: (MoEDI&WR, 2015)

# 4.16 KEY ISSUES, POTENTIALS AND OBJECTIVES FOR THE DEVELOPMENT OF THE BASIN

## 4.16.1 Introduction

Key socio-economic issues which serve as necessary conditions for the stable, relevant and sustainable development of the basin include the following:

## 4.16.2 Key issues, challenges and opportunities

Important social and socio-economic issues that need to be addressed in future development plans in the basin include the following:

- **Incidence of poverty and food insecurity** is still high in the sub-basin and way of addressing poverty eradication will be a key focus area.
- **Low level of well-being**: The basin area has low level of wellbeing and the development options will consider ways of enhancing the basin's population wellbeing.
- **Low level of provision of social services** due to weak social and infrastructural services and facilities: Most, if not all, of the basin areas are poorly served in terms of basis social services.
- **Vulnerable groups** (pastoral groups, women and children, conflict and war displace people, IDP, refugees, etc): The basin areas are marginalized from the main stream economy of the countries and have experienced various forms risks (both natural and economic) and as well conflicts which adversely affected vulnerable groups. The issue of protection of vulnerable groups should receive attention in the plan and development options.
- Addressing **gender inequality** at household, community and national levels as women have low access to productive resources, education and health services; and women have high work burden.
- **Recurrence of various forms, intensity, duration and impacts of conflicts** in the basin are the major impediment to future development activities.
- There is a **potential for influx of people** (various forms of migration) into the basin following ongoing and planned development initiatives and interventions. The likely consequences of the various development options/alternative on influx of people into the basin areas should be addressed in the development plans. In addition the potential effects of population increase, resettlement, increasing investment (commercial farm leaseholds) must be included in any future development plans.
- **Risks** (conflicts, flooding, disease outbreaks, economic shocks, insecurity) are common in the area. Therefore, the likely consequences of the various development options, either in exacerbating or reducing these risks will be addressed in the plan.
- **Land security/land tenure issues**, regarding rights of indigenous people will the social and economic issue while designating land for any type of development (commercial farm; large scale irrigation, hydropower, national parks, protected areas). The plan will take into account these issues.
- **Basin population dynamics place heavy pressure on natural resources** (e.g. water, land, wetlands and forest) for their livelihoods: Thus, potential impacts of development of any of these resources on people's livelihoods will be adequately addressed in the IWRDM Plan.

- **Weak institutions, poor coordination and cooperation among existing institutions**: There are varying levels of capacities and resources in the basin countries and the BAS sub-basin. Therefore, the issue of capacity building for coordinating and implementing development programs and plans is important for planning and implementing basin development activities.

Other development priorities include the following:

- Achieve and maintain political unity, legitimacy and stability at all levels
- Support the transition from humanitarian aid to development
- Promote a common, unifying national identity and purpose including a common national language such as English and/or Arabic
- Inclusive stakeholder consultation and participation in planning development interventions, resettlement and just compensation for loss of property and productive assets
- Respect of the livelihood needs of varied ethnic groups living in the basin
- Increase local production of foodstuffs, distribution and food security
- Provide basic services to and upgrading infrastructure in small towns and rural growth and market centers throughout the basin
- Provide wider opportunities for vocational training, with particular focus on women and youth
- Provide basic literacy training for adults
- Increase availability of mosquito nets and anti-malarial drugs, especially during the rainy season
- Support implementation of national gender policies and strategies, especially activities relating to women’s economic empowerment and the protection and conservation of water and other natural resources
- Promote environmentally friendly enterprises like plant nurseries, vegetable cultivation by women’s and youth groups, beekeeping, woodlots and reuse of agricultural by-products and residues for energy source
- Strengthen market linkages and cross-border trade within the region for food and agricultural inputs

*Table 4-22: Issues, Challenges and Opportunities for Development of the BAS Basin*

| Key issues | Opportunities | Challenges |
|---|---|---|
| Incidence of poverty | availability of good working policy framework and political commitment of the basin countries for poverty reduction | Lack or level of funding<br>Social, economic and natural risks |
| Low level of social services and well-being in the basin | Existence of various efforts and institutional setups for enhancing capacity to design and implement programs and projects. | Lack of funds, and low capacity for evaluation and monitoring programs and projects |
| Social vulnerability (various vulnerable groups ) | Various ongoing programs for poverty reduction and tacking food insecurity | Lack of fund, resources and capacity for implementing programs. |
| Gender inequality | Availability of Gender Mainstreaming Policy and Strategy.<br>Ongoing social development programs in health education, water supply, and wellbeing run by governments and NGOs etc | Social constructed bias and practices that constrains gender equality, and women' s work burden.<br>Lack of funds and resources and capacity for implementing policies, strategies and programs; lack of coordination |
| Migration into the basin. | Enhancing local economy due to commercial farms and labour migration into the area. | Increased pressure on the local natural resources and on existing social and economic services and infrastructures. |
| Various forms risks (conflict, natural disaster, flood, insecurity) | Long-established local level adaptation and coping strategies | Dynamics nature of risks and uncertainty in time, scope and location of most risks. |
| Sustainable use natural resources potential for development. | High natural resources potential in the basin | Various adverse impacts on the natural resources and on the livelihoods that are based these resources. |
| Land tenure | Availability of land for new development initiatives. | Loss of access to traditional or customary land rights, grazing and farmland to other uses like commercial farms, protected areas, etc. |
| Capacity building (human, resources and institutional). | Various ongoing trainings and capacity building activities in the basin countries | Low capacity and poor coordination among institution<br>High turnover of trained manpower |
| Development cooperation and designing win-win programs | Established framework for development cooperation between the basin countries | Low institutional capacity and poor coordination between countries and among institutions within a country.<br>Accommodating Varying interests. |

***Source:*** *Adapted from Inception Report and updated during the Baseline Study in 2016*

## 4.17 DEMOGRAPHIC AND SOCIO-ECONOMIC INDICATORS

The table below brings together information presented in the preceding parts of this chapter and the country annexes to derive a set of indicators for monitoring demographic and social change and impact in the basin over time.

*Table 4-23: Demographic and Socio-economic indicators*

| Parameter/Indicator | |
|---|---|
| **Population** | **Humanitarian Assistance** |
| - Size<br>- Density<br>- Mobility<br>o Migration<br>o Resettlement<br>o Displacement<br>o Natural Disasters | - Size<br>- Type<br>- Location<br>**Livelihoods**<br>- No. in resource-stressed areas<br>- Changes in livelihoods over time<br>**Food Security** |
| **Education** | - No. of people food insecure<br>- Location of food insecurity |
| - Enrolment rate for girl students<br>o Primary school<br>o Secondary school<br>- Attainment rate for girls<br>- Female literacy rate<br>- Female enrolment in vocational courses | - Ethnic groups affected<br>- Trends in food insecurity<br>**Poverty**<br>- Incidence of poverty<br>**Agricultural markets** |
| **Health** | - Number and size |
| - Birth rate<br>- Infant mortality rate<br>- Maternal mortality rate<br>- Fertility<br>- Attended births<br>- Life expectancy<br>- Access to safe water sources<br>- Access to improved sanitation<br>- Incidence of malaria | - Number and types of traders<br>- Number of disruptions<br>- Access<br>**Social Vulnerability**<br>- Poverty<br>- Conflicts<br>- Displacement<br>- Health<br>- Education |
| **Gender Relations and Inclusion** | - Dependence on humanitarian aid |
| - Legal rights for women to inherit property and obtain custody of children<br>- Women in paid employment outside the home<br>- Women running businesses<br>- Representation in government | - Agricultural Market disruptions |
| **Ethnic Groups and Relations** | |
| - Interethnic incidents/cattle raids<br>- Protests/disputes with government<br>- Participatory planning<br>- Political representation<br>- Patronage<br>- Economic empowerment<br>- Balanced development | |

# 5. POLICIES, LEGAL AND INSTITUTIONAL ARRANGEMENTS IN THE BASIN: CURRENT SITUATION AND KEY ISSUES

## 5.1 INTRODUCTION

Institutional and organizational arrangements, based on relevant legal grounds as well as policy and strategy documents, are a key issue when it comes to practical considerations of implementation of such an ambitious and complex IWRDM plan for the Baro Akobo Sobat river basin.

Challenges that might be encountered while developing the IWRMDPlan may include, but not limited to:

- How to address the multipurpose (i.e. inter-sectoral) nature of the Plan?
- How to properly and efficiently cooperate when activities with transboundary effects are planned?
- How to address the short, medium and long terms for a Plan which will certainly be developed over several decades and which will be certainly updated from time to time based on needs, development opportunities and emerging water resources issues?
- Which institutional arrangement is at the same time robust and flexible and could also be adapted in the medium and long term if necessary (based on the monitoring and evaluation feedbacks)?

Having these questions in mind, this section first depicts the current institutional background and framework at national and international scale, and then identifies key issues as well as preliminary ideas for the future. These ideas are aimed at being discussed with stakeholders and further developed in the Plan itself.

This section has been elaborated on the basis of key documents as quoted below and a series of face to face interviews with major stakeholders concerned by the BAS and the IWRMD Plan..

## 5.2 NATIONAL POLICIES AND INSTITUTIONS

### 5.2.1 Ethiopian National Policies and Institutions

#### *5.2.1.1 Water management, development and IWRM*

##### GENERAL FRAMEWORK FOR IWRM

Ethiopia is endowed with a long series of legal documents addressing the water resources in general and their management in particular. In chronological order, it is worth mentioning:

- The water policy, 1999
- The water strategy, 2001
- The water resources proclamation, 2000
- The water resources regulation, 2005
- The proclamation on river basins Councils and Authorities, 534/2007 (see detail in appendix)
- The definition of powers and duties of the executive organs, proclamation 691/2010 (see detail in Annex 4)

From the last document it can be seen that the ministry in charge of water has a very broad spectrum of responsibilities, now including in addition the development of irrigation in a more general manner. It is also clearly stated that the Ministry is the institution in charge of transboundary negotiations and related implementation of actions.

#### RIVER BASINS AUTHORITIES IN ETHIOPIA

The most specific characteristic on how IWRM is addressed in Ethiopia is the ongoing process of creating River Basin Authorities, according to the proclamation 534/2007 (see detail in appendix)

From the list of their powers and duties, it can be seen also that river basin Authorities have a wide range of duties and power, including: i) prepare a basin Master Plan and monitor its implementation ii) set up a river basin model for strategic planning purposes iii) support the body in charge of transboundary aspects by delivering proper information.

Therefore, as a summary, IWRM at Ethiopian basin scale pertains to the river basin Authorities while the active role for transboundary aspects belongs strictly to the Ministry. The proclamation 534/2007 gives provisions how to address the transboundary aspects by the High Council and the river basin Authorities as well as relationships between regional States in Ethiopia. A specific department is in charge of transboundary aspects within the MoWIE.

Today, there are already three River Basin Authorities officially created, i.e. Abbay, Awash and Rift Valley Lakes Authorities. Baro Akobo, Tekeze and Omo Authorities will be set up shortly. The proclamation for setting up the Baro Akobo Authority is already drafted (copy given to the Consultant).

Awash river basin will be complemented with Danakil and Aisha river basins to form one single Authority together.

Genale Dawa, Wabi-Shebelle and Ogaden will form one single river basin Authority in the future.

### *5.2.1.2 Environment protection organs*

The main document of reference is the proclamation 295/2002. This proclamation gives a series of definition, and especially the organs mentioned in the title, i.e.

- "Competent Agency" means any federal or regional government organ entrusted by law with a responsibility related to the subject specified in the provisions where the term is used;
- "Environment" means the totality of all materials whether in their natural state or modified or changed by human, their external spaces and the interactions which affect their quality or quantity and the welfare of human or other living beings, including but not restricted to, land atmosphere, weather and climate, water, living things, sound, odor, taste, social factors, and aesthetics;
- "Environmental Protection Organs" means the Authority, the Council, the Sectoral and Regional environmental units and agencies
- “Regional Environmental Agency" means any regional government organ entrusted, by that Region, with a responsibility for the protection or regulation of the environment and natural resources.

At federal stage, is established the “Environmental protection Authority” (EPA). Among a long list of duties and powers (26), it is worth focusing on what are the most prominent aspect of the BAS sub basin development plan, which are:

- Prepare as necessary environment policies and laws in consultation with competent organs and the public at large
- Establish a system for EIA as well as social and economic development policies, strategies, laws and programs
- Review inter-regional EIA and notify its decision, and follow up the conditions set out in case of authorization
- in consultation with competent agencies, take part in the negotiations of international environmental agreements and, as appropriate, initiate or cause the initiation of a process of their ratification;
- in consultation with the competent agencies, formulate, or initiate and coordinate the formulation of policies, strategies, laws and programs to implement international environmental agreements to which Ethiopia is a party; and upon approval, ensure their implementation;

The EPA is steered by a Council, placed under the authority of the Prime Minister acting as the chairman.

Sectoral environmental units and regional environmental agencies are created to translate and enforce the law in each sector and region under the guidance of the EPA.

#### *5.2.1.3 Rural land administration and land use*

This field of administration is governed by the proclamation 456/2005. Section 1 gives a detailed list of definitions on rural land, land administration, farmers, peasants, pastoralists…

Section 2 is more specific and addresses the “right to hold and use rural land”. Among others:

- It is stated that “farmers, peasants, pastoralists engaged in agriculture for a living shall be given rural land free of charge”.
- It is also stated that the Government is the owner of rural land, status which can be changed to private ownership as may be necessary.
- Private investors that engage in agricultural development shall have the right to use rural land in accordance to laws and policies at national and regional levels.
- Specific provisions are given regarding rural land measurement, registration and holding certificate
- There is no time limit for land use
- In case of eviction for purpose of public use, the holder of rural land shall be given compensation or substitute land
- Specific provisions are given for the transfer of rural land including possibility of lease and transfer to family members through inheritance
- Distribution of rural land is the subject of several provisions, including irrigation schemes where the principle of equity is central
- Specific provisions are given regarding the minimum land holding size and encouraging land consolidation
- Dispute resolution: in case a dispute would arise, it is recommended that the parties find an agreement on their own. At a last solution, the dispute will be solved according to the laws of the Region.

Section three relates to “rural land use restrictions” and mostly to land use planning and proper use of sloppy, gully and wetlands.

A series of recommendations and restrictions are formulated in this general purpose. Note two specific provisions: i) “the biodiversity in rural wetlands shall be conserved and utilized as necessary, in accordance to a suitable land use strategy” and ii) “a strategy of settlement, villagization and development of social services […] shall be formulated”

Section four relates mainly on the sharing of responsibilities between the federal Ministry of Agriculture (MoA) and the Regions.

At federal stage the MoA is in charge of:

- Implementing this proclamation by providing the necessary support and doing coordination,
- Initiate […] new policies ideas and amendments, as necessary,
- Create the system for exchange of information between the regions and the Federal Government

At regional stage the duties are:

- Each regional council shall enact rural land administration and Land use law, which consists of detailed provisions […]
- Regions shall establish institutions at all levels that shall implement rural land administration and Land use systems […]

#### *5.2.1.4 Irrigation*

Irrigation in Ethiopia has been a national endeavor for several decades.

The policy is very ambitious and as quoted and summarized in an article[15] dated 2006, it can be expressed with the following objectives.

- Development and enhancement of small scale irrigated agriculture and grazing lands for food self-sufficiency at household level
- Development and enhancement of small, medium and large-scale irrigated agriculture for food security and food self-sufficiency at national level including export earnings and to satisfy local agro-industrial demand.
- Promotion of irrigation study, planning and implementation on economically viable, socially equitable, technically efficient, environmentally sounds basis as well as development of sustainable, productive and affordable irrigation farms.
- Promotion of water use efficiency, control wastage, protection of irrigation structures and appropriate drainage systems.
- Ensuring that small-scale, medium-scale and large-scale irrigation potential projects are studied and designed to stage ready for immediate implementation by private and/or the government at any time.

In 2001 the “Ethiopian Water Sector Strategy” set up the basis, among other fields related to water, of the strategic framework for irrigation development.

[15] MoWR/MoARD:USAID/IWMI workshop - Solomon Cherre

From a purely institutional point of view, the components of this strategy were expressed as:

- Strengthen institutional and regulatory frameworks at the federal and regional levels,
- Reactivate and reinforce the role of the federal government and regional states in the development of small, medium and large scale irrigation schemes,
- Enhance greater participation of the regional states and federal government in the development of large scale irrigated schemes and farms in high water potential basins where there is low population density (with compensations),
- Ensure operational sustainability of the small scale irrigation schemes by establishing O&M departments within the regional bureaus,
- Establish self-financing autonomous public institutions to undertake O&M activities of large scale irrigation schemes. Involve major stakeholders in the BOD of these institutions,
- Encourage the participation of private sector, specially for the O&M and management phases of medium and large scale irrigation schemes

The MOWIE is the Ministry in charge of developing irrigation (see the organogram below).

From the situation today, it can be seen that this policy and strategy are being actively implemented, including real involvement of the private sector and extensive use of lowlands. In the BAS sub basin irrigation of all sizes is developing quickly and this is a challenge to continue such a development together with commitments regarding the compensations to the people displaced as well as the safeguards for the natural environment and biodiversity.

#### 5.2.1.5 Energy

The MOWIE is also the Ministry in charge of energy. Referring to the proclamation 691/2010 “definition of powers and duties of the executive organs”, the duties and organization related to energy can be summarized as follows.

The Ministry of Water and Energy shall have the powers and duties to:

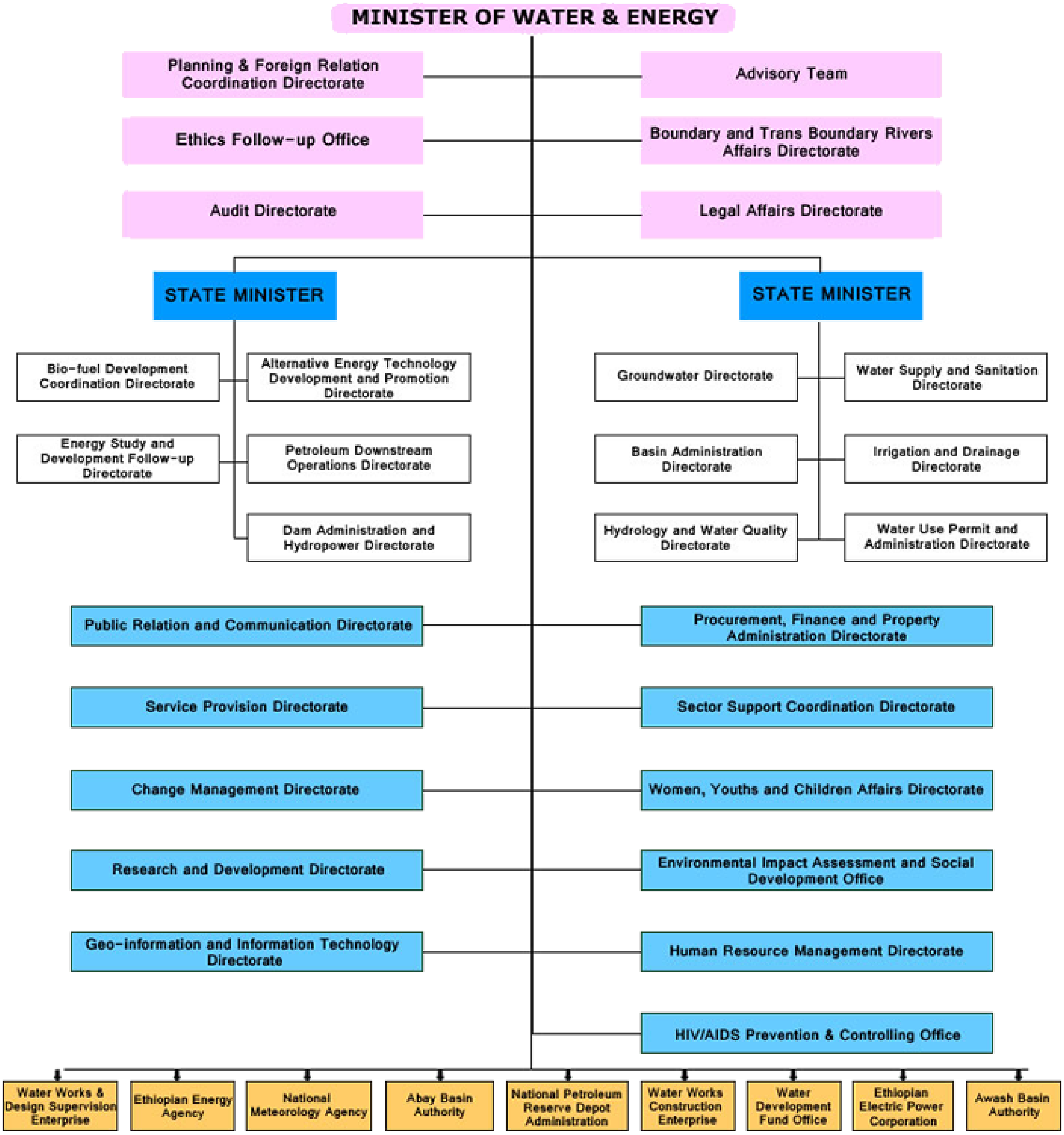
a) promote the development of water resources and energy
b) administer dams and water structures constructed by federal budget unless they are entrusted to the authority of other relevant bodies;
c) undertake studies concerning the development and utilization of energy; and promote the growth and expansion of the country's supply of electric energy;
d) promote the development of alternative energy sources and technologies;
e) set standards for petroleum storage and distribution facilities, and follow up the enforcement of same;
f) issue permits and regulate the construction and operation of water works relating to water bodies referred to in paragraphs (c) and (d) of this sub article
g) in cooperation with the appropriate organs, determine the volume of petroleum reserve and ensure that it is maintained;

The powers and duties given to the Ministry of Water Resources and the Ministry of Mines and Energy, with respect to energy, by the provisions of other laws, currently in force, and with respect to rural electrification, to the Ministry of Agriculture and Rural Development and the Ethiopian Rural Energy Development and Promotion Center and fund under Proclamation No. 317/2003 are hereby given to the Ministry of Water and Energy.

Apart these general duties, it is worth mentioning that Ethiopia has embarked in an ambitious strategy and realization of major HP plants would it be around lake Tana and the future GERD. To this respect EEPCO (Ethiopian Electricity Production Corporation) is a major player in charge of implementation for the GoE and an operator as well for production and operation.

The very large duties and powers of the MOWIE are reflected in the general organogram of the Ministry, with specific mention of two arms i.e. water and energy, each of them steered by a State Minister.

*Figure 5-1: Organization of the Ministry of Water and Energy*



#### 5.2.1.6 Health

Health is still a permanent concern in all countries, and it is certainly more than serious in the BAS sub basin. Among specific aspects regarding health challenges in the BAS su basin, it is important to mention, not being exhaustive:

- A high density of population in the highlands with still new comers; this is making this part of the sub basin prone to infectious diseases and accurately focus on the challenge of WASH
- A high proportion of poor people, or even very poor and high population of refugees
- The development of water infratructures may favor water borne diseases
- The weak network of health centers and the way of life of pastoralists in the lowlands are major challenges
- Insecurity at last is obviously a very high impediment to any sound health practices

Hereunder, some extracts of the Ethiopian policy and strategy, relating to the effects and challenges of development and the present situation are quoted.

**GENERAL POLICY**

i. Development of the preventive and promotional components of health care.
ii. Development of an equitable and acceptable standard of health service system that will reach all segments of the population within the limits of resources.
iii. Promoting and strengthening of inter sectoral activities.
iv. Assurance of accessibility of health care for all segments of the population.
v. Working closely with neighboring countries, regional and international organizations to share information and strengthen collaboration in all activities contributory to health development including the control of factors detrimental to health.
vi. Provision of health care for the population on a scheme of payment according to ability with special assistance mechanisms for those who cannot afford to pay.
vii. Promotion of the participation of the private sector and non-governmental organizations in health care.

**PRIORITIES OF THE POLICY**

i. Emphasis shall be given to:
   - The control of communicable diseases, epidemics and diseases related to malnutrition and poor living conditions;
   - The promotion of occupational health and safety;
   - The development of environmental health;
   - The rehabilitation of the health infrastructure
   - The development of an appropriate health service management system;
ii. Appropriate support shall be given to the curative and rehabilitative components of health including mental health.
iii. Due attention shall be given to the development of the beneficial aspects of Traditional Medicine including related research and its gradual integration into Modern Medicine.
iv. Applied health research addressing the major health problems shall be emphasized.
v. Provision of essential medicines, medical supplies and equipment shall be strengthened.
vi. Development of human resources with emphasis on expansion of the number of frontline and middle level oriented training shall be undertaken.

vii. Special attention shall be given to the health needs of:
- The family particularly women and children;
- Those in the forefront of productivity;
- Those hitherto most neglected regions and segments of population including the majority of the rural population, pastoralists, the urban poor and national minorities,
- Victims of man-made and natural disasters.

### GENERAL STRATEGIES

i. Inter sectoral collaboration shall be emphasized particularly in:
- Formulating and implementing an appropriate food and nutrition policy.
- Acceleration the provision of safe and adequate water for urban and rural populations.
- Developing safe disposal of human, household, agricultural, and industrial wastes, and encouragement of recycling.
- Undertakings in disaster management, agriculture, education, communication, transportation, expansion of employment opportunities and development of other social services.

ii. Health Education shall be strengthened generally and for specific target populations through the mass media, community leaders, religious and cultural leaders, professional associations, schools and other social organizations for:
- Inculcating attitudes of responsibility for self-care in health and assurance of safe environment.
- Encouraging the awareness and development of health promotional life-styles and attention to personal hygiene and healthy environment.
- Enhancing awareness of common communicable and nutritional diseases and the means for their prevention.
- Inculcating attitudes of participation in community health development.
- Identifying and discouraging harmful traditional practices while encouraging their beneficial aspects.

iii. Availability of Drugs, supplies and Equipment shall be assured by:
- Preparing lists of essential and standard drugs and equipment for all levels of the health service system and continuously updating such lists.
- Encouraging national production capability of drugs, vaccines, supplies and equipment by giving appropriate incentives to firms, which are engaged in manufacture, research and development.
- Developing a standardized and efficient system for procurement, distribution, storage and utilization of the products.

iv. Traditional Medicine shall be accorded appropriate attention by:
- Identifying and encouraging utilization of its beneficial aspects.
- Coordinating and encouraging research including its linkage with modern medicine.
- Developing appropriate regulation and registration for its practice.

v. Family Health Services shall be promoted by:
- Maintaining breast-feeding, and advocating homemade preparation, production and availability of weaning foods at affordable prices.
- Expanding and strengthening immunization services, optimization of access and utilization.
- Encouraging early utilization of available health care facilities for management of common childhood diseases particularly diarrheal diseases and acute respiratory infections.

vi. Health Legislations shall be revised by.
- Updating existing public health laws and regulations.
- Developing new rules and regulations to help in the implementation of the current policy and addressing new health issues.
- Strengthening mechanisms for implementation of health laws and regulations.

vii. Financing the Health services shall be through public, private and international sources and the following options shall be considered and evaluated.
- Raising taxes and revenues.
- Formal contribution or insurance by public employees.

## 5.2.2 South Sudan National Policies and Institutions

### *5.2.2.1 General framework to water management, development and IWRM*

Despite being a young independent State, South Sudan has prepared several documents of importance addressing water resources and their management, including provisions on institutional arrangement and trans-boundary aspects. The most important to be mentioned are:

- The Water Policy, GoSS November 2007 (i.e. before the independence, after the 2005 Comprehensive Peace Act)
- The Rapid Water Sector Needs Assessment and a way Forward, the World Bank January 2013
- Draft Water Bill, GoSS September 2013

***The Rapid Water Sector Needs Assessment and a way Forward***

This document explores into detail the Water Policy (2007), delivers some recommendations and identifies a way forward (see detail in appendix)

***Draft Water Bill, September 2013***

This document is much more comprehensive and encompasses a series of specific provisions relating to water resources management as well as transboundary aspects. It remains to ascertain the legal status of this bill and whether and how all provisions have been put into force.

The draft Water Bill comprises five sections, 22 chapters, three schedules and 169 articles.

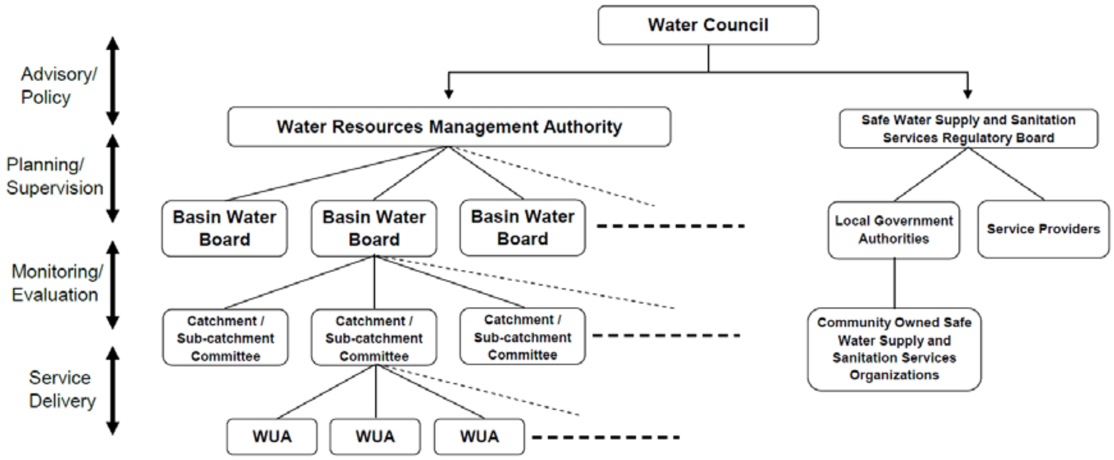
Not going into details (general provisions, transitional aspects etc.), it is worth mentioning the most prominent new arrangements envisaged.

- Section 2, chapter 2 gives provisions for establishment of a Water Council: in brief, the Water Council is under the authority of the Minister in charge of water. Its main purpose is to coordinate inter-sectoral approaches at the highest level. It is also supervising the Water Resources Management Authority (see below) and is endowed with a dedicated secretariat.
- Section 2, chapter 3 relates to duties and powers of the Minister (in charge of water): the Ministry of Electricity, Dams and Water Resources - MEDIWR). Among others, the Minister shall be responsible for RSS policy and strategy formulation and for ensuring the proper execution; Ensure and safeguard RSS interest on trans-boundary water resources; Provide for the safe construction of and management of dams; Appoint members of the Water Resources Management Authority; Appoint Basin Water Boards
- Section 2, chapter 5, articles 16 to 18 relate to the Water Resources Management Authority; among other provisions: this Authority is a corporate body under the authority of the Minister and acting for several concrete activities relating to IWRM. One specific duty is to Liaise with other regional, RSS and international bodies for the better assessment, management, development and use of the water resources; also this Authority is in charge of determining the basins catchments and sub-catchments. Upon its proposition, the Minister creates Basins Water Boards in the basins and sub-basins.

These Basin Water Boards are the acting arm at local scale in catchments and sub-catchment. Each is accompanied by a specific Committee appointed by the Minister

A summary of this organization is shown on the following sketch:

*Figure 5-2: Organization of the Basin Water Boards*




### 5.2.2.2 Environment protection

The most recent information to refer to is the draft "National Environment Bill" dated 2014. Most of the description below is extracted from this draft bill.

This is also quite a long and comprehensive document comprising 13 chapters and 120 articles. Not entering into all provisions, it is of interest to have a quick look at the general structure of the bill.

- Chapter 1: Preliminary
- Chapter 2: Guiding principles goals and objectives
- Chapter 3: Governance
- Chapter 4: Management of natural resources
- Chapter 5: Climate change
- Chapter 6: Promoting environment rule of law
- Chapter 7: Institutional and human capacity building
- Chapter 8: Funding environment programs
- Chapter 9: Environmental planning
- Chapter 10: Natural heritage
- Chapter 11: Environmental education information and public awareness
- Chapter 12: Corporate social and environmental responsibility
- Chapter 13: Miscellaneous

**Governance**: a Ministry of Environment is established at national level. Each state will also be endowed with a State Ministry in charge of the Environment. At local scale (county, city council) it will be established a local environment department. The roles and duties of NGOs, CBOs, and private sector are also detailed. The Ministry is in charge of coordination, monitoring an evaluation.

**Management of natural resources**: chapter four states that i) nobody can cut trees or forests, except with official authorization ii) all wetlands, rivers, lakes and other water resources shall be protected natural assets and their use shall be regulated by law iii) the Ministry and the relevant government agencies shall ensure protection of habitats and ecosystems to preserve rare species and biodiversity of fauna and flora

**Environmental planning and land use**: chapters 9 and 4 identify the commitment of the Ministry to prepare in close consultation with partners (including other ministries) a land use plan as well as an environment plan.

**Environment impact assessment**: provisions are given for the necessary EIA

### COMMENTS

It is of great interest that such a bill would be passed. However, full enforcement on the field remains a major challenge due to the situation in South Sudan.

### *5.2.2.3 Land administration and land use*

There is currently a land policy initiative supported by the African Union. Land is now classified into three groups:

- Public
- Communities
- Private

Public land (as per the colonial era) is managed by the Government of South Sudan; this comprise the national territory up to international borders, navigable rivers, sub terrain surfaces deeper than 3 m, wildlife including national parks, game reserves…etc.

Digging wells of building dams requires the consultation with local communities in order to secure a social cooperation.

Individuals and communities can acquire public lands.

A new Land policy is under preparation at the Parliament to refresh and update the land act dated 2009 (before the independence)

It does exist a procedure for land registration but it needs major improvement which is expected to be possible through the new land policy.

The situation today is an improper general land registration which will need great efforts to pay. Many old registers are still in Khartoum….

Akobo should be considered as a priority region for such a process of registration.[16]

In preparation to the expected new land policy, a draft version was issued in 2010. It is of interest to have in mind the road map expressed in this draft (under the denomination of "Policy statements"):

i. The government shall promote secure land tenure for all legally-recognized rights holders and protect their rights
ii. Secure land rights are a fundamental enabling condition for poverty reduction
iii. Government at all levels will work closely with traditional authorities and civil society organizations to develop durable solutions for land and property restitution in the event of return, or resettlement of refugees and IDPs
iv. Government at the federal and state levels will establish and implement laws, regulations, and procedures that foster transparent and accountable land administration
v. Government is entrusted with the authority to administer land in the public interest
vi. The GOSS and State governments will establish laws and regulations that recognize the role of and provide opportunities for public participation and protect the right of citizens and rights-holders to present their views on land-use and development decisions that affect their rights.
vii. Government will establish and implement laws and programs that expand awareness, recognition, and protection of women's land rights.

[16] Personnal communication with the head of land commission

viii. Customary land rights and tenure arrangements will be retained and their legal status strengthened and protected

ix. Government should support education, training and research that expands awareness and understanding of land rights and land issues among all stakeholders in South Sudan

x. Government agencies at various levels and customary authorities will assist in mediation of land rights conflicts

xi. GOSS and State governments will maintain accurate records of held under leasehold and freehold tenure in efficiently managed and publically-accessible data bases.

xii. Orderly, transparent and efficient land markets will be encouraged

xiii. The government recognizes that the allocation and use of land for private investment is a legitimate and potentially effective means for national economic growth, but must be done with in accordance with provisions that protect the public’s interests.

### 5.2.2.4 Irrigation

Irrigation in South Sudan is under the authority of the MEDIWR, with involvement of the different states as well.

An “Irrigation Development Master Plan” (IDMP) was completed and released quite recently (2015-2016), which formulates a lot of recommendations and ambitions for the sector, with detail for each of South Sudan states.

Not entering in many specific institutional aspects, it is of interest to understand the sharing of responsibilities (who does what) according to task to be performed and the size of the irrigation schemes envisaged. The following table summarizes this as a snapshot.

*Table 5-1 : proposed sharing of duties for irrigation in South Sudan*

| Programme | Scheme/ Farm Size | Definition | Responsible Organization for Land Allocation | Ownership | Technical Assistance | Capital Investment i.e. funding source for implementation | O&M (Short-term)/a | Supervision of Scheme/Farm Management (Short-medium term)/b |
|---|---|---|---|---|---|---|---|---|
| National Irrigation Scheme Development Programme (NISDP) | 500 ha or more | Large scale | National/ Community | Land property acquired by National Government | National/ DPs | National/Private Sector (Bank)/ International Development Bank/DPs (grant) | National/IB/ WUA | National |
| State Irrigation Scheme Development Programme (SISDP) | Up to about 500 ha | Medium scale | State/ Community | Land property acquired by State Government | National/ DPs/ | State/ National/ Private Sector (Bank)/ International Development Bank/DPs (grant) | National/ State/IB/ WUA | State/ National |
| County Irrigation Scheme Development Programme (CISDP) | Up to about 200 ha | Small scale | County/ Community | Land property acquired by Local Government | National/ State/DPs | County/State/ National/ Private Sector (Bank)/DPs (grant)/ NGOs | National/ County/IB WUA | County/ State/ National |
| Community Irrigation Farms Development Programme (CIFDP) | Up to about 200 ha | Small scale | Community | Land property acquired by Community group | National/ State/ County/ DPs/ NGOs | Community/County/State/National/ Private Sector (Bank)/DPs (grant)/ NGOs | National/ State/ County/ Community/ IB/WUA | Community/ County/State/ National |
| Private Sector Investment Promotion in Irrigation Development Programme (PSIPIDP) | Undefined | Undefined | National/ State/County/ Community | Land property acquired by Private Sector Organization | Private Consultants/ Government Facilitation | Private Sector, Government Support and Community Contribution | Private Sector WUA, IB, BW & C/SC | Private Sector |

#### 5.2.2.5 Energy

So far, there is no policy regarding energy in South Sudan.

Energy is widely coming from biomass source as well as from thermal plants and oil, and electricity generation is close to non-existence despite a fair potential in the country.

Electricity is managed by a directorate of the Ministry of Energy Dams and Water.

It is recommended strongly that, as soon as possible, a general master plan for energy will be elaborated and that this document will consider on the long term the development of the BAS sub basin and its potentials for HP generation.

The World Bank released a note dated April 2013 “Electricity Sector Strategy Note for South Sudan”, where three steps are identified:

- **Short term**: laying the foundation of growth. Planning, legal and regulatory framework, capacity building, continuation of emergency generation program, transmission and distribution program
- **Medium term**: implementing strategic projects, initiation of diverse mix generation with special attention to large HP projects, reinforcement of ageing network and planning for participation in power pools
- **Long term**: scaling up of expansion programs, including higher generation and diverse mix of resources including large HP projects; engage in regional power trade; interconnect grids and consider off-grid programs

#### 5.2.2.6 Health

Even more than for other sectors (above), the situation of health in South Sudan is more than critical. A description of what should have been the Health Sector Development Program is however given below. It should have been under the auspices of the Ministry of Health (document dated for the period 2011-2015)

Strategic Objectives

i. To increase access to quality primary health care services
ii. To strengthen prevention and control of communicable and non-communicable diseases
iii. To improve Prevention of HIV/AIDS and Care for clients
iv. To improve maternal, newborn and child health
v. To improve nutritional status of the population, especially women and children
vi. To improve hospital services and complement the referral system especially for mothers
vii. To improve Management and Governance of the health sector
viii. To Strengthen Human resources production, management, distribution, development and retention:
ix. To create an enabling environment to ensure availability and management of quality pharmaceuticals and supply systems
x. To rationalize distribution and improve the infrastructure of health services delivery points to ensure quality health care delivery
xi. To improve Health Sector Financing
xii. To enhance evidence based decision making through establishing HMIS and M&E systems and promoting a culture of data use
xiii. To further strengthen the health system through addressing a set of cross cutting priorities:

# 5.3 REGIONAL INSTITUTIONS, PROGRAMS AND FRAMEWORKS

## 5.3.1 Nile Basin Initiative

The Nile Basin Initiative (NBI) was founded in 1999 by the Council of Ministers of Water Affairs of the Nile Basin States. It includes all Nile countries and provides an agreed basin wide framework to fight poverty and promote socioeconomic development in the region. It is guided by a shared vision: *"to achieve sustainable socioeconomic development through the equitable utilization of, and benefit from, the common Nile Basin water resources*."

## 5.3.2 ENSAP

The Eastern Nile Subsidiary Action Program (ENSAP), investment program developed by the NBI, is to promote poverty alleviation, economic growth and reversal of environmental degradation from a joint action of Egypt, Ethiopia, Sudan and South Sudan.

It is led by the Eastern Nile Council of Ministers (ENCOM) representing the four countries.

The first ENSAP project is referred to as the Integrated Development of the Eastern Nile (IDEN) project. Its objective is to initiate a regional, integrated, multipurpose development project that confirms tangible win-win gains and demonstrates joint action for the Eastern Nile countries.

IDEN comprises the following seven subprojects: Eastern Nile Planning Model (ENPM), Baro-Akobo Multipurpose Water Resources Development, Flood Preparedness and Early Warning, Ethiopia-Sudan Transmission Interconnection, Eastern Nile Power Trade Investment, Irrigation and Drainage, and Watershed Management.

## 5.3.3 ENTRO

The Eastern Nile Technical Regional Office (ENTRO) was established by ENCOM in June 2002 in Addis Ababa as the executive arm of the ENSAP. Initially the countries were three (Egypt, Ethiopia and Sudan) and since the independence of South Sudan in 2011, ENSAP and ENTRO comprise four countries. ENTRO manages, coordinates and supports ENSAP projects through: capacity building in social development, input to project design, formulation of guidelines, initiation of pilot and background studies and analysis; and networking with stakeholders.

ENTRO is funded by the Eastern Nile countries and several foreign donors: among others, the African Development Bank, the NEPAD etc.

The roles of ENTRO are summarized as follows:

- Providing technical expertise and adopting best practices for the coordinated identification, preparation and possible implementation of regional development programs and projects in the Eastern Nile;
- Enhancing capacities of ENSAP institutions;
- Building and strengthening networks among the stakeholders; and
- Enabling people from the Eastern Nile to work together.
- Facilitating Eastern Nile Dialogue and Consultations
- Promoting EN Water Resources Management (knowledge management & planning), and
- Promoting EN Water Resources Development

### 5.3.4 The Cooperative Framework Agreement (CFA)

The Member States of the NBI have worked, discussed and negotiated for years with the aim of establishing a general agreement on water resources in the Nile river basin. This resulted in a document named "Cooperative Framework Agreement" which was completed in 2010, with, among others, the purpose of setting up a "Nile river basin Commission". However, at that time Egypt and Sudan decided to withdraw from any negotiation and definitely not to sign the CFA.

To enter into force, the CFA requires signature by the Member States, plus ratification. One provision of the CFA (article 42) is relating to the entry into force of the CFA as *"The present Framework shall enter into force on the sixtieth day following the date of the deposit of the sixth instrument of ratification or accession with the African Union".* So far, three ratifications are still missing to meet such a condition and the CFA is not yet activated.

In addition to the great interest lying in institutional provisions expressed in the CFA, article 31 of the CFA addresses the *"sub basins organizations and arrangements"*, recognizing their utility. This article could be of high interest if the CFA is put into force, for the BAS river basin. However, this article is a very general provision, mainly addressing existing sub-basin organization (LVBC for example), and would need a very specific work and details on how new sub-basins could be considered and set up.

## 5.4 ASSESSMENT OF THE ROLES AND FUNCTIONS TO BE PERFORMED FOR IWRM PLANS

It is of high interest to identify the main functions which will to be performed for IWRM plans, from the very beginning to operation stage. In front of this list of functions (possibly to be enriched), a first attempt of suggestions and comments can be made according to the specific situation of the BAS river basin. Table 5-2 below summarizes this approach.

*Table 5-2: Main functions to be performed by the BAS IWRMDPlan – suggestions and comments*

| Functions for BAS IWRMD plan | Detail of Functions | Actors - comments |
|---|---|---|
| Policy Formulation & Cooperation | Develops basin-wide policies for water management | This should be a major output of the BAS IWRMD Plan. In addition it should be imagined that the two countries sharing the BAS catchment dedicate specific means (in depth studies, coordination meetings…etc.) in view of ensuring harmonization of coordinated water management policies in the BAS catchment. This could be naturally supported and facilitated by NBI/ENSAP/ENTRO |
| Strategic Planning | Develops medium to long-term strategic options for basin-wide water development and management. | This is the BAS IWRMD Plan. The key point is to ensure that both countries and stakeholders are committed and willingfull for implementation. |
| | Develops strategic options for sector development and/or management | This relates to the multi-sector nature of the BAS IWRMD Plan. This requires a coordination in each country under the auspices of the Ministries in charge of water, as well as a bilateral coordination at least for some items: hydropower generation, watershed management etc. |
| Water Resources Management | Coordinates member states. land and water management activities (can include agricultural water use) | This depends on the accuracy and willingness stemming from strategic options as above mentioned. The quality and the frequency of bilateral coordination between the two states will determine the efficiency of this function (example of big dams to be operated for the lager benefits). |
| | Water Allocation/Quota Management | The water allocation/quota issue is still controversial in the Nile Basin and especially the ENSAP region. A specific attention must be paid to this issue in order to build a safe arrangement in the future. This would be under the auspices of NBI/ENSAP. A specific effort is to be paid (first rank priority) to improve and densify the hydro-meteorological network especially in South Sudan. |
| | Water Quality Management | This remains a field of very limited knowledge and understanding. Monitoring of quality will need specific preparation and investment specifying parameters, means and cooperation agreements between the two countries, and in line with NBI/ENSAP activities |
| | Protecting and conserving ecosystems and environment | The SVP NTEAP provided a strategic environmental framework for the management of the transboundary waters and environment challenges in the Nile River Basin.<br>The ENSAP Watershed Management Project Established sustainable framework for the management of selected watersheds to improve living conditions of the people, enhance agricultural productivity, protect the environment, reduce sediment transport and siltation of infrastructure, and prepare for sustainable development oriented investments.<br>However, a specific research program anticipating future specific ESIA is to be set up in addition, specially aiming at a better understanding of the functioning of wetlands and marshes. These particular ecosystems could possibly be heavily impacted by some activities (big dams) and they are of international interest. The two countries together should consider carefully this issue under the umbrella of NBI/ENSAP. |
| | Operational rules and procedures (e.g. flow management) | Operation rules and procedures regarding water quantity should be considered especially for the medium and long term when large infrastructures are likely to be implemented. This should be at least on a bilateral basis, but not ignoring that other member states of ENSAP are concerned which will eventually lead to a more general discussion |

| Functions for BAS IWRMD plan | Detail of Functions | Actors - comments |
|---|---|---|
| | Emergency Measures (floods, spills, droughts...) | The ENSAP FPEW project strengthens the existing capacities of the EN countries in flood forecasting, mitigation and management. In addition specific provisions for future large infrastructures must be addressed by the two countries. |
| Knowledge Management | Collects and/or collates basin information and manages quality assurance - Develops & Operates Decision Support Systems | The SVP WRPM project developed the Nile-DSS, which includes a large information management system.<br>However, in depth research for the BAS IWRMD Plan study demonstrates that there are many gaps in basic knowledge of hydro-meteorology in the basin. Any initiative and implementation will need to collect significant additional data over a sufficient period of time. This is especially true for wetlands and marshes of South Sudan where no data are available. This is a first priority action to be considered in the Plan with support of IGAD HYCOS and donors. |
| | Protocols for harmonizing/sharing data, and KM programs | Depends / relates with the previous item when operationalized |
| Water Resources Development | Mobilizes resources for water resources development projects | Each country (Ethiopia and South Sudan) expresses the intention to keep autonomous and address activities/projects on a case by case approach. However, it is sure that acting in a cooperative manner and benefiting of the umbrella of ENSAP will greatly enhance opportunities and chances for resources mobilization. |
| | ESIA *(develop criteria – harmonize, develop criteria, supervision)* | Joint ESIA are needed as soon as activities have transboundary nature. The recommendation would be that ESIA will not be limited to separate studies but will address cumulative effects. Support of ENSAP/ENTRO is a real opportunity. |
| | Mitigation measures for transboundary impacts (including ESIA.) | Depends / relates with the previous item when operationalized. Specific involvement and strong commitment of BAS countries is necessary. |
| | Safeguard measures such as relocation… | Depends / relates with the previous item when operationalized. Specific involvement and strong commitment of BAS countries is necessary. |
| | (Pre) Feasibility and design studies of specific developments | Depending on the nature of activities and developments, each country could be directly in charge on its own territory. For developments with transboundary effects, it is desirable that a bilateral arrangement would be set up or use the vehicle of ENTRO. |
| | Decision making to implement on various components of the BAS IWRMD Plan | Components with effects in one country only would pertain to the said country. Components/activities with transboundary effects should be decided on basis of sound design studies and ESIA by the two countries together (and even possibly other countries). The umbrella of ENCOM/ENSAP/ENTRO would therefore to be used for facilitating the dialogue and support an agreement. |
| | Engineering, Procurement & Construction | Activities in one country only without transboundary effects would pertain to the country alone (e.g. program of boreholes for water supply). ENTRO could support the engineering activities. Procurement and construction, as per the countries' views, would remain the duty of each country . |
| | Owns | As per the views expressed by the two countries, ownership would be lying strictly in each country |
| | Operates or Manages Infrastructure (e.g. dams) | As soon as large infrastructures are at stake with transboundary effects, the recommendation would be to set up a dedicated permanent technical Committee aimed at evaluating and when necessary adapting operation rules (yearly at least) |

## 5.5 POLICIES, LEGAL AND INSTITUTIONAL ARRANGEMENTS IN THE BAS BASIN: IDENTIFICATIONS OF KEY ISSUES AND CHALLENGES

As a provisional conclusion and before defining options to be scrutinized by the stakeholders, the Consultant proposes to address the situation under the format of a tentative SWOT analysis.

***Strengths***

The major strength lies obviously in the existence of NBI/ENSAP/ENTRO. This is at the same time a legal framework and a source of various services developed since the establishment of these bodies. As an example, it is easy to mention the constitution of the Nile DSS: this tool has been developed and is shared by all riparian countries. Many other activities have been performed either in the frame of the SVP by the NBI or at the Eastern Nile scale by ENSAP/ENTRO.

It is worth underlining the existence of ENTRO as a major strength: ENTRO is endowed with full legal status and is able to conduct directly or to steer numerous and various activities (like the present IWRM Plan study). It is recommended that ENTRO would continue to manage and steer different studies which will be needed pursuant to the BAS multipurpose water resources development study. Indeed, ENTRO as an institution and the persons belonging to ENTRO have gained high experience for years on the situation of the BAS, the stakeholders expectations etc. and this is to be properly enhanced.

Another strength is that the BAS sub- basin is almost pristine in the meaning of the absence of large hydraulic infrastructures and more generally a low use of water resources. This keeps the door wide open for formulating development strategies and even for organizational arrangements to support such strategies.

The BAS sub-basin is also endowed with multiple natural resources, not only water but also land, the natural environment, fishes etc. This brings the idea in mind that a real IWRM process can be imagined and set up with a true integrated approach. There is the potential to address the nexus food-energy-environment, with significant benefits shared by the two countries and various categories of stakeholders.

***Weaknesses***

Purely from an institutional point of view, it is to be stressed that the Cooperative Framework Agreement has not been put into force. This is certainly a gap in itself and beyond this situation, it appears that very little institutional organization has been developed since 2010. This situation is not counterbalanced by other mechanisms such as possible bilateral agreement relating to development based on water resources, nor future management and operation of activities having transboundary effects.

Due, among others, to the insecure situation of South Sudan in the most recent years, there is little preparedness for large developments based on water in general. Despite several master plans have been issued recently at national scale (agriculture, irrigation…), it is doubtful that grass root level consultation of stakeholders was possible. When the security situation comes back to normal, it will be of higher importance to determine the priorities with the stakeholders.

One major weakness is relating to data, for water resources and many other items. A lot of data are old or totally missing and the literature references often cross quote each other. This is first a technical issue, but not only. This is also an organizational issue when considering that developing a much more extensive and reliable monitoring network should be put at the first rank of priorities (hydro-meteorology especially). As an example, the *Machar marshes* are almost not known at all, except from qualitative description, most often old. Due to the extreme value of this ecosystem, of international importance, which is also a source of livelihood for many people, any large hydraulic infrastructure will need very careful evaluation (ESIA, possibly resettlement action plan…). This can only be envisaged in the frame of a close cooperation between the two countries, through: exchange of data, water information system, global ESIA (not case by case) etc.

### *Opportunities*

Among opportunities, it is of importance to underline that the two countries sharing the BAS sub-basin are confident to each other. One highly positive and concrete aspect of this confidence is the simple fact of conducting such a big strategic study on the BAS in good cooperation.

Important outputs of this study will be: i) setting up a strategic vision on the long term and ii) address and study priority projects. Preparation of organization of these priority projects should be launched quite rapidly between the two countries.

One particular opportunity, or more generally conducive conditions, is the fact that the two countries sharing the BAS river basin own some comparable administrative and institutional organization as far as water is concerned, i.e. i) the Minister in charge of water is responsible for transboundary aspects ii) the two countries are organized on basis of regional states iii) the two countries have set up a water council or high water council which are in charge of the multi sector approach, that is fostering the IWRM philosophy iv) in both countries, the catchments (or river basins) and possibly sub-catchments are the key institutions for managing water. Ethiopia is well advanced in this direction with three River Basin Authorities already created, three others to be created in the short term, including the BAS.

Another aspect to be considered as an opportunity is the idea of keeping flexible in building an institutional arrangement. It is actually difficult to make propositions and imagine solutions ahead of a development program. The nature and the magnitude of activities incorporated in such a program will widely determine the requested ad hoc arrangement. In particular, would the program consider medium and long term investments for large infrastructures, this could leave enough time to decision makers to organize and negotiate the most appropriate mechanism. In the short, a simple mechanism could be used, serving as a transitional arrangement to be revisited and strengthened when and if necessary.

### *Threats*

In such an ambitious endeavour, threats are potentially numerous and of high impact. Some of them deserve to be identified.

Case by case approach and implementation remaining in charge of each country separately: several stakeholders expressed this idea during consultations. If this idea may prove efficient for some “simple” activities (for instance, developing drinking water supply on basis of boreholes), as soon as the transboundary nature of the BAS is concerned, this will be much more complex or even hazardous (example of a series of big dams). A series of activities are to be carefully planned and conducted at river basin scale, such as:

- Feasibility studies, ESIA
- Detailed design, in depth mitigation measures, regime of storage/release, environmental flows, cost benefit analysis and optimal/equitable sharing of effects
- Decision to do the considered development
- Financial resources mobilization
- Construction
- Operation and maintenance

This last item is crucial as the previous steps. In fact it is not the reality that one could rely on a single initial rule of operation of big dams. There are plenty of possible situations which will need to adapt, even slightly, operation at least on a yearly basis. Let's think about plentiful hydrology one year, likely to give rise to floods; on the contrary we can imagine dryer years which would request anticipation in storage. In other words, a specific hydro-meteorological model is strongly requested, and, as part of the regular exchange of information/data, both countries will be concerned in that example. One option is certainly to create a specific joint committee in that purpose.

Another important threat is related to thinking the long term. Most people are really enthusiast with the perspective of generating development and responding to the huge needs of the population in various sectors. However, it must be clearly understood that implementation of such a plan may be over several decades, which is an intrinsic feature. The more carefully planned institutional arrangement from the beginning (not excluding several successive steps), the easier will be the capacity to address the long term, organize efforts and secure resources mobilization.

The present study is addressing strictly the BAS; the original idea and intention was to incorporate the White Nile up to Khartoum, as previously done in preliminary studies. For financial resources obstacles, this was not made possible. The question remains of the relationship and fair discussions with the downstream countries along the Nile. The suggestion is that this could be organized at early stage when the first drafts of the Plan are available.

# 6. DEVELOPMENT OF WATER RESOURCES: CURRENT SITUATION

## 6.1 INTRODUCTION

The current development of water resources is part of the situational analysis of the baseline. It aims at defining the general tendency related to water resources development projects. This analysis is also crucial to identify the key issues and challenges encountered in the different sectors.

The development of water resources has been divided into three main categories:

- **Economic sectors related to water resources**: these sectors create wealth and employment and participate directly to the reduction of poverty. It includes the following sectors:
  - Agriculture (rainfed and irrigated)
  - Hydropower,
  - Livestock farming
  - Fisheries and aquaculture
  - Ecotourism.
- **Service sectors related to water resources**: these sectors do not create wealth directly but are essential to create an environment suitable for the well-being of the population and for the development of the economic sectors related to water resources. It includes the following sectors:
  - Potable water supply and sanitation
  - Navigation
  - Flood and drought mitigation
- **Cross cutting sectors and themes**: these sectors are at the crossroads between economic and service sectors. They create wealth directly and, at the same time, they are essential to develop economic sectors. It includes the following sectors:
  - Livelihood-based watershed management
  - Biodiversity, habitats and landscape conservation
  - Climate change mitigation

## 6.2 ECONOMIC SECTORS RELATED TO WATER RESOURCES

### 6.2.1 Rainfed agriculture

#### *6.2.1.1 Rainfed agriculture in South Sudan*

It is reported in the CAMP (2015) that “over 95% of the territory of South Sudan is arable and 50% of it is prime agricultural land suitable for various crops” but that only 3.8% is utilised. 62.6% is covered by forest and woodland. Almost all crop-farming is rainfed, with the main crops cultivated being sorghum, maize (in the north), cassava, groundnuts, sesame, pearl and finger millets, beans, peas, sweet potato and rice. Sorghum is the staple food and is widely grown countrywide. About 78% of households are engaged in agriculture and the average area harvested per household is about 1.12ha. The majority are subsistence farmers using traditional methods, seed of variable quality and generally low-yielding. Pesticides and herbicides are rarely used outside of the large-scale mechanised schemes.

Crop-farmers in South Sudan are categorised into three main types (CAMP, 2015):

- **Subsistence farmers**. These represent the large majority of crop farmers. Average yields (1t/ha) are low and the areas harvested (2feddans) per household too small. Other challenges include lack of financial resources, scarcity of labour, outdated and inefficient farming methods and large post-harvest losses. The additional major challenge of insecurity is of particular concern. Due to insecurity caused by the civil unrest that started in December 2013 and intercommunal or tribal conflicts, some farmers leave their homes and become internally displaced persons (IDPs). The result is serious food insecurity.
- **Medium scale commercial farmers (progressive farmers).** The CAMP reports that there are some medium-scale commercial farmers. They are cultivating relatively large farmlands and are engaged in commercial farming. Many of them have access to tractor services for ploughing, agricultural inputs (e.g. quality seeds, pesticides and chemical fertilisers), hired labourers, market information and traders for selling produce. Many of the medium-scale commercial farmers started commercial farming recently and it seems that their number is increasing rapidly, especially in the Greenbelt Zone. The CAMP presents a positive picture of this sub-sector and indicates that there is already relatively rapid expansion and a potential for further rapid expansion.
- **Large-scale commercial farmers**. In Renk County, Upper Nile State in the Eastern Flood Plains Zone and outside of the BAS basin. These farmers mainly grow sorghum, sesame, millet and groundnuts. Their farm sizes are very large compared to farms in other areas of the country, with one farmer owning more than one thousand feddans. Land preparation is done by hired tractors and sowing is done by both mechanised broadcasters and manual labour. This area has a semi-arid climate with total annual precipitation of about 500 mm. Farmers have no irrigation facilities, thus rainfall is the most crucial determinant of yield. Bird damage is a major challenge.

#### *6.2.1.2 Rainfed agriculture in Ethiopia*

Recent progress in the improvement of rainfed agriculture was reported to the team during visits to the field. While it was reported that many famers have indicated that they need access to at least some supplementary irrigation, there has been a major increase in productivity in recent years. This is largely due to progress with the generalisation of improved farming practices and access to credit.

The highland areas of the basin are extensively and intensively cultivated. Due largely to population pressures and improved access roads, cultivation in the highlands is still expanding, in places (close to roads etc) very rapidly. This is leading to the cultivation of increasingly marginal lands and the clearing of woodland.

It should be noted that there are large plantations of coffee and tea in the basin highly profitable. The following have been identified:

- Gumaro Tea Plantation close to Metu: 860 ha
- Duyina Coffee Plantation close to Tepi: 1,000 ha
- Gemadro Coffee Plantation close to Mizan Teferi: 1,153 ha
- Bebeka Coffee Plantation (Gesha, Bench Maji Zone): 10,000 ha

## 6.2.2 Irrigated Agriculture

### 6.2.2.1 Existing infrastructure in the basin

#### ETHIOPIA

There is one dam/reservoir in the middle course of the Baro watershed, on the Alwero River, in Ethiopia. The reservoir was initiated in 1987 for agriculture purposes, but the proposed irrigation scheme never completed. The command area for irrigation was transferred to private company, Saudistar and the construction of 21 km long main canal and associated field irrigation faculties for a command area of 10,000 ha is currently ongoing. The Baro-Akobo Master Plan Study in Ethiopia (MoWR, 1997), had also identified 5 dams/reservoirs for irrigated agriculture development purpose out of which one was multi-purpose.

Twenty river diversion head-works for small scale irrigation schemes are available in the upper most part of the basin in Gambella region and West Wollega, Qelem Wollega and Illubabor zones of Oromia region. Small scale pumps irrigation schemes (10hp -20hp) that use surface water from rivers for irrigation purposes are also found in the areas.

#### SOUTH SUDAN

According to the South Sudan Comprehensive Agricultural Master Plan, (MAFCRD & MLFI, 2015), key infrastructure for crop production and marketing such as main roads, feeder roads, irrigation facilities, storage, drying yards and market facilities are not well developed in either the public or private sectors in the entire South Sudan. Investment for infrastructure, such as feeder roads, irrigation facilities, storage and market facilities, is minimal. Public investment for infrastructure development is insufficient to meet demand. The road density for Sobat River basin was 4.4% by area (km/100km$^2$) and 2.24% by population (km/1000 person). In particular, the poor infrastructure for road transport leads to very high transportation costs and long transit time, which impedes collection of products from production areas.

### 6.2.2.2 Existing irrigated schemes in the basin

#### ETHIOPIA

Assessments of existing irrigation and drainage schemes were carried out at country level in the Ethiopian part of the basin. The baseline study showed that there was an increase in number and extent of schemes constructed recently in the basin to overcome rainfall variability and the need to intensify land use due to shortage of croplands associated with increasing number of population. The scheme specific data on technical as well as agronomic performance are presented as follows:

Large Scale Irrigated Schemes

There is no existing operational large scale irrigated agriculture in the basin apart from the ongoing development of Alwero irrigation project which is located in the Gambella Regional State. Detail of status of the scheme is presented in the section 2.2.1, Part 2 of this report.

Small Scale Irrigation Schemes

The Baro-Akobo river basin covers parts of the SNNP, Benishangul-Gumuz, Gambella, and Oromia, regional states. In the regions both traditional irrigated farming is practised and communal owned modern small scale irrigation is also practised in the basin, According to Oromia Economic Study Project Office (OESPO, 1999), the development of traditional irrigation has been practised in different parts of the upper part of the basin in the highlands of Oromia for a century. Though recorded history could not be located, the history of the development of modern schemes doesn't exceed four decades. Wetland edge cultivation with residual moisture locally called 'Bone' is widely practised in the Oromia region part of the basin.

According to this baseline survey, about 64,774.15 hectares of land area were under small scale irrigation schemes benefiting a total of 179,995 beneficiary households during the production year of 2014/15. The status of existing small scale irrigation in different regional states in Ethiopia is listed in Table 6-1 below.

*Table 6-1: Summary of Irrigated Area under Small Scale and Production (2014/15)*

| Region | Area (Ha) | ton | HH | % Area | % Production |
|---|---|---|---|---|---|
| GMB | 3,052.00 | 23,710.00 | 3,470 | 4.71 | 2.83 |
| SNNP | 8,016.17 | 161,729.69 | 43,702 | 12.38 | 19.29 |
| Oromia | 53,705.98 | 653,158.21 | 132,823 | 82.91 | 77.89 |
| **Total** | **64,774.15** | **838,597.90** | **179,995** | 100.00 | 100.00 |

*Source: Computed from field survey, March, 2016*

The total crop production from the irrigated area was 838,597.90 tones. Crops grown in the irrigated area included cereals, vegetable, pulses, root crops, spices, chat and sugar cane. The most widely grown vegetables were onion and tomato and the total land area under these crops was 34,013.78 Ha (52.51%). The total area under pulses was 15,393.53 ha (23.76%). The important root crops grown in the basin were potato, sweet potato, carrot and beet roots and the total land area covered by these crops was 3,626.67 (5.6%). An area of 5185.2 ha (8%) and 1698.46ha (2.62%) was covered by cereals and spices cultivation respectively. Other crops such as chat and sugarcane covered 4,210 ha (6.5%) and total land area under fruits was 648.39 (1%). Basin wise details of cropping pattern are given in Table 6-2 below.

*Table 6-2: Area coverage of different types of crops (2014/15 production year)*

| No | Crop Type | Area (Ha) | | | | % of Total |
|---|---|---|---|---|---|---|
| | | **GMB** | **SNNP** | **Oromia** | **Total** | |
| 1 | Cereals | 185 | 103.1 | 4897.1 | 5,185.20 | 8.00 |
| 2 | Vegetables | 1114 | 5918.18 | 26981.6 | 34,013.78 | 52.51 |
| 3 | Pulses Crops | 1275 | | 14118.53 | 15,393.53 | 23.76 |
| 4 | Root Crops | 175 | 1969.89 | 1481.775 | 3,626.67 | 5.60 |
| 5 | Fruits | 50 | | 598.385 | 648.39 | 1.00 |
| 6 | Spices | 173 | | 1525.46 | 1,698.46 | 2.62 |
| 7 | Others (Chat, Sugarcane), | 80 | 25 | 4105.88 | 4,210.88 | 6.50 |
| | **Total** | **3,052.00** | **8,016.17** | **53,708.73** | **64,776.90** | **100.00** |

*Source: Ibid*

Four categories of small Scale Irrigation (SSI) schemes are recognized in the basin based on water sources and abstraction system. These include (1) traditional (2) Modern (3) pump and (4) Hand dug well

a) Traditional Irrigation schemes

Traditional Irrigation has been practised for quite some times throughout the highlands and part of the middle altitudes including in the Gambella plain. The schemes are generally based on diversion of small streams, with temporary diversion structures constructed by farmers from mud, rocks, twigs or mixture of these. These structures are generally washed away during each rainy season by floods, consequently requiring maintenance or full reconstruction by the beneficiary farmers at the end of each rain season. They generally, range from micro scale to small scale in size and are generally less than 50 ha. The sizes are determined by either the water resource or the land resource available or both. Their water sources are springs and diversion of small streams and use surface irrigation methods. These schemes produce crops for consumption, while some may be intended for commercial purposes particularly vegetables, sugarcane, and fruits such as banana. The operation and maintenance tasks are managed by traditional water use association, lead by "Aba-Laga", the elected association leader. Developed area using traditional scheme to date in the basin was estimated to be about 50,258 ha and it constitutes 77.59% of the total irrigated land area under the small scale irrigation in the Baro-Akobo basin. The distribution of the schemes among the region varies as shown in Table 6-3 below.

*Table 6-3: Irrigated Area (Ha) by Scheme type (2014/15)*

| | **GMB** | **SNNP** | **Oromia** | **Total (Ha)** | % |
|---|---|---|---|---|---|
| Tradition | 2 770 | 6 463 | 41 024 | 50 258 | 77.59 |
| Modern | 150 | 551 | 671 | 1 372 | 2.12 |
| Pump | 132 | 1 001 | 8 962 | 10 095 | 15.59 |
| Hand dug | | | 3 047 | 3 047 | 4.71 |
| **Total** | **3 052.00** | **8 016** | **53 705** | **64 774** | **100** |

. *Source: Ibid*

b) Modern Irrigation schemes

The development of modern small-scale irrigation scheme in Ethiopia started only during the second half of the 1980s, after the devastating famine of 1984/85. The schemes were constructed by the government, NGOs and other funding agencies in an effort to combat drought and contribute to food security as well as improving the standard of living of the beneficiary farmers. The schemes were developed as gravity-fed irrigation systems based on water resources of springs, streams, small rivers, and reservoir or storage. The size of the schemes generally varied from few ha to 200 ha, intended to use permanent and less complicated head work structures as well as water distribution systems with minimal land development works. The aim of the schemes were to increase food security using traditional farming system, though in some cases commercial crops particularly were produced for markets located in the vicinity of schemes or where reliable transport facilities exist to link the site with potential market centres.. A total of about 1 372.25 hectares of land was cultivated to date by modern irrigation schemes which were 2.12% of the total land area developed with the small scale irrigation in the sub basin.

There are also 14 schemes under construction with total land areas of 1 125ha. These include three schemes in Gambella with 600ha, three schemes in SNNPR with 190ha and eight schemes in Oromia with 480ha. The schemes are all scheduled to be finalized and enter into production towards the end of third quarter of 2016.

c) Pumps

The other method of water abstraction is to draw water from rivers to high ground for irrigation by using water pump where water surface in the river is at an economical level below the area to be irrigated. A total of about 10,095 hectares of land area were under small scale irrigation that uses small pumps (10-20 hp) for water abstraction and this accounts for about 15.59% of the total land area under small scale irrigation in the basin (for 2014/15 production year).

d) Hand dug wells

Hand dug wells are used in areas where a shallow ground water resource is available. Water lifting is done manually either by the use of treadle pumps or rope and washer type pump or rope and bucket. The scale of the hand dug well is usually for individual holding and sometimes used along with family drip kits. A total of 3047.91ha of land area were under irrigation using the hand dug well as water source and this accounts for 4.71% of the total land area under irrigation during the production year of 2014/2115.

e) Wetland Farming

(ENTRO, 2009) and (Kassahun et al.,2015), in their research indicated that farmers in the Bench Maji zone around Mizan Teferi, and in Sheka zone around Tepi were practising wetland farming and growing taro (colocasa esculenta), banana, sugarecane, vegetable and maize mostly to secure their food shortage and for some income generation. However, records on the extent of land area under wetland farming and other agronomic performance of the farming in the areas were not available.

Wetland of valley bottom cultivation with residual moisture locally called 'Bone' is also widely practised in the northern and eastern parts of the upper Baro-Akobo sub-basin in East Wollega, West Wollega, Qelem Wollega and Illubabor zones of Oromia Region. Valley bottoms are drained by open drains for cultivation of maize and some vegetables during the long dry season. Some of these wetland farming are those consisting of springs or streams that could supplement the ground water during extended dry season or where the ground water drops deeper than the root zone. During the rainy season, the land remains fallow as it is prone to flooding and seepage from adjacent hill side slope. The open drains are filled by silt and require desilting during each year.

The land area under wetland cultivation in the Oromia Region including Gambella area was about 64,860.50 ha and production during the 2014/15 production year was 168,885.2 tonnes benefiting 129,838 households. Of this number 91% was in Oromia and 9% were in Gambella region in terms of total production from the wetland during the same production year. The area, total production and beneficiary households in Oromia and Gambella Regions are presented in the Table 6-4 below.

*Table 6-4: Wetland Farm Area and Production (2014/15)*

| Region | Area (Ha) | Production (tonnnes) | Households | | |
|---|---|---|---|---|---|
| | | | F | M | Total |
| GMB | 17 428 | 31 770 | 8 859 | 17 987 | 26 846 |
| SNNP | 0 | 0 | 0 | | - |
| Oromia | 47 432 | 328 807 | 2 375 | 100 617 | 102 992 |
| **Total** | **64 860** | **360 578** | **11 234** | **118 604** | **129 838** |

*Source: Ibid*

***Operation and maintenance of the Small Scale Irrigation Schemes***

- Traditional schemes: The responsibility for operating and maintaining the schemes lies on the beneficiary farmers. Traditionally, the beneficiaries organize themselves into associations led by elected leaders, the "Aba-Laga", who coordinate irrigation turns and annual maintenance works: maintenance of diversions, desilting of main canals and regular maintenance works. In some cases, NGOs improve the diversion structures for the farmers to make them permanent to reduce the effort of the farmers. The schemes are more productive than the rain fed farms, and use idle labour during the dry season
- Modern Schemes: Operation and maintenance of small scale irrigation scheme is the responsibility of the beneficiaries through their Water User Association (WUAs) and technically supported by district agricultural offices' subject matter specialists. The main function of water users' associations is to fairly and equitably distribute the water resource among the members and mobilize them for the maintenance works. However, due to limited attention given to strengthen their capacity, they have poor records of performance for most of the schemes. Agricultural offices at district level, which are expected to play a key role in this respect, do not have the necessary staff and commitment in most cases.

### *6.2.2.3 Current water abstractions or uses*

#### LARGE SCALE IRRIGATION SCHEMES

Almost all agricultural investment projects are currently employing rainfed agriculture. The Alwero Irrigation project is the only ongoing large-scale irrigation scheme in the Baro-Akobo basin however only 315 hectares were under irrigation i.e. only 4.128 $Mm^3$ of water per year for the 315 ha at the rate of 13,106 $m^3$/ha/year and the remaining area was under construction by the private company, Saudistar.

*Table 6-5: schemes under operation in the basin*

| No | Sub catchment | Scheme under Production | Scheme under construction | Study & Design | Planned | Total | Remark |
|---|---|---|---|---|---|---|---|
| | | (ha) | | | | | |
| 1 | **Saudistars- Alwero Irrigation - Private company** | | | | | | |
| 1.1 | Alwero | 315.00 | 9,685.00 | | | 10,000.00 | To be finalized in 2020 |
| | **Total** | **315.00** | **9685.00** | | | **10,000.00** | |
| 2 | **Farmers managed Small Scale Irrigation Scheme** | | | | | | |
| 2.1 | Gillo | 40.00 | | | 200.00 | 240.00 | Farmers managed Small-scale Schemes |
| 2.2 | Alwero | 700.00 | 200.00 | | 600.00 | 1500.00 | |
| 2.3 | Baro | 2312.00 | 400.00 | | 600.00 | 3312.00 | |
| 2.4 | Gaba | 25155.60 | 1200.00 | 190.00 | 12473.60 | 39,019.20 | |
| 2.5 | Birbir | 36566.55 | 345.00 | 185.00 | 36525.97 | 73,622.52 | |
| | **Total (ha)** | **64,774.15** | **2,145.00** | **375.00** | **50,399.57** | **117,693.72** | |

a Farmers managed schemes under construction are planned to be finalized towards the end of 2016

b All farmers managed schemes under study and design and planned schemes are planned to be finalized in 2020

### 6.2.3 Hydropower and Interconnection

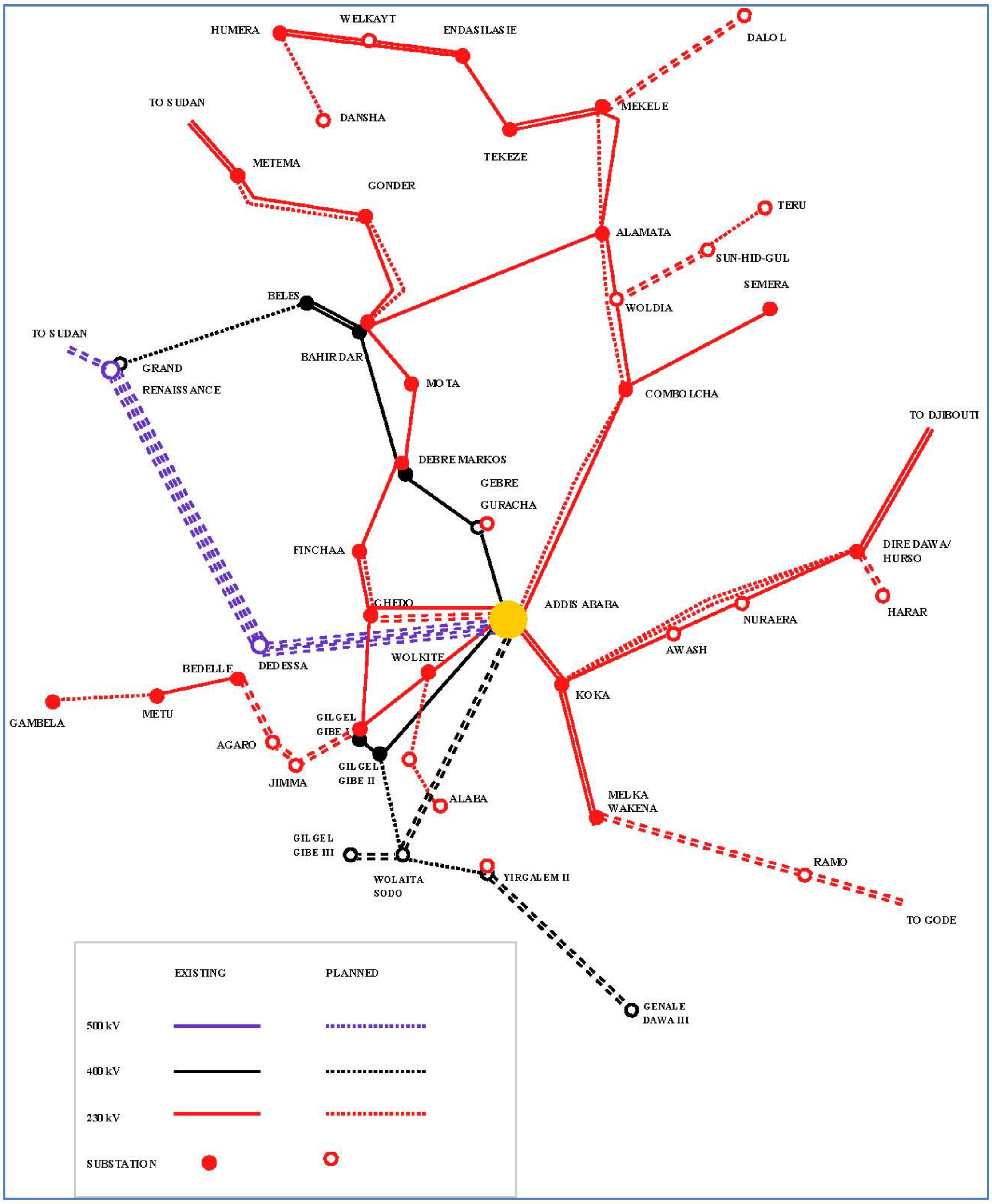
#### *6.2.3.1 Existing infrastructure in the basin*

Ethiopia is a member of the East Africa Power Pool (EAPP). The main objective of the EAPP is to provide among the member countries a robust power system. This in turn requires various generation units disseminated in the area covered by the Power Pool and an extensive network of interconnectors in order to ensure that the regional electrical system is reliable. Much effort has been directed towards the development of both generation and transmission and in particular a number of regional generation and transmission planning studies have been completed in the last few years at the regional level (AECOM, et al., 2011; SNC-Lavalin & al, 2011; Energynet.dk & EA Energy Analysis, 2014).

Because of its geographical location and endowment in hydropower resources, Ethiopia occupies a key position within the EAPP. The country is one of the main sources of power generation either existing or planned to be developed in the next 20 years and located strategically to provide interconnection between the Southern part of the region (Kenya) and the Northern part (Sudan, Egypt). At the National level, a generation and transmission planning study has recently been completed that describes among others the current situation of the Ethiopian connected power system (Parsons Brinckerhoff, 2014).

With respect to the study basin, BAS, a major effort has taken place to connect the main load centres of the country to the integrated network. Figure 6-1, reproduced from the PB generation planning study shows the current national high voltage transmission network.

*Figure 6-1: Current Ethiopian high voltage transmission network*




With reference to the BAS sub-basin the extension of the 230 kV network to the south west has been completed along the route Gilgel Gibe-Jimma-Agaro-Bedele-Metu-Gambella and is currently being commissioned. This represents the major infrastructure in the sub-basin.

### 6.2.3.2 Energy sources used in the basin

Once the 230 kV line to Gambella is fully functional, it will represent the major energy source of the basin. Connected to this line is the existing small scale Sor HPP whose characteristics are:

- Installed capacity 5 MW;
- HPP type run-of-river (no reservoir);
- Rated head 210m;
- Rated discharge 15 $m^3$/s.

With the exception of urban centres, most of the basin is not connected to the grid. In this respect, in 2009, 89% of Ethiopia's population lived in rural areas and rural electrification was estimated at a mere two per cent (UNIDO & ICSHP, 2013). This reference also states that in the basin of interest, there is no other existing HPP however small, mini or micro but Sor. In addition there are a number of diesel generators whose total capacity did not exceed 5 MW some 15-20 years ago (TAMS-ULG, 1997e). Current aggregated thermal capacity within the basin has not been updated. The BAS sub-basin is one of the least developed areas of the country hence the rural population has access to traditional sources of energy, mainly biomass fuel.

The South Sudan portion of the sub-basin is also in the same condition, without access to an integrated power network. Only one per cent of the South Sudan population has access to power, though intermittently during a 24-hour period. Only seven per cent of the urban areas in South Sudan are electrified and virtually no rural areas have electricity, because the formal energy sector is limited to only the South Sudan Electricity Cooperation which operates eight diesel generators with a capacity of 1.5 MW each (UNIDO & ICSHP, 2013).

### 6.2.3.3 Level of electrification in rural, peri-urban and urban areas

According to the information obtained, the level of rural electrification in the BAS sub-basin is currently nil, although with the new interconnector to Gambella, the situation may change at least in the medium term in Ethiopia if one considers the level of effort throughout the country. The Rural Electrification Fund (REF) with its loan programmes for diesel-based and renewable energy based projects is the main implementing institution. With an initial budget of €29 million, REF has been supporting 180-200 rural micro-hydropower and photovoltaic (PV) mini-grids for educational and health care facilities. The fund provides loans up to 95 per cent of investment needs with a zero interest rate for renewable energy projects. Renewable energy technologies that receive support under this programme include solar PV, mini- and micro-hydro, and biomass co-generation (UNIDO & ICSHP, 2013).

In peri-urban and especially in urban areas, the situation is evolving rapidly with the addition of the high voltage line to Gambella. Precise information on current levels of electrification have not been obtained for the BAS sub-basin. This information is available countrywide and not detailed at the regional level.

### 6.2.3.4 Current energy production in the basin

No information could be identified that provides the MW capacity of the line to Gambella. However the PB transmission planning study specifies that the Metu-Gambella leg of the 230 kV line consists of a single circuit on double circuit carrying poles, indicating that a second line can be installed as the need arises. This single line size can typically carry around 200 MW. It should also be noted that this line will eventually be extended to Malakal in South Sudan where part of the power carried by the line will be exported.

It should also be noted that the information provided in the various generation and transmission planning studies on current energy production provide information at the country level but not the in-country regional level.

## 6.2.4 Livestock farming

### *6.2.4.1 State of Livestock production and watering in the basin*

#### *6.2.4.1.1 Production Systems*

**INTRODUCTION**

Three production systems are observed in the Baro-Akobo-Sobat (BAS) basin namely pastoral, agro-pastoral and mixed farming systems. In all of these production systems, livestock play multitude of economic and socio-cultural functions. They are the means for store wealth and providers of food and income. Milk is the most important nutritious diet derived from livestock in both production systems, though its supply drops during the dry/drought periods due to feed scarcity and limited access to drinking water. Among ruminants, small ruminants stand out as important sources of cash required to buy food items and meet incidental household expenses. Equines (donkeys and mules) and camels play vital role in transporting goods and people throughout the basin. The features of the three production systems are described below briefly.

**PASTORAL SYSTEM**

The pastoral production system covers a wide stretch of land lying along the either sides of the marshlands in Ethiopia and the South Sudan where the natural vegetation is predominantly Savannah grassland and shrubs. Livestock rearing is the sole livelihood strategy. Land and water degradation is serious threats of the production system and the underlying cause of low livestock productivity. The natural resource degradation and the under utilization of the inaccessible pasturelands are associated with inadequate distribution of livestock watering points.

**AGRO-PASTORAL SYSTEM**

Local communities in much of the Gambella and the north western parts the upper catchment in Ethiopia, and the States in South Sudan close to the flood plains follow an agro-pastoral mode of production. In addition to livestock rearing, local communities in these areas practice retreat farming to compliment food and income generated from livestock. The food that the agro-pastoral households produce from farming often is inadequate and do not last them to the next harvest because of frequent flood damage, low production capacities and high humidity hampering storage.

On the Ethiopian side, large scale irrigated commercial farms are also expanding along the big rivers. The proliferation of such farms would likely intensify the competition for water and may marginalize agro-pastoralists and herders and create tension. Pressure on land and water is further aggravated by the exclusion of land for game reserve.

**MIXED CROP-LIVESTOCK FARMING SYSTEM**

This system of production is predominately found in the upper part of the basin – the Zones in Oromia and SNNP Regions of Ethiopia. This system of production comprises the inset-(false banana) livestock, cereal-coffee-livestock and cereal-livestock subsystems. In all these sub-systems, livestock are the integral parts of the subsystem contributing manure and traction power for the crop sub-component. Unfortunately only few livestock keepers who practice farming use the available manure due to lack of knowhow and labor for gathering, transport and spreading. Introducing the oxen-traction technology in the other parts of the basin where the weather for crop farming is suitable and households practice hoe cultivation is important. The hoe cultivation is practice drudgery and backbreaking. Combined with appropriate equipment, use of animals to generate farm power could maximize benefit derived from livestock. Farm implements are now available in Ethiopia that conserve moisture and help crops complete growing cycle or reach maturity in the events of early session of rain.

Overgrazing, misuse of crop residues, and the degradation of water and vegetation are the major causes of inefficient utilization of the surface water resources for livestock production.

#### 6.2.4.1.2 Species and distribution of livestock

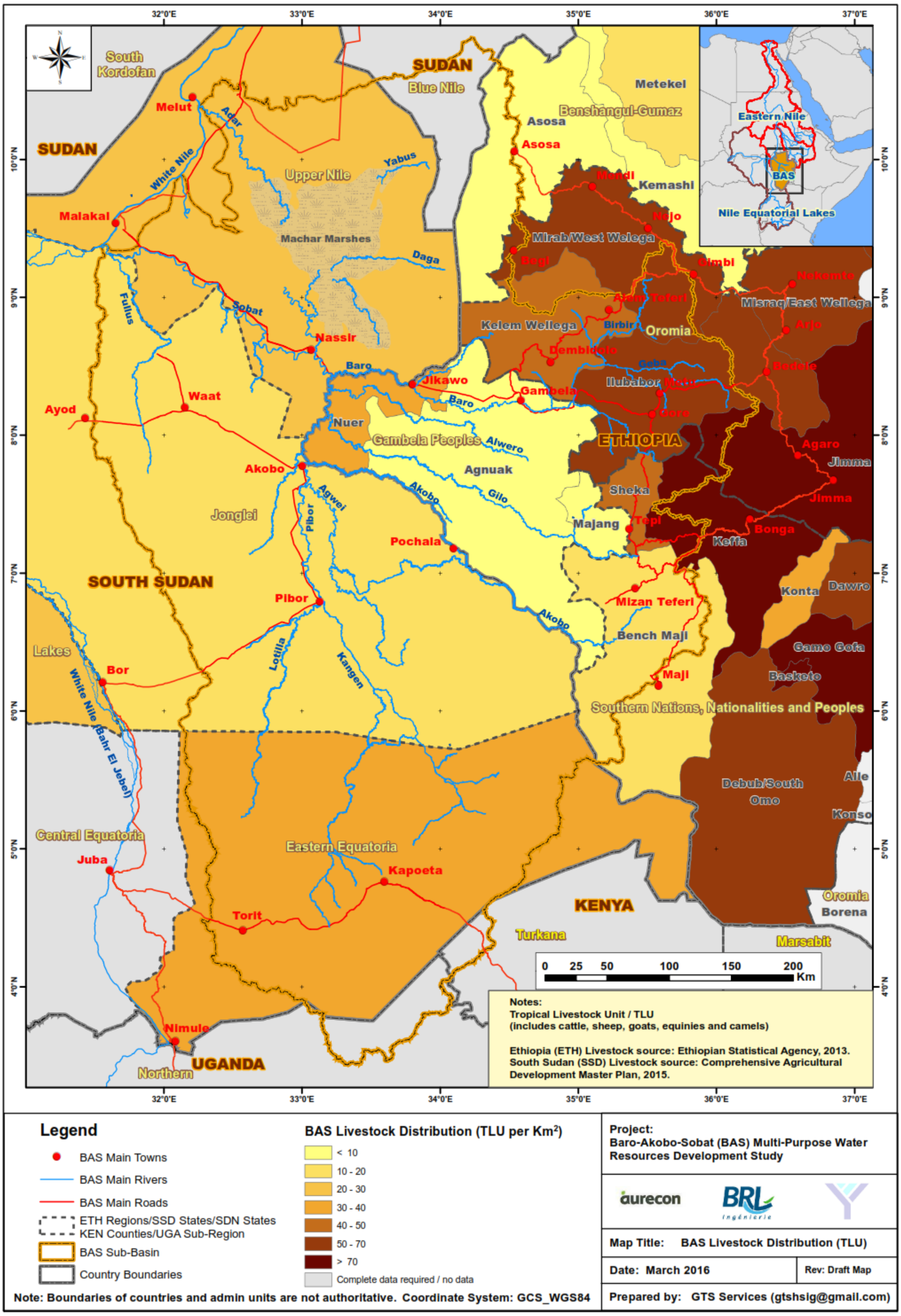
Cattle, sheep, goats, and equines are the major herbivores species reared in the basin. The BAS basin has over 25.5 million heads of domestic herbivores population, of which 10 million are cattle, 6.5 million, sheep, 9 million goats, 0.02 million equines (donkey, mules and horses) and 0.01 million camels (refer to Table 6-6). The density of the livestock population within the basin expressed in Tropical Livestock Unit (TLU) is shown in Figure 6-2. Expressing the livestock density in biomass eases comparison across geographic locations. A conversion factor (where one TLU is equivalent to 250 kg live weight animal) was employed to change the domestic herbivores population into TLUs.

Biomass wise, cattle and small ruminants (sheep and goat) account for 86.4% and 8.2% of the herbivores livestock population, respectively. Communities have good reasons to keep different inter-specific mixes. Keeping different species mixes enable owners meet the need for livestock produces notably milk throughout the year - goats and camel in the herd ensuring the supply of milk well into the dry season at the time when cows cease producing milk. The inter-species herd proportion is also influenced by the availability of water. Where there is shortage of water, the proportion is skewed to the moisture tolerant species such as camel and goats than cattle or sheep.

Due to the relatively higher population strength, cattle exert more pressure on the grazing resources including pasture and drinking water and more importantly associated with grazing land water resources degradation. Across the basin, number of cattle owned generally signifies symbol of social status, with the poor possessing few heads of cattle or only small ruminants. This has an implication on overall food security and ecosystem health. Where appropriate, reversing the inter-species balance in favor of small ruminants will positively contribute to food security and the sustainable management of the ecosystem. In terms of management small ruminants require less feed and their needs are more compatible with available grazing/browse resources and ideal to reach out the poorest of the poor. Above all, small ruminants are efficient feed converters and have higher reproductive and off-take rates.

The livestock repartition in the BAS basin is shown is the figure here after.

*Figure 6-2: BAS sub-basin – livestock repartition*



### 6.2.4.1.3 Livestock husbandry practices

Although some level of variability exists amongst different livelihood and ethnic groups, the application of improved livestock husbandry practices is very much limited throughout the basin. Pastoralists, agro-pastoralists and farmers alike do not practice controlled seasonal mating, culling, rangeland enclosures, hay making, forage production, parasite control and water harvesting. Irrespective of the production systems, livestock keepers have the inclination and the desire to keep large number of herd despite the negative impact of the practice on livestock productivity and the natural resource.

Given the above mentioned livestock husbandry practice gaps, there is an obvious need for continued dialogues with the livestock rearing community and building the technical skills and knowledge of the livestock keeping households. Such measures are vital for improving the socio-economic benefit of livestock to their owners, and the conservation of water and the sustainable management of livestock and the grazing resources.

### 6.2.4.1.4 Livestock feed

Irrespective of the parts of the basin, feed shortage constrains livestock production. Causative factors for the inadequate supply of livestock feed are many and differs from one part of the basin to the other. In the upper part of the basin, for instance, the continued conversion of grazing lands to crops and the increase in livestock population are the over-riding challenges. In the agro-pastoral areas of the lower basin, seasonal flooding and the absence of tradition to conserve excess fodder in the form hay is the major cause for the imbalance of the feed supply. For the pastoral systems, overgrazing around watering points and inaccessibility of rangelands distant from watering-points are the major problems.

Grazing, which depends on native pasturelands, constitutes the most important sources of livestock feed in the basin. The pastureland vegetation across the basin varies considerably largely influenced by altitude and rainfall pattern. In places lying along the marshes and the river courses, the transitional vegetation, i.e. tall grasses interspersed with bushes and trees account for the major vegetation cover. In the upper part of the basin and high lying areas in between, the vegetation is dominated by higher density of pro-climax tree species, grasses with scattered trees and multi-storey crops. Where managed and utilized properly, i.e. the livestock density adjusted to the utilization of about 50% of the annual primary biomass production of the pasturelands, huge opportunity exists to increase the efficient and sustainable use of water along the grazing landscape. As it stands now, grazing lands are over grazed, at least around watering points.

Crop residues are important as livestock feed source increase where the share of crop lands in the land use system is significant. These include geographic areas of the upper parts of the basin and the pocket agro-pastoral systems across the basin. The *in situ* grazing of crop aftermaths and crop residues (mainly millet and maize) compliments the feed needs of animals at least for a brief period of the year. From the viewpoint of agricultural water use, the practice of feeding animals with crop residues has considerable economic advantage. Basically, the crops are grown primarily for their grain yield and hence little additional water is required to produce the crop residues. Therefore, the efficient use of crop residues through timely conservation, processing and treatment while sustaining reasonable livestock production minimize the pressure on the available water resources.

Though the edaphic and the climatic conditions are suitable for growing tropical and subtropical forage crops, literally the culture of forage crop production to bridge the seasonal feed supply is non-existent in the BAS basin. Introducing and promoting cultivated forage undoubtedly boost livestock productivity and the socio-economic welfare of livestock keeping communities. As forage genotypes differ in their water demand, the use of high water demanding forage genotypes could increase the competition for water. Among forage crops, those plant species using the C4 photosynthetic pathways (grasses - e.g. Sudan grass) require less water for their production than species using the C3 photosynthetic pathways (e.g. legumes) and hence are the most preferred choices.

#### 6.2.4.1.5 Livestock health care

Hosts of diseases and parasites pose serious challenge to livestock production in the entire basin. Among the parasites, Trypanosomiasis is the biggest impediment to the livestock rearing particularly in place with dense vegetation and humid climate. The widespread problem of Trypanosomiasis in these areas is the major disincentive for the adoption of oxen-based land preparation.

Absence of watering facilities such as troughs that help to physically separate livestock of different species and age groups along the perennial rivers and other natural water sources does also compromise domestic animals' state of health as it encourages disease transmission.

The proper management of such animal health problems will substantially increase animal production per unit of water utilized for production of feed and livestock consumption. However, if left uncontrolled parasites and diseases could cause high morbidity and mortality amongst all livestock species.

### 6.2.4.2 Assessment of the production and contribution to the socio-economy of the region

#### 6.2.4.2.1 Livestock and livestock products marketing

The trading of livestock products specifically those of milk and butter is non-existent or at best under developed in the BAS basin. Trade of live animals takes place throughout the basin, although the level of its development varies amongst the socio-economic groups and production systems. The major challenge for livestock marketing is price fluctuation. Livestock prices fluctuation from year to year and within the year, and this was identified as the major problem. Another fact is that livestock is largely seen a social mark of prestige and is mainly exchanded.

Increase in population, particularly the proliferation of towns in the basin will increase the demand for livestock and livestock products. To meet this demand, among other things the livestock keepers have to invest time and resources for better and sustainable supply of feed and water, e.g. irrigated forage production and the construction of good livestock watering facilities. These will substantially increase the requirement of agricultural water. The traditional way of livestock rearing where food and water are regarded as God given resources could not allow to exploit such an opportunity. However, it should be noted that new generations are keen to access market for income.

#### 6.2.4.2.2 Livestock development policies and strategies

The governments of both Ethiopia and South Sudan have elaborated nation-wide livestock subsector policies, strategies and programs contributing to the national economy, improved food security, job creation and reduction of poverty. These policies and strategies have wider application to the basin. From the Ethiopian side, the recently issued GTP2 (2016-2020) and Livestock Master Plan (2015-2020), sets an ambitious targets for the subsector. Similar livestock developments are foreseen in the CAMP (2015-2040) road map of the Southern Sudan. In the light of the relatively low under development of infrastructure (roads, livestock water points and animal health care facilities) and the huge skill gaps, meeting the set targets in these policies and programs would remain a daunting challenge. The other serious challenge is the heterogeneity of the production systems and the socio-cultural diversities, which necessitates tailoring the strategies and intervention schemes to meet the specific biophysical environments and socio-cultural settings.

From the context of agricultural water use, provisions have been made for livestock water, at least within the framework of the Water Sector Policy in Ethiopia. Ethiopia's Livestock Water Supply Policy emphasizes the necessity of availing adequate, quality and reliable water for livestock. The policy also underscores the necessity to engage the livestock keepers in the development and cost-sharing through 'user pays' principle with willingness and ability to pay.

To this end, the government and development partners in Ethiopia are working to materialize this aspiration, though the level of achievement within the BAS basin is far short of the plan. The coverage, quantity and quality of water supply infrastructures particularly that intended for livestock are among the lowest in the country. This has negative implication on livestock production and productivity, and hence the socio-economic wellbeing of the livestock keeping population.

The problem of seasonal water shortage is specifically critical for pastoral communities of residing within the basin. Here, pastoralists are forced daily to trek their animals longer distances to watering points under high temperature and often insecure conditions. Water supply sources for these households and their animals are mainly perennial rivers. As these water sources are often polluted and lack mechanism to refine them, the communities are predisposed to water-borne diseases such as diarrhea, bilharzia, and amoebic dysentery. No less serious is the livestock water supply in the agro-pastoral and mixed farming areas. Here, too, the problem of livestock water scarcity escalates during the dry season.

Depending on the cultural, topographical, hydrological and financial circumstances, different kind of investment in livestock water infrastructure may be sought. These may include the development of ponds, machinery or hand dug wells, boreholes, micro-dams and cisterns. In all cases, however, it’s essential to relate the placement of such water points with the carrying capacity of the grazing resources. Misguided water development initiatives will result in the degradation of the rangelands and the environment at large.

### *6.2.4.3 Livestock Watering demand*

The livestock water resources availability and distribution across the BAS basin greatly varies in space and time. Places in close proximity to the perennial rivers have less of a problem of access, though they have the problem of utilization. But the largest share of the grazing lands has serious water access difficulties particularly during the dry periods.

Rivers flow in the BAS basin reaches its peaks during the months of July to September when the rainfall is the highest. This is the period where much of the lower lying areas are flooded and become inaccessible to livestock. Till the water recedes, livestock graze distant upland grazing areas. Ephemeral water sources such as shallow natural ponds, springs and streams supply water required by livestock during the rainy season. As the water start to recede, livestock start to move into the grazing grounds in the flooded areas and along side the water courses of Baro, Alwero, Gilo, Akobo and Pivor Rivers. The impassable swamps and marshes that stretches from the lower courses of Baro-Akoba to Sobat deep into the Northern part of South Sudan serve as fallback grazing areas at least on its outer edges. Surface water from these rivers is directly used by livestock. In some places within the basin, rivers/streams are diverted for downstream irrigation users and livestock via canals or trenches.

Throughout the basin, treatment of water from natural sources or the use of troughs is largely uncommon. No deliberate attempt so far on livestock water development. Largely livestock use natural water sources and to a limited extent share water developed for people. Livestock watering infrastructures such as hand dug wells, ponds, and micro-dams are also few and their use is largely limited to human use. For existing water infrastructures, the level and care accorded by the communities is largely poor. Experience in other areas show that such modern infrastructures are often abandoned soon after opening to service. The causes of unsatisfactory utilization include:

- Low involvement of the local community in the planning, designing, and implementation of water infrastructure
- Lack of ownership and absence of cost sharing mechanism
- Technical and organizational gaps of the local communities to effectively manage the livestock water infrastructures
- Limited awareness of the local communities on the benefits and consequences of mismanagement
- High maintenance cost and lack of spare parts

To redress the knowledge and attitudinal gaps in the management of these infrastructures, there is considerable need for community awareness creation, build sense of ownership, develop capacity through training, and strengthening the organizational aspects. Besides, these interventions do require strong financial and institutional capacity, both of which are lacking at the present.

The type and number of water infrastructure schemes to be developed depends on livestock needs. However, it is often difficult and economically unfeasible to develop water infrastructure everywhere needed. Among others, the investment in livestock water development should be weighed against the anticipated beneficiary population, subsequent management and its environmental impact. It is also important to assessed prospective investments in the light of the traditional grazing resources management notably with respect to the alignment of seasonal livestock migration routes and settlements patterns.

The investment in livestock water development can be seen from two standpoints. First one is the availing of water for livestock consumption, while the second is the water required for fodder production. In the context of the BAS basin, the first one is the most important. Existing livestock water points rely on the naturally available water sources such as rivers, streams, springs and ephemeral shallows ponds. Livestock water supply from these sources is largely inefficient due to lack of livestock watering facilities (troughs) and the seasonality of the ephemeral water sources. This will call for the construction of new livestock watering points and livestock watering troughs catering for large and small stocks.

The construction of new watering points in inaccessible pasturelands will spread out the grazing pressure and allow the effective use of pasture in such areas. More livestock watering points in strategic locations also help overcome the contamination of drinking water and excessive run-off, which presently are very serious around the natural water sources. In addition to these; the development of livestock watering points in inaccessible places will have the following benefits:

- ensure the year round water supply particularly in place far away from the perennial rivers
- increase the chance of off-season gardening and fish rearing that could improve household nutrition, income and employment
- improve animal health and nutrition and the incidences of conflicts and livestock losses through theft
- surface reservoirs increase ground water recharges and wells or boreholes in the vicinity
- help collect surface run-offs and thus reduce erosion
- enable the fodder tree and grass planting thereby increasing the availability of supplementary quality fodder for animals

The main areas of investment employing modern abstraction technologies for livestock watering may include the following:

- Shallow hand dug wells in the flood plains and along the river courses protected and fitted with hand pumps. Water could be reached within the depth of 20 meters.
- Boreholes can be constructed in dry stream beds or at river banks with sufficient protection of the well heads from flood. Well heads have to be built higher than the river bed with concrete rings and cover to protect it from siltation. They are relatively deep (deeper than 70 meters).
- Springs capping for point source or gravity supply. These water sources are more relevant for the upper parts of the basin and lasts for short period of time during the rainy seasons. But could be stored in walled containers.
- Ponds and cisterns as water harvesting schemes along the protected watersheds' small catchment areas. Runoffs so harvested could meet temporary livestock water needs.
- Micro-dams constructed on small streams with the water also used for fodder/horticultural crops production. They are constructed from earth dams and if managed properly, the store large amount of water.
- Deep water wells fitted with motorized pumps away from rivers and to encourage the use of distant grazing lands. Such wells continue to supply water even when the water tables fall at the peak of the dry season.

There is a consideration that needs to be taken into account while carrying out livestock water point development. One of these is the need to match water point development with livestock water requirements. Livestock water requirements vary with the species, breed and production states of the animals and the season of the year. Water requirements of livestock, for instance, are lower for tropical cattle breeds (*Bos indicas* cattle) than temperate cattle breeds (*Bos taurus*). Likewise, the water requirement of animals rises by a factor of 5-10% of body weight in dry as compared to wet season. A more conservative water requirement estimate for livestock ranges from 20 to 50 liters per TLU. Taking the commonly used figure of 25 liter of water per TLU, the annual livestock water consumption requirement for livestock in the basin at the current livestock population is over 78.9 million $M^3$ water. Table 6-6 below shows the annual water requirements of livestock in different parts of the basin by species.

*Table 6-6: Estimated livestock water requirement*

| Zone[1]/State[2] | Cattle ('000) | Sheep ('000) | Goats ('000) | Equines ('000) | Camel ('000) | All species in TLU ('000) | Annual water demand ('000) |
|---|---|---|---|---|---|---|---|
| Asosa | 31 | 9 | 70 | 11 | - | 35 | 319 |
| Kelem Wellega | 379 | 184 | 88 | 45 | - | 315 | 2 871 |
| Ilubabor | 742 | 276 | 151 | 71 | - | 597 | 5 452 |
| Sheka | 137 | 64 | 22 | 12 | - | 110 | 1 008 |
| Bench-Maji | 181 | 73 | 43 | 6 | - | 142 | 1 293 |
| Majang | 21 | 6 | 2 | 1 | - | 16 | 143 |
| Agnuak | 29 | 1 | 19 | 0 | - | 22 | 203 |
| Nuer | 213 | 41 | 59 | NA | - | 159 | 1 450 |
| Upper Nile | 1 435 | 1 076 | 1 674 | 0 | 6 | 1 286 | 11 733 |
| Jonglei | 1 695 | 895 | 222 | NA | - | 1 298 | 11 844 |
| Eastern equatoria | 1 889 | 1 813 | 3 928 | 2 | 1 | 1 898 | 17 317 |
| **Total** | 6 750 | 4 439 | 6 278 | 147 | 7 | 5 878 | 53 633 |

*Source: Ethiopian Statistical Agency, 2013; Comprehensive Agricultural Development Master Plan, 2015.*

The use of water to grow fodder is literally not practised by the livestock keeping communities of the basin. However, the potential for irrigated fodder development in the basin is quite enormous. In places where irrigation is feasible, fodder production could be treated along with food crops. The practices of sustainable grassland management, which improves grass cover and infiltration of rain water, would work towards the increased availability of feed and water to livestock.

It is evident from the **livelihood map** shown in Figure 4-9 **that livestock are very important in the BAS catchment** in South Sudan and in some parts of Ethiopia, as indicated by the name of some of the livelihood areas of the BAS.:

- SSO5: Semi-Arid Pastoral, except in the high lying areas to the south (Eastern Equatoria; Jonglei);
- SS06: Eastern Plains Sorghum and Cattle (Jonglei);
- SS10: North Eastern Maize and Cattle, except in the eastern high lying areas (Jonglei);
- SS10: North Eastern Maize and Cattle (Upper Nile);
- SS11: Sorghum and livestock (Upper Nile);
- GAG: Gambella Agropastoral (Gambella);

- MMC : Mendi-Dabisu Maize, Sesame & Cattle (Oromia);
- NTC : Nole-Meko-Diga Teff & Cattle (Oromia)
- QBC: Keto-Begi Cereals & Cattle (Benshagul-Gumaz);
- SDP : Surma Agro-Pastoral (SNNPR);
- SPO : Salamago Pastoral (SNNPR).

The report **South Sudan Development, Utilization and Management of Water Resources, Rapid Water Sector Needs Assessment and a Way Forward** dated August 2012 which was prepared by the Water Resources Unit of the Sustainable Development Department of the World Bank indicates that in 2010 there were 895,000 cattle in Eastern Equatoria, 1,475,000 in Jonglei and 990,000 in Upper Nile.

Water consumed per head of cattle is 20 to 100 l/day (70 to 100 l/day for lactating cattle). During the dry season when water sources dry up farmers and pastoralists follow the patterns of water availability, whereas during the wet season they usually depend on water and grazing land in the vicinity of their homesteads and camps.

Livestock is mainly perceived as a financial saving by many livestock keepers, particularly nomadic and semi-nomadic. Many of pastoralists keep cattle not for meat and milk production but as a symbol of wealth, and for the pastoralists the number of cattle is more important than their quality. On the other hand livestock milk constitutes the main diet of pastoralists. Livestock is traditionally the major sole source of prestige among the cattle-keeping groups and the currency for marriage arrangements, fines and other social transactions. The majority of cattle transactions (80%) take place within this context. Cattle sales, unless forced by circumstances are still unusual though the domestic livestock market is growing.

The development of water facilities for livestock has been ad hoc. More recently, pilot experiments have been carried out to construct haffirs and technical guidelines, specifications and type engineering drawings have been developed by the Ministry of Irrigation and Water Resources of Unit State and MWRI. The sustainability of haffirs may be questionable if the arrangements for sustainable use and O&M at community level are not clear. The Ministry of Livestock and Fisheries have carried out surveys in several areas for the design and construction of water facilities, and Sweden is supporting a similar approach in Jonglei State as a part of the national food security program. These interventions are progressive steps towards the systematic development of water for livestock.

The Water, Sanitation and Hygene Sector Strategic Framework of the Republic of South Sudan, Ministry of Water Resources and Irrigation, August 2011 states that conflict over water resources is common in the selected areas, particularly during the dry season when water scarcity often forces people to migrate. Conflict prevention and mediation capacity is an important tool to pre-empt and offset problems arising from competition for scarce water resources by farmers, livestock keepers, domestic consumers, and other users and stakeholders.

### 6.2.4.4 Conclusion

The overall livestock production system in the BAS basin was analyzed in the context of agricultural water development, management and utilization. The analysis covered areas such as livestock species distribution, husbandry practices, feeding and health systems, sources of livestock water and its management, marketing, and the policy and institutional environments around livestock water development, which ultimately used to identify sets of key issues. It is envisaged that the identified issues will guide the formulation and preparation of programs and projects that leads to the sustainable development of livestock watering points and the eventual transformation of the livestock sub-sector.

In its totality, the identified issues revolve around cases compromising the supply and quality of water intended for livestock production. Identified issues and suggested options include strategies maximizing the productive use of agricultural water such as improving the spatial distribution, conservation, and the proper management of livestock water sources. The key issues and follow-up actions are presented as follows:

- **Neglect of livestock in water development programs**: Livestock water use in the basin is largely inefficient and often implicated with water pollution and the degradation of the natural resources including that of water. Partly these problems are associated with disregard or the total neglect of livestock in the human and agricultural water development programs. The BAS basin project recognizes livestock as an important component of the agricultural water use and foresees the huge benefits of this viewpoint. Due consideration of livestock in the water development programs apart from improving livestock productivity per unit of water and could help make provisions that minimize or avoid the undesirable consequences of livestock on natural resources including water.
- **Temporal and spatial shortage of livestock water**: For the largest part of the basin, mismatch between livestock population and the available grazing resources (water and pasture) are implicated with natural resource degradation and poor livestock productivity. The water shortage is phenomenon is a year-round problem in the grazing lands distant from perennial rivers but transitory and seasonal in most parts of the basin. Investing on livestock watering points in such places will boost animal productivity and benefits derived from livestock rearing. To be cost effective and sustainable, such water points' developments should take into account the livestock density, local suitability and simplicity of the scheme, and the potential of the grazing resource. The water development schemes could employ one or more of the following strategies:
  - Development of livestock water points (dugouts, micro-basins, boreholes, and cisterns) in strategic positions to strike an optimum balance between livestock population and available pasture. This will avoid the over grazing of pasturelands near and around rivers and the under utilization of feed in inaccessible pasturelands.
  - Conserve water across the landscape through better management of existing watering points
  - Shift the species mix in favor of small ruminants. Across the BAS basin, cattle make up the largest share of the livestock population. Tipping the species mix balance in favor of small ruminants will reduce the overall livestock water demand and ensure the water investment benefit to trickle through the disadvantaged segments of the livestock keeping population.
- **Inefficient livestock water conservation**: This is the problem experienced along most livestock watering points like rivers, streams and ponds. During watering time, herders let livestock of different species and age groups to drink directly from the watering points. In the process animals pollutes the drinking water through defecation and impart serious damage to vegetation in the vicinity of watering points. The construction and placement of watering troughs around the existing natural watering points leads to increased water use efficiency and sound management of the grazing resources. The watering troughs can be adapted to the local situation and should have designs that accommodate small and large stocks in separate units.

- **Lack of community involvement in the development and management of livestock water points:** As it stands now, the involvement of the livestock keeping communities in the development and management of livestock water points are minimal. Water is largely regarded as good given resources and little is done to improve its availability and management. A lot have to be done to secure the full engagement and effective livestock water points' management of the livestock keepers in all production systems. These could be done in several ways. Most important ones include:
  - Engage livestock keeping communities in the planning, implementation of water development programs and projects
  - Establish and capacitate livestock watering point managing bodies or committees with due consideration to the local customs and traditions
  - Negotiate how best to engage livestock keepers in sharing of the cost for maintaining and managing watering facilities, a condition vital for the sustainability of watering schemes
- **Low capacity of the institution responsible for livestock water development:** The existing livestock water management policy clearly states the actions to be taken in order to increase the availability, quality and needs. At least this is so for Ethiopia. Unfortunately, the institutional support to translate the policy into action is absent in the entire basin. Clarifying responsibility and equipping the institutions concerned with the necessary skills and facilities is of paramount importance for sustainable development of livestock water resources. It is equally important to strengthen the inter-institutional linkage and collaboration among key partner institutions.
- **Low level of livestock productivity per unit of water:** Limited application of improved livestock and water management practices is among the causes of low livestock productivity per unit of water. The intensification of livestock production wherever it is feasible within the basin, could allow livestock owner get the best out of the subsector. Livestock interventions complimentary to the conservation and efficient utilization of water include the following:
  - Promote sound grazing lands management practices that encourage the maintenance of adequate vegetation cover, increase rain water infiltration and reduce run-off. Such practices would stabilize the water supply of upstream and downstream population within the basin and can be linked with water harvesting technologies that increase the availability of water to livestock and human beings.
  - Wherever appropriate, introduce and scale up the production and use of forage crops with high water use efficiency. Year round livestock productivity could be maintained by growing fast growing and nutritious forage crops such as Sudan and Elephant (*Pennisetum*) grasses where the rainfall and supply of irrigation water is reliable.
  - Promote technologies enhancing the efficient utilization of crop residues. In the agro-pastoral and mixed farming systems of the basin, efficient use of crop residues would enhance the supply of feed without the use of additional water. This strategy help bridge the widely observed seasonal feed deficit in these two production systems.
  - Enhance livestock production and reproduction efficiency through curative and preventive veterinary practices. These involves the periodic vaccination of animals against major diseases, control of internal and external parasites including the vector transmitted Trypanosomiasis. Hosts of Trypanosomiasis control measures are now available, which help increase livestock number in the less densely populated areas such as the middle of the basin along the major rivers and marshlands. Furthermore, strengthening the animal health regulatory standards and quarantine system help overcome live animals and animal products trade restriction of the export market.
  - Support the increased integration of livestock keepers with the mainstream market. The increased market-orientation and the trading of livestock and livestock products will become a motivational factor for livestock keepers to invest on water and feed development and management schemes. Market integration, would require overcoming barriers such as high transaction costs, the under development of feeder roads, limited access to market information, and shortage of feed and water along livestock marketing routes.

## 6.2.5 Fisheries and Aquaculture

### 6.2.5.1 Current situation of fisheries and aquaculture in the basin

#### THE UPSTREAM AREAS WHICH ARE SOURCES AND ORIGINS OF TRIBUTARY RIVERS TO THE MAIN BARO-AKOBO-SOBAT RIVERS

These streams and rivers are found within the Oromia and Southern Regions of Ethiopia covering about 22,457 km2 and 15,653 km2 areas, respectively, which is within the BAS system. These rivers are fast flowing higher altitude (above 1000 m) water bodies with relatively low diversity of fishes and other aquatic organisms. The rivers include Sur, Waber, Baro-Kelo, Yabi, Dibo, and Uka Rivers (Source: TAMS-ULG study). There are also very many streams in Godere and Mengesh Woredas of Gambella Region (origins above 1000 m) in which at their lower reaches make up the Gillo River, which is one of the major and productive rivers of Gambella Region. The main fish species in the upper reaches of these rivers are largely highland stream-adapted cyprinid fishes that include Labeobarbus, Barbus, Labeo, Varicorhinus and Garra spp. African cat fish (Clarias gariepinus) and Nile tilapia (Oreochromis niloticus) are also available in these water bodies.

There are no major fisheries activities in these upstream rivers, as the rivers and streams are located at higher altitudes and the rivers are fast flowing and hence the productivity is limited. Therefore, there are only few artisanal fisheries catching fish largely for household consumptions or limited local sales.

The only lake in the highlands (above 1000 m) is Lake Buri (Lake Bishan Waki) in Mengeshi Woreda (Majang Zone, Gambella Region). The lake is located at an altitude of 1353 masl (N 07o17.960 and E035o16.344’). There is some fishing using hooks and lines and some boats are used for catching fishes. The boats were donated by the Mekane Yesus Church.

#### THE LOWER STREAMS OF MAJOR RIVERS IN ETHIOPIA IN GAMBELLA REGION

Main fish species and migration patterns

The major lakes and rivers of the Gambella region in Ethiopia include Lake Tatta (which is actually a natural pond formed as a result of overflow of the Gillo River), Baro River, Akobo River, Gillo River, Alwero River, Alwero Reservoir and several natural ponds. The major rivers and swampy areas and their coverage (length and catchment area) are provided in Table 6-7 and Table 6-8.

*Table 6-7: List of major rivers with their length and catchment area*

| River | Length (km) | Catchment area (km$^2$) |
|---|---|---|
| Baro | 285 | 38400 |
| Akobo | 203 | 21890 |
| Gillo | 252 | 13050 |
| Alwero | 321 | 8098 |
| Pibor | 96 | 4300 |
| **Total** | **1157** | **85738** |

*Table 6-8: Swampy areas in relation to the total area in Gambella Region*

| Woreda | Total Area ($Km^2$) | Swamp Area ($Km^2$) | Proportion of swamp in each Woreda | Proportion of swamp in the region (%) |
|---|---|---|---|---|
| Gambella | 294000 | 10112 | 3.4 | 0.3 |
| Itang | 178448 | 55032 | 30.8 | 1.7 |
| Akobo | 366116 | 16696 | 4.6 | 0.5 |
| Jikawo | 235696 | 58516 | 24.8 | 1.8 |
| Abobo | 329720 | 20876 | 6.3 | 0.7 |
| Gog | 701752 | 16932 | 2.4 | 0.5 |
| Jor | 254880 | 67236 | 26.4 | 2.1 |
| Godere | 192588 | - | 0.0 | 0.0 |
| Dima | 650080 | 2156 | 0.3 | 0.1 |
| Region | 3203280 | 247556 | 7.7 | 7.7 |

*Source: HussienAbegaz et al., 2010.*

The highest fish diversity in Ethiopia has been recorded from the Baro (Kir/Openo)-Akobo Basin. It has previously been indicated that there are 87 fish species of which only one species (Afronemacheilus abyssinicus) is endemic to this basin (Abebe Getahun, 2007). More recently, however, Golubtsov and Darkov (2008) recorded 113 fish species included in 61 genera and 27 families (Table 6-9). The low level of endemism in the basin is probably because of the basin having past and present connections with the Nile and west and central African river systems. As a result, all the fish fauna represent widespread Nilo-Sudanic forms. Tesfaye Melak (2009) indicated that there is no exotic species reported from the basin and there is no indication of the presence of any fish species listed by IUCN as threatened species. Although there is high fish diversity in the region those important in the artisanal fishery, because of their abundance and preference by the local communities, are limited to about 20 species.

*Table 6-9: List of Freshwater fish families of Gambella Region in Baro-Akobo Basin*

| No. | Order | Family Name | Common Name | No. of Genera | No. of species |
|---|---|---|---|---|---|
| **1** | Lepidosireniformes | Protopteridae | *mud fishes* | 1 | 1 |
| **2** | Polypteriformes | Polypteridae | *bichirs* | 1 | 3 |
| **3** | Osteoglossiformes | Osteoglossidae | *African bony tongue* | 1 | 1 |
| | | Notopteridae | *African knife fishes* | 1 | 1 |
| **4** | Siluriformes | Malapteruridae | *electric catfish* | 1 | 2 |
| | | Schilbeidae | *schilbeid cat fishes* | 3<br>2 | 5<br>5 |
| | | Clariidae | *airbreathing catfishes* | 3<br>1 | 4<br>2 |
| | | Claroteidae | *claroteid catfishes* | 5<br>2 | 15<br>2 |
| | | Bagridae | *bagrid catfishes* | 1 | 2 |
| | | Mochokidae | *squeakers* | 5 | 15 |
| | | Amphiliidae | *loach catfishes* | 2 | 2 |
| **5** | Perciformes | Centropomidae | *Nile perch* | 1 | 1 |
| | | Cichlidae | *Cichlids* | 4 | 5 |
| | | Anabantidae | *climbing gouramies* | 2 | 3 |
| **6** | Atheriniformes | Nothobranchiidae | *African rivulines* | 2 | 3 |
| | | Poeciliidae | *Poecillids* | 1 | 2 |
| | | Balitoridae | *African stony loach* | 1 | 1 |
| **7** | Channiformes | Channidae | *Snakehead* | 1 | 1 |
| **8** | Cypriniformes | Citharinidae | *Abeels* | 1 | 2 |
| | | Characidae | *Characins* | 4 | 7 |
| | | Cyprinidae | *Carps* | 7 | 21 |
| | | Distichodontidae | *Purus* | 4 | 9 |
| | | Gymnarchidae | *Aba* | 1 | 1 |
| | | Cyprinodontidae | *Killifishes* | 1 | 1 |
| **9** | Tetraodontiformes | Tetraodontidae | *Puffers* | 1 | 1 |
| **10** | Gonorhynchiformes | Cromeriidae | *Nakesheltear* | 1 | 1 |
| **11** | Mormyriiformes | Mormyridae | *Elephant fishes* | 8 | 15 |
| | **Total** | | | **61** | **113** |

*(Golubtsov and Darkov, 2008)*

Thachuor Biel Paul (2013) has also identified 46 species with their local names (in Nuer as well as Agnwaa) (Table 6-10).

*Table 6-10: Fish species identified from Gambella Region arranged in orders, families, scientific and local names*

| No | Order | Family | Scientific Name of species | Local Names | |
|---|---|---|---|---|---|
| | | | | Nuer | Anyuak |
| 1 | Lepidosireniformes | Protopteridae | *Protopterus aethiopicus* | *Luth* | *Luth* |
| 2 | Polypteriformes | Polypteridae | *Polypterus bichir* | *Jueth* | *Odeela* |
| | | | *Polypterus endlicheri* | *Jueth* | *Odeela* |
| | | | *Polypterus senegalus* | *Theether* | *Odeela* |
| 3 | Osteoglossiformes | Osteoglossidae | *Heterotis niloticus* | *Lek* | *Oluek* |
| | | Gymnarchidae | *Gymnarchus niloticus* | *Riel* | *Withe* |
| | | Mormyridae | *Marcusenius cyprinoides* | *Konthok* | *Ataato* |
| | | | *Mormyrops anguilloides* | *Not* | *Dolo* |
| | | | *Mormyrus caschive* | *Norial* | *Dolo* |
| | | | *Mormyrus kannume* | *Konthok* | *Ataato* |
| | | | *Mormyrus niloticus* | *Norial* | *Dolo* |
| | | | *Pollimyrus isidori* | *Kuoth* | *Ataato* |
| 4 | Characiformes | Alestiidae | *Alestes baremoze* | *Pithe* | *Apith* |
| | | | *Brycinus macrolepidotus* | *Kuechlek* | *Obola* |
| | | | *Brycinus nurse* | *NyiboljokJiokle chRathe* | *Apith* |
| | | | *Hydrocynus forskallii* | | *WeeriApith* |
| | | | *Micralestes acutidens* | | |
| 5 | Cypriniiformes | Distichodontidae | *Distochodus niloticus* | *Jiokyiel* | *Ogere* |
| | | | *Distochodus rostratus* | *Jiokyiel* | *Ogere* |
| | | Citharinidae | *Citharinus latus* | *Patpat* | *Abeela* |
| | | Cyprinidae | *Barbus prince* | *Polong* | *OguiOgui* |
| | | | *Labeo forskalii* | *Polong* | *Obi* |
| | | | *Labeo horie* | *Polong* | *Dur* |
| | | | *Raiamas senegalensis* | *No* | |
| 6 | Siluriformes | Auchenoglanididae | *Auchenoglanis biscutatus* | *Ngok* | *Okok* |
| | | | *Auchenoglanis occidentalis* | *Ngok* | *Okok* |
| | | Bagridae | *Bagrus bajad* | *Diap* | *Gura* |
| | | | *Bagrus docmak* | *Lam* | *Odura* |
| | | Claroteidae | *Clarotes laticeps* | *Pung* | *Pung* |
| | | Schilbeidae | *Schilbe intermedius* | *Theen* | *Otua* |
| | | | *Schilbe mystus* | *Theen* | *Wuro* |
| | | Clariidae | *Clarias anguillaris* | *Pet* | *Aguyueele* |
| | | | *Clarias gariepinus* | *Rachar* | *Aguyueele* |
| | | | *Heterobranchus bidorsalis* | *Chur* | *Churo* |
| | | Malapteruridae | *Malapterurus minjiriya* | *Dar* | *Adanga* |
| | | Mochokidae | *Synodontis clarias* | *Ngook* | *Okok* |
| | | | *Synodontis eupterus* | *Ngook* | *Okok* |
| | | | *Synodontis frontosus* | *Ngook* | *Okok* |
| | | | *Synodontis nigrita* | *Ngook* | *Okok* |
| | | | *Synodontis orientalis* | *Ngook* | *Okok* |
| 7 | Channiformes | Channidae | *Parachanna obscura* | *Jul* | *Ajul* |
| 8 | Perciformes | Latidae | *Lates niloticus* | *Chiel* | *Gur* |
| | | Cichlidae | *Oreochromis niloticus* | *Rueth* | *Orueth* |
| | | | *Sarotherodon galilaeus* | *Rueth* | *Orueth* |
| | | | *Tilapia zillii* | *Rueth* | *Orueth* |
| | | Anabantidae | *Ctenopoma petherici* | *Korkuach* | *Amuyu* |

*( Source: Thachuor Biel Pal, 2013)*

### CURRENT SITUATIONS OF THE FISHERIES AND AQUACULTURE SECTOR IN SOUTH SUDAN

The White Nile sub-basin is home to about 140 species belonging to 42 genera and 21 families. The most preferred (for consumption) and commercially important fish species include *Lates niloticus* (Nile perch), *Gymnarchus niloticus*, *Tilapia* spp., *Clarias* spp., *Heterotis niloticus*, *Labeo* spp., *Distichodus niloticus*.

The size of the fish resource in South Sudan is not known with accuracy, but probably exceeds a Maximum Sustainable Yield of 200,000 tons/year. Most of this resource is located in the Sudd, primarily in Jonglei State, but also along the Nile in Central Equatoria, Lakes, Unity and Upper Nile states and, seasonally, in the Eastern and Western floodplains.

The actual total catch from the capture fisheries is estimated at about 143,000 tons/year which is about 17 kg per capita productions. Fishery is regarded as one of the main sources of income for the Nuer, Dinka, Bari, Shilluk and the Falata tribes (ENTRO, 2008-2009). According to the 2010 base line survey report on agriculture and animal resources in South Sudan, about 14% of households in South Sudan, particularly those in the Sudd area along the River Nile and its tributaries engage in fishery as a means of livelihood.

The main fishing gear is the gill net, with cast nets, long lines, spears and cover pots being common, depending on the locality. Suitable gear is sold in every major town and is not a limiting factor on fish catches. A variety of boats and canoes are used, the most common ones being unmotorized planked and dugout canoes. Outboard motors are rarely used for fishing but are commonly used to transport fresh and dried fish. The sector directly employs both in small scale commercial and subsistence fisheries, approximately 220000 individuals in South Sudan. More than 1.7 million individuals in South Sudan are living in households where someone in the family catch fishes, and are thus directly dependent in some way (livelihood, income or food security) on the country's wild fisheries.

Most of the fish produced is dried or smoked as it is impossible to get the fish to market while it is still fresh, due to low availability of ice, poor roads, and limited transport. Dried fish is distributed throughout the country. Fresh fish is brought and sold fresh in large towns. There are considerable imports of smoked fish as well as fresh fish on ice from Uganda. Some 16 000 tons/year of fresh fish product coming from the Sobat and Nile have been exported to Khartoum; dried fish is also exported to Sudan and Ethiopia.

### 6.2.5.2 Main fishing system in the basin

Fishing in Gambella Region is conducted using traditional fishing gears like traps, lines and hooks that are largely made up of locally available materials. The main fishing season is the dry season that extends from October to May, although fishing may be practised throughout the year in most areas. The exact number of fishers operating in the different areas of Gambella Region is not known, as most of the fishers are not registered and the water bodies are open access resources. The modes of consumption of the fishes by the different ethnic groups include fresh, drying, fry-drying and smoking.

Much of the fish production is used for household consumptions, as many of the ethnic groups in Gambella are traditional fish eaters. A small portion of the production which is excess to the family's needs is brought to nearby markets (towns) for sale. It has been reported that fresh fish handling and the way it is presented to the market is very much poor and unhygienic. The market places in almost all towns are reportedly without protective sheds, racks and potable water. These are simple infrastructures that could easily be in place with little investment. The linkage between the fisher's community and the fish traders at different levels is not very close and tight. The transport network and facility is largely not satisfactory which has impact on the timing and adequacy of the supply chain and also contributes to high variability in the price of fish at different localities. The best market locations are around major towns in the region. Maps of appropriate market sites according to the degree of their appropriateness are given for each planning unit.

The commercially important fish species according to LFDP report (1996) are *Lates niloticus*, *Oreochromis niloticus*, *Labeo horie*, *Bagrus docmac*, and *Clarias gariepinus* from mainly the lake and the reservoir. Fishing is highly seasonal in the Baro, Gillo, Alwero and Pibor Rivers. Flooding between June and October prevents most fishers operating and thus the main fishing season is restricted to the drier periods between October and May. According to a report by the Bureau of Finance and Economic Development (2008) fishing activity takes place throughout the year in Jikawo (except in April); in Lare Woreda (Except in January and February); and in Itang (in all months).

According to the report by the Gambella Peoples Regional State Bureau of Agriculture (2004), the fish production potential was estimated to be about 2500 tons/year. Studies from Hussien Abegaz et al., 2010, however, indicated that the fish production potential of the various water resources of the Gambella Region based on empirical models are found to be in the range of 15,417 and 17,308 tons per year (Table 6-11). This could be taken as a conservative estimate as it is based on empirical models. Much of the production potential was estimated from the floodplain areas including Lake Tatta, Alwero Reservoir and the natural ponds. Of these about 3720 tons was estimated from the rivers (Baro, Alwero, Gillo, Pibor, Akobo) (Table 6-13), while about 159 tons/ year was estimated from Alwero Reservoir and Lake Tatta (Table 6-12). The remaining 13,429 tons/ year was estimated from the floodplains.

The mean annual catch from the region in 1990 was about 213 tons (Baro-Akobo Master Plan, 2008). However, the catch in 2010 has reached 380 tons/year (Hussien Abegaz *et al*., 2010), which is less than 3% of the potential of the water bodies of the region.

*Table 6-11: Estimated fish production potential of the various water bodies in Gambella Region*

| **Method** | **Potential yield (t/year)** | **Total production potential of the region (t/year)** |
|---|---|---|
| Catchment based analysis | 1,829 | |
| River length based analysis | 3,720 | |
| Floodplains | 13,588 | |
| Sum of 1 & 3 | | 15,417 |
| Sum of 2 & 3 | | 17,308 |

*Source: Hussien Abegaz et al., 2010*

*Table 6-12: Estimated fish production potential of Alwero Reservoir and Lake Tatta*

| **Water Body** | **Ha** | **Km2** | **Potential yield (t/year)** |
|---|---|---|---|
| Alwero Reservoir | 2,210 | 22.1 | 144 |
| Lake Tatta | 185 | 1.85 | 15 |
| **Total** | | | **159** |

*Source: Hussien Abegaz et al., 2010*

*Table 6-13: The fisheries potential of major rivers in Gambella Region*

| **Rivers** | **Length (km)** | **Proportion from the total** | **Potential yield (t/year)** |
|---|---|---|---|
| Baro | 285 | 24.6 | 916 |
| Akobo | 203 | 17.5 | 653 |
| Gillo | 252 | 21.8 | 810 |
| Alwero | 321 | 27.7 | 1,032 |
| Pibor | 96 | 8.3 | 309 |

*Source: Hussien Abegaz et al. 2010*

### TYPE AND NUMBER OF FISHING GEARS UTILIZED

The traditional fishing gears in the Gambella Region are more than 15 and diversified in season, method of fishing and the materials from which they are made. It is noteworthy that unlike in other regions, there is no report on the use of either natural or artificial poisons of fishing in Gambella Region.

The individual fishing methods are fishing by line and hook, net and basket. Modern fishing gears such as gill nets, hook and line, and cast nets were introduced into the region and have been in use. Some of these gears were supplied to the community by NGOs, especially for displaced communities.

There is a scarcity of fishing net accessories such as floater and sinker at local and national markets. Some twines are available at Gambella and Pugnido towns, in which they are imported from Sudan. All fishers operating in the rivers, lake and reservoir use traditional tree trunks /wooden dugout canoe with lengths of about 6-8 m. Generally, it appears that there is no modern fishing boat operating in the region.

There are about 263 registered fishers in organized cooperatives that have legal entities, of which 39 are women. The number of subsistence fishers is in thousands with more than 34,000 family heads, of which 9,000 are Agnwaa and 23,400 are Nuer family heads (Hussien Abegaz *et. al.*, 2010).

There are about ten fisher cooperatives with a total of 263 members (Table 6-14). Most of the cooperatives are not strong associations with one to two wooden boats and none of them have motorized boat. Although most of the fishers are males, females are also actively serving as treasurers and involved in gear making and maintenance as well as marketing.

*Table 6-14: Profile of cooperatives engaged in fisheries*

| Name of cooperative | Males | Females | Total | Woreda | Kebele | Registration date |
|---|---|---|---|---|---|---|
| Itang-Kir Fishery and grain farming | 28 | 0 | 28 | Itang | Itang | 18/4/98 |
| Pugnido Fishery Cooperative | 23 | 3 | 26 | Gog | Pugnido | 20/4/98 |
| Tatta Farmers Fishery Cooperative | 10 | 4 | 14 | Gog | Tatta | 20/4/98 |
| Tatta Youngsters Fishery cooperative | 14 | 7 | 21 | Gog | Tatta | 08/7/07 |
| Gnikiwo Fishery Cooperative | 27 | 22 | 49 | Gambella | Gnikuwo | 21/3/99 |
| Dolfin Hulegeb Fishery Cooperative | 22 | | 22 | Gambella | Kebele 02 | 23/3/99 |
| Ediget Fishery & Marketing | 7 | 3 | 10 | Abobo | Abobo | 18/8/99 |
| Kano Fishery & Marketing | 14 | | 14 | Abobo | Kano | 19/8/99 |
| Puchala Fishery | 18 | 2 | 20 | Gillo | Puchala/ Tatta | 20/4/98 |
| Utel Hulegeb | 10 | | 10 | Gillo | Utel | 20/4/98 |
| Gnekuwo Fishery | 27 | 22 | 49 | Gambella | Gnekuwo | 21/3/99 |
| **Total** | **200** | **63** | **263** | | | |

*Source: Hussien Abegaz et al., 2010*

Some 15 years back, few marketing infrastructures such as fish cleaning shed and storage were built through LFDP project in Gambella, Itang and Pugnido Towns. However, it is unfortunate not to find anyone of them to be functional and serving the purpose in which they were intended to serve.

According to Hussien Abegaz *et al*. (2010), the fish processing shed and fish shop and/ or storage in Gambella town is far from the center and landing sites. In addition, the fish cleaning shed for fisher cooperatives was built near Baro River. However, the place is usually flooded during wet seasons and not preferred by the fishers. The fish cleaning shed and storage built in Itang town is situated in an appropriate place but it does not have access to pure water for cleaning and sewerage system. Interestingly, the ZOA Refugee Care (NGO) has built new fish store about 100 m far from the existing one but still ZOA did not finish the water, sewerage and power installation for the new building and hence, it is not also functional at the moment. The early built boat yard workshop is not also functional due to lack of attention and now transferred to Gambella TVET College.

#### 6.2.5.3 Assessment of the production and contribution to the socio-economic of the region

The main fish markets are the major towns in Gambella closer to water bodies (Gambella Town, Itang, Abobo and Pugnido). In these towns it appears that there is great demand for fish, in which the supply is not coping up. According to Hussien Abegaz *et al*. (2010), it appears that almost all cooperatives have serious market problems because of poor transportation facilities. The transportation problem is serious in most areas and the cooperatives are very much discouraged by the small price they get locally.

According to the survey made by Hussien Abegaz *et al* (2010), there is significant price difference between Itang and Gambella towns as well as between Abobo and Gambella Towns (Table 6-15). It has been reported that the difference in average price/kg of fish between Itang and Gambella is very high as compared to the differences between Abobo and Gambella. This difference was mainly attributed to low access for transportation facility in Itang than Abobo. Abobo is more accessible than Itang and hence, fishers in Itang are forced to sell their fish in Itang town even at a lower price. However, this may not be the case now as transportation is easier in Itang than Abobo, because of the asphalted road.

Fish processing (value addition) is rarely practised and in most cases, the fishers sell whole fish which brings low price at landing sites as well as secondary markets. In addition, the fishers are weak in determination of price as their cooperatives are not well organized and there are very few fish traders which force them to sell the fish in whatever the price the traders offered to them. Moreover, the fish traders from Abobo area are not highly encouraged in trading fish to Gambella Town due to the distance (Table 6-16) and high cost of transportation. Depending on the distance, fresh fish are transported on foot, by bicycle or public transportation.

*Table 6-15: The fish species and their respective prices in the different towns of the region*

| Fish species | Price in Itang (Birr/kg) | Price in Abobo (Birr/kg) | Price in Gambella Town (Birr/kg) |
|---|---|---|---|
| Lates niloticus | 25 | - | 45 |
| Gymnarchus niloticus | 20 | 25 | 30 |
| Clarias sp. | 10 | 12 | 15 |
| Heterotis niloticus | 10 | - | 20 |
| Bagrus docmac | 18 | 22 | 24 |
| Barbus sp. | 15 | - | 22 |
| Tilapia sp. | 10 | 12 | 15 |
| Polypterus bichir | 24 | - | 30 |
| Dried Clarias sp. | - | - | 100 |

*Source: Hussien Abegaz et al., 2010*

Table 6-16: Fish market distance from the major production areas

| Major Landing sites | Fish market towns | Distance from production areas (km) |
|---|---|---|
| Puchala Site/Gillo River-Gog Woreda | Pugnido | 12 |
| Lake Tatta-Gog Woreda | Pugnido | 10 |
| Pugnido Town-Gog Woreda | Abobo | 62 |
| Alwero Reservoir | Abobo | 6 |
| Kano site/ Alwero Reservoir/Abobo Woreda | Abobo | 2.5 |
| Abobo Town | Gambella | 58 |
| Pugnido Town | Gambella | 120 |
| Itang (Kir/Baro River) | Gambella | 45 |
| Eliana Pond & Ibago village along Baro River | Itang | 12 |
| Eliana pond | Gambella | 43 |

*Source: Hussien Abegaz et al., 2010*

### THE TREND IN CONSUMPTION OF FISH (HOUSEHOLD, RESTAURANTS, OUTSIDE OF THE REGION, EXPORT)

Fish appears to be one of the major protein sources for the people who live in nearby major water body of the region. The existing food culture for these people depend on predominantly on fish and they strongly desire fish for daily consumption.

There appears to be no specific choice for the fish species to be consumed in the region. It all depends on availability and ease of production and hence eat diversified range of fish species.

However, generally *Heterotis niloticus* (Uluak), *Lates niloticus* (Gur), *Gymnarchus niloticus* (Wit), *Tilapia* spp (Uraedo), *Clarias gariepinus* (Aguyula), *Hydrocynus foskahlii* (Uaeri) rank first to sixth, respectively. The price of *Lates niloticus* (Gur) is very high and consumers prefer that fish because of its tastiness and the presence of fewer inter-muscular bones as compared to other species.

### CURRENT SITUATION OF AQUACULTURE IN THE BASIN

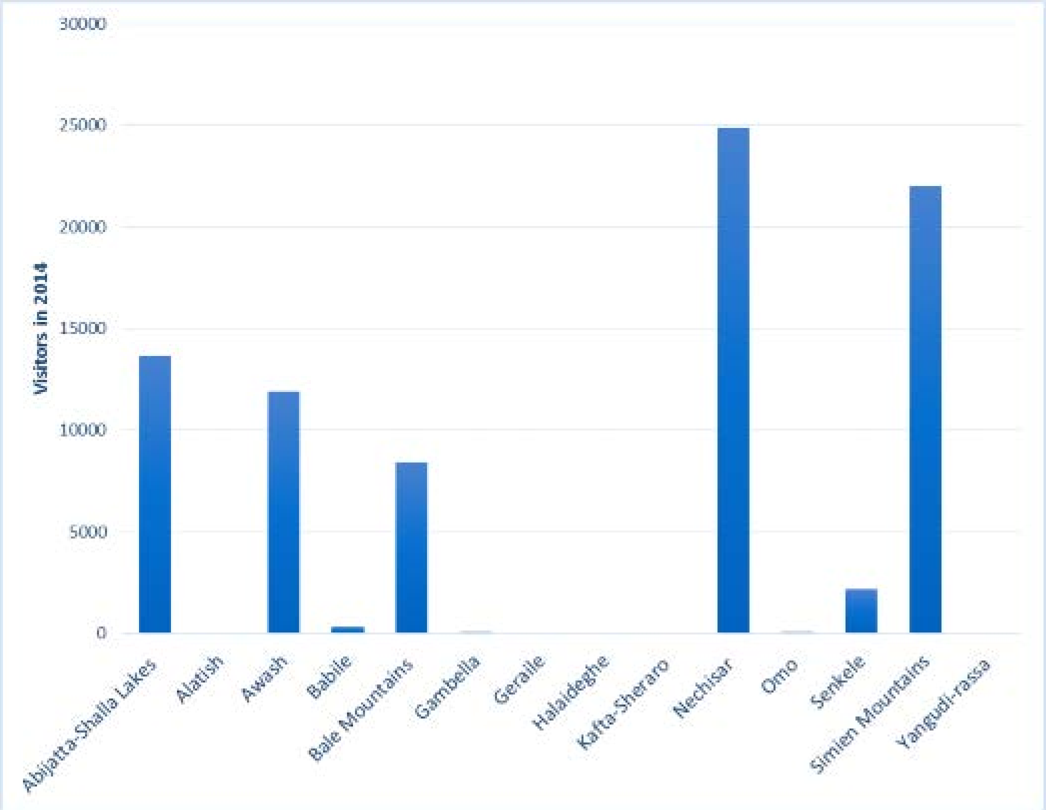
It appears that currently there is no aquaculture practice in the region, despite favorable conditions for development of the sector (abundant water and land, low altitude and high temperature, appropriate and proven indigenous fish species for aquaculture, inexpensive labor and compacted clay soil that can retain water for long). It is expected that with appropriate land planning and identification of areas appropriate for aquaculture developments, the region would be a highly preferred and targeted area for aquaculture production. Obviously, aquaculture will have significant contribution to the economic, social and environmental well-being of the region. Aquaculture will produce more fish year round and also reduce the pressure that could otherwise be exerted on the natural system.

### 6.2.6 Eco-tourism

Currently, tourism and ecotourism are largely underdeveloped in the BAS despite the huge potential offered by its rich natural resources, especially by water resources.

Since 2001, International visitor arrivals in Ethiopia have shown a strong upward trend (WTTC, 2014). Ethiopia has become a quite important tourism destination in Africa, not far from Kenya when one compares tourism and travel's direct and total contribution to GDP. However, the Ethiopian part of the basin do not benefit yet from tourism growth (see figure below), mainly because of a lack effort to develop infrastructures that facilitate tourism and lack of coordinated management.

*Figure 6-3: Visitors numbers and growth for all EWCA protected areas*




*Source: (EWCA, 2015)*

In South Sudan, tourism has emerged recently but is currently insignificant for security reasons. No readily available brochures were found. Tourism development suffers from security issues but also from bad accessibility and poor accommodation services. Wildlife discovering in the National Parks and trekking in the Imatong Mountains (Mount Kinyeti, South Sudan highest peak) consist of the high potential attractions of the South Sudan part of the BAS.

# 6.3 SERVICE SECTORS RELATED TO WATER RESOURCES

## 6.3.1 Potable water supply and sanitation

The situation and development of water supplies and sanitation facilities in the South Sudan and Ethiopian portions of the catchment area of the BAS are different and therefore the situations in these countries are addressed separately in the following sections of this report.

### *6.3.1.1 Potable Water Supply and Sanitation in South Sudan*

#### *6.3.1.1.1 Existing Development in the Basin*

The Republic of South Sudan Draft Water Bill dated September 2013 contains the following clauses concerning potable water:

- Clause 4: Interpretation
  - **potable water** means any water that is considered safe to be used for human consumption according to the opinion of the Safe Water Supply and Sanitation Services Regulatory Board";
  - **potable water supplier** means an individual or organisation which supplies potable water and may be a State Government, a Local Government Authority, a Service Provider, or a Community Owned Safe Water Supply and Sanitation Services Organisation, or a supplier of bottled water;
  - **potable water works** means a works intended for the supply of potable water:
- Clause 71: Powers and functions of the Safe Water Supply and Sanitation (Services Regulatory Board)
  - The powers and functions of the Safe Water Supply and Sanitation Services Regulatory Board shall be as follows:
    - Set and monitor compliance with potable water quality standards;
- Clause 95: Provision of safe water and sanitation services
  - b.Services which must be licenced include any part of:
    - i. Treatment, distribution and selling of potable water, sourced from either surface or groundwater;
    - ii. Treating, bottling and selling potable water;
    - iii. Treating and selling potable water from a kiosk;
    - iv. Supplying potable water in bulk to the public or any person;
    - v. Selling potable water through a tanker service;
    - vi. Selling potable water through jar services;
- Clause 102: Supply of water in bulk
  - No person without a licence issued by the Safe Water Supply and Sanitation Services Regulatory Board shall supply potable water in bulk to a Service Provider.
- Clause 146: Compounding of offences
  - In this section "responsible authority" means:
    - In the case of an offense involving potable water, the State Government, or the Local Government Authority, as the case may be.

**The Water Policy of November 2007** established the basic principles that guide the entire water sector and all water usage. The Sector Strategic Framework described below elaborates on approach to WASH.

**The Water, Sanitation & Hygiene (WASH) Sector Strategic Framework of the Ministry of Water Resources and Sanitation dated August 2011** prioritised the strategic approach for each of the main WASH subsectors and indicated the current status at that time which is similar to the current status on account of the war:

- Water Resources Management: These requirements were not being taken into account.
- Sanitation and Hygiene: Access to sanitation was 14.6% one of the lowest worldwide.
- Rural Water Supply: The average consumption was 6 l/capita/day, only 20% of the population contributed to operation and maintenance costs and between 20% and 50% of water points were not operational.
- Urban Water Supply: Technology only exists in some parts of Juba and a few regional capitals.

**The Data Base of the Directorate of Rural Water Supply and Sanitation** contains a wide range of valuable information on the water supplies in South Sudan. The locations of the various sources of water supply in Eastern Equatoria and Jonglei are shown in Figure 6-4 (the data for Upper Nile was not provided).

Table 6-17 and Table 6-18 summarise the status of the various sources of supply in Eastern Equatoria and Jonglei respectively. It is evident from these Tables that boreholes are the main sources of supply. It is not possible to draw any other definite conclusions from these Tables on account of the large number of "Unspecified" items, however the data for Eastern Equatoria indicates that approximately one third of the boreholes are not fully functional. This also suggests that maintenance may be lacking.

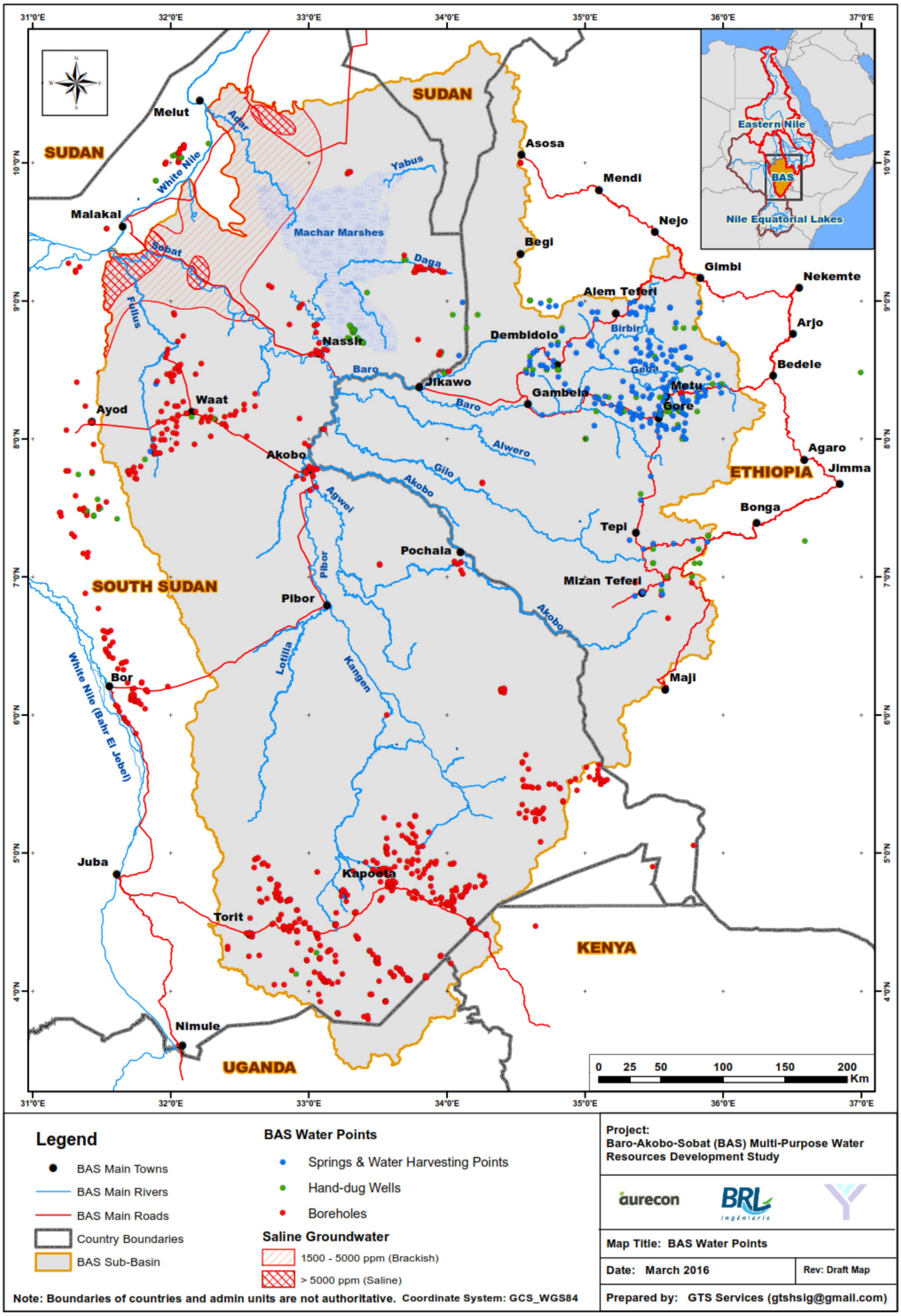
*Table 6-17 Status of Water Supplies in Eastern Equatoria*

| Status of Supply Sources in Eastern Equatoria | Borehole | Hand Dug Well | Spring | Water Yard | Stream | Total | Percentage |
|---|---|---|---|---|---|---|---|
| Zero, Blocked, Collapsed, Destroyed, Dry, Flooded, Pipes Fallen , Silting, Unspecified, Non Functional, Pipes Fallen | 169 | 2 | 0 | 0 | 0 | 171 | 10% |
| Low Yield, Needs Repair Flushing, Replacement, Partially Functional but Needs Repair, Seasonal, Silting | 332 | 1 | 0 | 1 | 2 | 336 | 20% |
| Operational | 967 | 14 | 15 | 28 | 6 | 1030 | 63% |
| Unspecified | 103 | 1 | 0 | 0 | 0 | 104 | 6% |
| **TOTAL** | **1571** | **18** | **15** | **29** | **8** | **1641** | **100%** |

*Table 6-18 Status of Water Supplies in Jonglei*

| Status of Supply Sources in Jonglei | Boreholes | Hand Dug Well | Spring | Water Yard | Stream | Total | Percentage |
|---|---|---|---|---|---|---|---|
| Zero, Blocked, Collapsed, Destroyed, Dry, Flooded, Pipes Fallen , Silting, Unspecified, Non Functional, Pipes Fallen | 14 | 1 | 2 | 0 | 0 | 17 | 6% |
| Low Yield, Needs Repair Flushing, Replacement, Partially Functional but Needs Repair, Seasonal, Silting | 3 | 0 | 1 | 0 | 0 | 4 | 1% |
| Operational | 197 | 3 | 8 | 0 | 1 | 209 | 68% |
| Unspecified | 59 | 0 | 18 | 0 | 0 | 77 | 25% |
| **TOTAL** | **273** | **4** | **29** | **0** | **1** | **307** | 100% |

*Figure 6-4: Locations of water Points in Eastern Equatoria and Jonglei in South Sudan*



### 6.3.1.2 Current situation in Ethiopia towards the Millenium development goals

#### 6.3.1.2.1 Existing development projects in the BAS basin in Ethiopia

The following reports provide an indication of the existing water supply and sanitation developments in the BAS basin in Ethiopia.

**WASH Policy, Legislation and Regulation in Ethiopia:** The Ethiopian Water Resources Management Policy (1999) prepared by the Ministry of Water Resources highlights the goal of promoting national efforts for efficient, equitable and optimum utilization of water resources in Ethiopia. To transform policy into action, the National Water Sector Strategy was introduced followed by the Water Sector Development Program (2002-2016). The Water Resource Management Proclamation No.197/2000 states that water resources are the property of the Ethiopian people and the State. The Proclamation also states that domestic use of water shall have priority over other uses.

**Growth and Transformation Plan (GTP) II:** The general objective of GTP II water supply sector is to provide access to safe, sustainable, efficient and reliable water supply service to all Ethiopian Citizens by the Year 2020 using appropriate technologies at affordable cost and improve waste water management capacity of major cities and towns that contribute to the country's vision of reaching at the level of middle income countries. By the Year 2020, GTPII plans to:

- Meet the universal target of providing access to safe and sustainable water supply for all citizens of the country in the planning period as per the minimum water supply access standard level set for GTP-1, i.e. for rural water supply 15 liter per capita/day within a distance up to 1.5 km and for urban water supply 20 l/c/day within a distance up to 0.5 km particularly for Somali and Afar regions that would have un-served rural population by the end of the 2015.
- Provide 85% rural water supply access coverage with upgraded minimum service level of 25 l/c/day within a distance of 1 km from the water delivery point, out of this coverage 80% are beneficiaries of tap water service
- Provide 75% urban water supply access coverage with upgraded minimum urban utilities service levels of 100 l/c/day, 80 l/c/day, 60 l/c/day, 40 l/c/day and 30 l/c/day for category 1, 2, 3, 4, and 5 towns/cities respectively,

The financial demand is Birr 82.8 billion to implement the overall plan. Out of the aforementioned amount Birr 28 billion will be used for construction of potable water schemes in rural areas and Birr 44.2 billion will be used for construction of urban potable water schemes. 49% of the financial demand is estimated to be covered by the government, 31% by donors in the form of Grants and Credit, 4% by NGOs, and 16% by the beneficiary community and urban utilities.

**Sustainable Development Goal (New MDG):** The sixth goal sets a separate and ambitious target of bringing basic access to water and safe sanitation to everyone, everywhere by 2030, including:

- universal and equitable access to safe and affordable drinking water for all
- access to adequate and equitable sanitation and hygiene for all
- an end to open defecation by 2030.

**One WaSH National Program (OWNP)**: This is the Government of Ethiopia's (GoE) instrument for achieving the goals set out for Water Supply, Sanitation and Hygiene (WaSH) in the Growth and Transformation Plan (GTP). The Program's Development objective is to improve the health and well-being of communities in rural and urban areas in an equitable and sustainable manner by increasing access to water supply and sanitation and adoption of good hygiene practices.

The intermediate objectives of the program are directed towards attaining:

- GTP targets of 98% and 100% access to safe water supply for rural and urban areas respectively
- Access to basic sanitation to all Ethiopians having:
  - 77% of the population practicing hand washing at critical times, safe water handling and water treatment at home, and
  - 80% of communities in the country achieving open defecation free (ODF) status.

The program was designed to be implemented in two Phases: Phase I from July 2013 to June 2015 and Phase II from July 2015 to June 2020. During Phase I the program was supposed to increase harmonization and alignment among and between development partners and GoE. During this phase WaSH organizations and procedures are expected to be fully established and become operational at all levels. In the case of phase II of the Program will be either continuity or redesign. Continuity will consist of completing work that began in Phase I.

Various development partners have committed to participate in the OWNP and pool their resources into a Consolidated WaSH Account (CWA) in order to finance part of the OWNP. These partners include AfDB, DFID, UNICEF and the WB. Funding has been received from the AfDB, DFID, UNICEF, the WB and 10% contribution from the GoE to the CWA over a five-year period (July 2014 –June 2019) in total amounting to USD $485 million.

Table 6-19 and Table 6-20 list the ONWP- CWA benefitting woredas/districts and towns within the BAS basin respectively. While Table 6-21 shows the overall budget allocated from the CWA to all WaSH activities both urban and rural at regional level. The towns of Bambasi and Gambella are funded through the Water Resource Development Fund on a loan basis.

*Table 6-19: List of OWNP - CWA Woredas/districts within the BAS basin*

| Region | Zone | Name of District/Woreda | Population | Present Water Supply Access Rate | Present HH access to basic Latrine |
|---|---|---|---|---|---|
| Benshangul-Gumuz | Assossa | Kurmuk | 21,198 | 87% | 7.50% |
| Gambella | Agnuak | Dima | 8,468 | 100% | 45% |
| | | Jor | 12,538 | 66% | 60% |
| | Majang | Mengesh | 29,384 | 55.70% | 2% |
| | Nuer | Akobo | 34,555 | 2.90% | 1% |
| | | Lare | 25,209 | 91.60% | 3% |
| | | Wantawo | 26,013 | 92.80% | 11% |
| Oromia | Illibabur | Becho | 44,749 | 76% | 99% |
| | | Bilo Nopha | 34,914 | 92% | 81% |
| | | Darimu | 175,010 | 76% | 98% |
| | | Didu | 39,403 | 92% | 96% |
| | | Dorani | 44,135 | 73% | 99% |
| | | Hurumu | 46,032 | 93% | 98% |
| | | Metu Zuria | 74,496 | 94% | 96% |
| | | Yayu | 64,570 | 88% | 94% |
| | Kelem Wellega | Anfilo | 93,835 | 55% | 98% |
| | | Dale Sadi | 89,664 | 63% | 98% |
| | | Dale Wabera | 127,422 | 66% | 100% |
| | | Gawo Kebe | 78,868 | 63% | 100% |
| | | Gidami | 104,050 | 67% | 100% |

| Region | Zone | Name of District/Woreda | Population | Present Water Supply Access Rate | Present HH access to basic Latrine |
|---|---|---|---|---|---|
| | | Lalo Kile | 59,145 | 51% | 99% |
| | | Sayo | 140,241 | 80% | 99% |
| | Mirab (West) Welega | Ayira | 61,077 | 71% | 99% |
| | | Boji Choqorsa | 58,964 | 90% | 99% |
| | | Boji Dirmeji | 52,464 | 90% | 99% |
| | | Gimbi | 91,060 | 93% | 99% |
| | | Guliso | 85,059 | 86% | 99% |
| | | Haaruu | 81,535 | 90% | 99% |
| | | Hoomaa | 29,863 | 91% | 99% |
| | | Lallo Assabi | 92,284 | 92% | 99% |
| | | Sayyo Nole | 91,716 | 66% | 99% |
| | | Yubdo | 47,039 | 89% | 99% |
| Southern Nations, Nationalities and Peoples (SNNP) | Bench Maji | Berro | 15,195 | 7% | 74% |
| | | Debub Bench | 132,912 | 56% | 76% |
| | | Minete-Goldya | 108,260 | 26% | 50% |
| | Keffa | Gesha (Deka) | 103,854 | 39.3% | 60% |
| | | Gewata | 88,180 | 31% | 80% |
| | | Sailem | 49,945 | 26.5% | 26.5% |
| | Sheka | Masha | 47,279 | | |
| | | Yeki | 133,082 | | |

*Table 6-20: List of ONWP - CWA Towns within the BAS basin*

| Region | Zone | Name of Town | Population (2012) |
|---|---|---|---|
| Benshangul-Gumuz | Assossa | Bambasi | 14,114 |
| Gambella | Agnuak | Pugnudo | 8,208 |
| | | Gambella | 66,095 |
| | | Dimma | 12,538 |
| | Itang Special Woreda | Itang | 8,554 |
| | Nuer | Kwatchtian | 5,000 |
| Southern Nations, Nationalities and Peoples (SNNP) | Keffa | Bita Genet | 3,716 |
| | Sheka | Masha | 9,185 |

*Table 6-21: ONWP - CWA Total Regional Budget*

| Region | Allocated ONWP- CWA budget in million (5 yrs) | Community Contribution in million | Transferred amount in 2014/15 fiscal year in million | # of Benefiting Woredas | # of benfiting towns |
|---|---|---|---|---|---|
| Benshangul-Gumuz | 151.53 | | 13.76 | 7 | 2 |
| Gambella | 108.24 | 0.4671 | 23.1 | 6 | 4 |
| Oromia | 2345.14 | 1.67219 | 232.24 | 140 | 36 |
| Southern Nations, Nationalities and Peoples (SNNP) | 1,450.38 | | 150.35 | 68 | 20 |

In most areas communities residing in BAS basin are pastoralist communities. The government of Ethiopia has designed a villagization program to semi naturalize these communities by providing agricultural land and basic services: water supplies, and school and health facilities. There is also a plan to reduce the number of livestock and to rather focus on their productivity.

## 6.3.2 Navigation

### 6.3.2.1 Navigable water ways and assessment of the river traffic

The Baro river is the only navigable river in Ethiopia. In South Sudan, the main navigable water courses are the White Nile which is navigable almost all the year round (abutting the BAS) and the Sobat river.

The river corridors in the BAS basin are used during the rainy season for transporting goods and passengers into South Sudan from Ethiopia through the Baro and Sobat Rivers via Nassir to Malakal and along the White Nile to join Khartoum in Sudan.

On the other hand, there are navigational waterways stretching from Khartoum in Sudan up to Juba in South Sudan. The river is serviceable throughout the year and a key element of the transport network.

*Table 6-22: Summary Chart for the navigable rivers along the White Nile and the Baro River*

| Country | River corridors | Main Port | Periods of navigability | Storage Total Capacity (tonnes) | Available Open Area (m²) | Status / remarks |
|---|---|---|---|---|---|---|
| Ethiopia | Baro River | Gambella | From July to October | Information required | Information required | |
| | | Itang | From July to November | | | |
| | | Matar | From July to December | | | |
| | | Burbe | All year long | | | |
| South Sudan | Baḥr al-Jabal (White Nile) | Malakal | All year long | 400 | - | Need complete rehabilitation for good functionality |
| | | Juba | All year long | 200 | 1500 | |
| Sudan | White Nile | Kosti | All year long | 400 | 6000 | |
| | | Khartoum | All year long | - | - | |

### 6.3.2.2 Existing ports infrastructure

There are four river ports in Gambella Region:

- Gambella : accessible from July to October
- Itang : accessible from July to November (distance from Gambella : 50 km)
- Matar : accessible from July to December (distance from Gambella : 152 km)
- and Burbe : accessible all year (distance from Gambella : 185 km)

These ports are used regularly for transportation of goods and passengers between Gambella and South Sudan. Depending on water levels, in dry season, the standard barges used on Baro River have a capacity of 30 to 50 tonnes and in rainy season, it is possible to utilize a larger barge that can carry up to 1600 tonnes (water levels are indeed higher during the wet season, the draft[17] is therefore higher and so is the weight that can be carried by a boat/ship/cargo) (Anon., 2013).

[17] The draft determines the minimum depth of water a ship or boat can safely navigate

### 6.3.2.3 Opportunities and constraints

The added value of navigation for transport of goods and passagers is higher during the rainy season, during which the key roads corridors from Ethiopia into South Sudan are not passable for all traffic as the road becomes increasingly muddy and impassable (Logistics cluster - World Food Programme, 2012). The Baro River has been utilized during the rainy season for transporting emergency supplies to the Upper Nile State of South Sudan in 2012 and 2013. This highlights the importance of this means of transport at the scale of the BAS when it comes to transboundary cooperation.

However, because of its seasonality, the contribution of the BAS rivers to the regional (at the Nile scale) is rather therefore currently limited (Nile Basin Initiative Secretariat, 2012).

*Figure 5: Transport barges on the Baro river at Gambela, waiting for river to become navigable*

*Source: (Nile Basin Initiative Secretariat, 2012)*

The main current challenges and constraints impeding navigation development in the BAS are reported below:

- Limited river practicability during the dry deason;
- Limited operational vessels / obsolete water vessels;
- Sedimentation due to erosion from the highlands. This presents hazards for navigation since there is no navigation charts (even if experienced drivers are experienced);
- Absence of navigation aids;
- Spread of water hyacinth: even if it does seem to be not problematic at this stage, increased coverage may lead to safetly and practicability issues for navigation;
- Unpredictable occurrences of insecurity on the Sobat River as one proceeds upriver;
- Little control on monitoring the safety and security of loads while in transit, (this may be mitigated with good contracting). (South Sudan Logistics Cluster, 2011).

Safety and infrastructure challenges can be overcome through river training works, provision of navigation locks, rehabilitation of water courses (dredging) and construction of suitable ports and beaches.

In addition, numerous opportunities are supposed to foster the development of navigation of the BAS:

- The hydropower dam projects in Ethiopia will lead to a better regulation of the water levels of both the Baro and the Sobat which could benefit to navigation if dams are adequately managed;
- “Sobat river operations are served with a good capacity, further volume boats are available for transport as needs and river practicability increase during the rainy season;
- Relations between ROSS and Ethiopia are stable and conducive to aid flows for ROSS humanitarian operations;
- Availability of river transport operators in Malakal who are experienced in navigating Sobat waterways and trading with Ethiopian markets;
- Good fuel availability in Ethiopian markets;
- Ethiopian markets close to ROSS boundaries are serviced with a good capacity all-weather road from Addis Ababa;
- Established and workable customs and duties transit procedures support Ethiopian transit corridors” (South Sudan Logistics Cluster, 2011).

## 6.3.3 Flood and drought mitigation

### *6.3.3.1 Floods mitigation*

The impacts of floods in the basin are numerous and they have been explained in the description of the Physical Environment (section 3.2.6). These impacts are mostly negative (loss of life, damages to infrastructure, etc.) but it should be kept in mind that annual floods also support the livelihood of many farmers who rely on recession agriculture and cattle farming. Finally, these floods are also an essential component for the good status of the wetlands.

The main existing programme for flood mitigation in the basin is the Flood Preparedness and Early Warning project (FPEW). This project was launched in 2007 by ENTRO to support national, regional and local authorities on flood preparedness, especially with early warnings and capacity building programmes.

### *6.3.3.2 Droughts mitigation*

As for floods, droughts can have devastating impacts: on agriculture, on potable water supply, on health, etc. (refer to section 3.2.6, Part 1, for more details). In order to mitigate the impacts of droughts, several actions are already implemented in the basin. These actions are based on securing access to potable water with boreholes, use of new crops resilient to drought, development of irrigation, etc.

# 6.4 CROSS-CUTTING SECTORS AND THEMES

## 6.4.1 Livelihood-based watershed management

### *6.4.1.1 Catchments of the Sub-basin*

The study document on watershed management of the Eastern Nile sub-basin by ENTRO indicates hotspots by the severity of soil erosion rates. The total soil eroded in the Baro-Akobo Catchment is estimated to be 43.7 million tons per annum and that from cultivated land 21.5 million tons per annum. The main contributing factors are the shifting cultivation and deforestation of the natural forests of the upper catchment areas of the Ethiopian highlands and Imatong Mountains in South Sudan.

On-site impacts of soil erosion are reductions in agricultural productivity. Productivity is reduced because of nutrient and organic matter losses and reduced water holding capacity caused by reduced soil depth.

There is no significant difference between the sediment yields of small and large catchments. This would appear to indicate there is little or no storage of sediment within the highlands system, a factor normally attributed to declining sediment yields with increasing catchment areas. However, in this case, this is to be expected given the steep gradients in both tributary and main rivers. Given the relatively high sediment delivery ratios and very similar sediment yields it would appear that within the Highlands the river system is relatively efficient in delivering and removing eroded sediment from the landscape. The inference of this is that interventions to reduce in-field erosion are likely to have a relatively immediate impact on sediment loading in the river system.

### *6.4.1.2 Existing/Ongoing livelihood based watershed management projects*

Before detailing local projects at national scale, it is worth reminding the regional work conducted by ENRO through the Watershed Management Project (involving Ethiopia and Sudan) which aimed at preserving the land cover and reducing the loss of vegetation cover (Anton Earle, 2015).

#### PROJECTS IN ETHIOPIA

The only project interventions known about are those woredas selected for SLMP 2. SLMP 2 is a Sustainable Land Management Project funded by the World Bank being implemented in few woredas of the sub-basin in Ethiopia. In addition to this, many woredas have plans for soil and water conservation interventions through mass mobilisation; funding for this comes from regional and central government.

Both the cooperative regional assessment and the reconnaissance field trip highlighted potential hotspot areas that may well prove to be corroborated during the master plan. The cooperative regional assessment identified ‘the northeast in the Upper Baro catchment, and in the southeast in the catchments of the Upper Gilo and Duna’ (part of the Akobo by an assessment of the extent of soil degradation while the reconnaissance field trip also identified slightly different areas in the northeast and southeast of the basin with the woredas of Yubdo, Ayra, Guliso, Haru and Genji in West Wellega Zone, part of the upper Bir basin and Meinit Goldiya and Meinit Shasha woredas in Bench Maji Zone in the Kilu, Bilang and Olmu river sub-basins in the upper Akobo sub-basin.

There are three major protected areas registered under UNESCO at the upper catchment of the sub-basin namely, Kefa and Sheka forests in Southern nations and nationalities and peoples’ region and Yayu forest biosphere in Oromia region. The protected forest areas are divided into Core, Buffer and Transitional categories with various measures implemented for sustainable coexistence of the forests and the local people residing in these areas. The major activities being implemented to support the livelihoods of the people relying on the natural forests include eco-tourism, pottery, production of honey, coffee, spices, medicinal plants and collection of tree seeds for sale to other regions of the country. Improved awareness of the local people through various advocacy strategies is regularly implemented through mass communication, coffee ceremonies, school children and biodiversity campaigners. Further efforts have been put in place to minimize human pressure on the natural forests through introduction of energy saving stoves, reliance on coffee briquettes for fuel and solar kiosks for lighting.

There are unique traditional conservation practices by the local people where different groups are engaged in utilizing and managing different resources underneath the natural forests such as forest coffee management, bee keeping, production of spices and root crops.

Major challenges still affecting the protected areas include encroachment of the river banks and wet lands by people outside of the region by converting to agricultural fields.

#### PROJECTS IN SOUTH SUDAN

The major ongoing livelihood based watershed management programme in South Sudan is located in the Imatong mountains. This project “Improving South Sudan’s livelihood and ecosystems management through watershed management” is being implemented by the AWF. The programme is a five years programme which aims at ensuring that the catchment area of the Upper Imatong mountains is well managed to ensure the sustainable access to water to the communities and ecosystems downstream. Activities being implemented are twofold:

- Training and equipping of forest guards and game rangers
- Interventions to enhance communities livelihood and provide alternatives

### 6.4.1.3 Main Issues and Challenges

The protected areas are facing various challenges on both side of the border. These challenges are: conflict of interest between various stakeholders on the use of the natural resources, conversion of forest and wetlands to agricultural lands, overgrazing, population pressure due to local population growth and influxes from other parts of the country as well as failure to implement regulatory programmes for protection of natural forests. In addition, in the Ethiopian part of the sub-basin, there are a number of commercial plantations of coffee and tea in the upper catchments which have made indiscriminate clearance of the natural vegetation and exposed vast areas of steep landscapes to soil erosion.Another concern related to livelihood based watershed is access to markets for better price specifically for cereals where there is no strongly organized cooperative. However, there are cooperatives organized in some zones in Ethiopia for facilitating access to national markets and fetch better prices. These cooperatives also play major roles of accessing seed money to watershed management households for improved productivity of needed agricultural products and sustainably manage their respective watersheds.

Upstream erosion causes downstream sedimentation, which decreases the existing and potential reservoirs lifetime, reducing the hydropower production potential. It also erodes bank slopes and damages habitat (Abdel·Fadil M., 2010)

#### MAIN ISSUES SPECIFIC TO THE ETHIOPIAN PART OF THE SUB-BASIN

Based reports from the Agriculture and Rural Development Office of Bench Maji zone, most of the cultivated fields are highly affected by soil acidity problem that have already shown negative impact on agricultural productivity in the zone. This problem could be solved through application of lime ($CaCO_3$). However, due to high cost of lime and lack of local technical capacity there has not been any action taken so far by the concerned government institution. It is obvious that this problem is affecting the food security and livelihood of the rural farming community in this part of the sub-basin.

The overall capacity and resources limitation for embarking on livelihood based watershed management in this part of the sub-basin in slow compared to other areas of the country since some of the efforts made for watershed management in the sub-basin are recent experience (SLM Programme and Mass mobilization for degraded land rehabilitation and natural resources management).

Land certification process as being done in other regions is not actually moving as required due to lack of technical capacity at zonal and woreda level for issuing certificates with all its roles and responsibilities of the land holder. This problem has been mentioned by the zonal offices as reasons for lack of farmers' confidence for investing on family plots where the use-rights have not been guaranteed through land certification.

**MAIN ISSUES SPECIFIC TO THE SOUTH SUDAN PART OF THE SUB-BASIN**

The Comprehensive Peace Agreement provided for the creation of the Southern Sudan Land Commission (SSLC), in 2006. The SSLC drafted a Land Act which was promulgated in 2009. Among others, the Land Act stipulates that the land is owned by the people of South Sudan, and that the Government is responsible for the regulation of the use of the land. Moreover, land administration is managed at a decentralized scale with County Land Authorities and Payam Land Councils. However, the implementation of the Land Act is slow and customary laws are still largely applied.

As emphasized in the environmental impacts, risks and opportunities assessment published by the UNDP in 2011, other threats in the South Sudan part of the sub-basin are the following:

- No value added through processing (forestry, agriculture),
- Land privatization associated with unregulated large scale clearing (land grabbing),
- Increased insecurity at community level and conflicts often related to resource access.

### *6.4.1.4 Potentials and Opportunities*

Given the initiatives so far on watershed management through various natural resources management projects in the sub-basin (SLMP, Forest Protection and Bio-diversity, Mass mobilization for natural resources conservation), there are vast hotspot areas to be considered for livelihood-based watershed management where the rural farming pastoral community could benefit on sustainable manner.

Those communities at upper catchments have mainly forest resources and cereal farming through shifting cultivation on relatively steep slopes of over 30%. Such areas require soil conservation and diversion structures to minimize soil erosion and improve agricultural productivity. Thus, these areas are needing such interventions sooner than later for the benefit of the community as well as protecting downstream potential areas from flooding and sedimentation.

The prevailing soil acidity problem of the sub-basin specifically in the southern region of Ethiopia could be alleviated through production and application of lime as this technology has already been applied in part of the sub-basin specifically in Oromia Region and other parts of the country through the Ministry of Agriculture and Natural Resources.

The move by the Ethiopian Government for provision of land certificates to rural land owners would be an opportunity for acceleration of the need for sustainable watershed management for improved livelihood of the rural community. There are efforts made by the Federal Government to implement the land use and land certification programme at national level.

The new initiative of Green Economy as well as climate smart agriculture programs would play the major role to develop and manage community based watersheds. In addition, the national guideline for planning and developing community based watershed management is a key document for zonal and district level institutions guiding and developing livelihood-based watershed management projects.

## 6.4.2 Biodiversity, habitats and landscape conservation

Around 30% of the basin surface area is covered by protected areas. The BAS totalizes over 30 protected areas which area briefly presented in the table below. Despite this large number and important coverage, important issues have been identified:

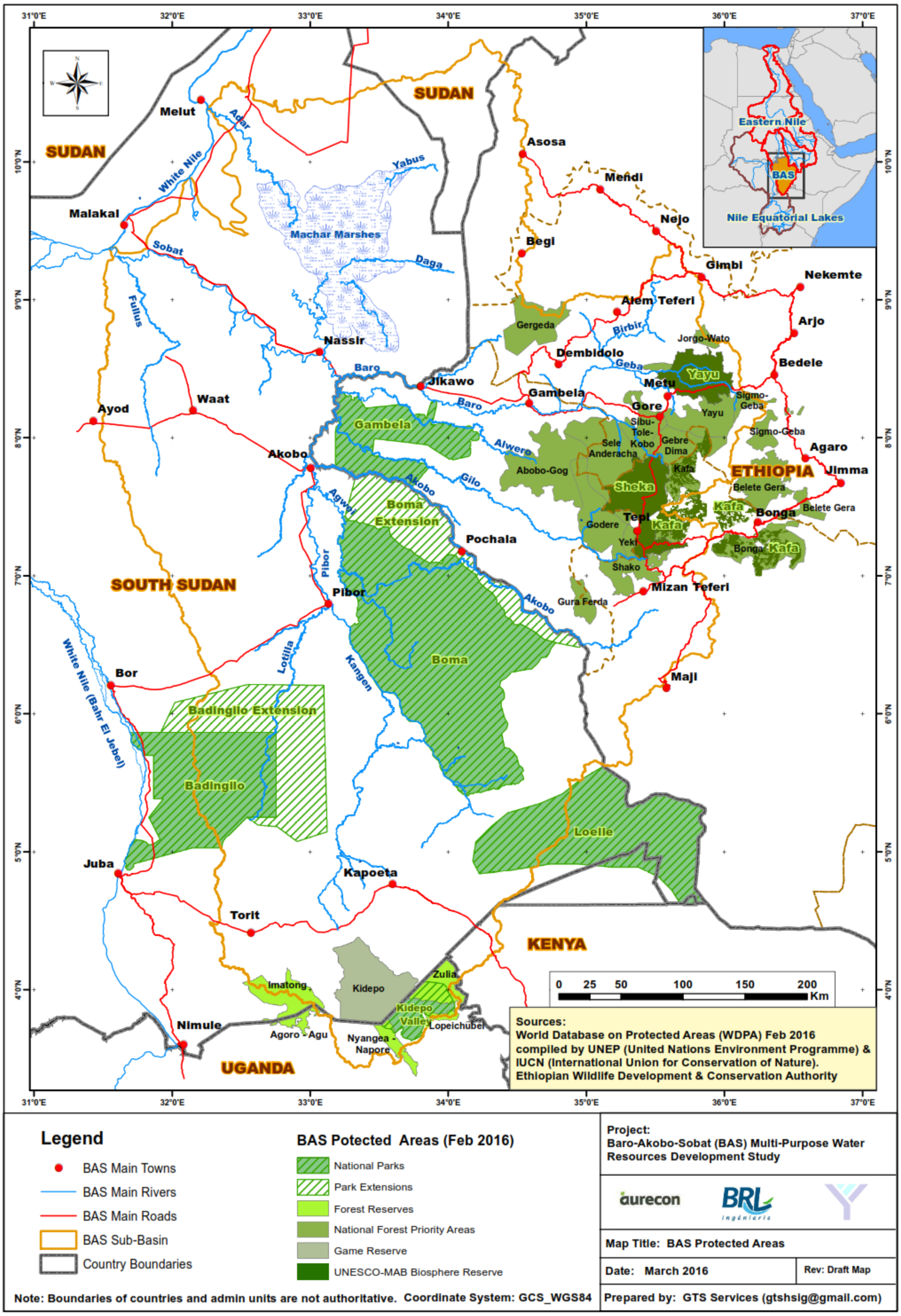
- Important (for biodiversity and livelihoods) and threatened ecosystems are not covered by any type of specific protection. This is for example the case of the Machar marshes (see figure below);
- Effective protection is quasi insignificant in the basin. However, recent planning initiatives (land use management plan under preparation in Gambella region and protected area management plan are under review for Badingilo and Boma national parks) and conservation projects in biosphere reserves can be noticed.
- Little general updated information is available, especially concerning National Forest Priority Areas, Forest reserves, and Game reserves;
- Little detailed information is available, including for the National parks.

*Table 6-23 : Main characteristics of protected areas in the BAS*

<table>
<tr><th>Type of protected area</th><th>Name</th><th>Country</th><th>Biophysical area</th><th>Total surface area (km²)</th><th>Date of creation</th><th>Current status</th></tr>
<tr><td rowspan="5">National Park</td><td>Gambella</td><td>Ethiopia</td><td>Floodplains and wetlands</td><td>4,554</td><td>1973</td><td>Gazetted and demarcated in 2014. Cooperation between EWCA and African Parks for the management</td></tr>
<tr><td>Boma</td><td>South Sudan</td><td>Floodplains and wetlands Foothills and Piedmonts</td><td>19,747 (24,634 with the proposed extension)</td><td>1977</td><td>Cooperation between MWCT and WCS for the management. Management plan under review. Currently closed for security reasons.</td></tr>
<tr><td>Badingilo</td><td>South Sudan</td><td>Floodplains and wetlands</td><td>8,934 (16,658 with the proposed extension)</td><td>1986</td><td>Cooperation between MWCT and WCS for the management. Management plan under review</td></tr>
<tr><td>Loelle</td><td>South Sudan</td><td>Floodplains and wetlands Foothills and Piedmonts</td><td>10,774</td><td></td><td></td></tr>
<tr><td>Kidepo valley</td><td>Uganda</td><td>Highlands, Escarpments</td><td>1,430</td><td>1962</td><td></td></tr>
<tr><td rowspan="6">Forest reserve</td><td>Imatong</td><td>South Sudan</td><td>Highlands, Escarpments</td><td>1,159</td><td>1952</td><td>No management plan</td></tr>
<tr><td>Agoro-Agu</td><td>Uganda</td><td></td><td>263</td><td>1948</td><td rowspan="5">No management plan reported</td></tr>
<tr><td>Nyangea-Napore</td><td>Uganda</td><td></td><td>423</td><td>1950</td></tr>
<tr><td>Lomej</td><td>Uganda</td><td></td><td>8</td><td>1963</td></tr>
<tr><td>Lopeichubei</td><td>Uganda</td><td></td><td>167</td><td>1963</td></tr>
<tr><td>Zulia</td><td>Uganda</td><td></td><td>925</td><td>1950</td></tr>
</table>

| Type of protected area | Name | Country | Biophysical area | Total surface area (km²) | Date of creation | Current status |
|---|---|---|---|---|---|---|
| National Forest Priority Area | Gura Ferda | Ethiopia | Highlands, Escarpments | 448 | | Bonga NFPA is the only demarcated NFPA in Kafa region; awareness level concerning NFPA is insignificant (NABU, 2011) |
| | Yeki | Ethiopia | Escarpments | 874 | | |
| | Shako | Ethiopia | Escarpments | 1009 | | |
| | Sibu-Tole-Kobo | Ethiopia | Highlands, Escarpments | 1006 | | |
| | Jorgo-Wato | Ethiopia | Highlands, Escarpments | 197 | | |
| | Sigmo-Geba | Ethiopia | highlands | 741 | | |
| | Yayu | Ethiopia | Highlands | 2301 | | |
| | Gergeda | Ethiopia | Highlands, Escarpments | 1405 | | |
| | Abobo-Gog | Ethiopia | Escarpments, Foothills | 2512 | | |
| | Gebre Dima | Ethiopia | Highlands, Escarpments | 2075 | | |
| | Godere | Ethiopia | Escarpments | 1699 | | |
| | Sele Anderacha | Ethiopia | Highlands, Escarpments | 2791 | | |
| Game reserve | Kidepo | South Sudan | Highlands, Escarpments | 2,856 | 1975 | No management plan |
| Biosphere reserves | Kafa | Ethiopia | Highlands | 2,474 | 2010 | Cooperation between Kafa zone administration and NABUfor the management Management plan approved |
| | Yayu | Ethiopia | Highlands, Escarpments | 1,662 | 2010 | Management: various administrative levels, Oromiya Forestry and Wildlife Enterprise, Oromiya Bureau of Agriculture and Rural Development and Ministry of Science and Technology. Management plan approved |
| | Sheka | Ethiopia | Highlands, Escarpments | 2,396 | 2012 | Cooperation between Sheka administration zone and MELCA for the management Management plan (2015-2019) approved |

*Figure 6-6: Protected area of the BAS*



### 6.4.3 Climate change mitigation

One of the principal consequences of climate change might be the increased occurrence of floods and droughts. As such, climate change mitigation measures are already implemented in the basin although these measures are not always formally announced as such. Indeed, climate change mitigation measures are not isolated measures but are usually integrated in projects.

Some measures, already introduced in the previous sections have their importance in climate change mitigation:

- Water storage and development of activities with the reservoirs such as livestock watering, fisheries, irrigation etc.This helps to face more severe droughts.
- Use of climate-resilient crops
- Protection measures to limit deforestation and increase water retention during heavy floods
- Etc.

## 6.5 CONCLUSION: CURRENT LEVEL OF WATER ABSTRACTIONS IN THE BAS SUB-BASIN

The table here after summarises, per sub-basin the current water uses for the main consuming sectors.

*Table 6-24: Current water uses for the main consuming sectors*

| sub-basin | Medium and large scale irrigation | | Small scale irrigation | | Current water supply ($Mm^3$) | | | Livestock watering ($Mm^3$) | | | TOTAL / year ($Mm^3$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Surface area (ha)** | Annual irrigation demand ($Mm^3$) | **Surface area (ha)** | Annual irrigation demand ($Mm^3$) | Ethiopia | South Sudan | Total | Ethiopia | South Sudan | Total | |
| Machar marshes | - | | - | | 8 | 8 | 16 | 1 | 9 | 10 | **26** |
| Birbir | - | | 73 622 | 481 | 25 | - | 25 | 4 | - | 4 | **510** |
| Geba | - | | 39 018 | 226 | 18 | - | 18 | 3 | - | 3 | **247** |
| Baro | - | | 3 312 | 22 | 7 | - | 7 | 4 | 0 | 4 | **33** |
| Alwero | 10 400 | 192 | 1 500 | 11 | 2 | - | 2 | 1 | - | 1 | **206** |
| Gilo | - | | 240 | 2 | 14 | - | 14 | 2 | - | 2 | **18** |
| Lower Akobo | - | | - | | 1 | - | 1 | 0 | 0 | 1 | **2** |
| Agwei | - | | - | | - | 1 | 1 | - | 2 | 2 | **3** |
| Upper Akobo | - | | - | | 7 | - | 7 | 1 | 1 | 2 | **9** |
| Upper Pibor East | - | | - | | - | 11 | 11 | 0 | 13 | 13 | **24** |
| Upper Pibor West | - | | - | | - | 5 | 5 | - | 6 | 6 | **11** |
| Lower Pibor and Sobat | - | | - | | - | 6 | 6 | - | 7 | 7 | **13** |
| **TOTAL** | **10** | **192** | **118** | **741** | **82** | **32** | **114** | **16** | **39** | **55** | **1 102** |

# 7. WATER BALANCE MODEL

## 7.1 MODELLING APPROACH AND OBJECTIVES

The main objective of the water balance modelling component as part of the baseline phase of this study is to quantify the available water within the study basin in both space and time. During subsequent phases of this study, the configured water balance model will be used as an analytical tool to assess the hydrological impacts of development interventions and management options, which can then be translated into relevant social, environmental and economic indicators to inform scenario evaluation. A two-step modelling approach was used. Firstly, a rainfall-runoff model was calibrated against observed stream flows at selected flow gauging stations in the basin. Secondly, the calibrated rainfall-runoff model was used to generate long-term monthly flows at various key locations within the basin. The modelling procedure involved seven sequential tasks:

i. Evaluation of flow records
ii. Delineation of model subcatchments
iii. Pre-processing of climate data
iv. Quantification of existing water demands and identification of existing water resources infrastructure
v. Calibration of the rainfall-runoff model
vi. Configuration and validation of the water balance model
vii. Simulation of long-term flow sequences and conducting a water balance

The NAM model was used for rainfall-runoff modelling, while MIKE HYDRO Basin was used as the water balance model. As far as possible, the configurations of both of these models made use of data and information from existing models which were evaluated in detail during the Scoping Phase of this Study.

## 7.2 EVALUATION OF FLOW RECORDS

Historically, an extensive river gauging network existed in the Baro-Akobo-Sobat sub-basin, with most of the major rivers and spills having been gauged at some time - even though it might have been only for short or intermittent periods. Flow data at stations in the basin are available from various sources including the Nile Basin Encyclopedia, the Ethiopian Master Plan Reports, the Nile Basin Research programme, the Nile Basin Initiative, ENTRO databases, the Ethiopian Ministry of Water, Irrigation and Energy and previous studies. Most of the stations have very little data available and are characterised by extensive periods of missing or incomplete data. It should be noted that several stations have more than one flow record from different sources. The spatial coverage of flow gauging stations also varies considerably across the basin. The upper Baro sub-basin as well as the lower Sobat River has good coverage of flow gauging stations, while the Gilo, Akobo and Agwei rivers are poorly gauged. There are no flow gauging stations located in the upper part of the Pibor sub-basin. Currently, there are three active flow gauging stations in the Ethiopian part of the basin namely the Baro at Itang, the Geba near Suppi and the Alwero at Dumbong Village, and only one in South Sudan at Hillet Doleib (NBI, 2014).

Time series plots, single mass plots, chronograms and unit runoff analyses were used to evaluate the quality of the available flow data in terms of stationarity, missing data and flow correlation (see Annex 5). Based on the outcome of the data quality control task, 28 stations were initially selected for further scrutiny. After further evaluation and consideration, a final selection of flow gauging stations and flow record periods were made to take forward in the hydrological analysis. These are highlighted in Annex 5, while a map showing the locations of the stations is also included in this Annex.

## 7.3 DELINEATION OF MODEL SUBCATCHMENTS

In order to ensure that the rainfall-runoff and water balance models accommodate the climate and physiographic variability across the Baro-Akobo-Sobat sub-basin, the basin was divided into smaller subcatchments for modelling purposes based on geographical, meteorological and drainage network considerations. The delineation of these subcatchments were further refined based on the locations of stream flow gauges, inter-catchment spills, wetlands, and future infrastructure developments. Annex 5-D displays a map of the model subcatchments and also includes a table which summarises relevant information per model subcatchement.

## 7.4 PRE-PROCESSING OF CLIMATE INPUT DATA

### 7.4.1 Derivation of Catchment Rainfall

#### MONTHLY RAINFALL

For the calibration of the rainfall-runoff model as well as for the simulation of long term flow sequences, reliable rainfall records are required. The primary source of rainfall data for this study was the database of patched monthly rainfall values across the Nile Basin for periods extending from 1904 to 2011 at some stations (NBI, 2014). The data originated from the Nile Basin Encyclopedia, the Ethiopian Masterplan Studies, the Global Historical Climate Network (GHCN) database, the Food and Agricultural Organization (FAO) climate database, the Ministry of Water and Energy in Uganda (MWE), the Nile Basin Research Program (NBRP) and previous recent studies. From this dataset, rainfall stations located within the Baro-Akobo-Sobat sub-basin as well as stations adjacent to the basin boundary were selected. Annex 5-C provides information about the selected stations (125 in total) in tabular format and also includes a chronogram showing the record length and data availability for both the raw and patched datasets. Locations of rainfall stations are also displayed on a map in Annex 5-B.

Each of the observed rainfall records was tested for stationarity, and assessed to ascertain the extent of any missing data. Two stations (Saiyo and Fangak) were identified as non-stationary, while two other stations (Alge and Dembi Dollo) had significant periods of missing data. All four stations were removed from the dataset. In addition, the Mean Annual Precipitation (MAP) at each station was checked against adjacent station MAPs to highlight possible spatial anomalies. Two stations were found to be comparatively inaccurate: Dembi Dollo, with a low MAP of 544 mm, and Mizan Teferri, with a high MAP of 2293 mm. These two stations were also excluded from the dataset.

Although the monthly patched values provide a comprehensive dataset in the upland areas of the main subcatchments, spatially, there is a paucity of rainfall stations in the Pibor, lower Gilo, Akobo and Sobat subcatchments as well as in the *Machar marshes*. Furthermore, except for six stations, the majority of the rainfall records do not extend beyond 2004.

*In order to extend the rainfall to 2014, the global high resolution, land precipitation gridded rainfall dataset from the Climatic Research Unit (CRU) at the University of East Anglia was used (Harris et al., 2014). The CRU dataset has a resolution of 50km by 50km and monthly CRU rainfall data are available from 1901 to 2014. The CRU monthly rainfall data were compared to the observed monthly rainfall data* *for overlapping periods. A selection of these comparisons is shown in*


Figure 7-1 for various model subcatchments. The correlation between the CRU and observed annual rainfall values vary in space and time within the study area and appears to be stronger pre- 1980 when more accurate rainfall data were probably available for improved meteorological modelling. The CRU data were not used to generate rainfall in parts of the basin which are lacking in observed rainfall data, due to concerns about the representativeness of the CRU data and interpolation between existing stations was preferred.

### DAILY RAINFALL

An important input to the deterministic rainfall runoff modelling undertaken as part of this study is daily rainfall depths. However, very limited daily rainfall data are available within the study area. Daily rainfall values at only four stations within the Baro-Akobo-Sobat sub-basin, from 1951 to 1991, were obtained from the Global Historical Climatology Network (GHCN) at Gore, Jimma, Juba and Malakal. These stations, however, are not spatially representative of the whole study basin, and also include missing values throughout the record period. In order to supplement the paucity of daily rainfall data, daily modelled rainfall data from the Swedish Meteorological and Hydrological Institute (SMHI) database at the locations of key stations within the basin were used to disaggregate monthly rainfall to representative daily rainfall patterns. The SMHI dataset is at a 45km by 45km resolution and provides daily rainfall values from 1951 to 2005. The datasets are downscaled from Global Climate Models (GCMs) which have been forced by known or estimated climate parameters from CMIP5 historical data. Since the SMHI data only extends from 1951 to 2005, an average daily distribution was used for the period between 1905 and 1950 and post 2006.


*Figure 7-1: Comparison of observed and CRU rainfall at selected locations*

## CATCHMENT RAINFALL

Daily catchment rainfall files (expressed as percentage of MAP) for each of the model sub-catchments were calculated using a Thiessen Polygon approach which weighted the contributions of selected rainfall stations within the vicinity of subcatchments based on the proximity of each station to that subcatchment. Annex 5-D provides information about the combination of rainfall stations which were used to generate monthly catchment rainfall files for each of the model subcatchments. The stations which were used to disaggregate the monthly rainfall for each subcatchment into daily patterns are also listed in the Annex.

A Mean Annual Precipitation (MAP) surface (Figure 3-9) for the study basin was generated based on the MAPs of all selected rainfall stations using Kriging. Based on the MAP surface, a MAP value was calculated for each model sub-catchment (see Annex 5-D), after which the daily percentage MAP file for each sub-catchment was multiplied by this value to obtain a time series of daily rainfall.

### 7.4.2 Evaporation Estimates

Average monthly evaporation values in the vicinity of the Baro-Akobo-Sobat sub-basin were available from the Ethiopian Master Plan studies and the Global FAOClim database. In addition, location specific observed and calculated datasets were sourced from previous study reports. Annex 5-D includes a map which displays the location of these evaporation stations, from which it evident that very little evaporation data are available in the southern part of the basin and particularly in South Sudan.

In order to supplement this data, the FAO Penman-Monteith ET0 Calculator was employed to calculate monthly average evaporation values using climate data at key station locations. Maximum and minimum daily temperatures and relative humidity were used as input to the Calculator, and were extracted from the SMHI climate dataset. The Calculator was used to determine the evapotranspiration at three additional locations, namely Pibor Post, Torit and Malakal. Annex 5-D includes a table which summarises the average monthly evaporation values at the available stations and sites as obtained from the above sources. The Mean Annual Evaporation (MAE) for each available station was compared to adjacent stations, and anomalous stations were not used for the purpose of this study. Stations with missing evaporation data were also excluded. The stations which were ultimately used in the hydrological modelling are highlighted in Annex 5-D. Using these stations' data, a Mean Annual Evapotranspiration surface was generated for the study area using Kriging, as shown in Figure 3-9. In order to calculate monthly reference evapotranspiration values for each model subcatchment, a representative evaporation station was assigned to each model subcatchment. The monthly values at each station were expressed as a percentage of the MAE and, based on the MAE value for each subcatchment as determined from the MAE surface, monthly percentage MAE values were converted to absolute monthly values. Estimates of open water evaporation, which was assumed to characterise the marshes and floodplains during the wet season, were based on an adjustment of +20% to the FAO Penman-Monteith ET0 values (USGS, 2013).

Annex 5-C provides information about the reference MAE values for subcatchments as well as the representative evaporation stations assigned to each subcatchment.

## 7.5 EXISTING SURFACE WATER USE AND WATER RESOURCES INFRASTRUCTURE

The Baro-Akobo-Sobat sub-basin is largely undeveloped. The only major scheme in the basin is the Abobo Irrigation Scheme. This is fed from the Abobo Dam, which is situated on the Alwero River. Construction of the dam began in the early 1980s and it was completed in 1997. The dam was intended for the development of large-scale irrigated agriculture, however, the dam was never used for its intended purpose. An irrigation potential of over 10,000 ha has been estimated for the dam. In 2013, two agricultural projects were initiated in the Gambella region, including a large-scale rice farm near Abobo and a large-scale sugar-cane and corn farm. These farms have shown interest in moving towards irrigated agriculture using water from the Abobo Dam or Baro River. There are no other existing commercial irrigation or hydropower installations in the basin (except Sor dam for hydropower).

Water from the rivers is used for domestic and livestock water requirements by riparian communities, while recession agriculture along the banks of rivers is also very important in certain areas. During the wet season, the domestic and livestock water demands are negligible compared to the average daily flows in the rivers. However, during the dry season, especially in certain parts of the basin, these demands cannot always be satisfied using run-of-river supply. The Anuwak, Opo and Komo peoples cultivate the banks of the Baro, Akobo and Sobat Rivers with mainly maize, beans and sorghum. The Shilluk people farm along the banks of the White Nile and Sobat Rivers with sorghum, maize, groundnuts, beans, vegetables and tobacco. Small-scale irrigated cropping also exists within the basin. Along the White Nile, small-scale irrigators pump water directly from the river to water mainly cereals and vegetables.

Rain-fed crop cultivation is the principal livelihood activity in the regions of the basin which receive adequate rainfall. The economy is subsistence oriented, implementing simple manual agricultural methods. Maize and sorghum are the main crops farmed. In the Ethiopian Highlands, the Mocha people produce mainly enset, cereals and tubers.

The South Sudan part of the basin has a high concentration of cattle, sheep and goats. In Ethiopia, and particularly the Gambella region, the possession of livestock is considered prestigious. Livestock watering is an issue, particularly in the dry season. In South Sudan, roughly 80 to 90% of the population live in agro-pastoralist communities. In 2012, the following populations were recorded for the agro-pastoralist communities of South Sudan: 36 million inhabitants, 11.7 million cattle, 12.4 million goats and 12 million sheep. This livestock was estimated to grow by 2 to 3% every year. During dry seasons, pastoralists travel long distances in order to find water for their livestock, often causing conflict between communities due to livestock movement across tribal boundaries.

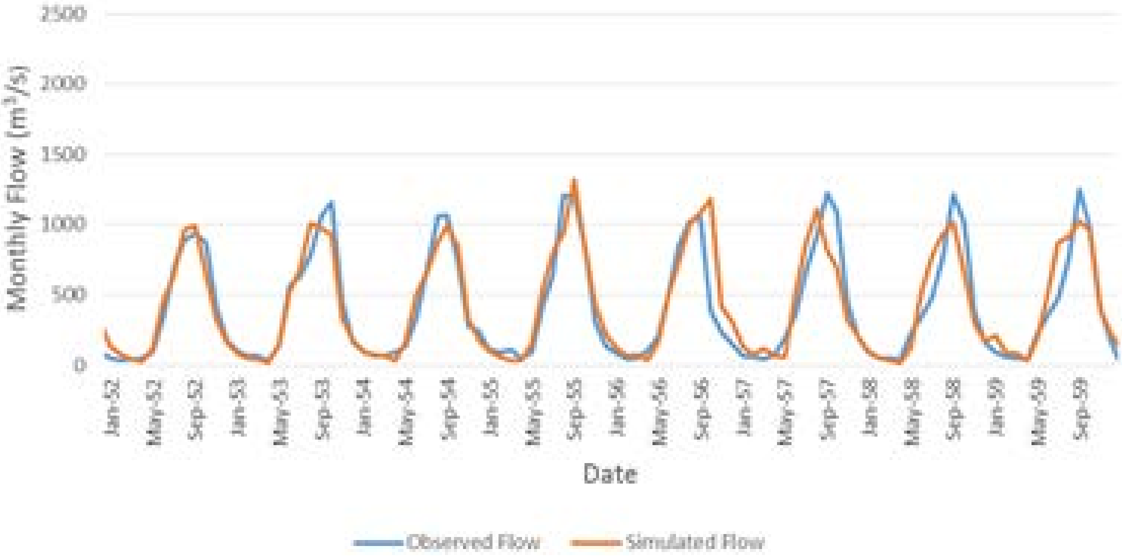
More details regarding current levels of water resources development are provided in Section 6 (Part 1) of this report.

## 7.6 Calibration of the NAM Rainfall-Runoff Model

The NAM rainfall-runoff model (Nielsen and Hansen, 1973) was used as the deterministic model for generating synthetic flow sequences. The model is based on physical processes and accounts for moisture in four inter-related storage zones, whilst it requires limited data inputs (rainfall and evaporation). In order to calibrate the NAM model at the location of a stream flow gauge, concurrent flow and rainfall data in the upstream catchment are required. After careful consideration of the availability and quality of the existing historical flow records within the study basin, only two gauges viz. Baro at Gambella and Alwero at Abobo were selected for model calibration.

### 7.6.1 Baro at Gambella

*The Gambella streamflow gauge has an upstream catchment area of 23 541 km2 and provides a good quality flow record which is relatively long and continuous. The Gambella sub-catchment also has a sufficient number of rainfall stations, offering good spatial coverage, and represents the highlands part of the catchment where a significant volume of water is generated. Using a combination of the available flow records from various sources, a record period from 1906 to 1989 was compiled and through an iterative process of NAM simulations, a calibration period from 1952 to 1959 was eventually selected. The final NAM calibration parameters are listed in Table 7-1, while the calibration statistics are summarised in Table 7-2. The observed and simulated flows for this period are shown in*




*, which shows a good overall agreement in terms of the shape of the hydrographs. A coefficient of determination of 0.92 was achieved, which indicates a good fit. The seasonality also shows a good fit*

*between the observed and simulated average monthly flows, as shown in*

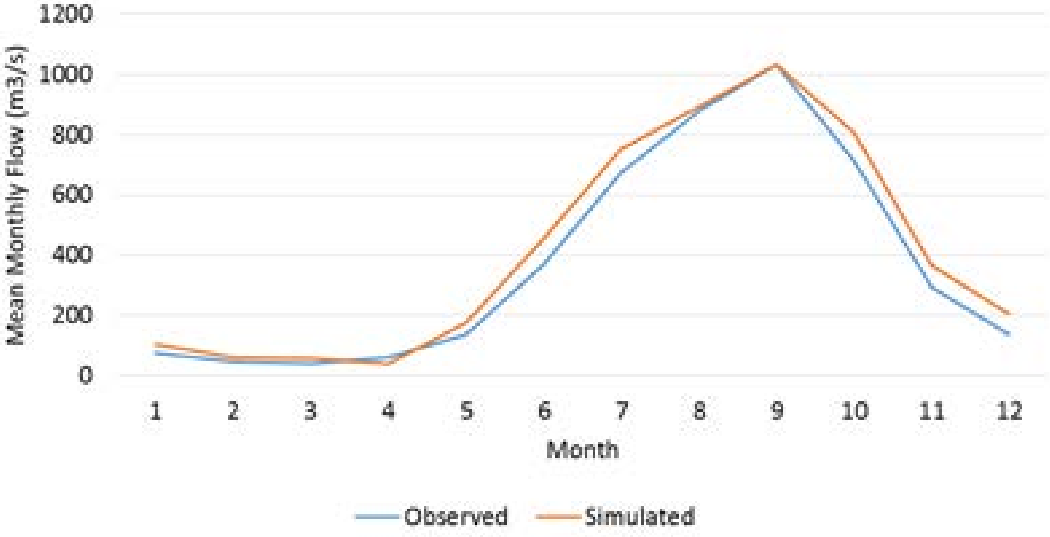



Figure 7-3, with the observed and simulated peaks occurring in September.

*Table 7-1: Calibration parameters for Gambella*

| Lmax | Umax | QOF | TIF | TOF | TG | CKOF | CKIF | CKBF | CQOF | CQIF |
|---|---|---|---|---|---|---|---|---|---|---|
| 550 | 30 | 0.7 | 0.75 | 0 | 0 | 2 | 20 | 50 | 0.5 | 0.1 |
| mm | mm | $m^3/s$ | - | - | - | days | days | days | - | - |

*Table 7-2: Calibration statistics for Gambella*

| | Observed | Simulated | Difference |
|---|---|---|---|
| Mean Annual Runoff (million $m^3/a$) | 13 091 | 13 434 | +2.6% |
| Standard Deviation of Monthly Flows ($m^3/s$) | 386 | 374 | -3.0% |
| $R^2$ | 0.92 | | |

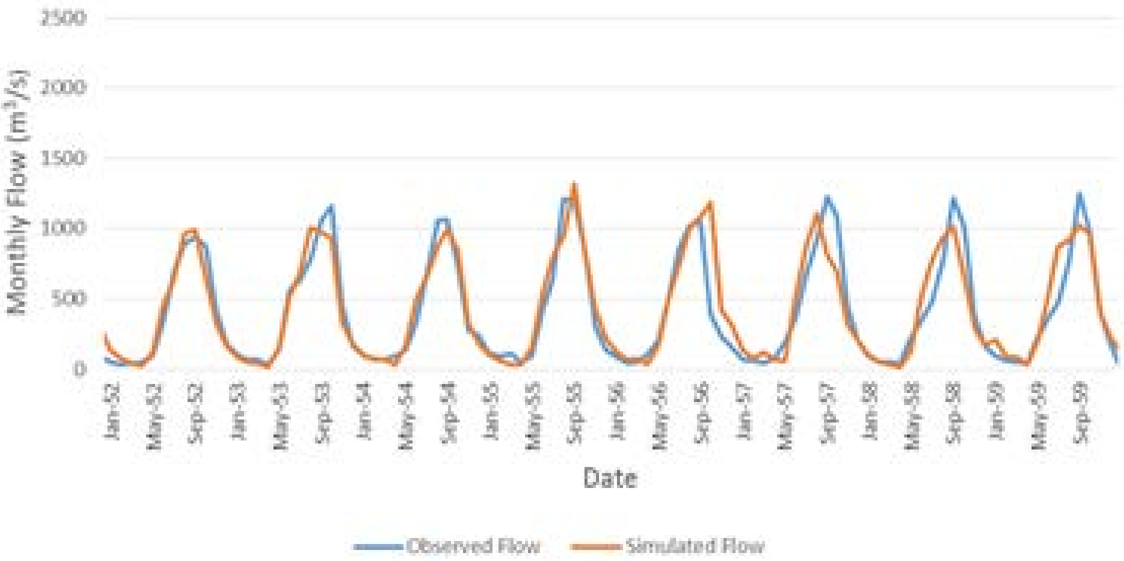



*Figure 7-2: Monthly flows in Baro River at Gambella*

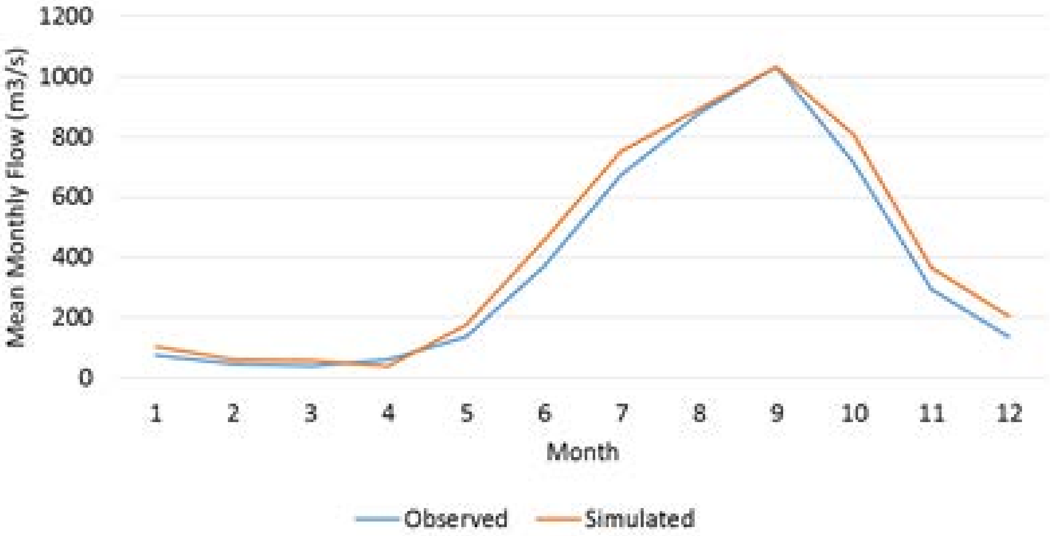



*Figure 7-3: Seasonal flows in Baro River at Gambella*

### 7.6.2 Alwero at Abobo

The Alwero at Abobo streamflow gauge provides a reasonable flow record for calibration, with a relatively good flow record compared to nearby flow gauges. The catchment area of 2 859 km2 is representative of a lowlands catchment with elevations below 500 masl. Through an iterative process of NAM simulations, a calibration period from 1976 to 1989, excluding the years from 1982-1987, was selected. The final NAM calibration parameters are listed in Table 7-3. The observed and simulated flows for this period are shown in Figure 7-4 and Figure 7-5, which shows a good overall agreement in terms of the shape of the hydrographs, although there is a tendency to over simulate peaks. The calibration statistics (excluding the missing years) are summarised in Table 7-4. A coefficient of determination of 0.85 was achieved, which indicates a good fit. Figure 7-5 shows a reasonable fit between the observed and simulated average monthly flows, although the simulated flows seem to lag behind the observed flows to some extent.

*Table 7-3: Calibration parameters for Alwero at Abobo*

| Lmax | Umax | QOF | TIF | TOF | TG | CKOF | CKIF | CKBF | CQOF | CQIF |
|---|---|---|---|---|---|---|---|---|---|---|
| 700 | 40 | 0.7 | 0.75 | 0 | 0 | 0.5 | 20 | 50 | 0.5 | 0.1 |
| mm | mm | $m^3/s$ | - | - | - | days | days | days | - | - |

*Table 7-4: Calibration statistics for Alwero at Abobo*

| | Observed | Simulated | Difference |
|---|---|---|---|
| Mean Annual Runoff (million $m^3/a$) | 577 | 599 | 3.8% |
| Standard Deviation of Monthly Flows ($m^3/s$) | 14 | 16 | 15.3% |
| $R^2$ | 0.85 | | |

Note: For the purposes of the calibration, the capacity of the Alwero River in the vicinity of the gauge was set equal to 55 $m^3/s$. According to Sutcliffe and Parks (1999), the river starts breaking its banks at this flow. Therefore, in order to compare observed and simulated in-channel flows, the simulated daily flows were truncated at 55 $m^3/s$.

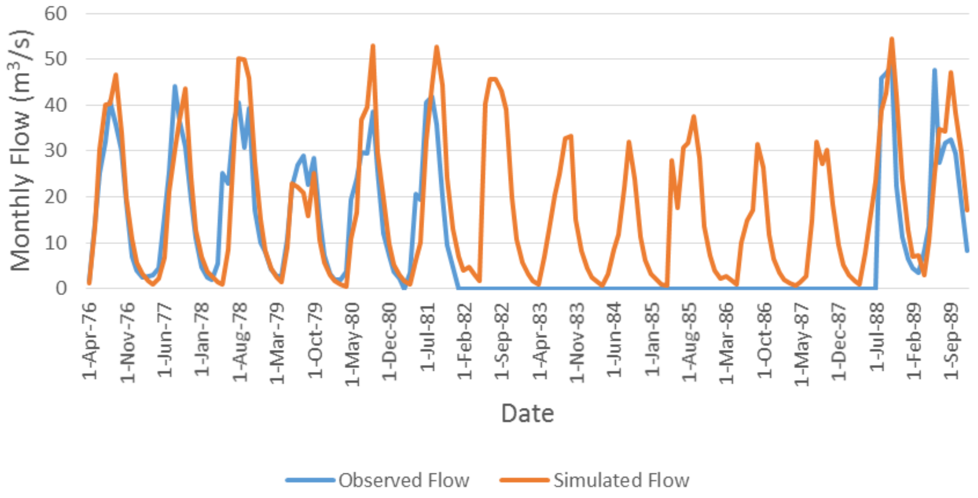



*Figure 7-4: Monthly flows in Alwero River at Abobo*

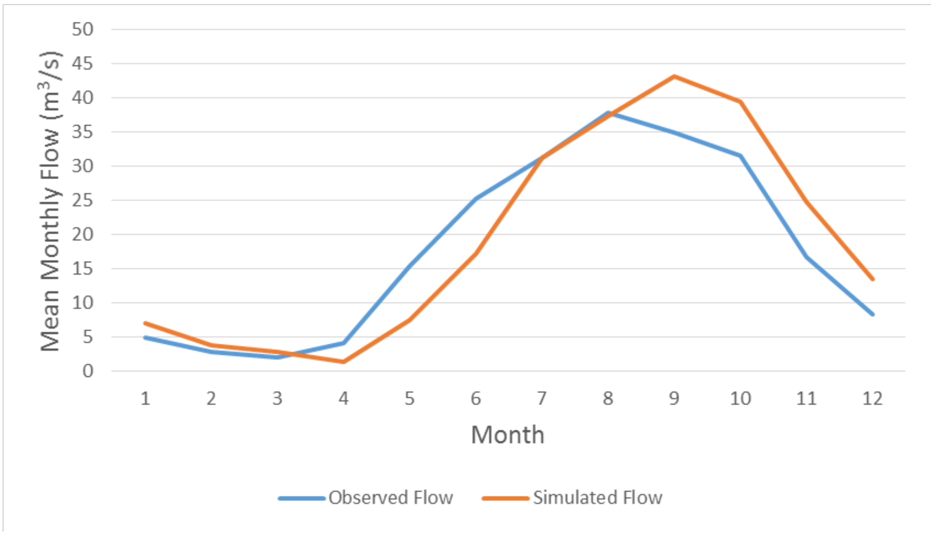



*Figure 7-5: Seasonal flows in Alwero River at Abobo*

### 7.6.3 Yabus at Yabus Bridge

The Jonglei Investigation Team (1954) conducted flow measurements over a five year period (1950 to 1955) in the Yabus River at Yabus Bridge, one of the so-called eastern torrents which drains to the Machar Marshes from the Ethiopian Highlands. Unfortunately, it was not possible to obtain the raw time series data. However, from Sutcliffe and Parks (1999), the mean monthly values of the recorded flows were available and used for calibration of the catchment upstream of Yabus Bridge using observed rainfall during the period 1950 to 1955. The results of the comparison between simulated and observed mean monthly flows for the calibration period is shown in Figure 7-6.

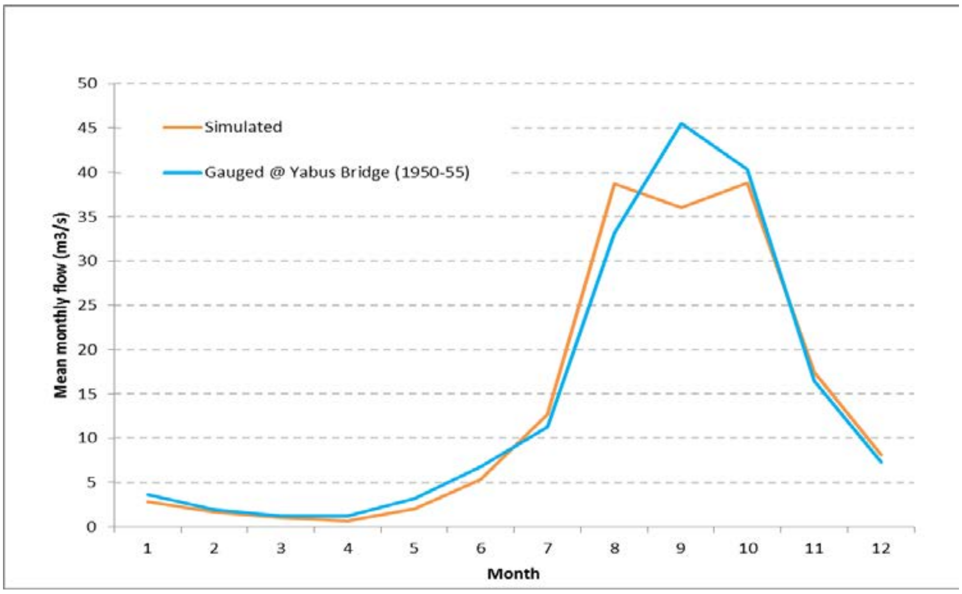



*Figure 7-6: Seasonal flows in Yabus River at Yabus Bridge*

The NAM calibration parameters for the Yabus catchment upstream of Yabus Bridge are listed in Table 7-5.

*Table 7-5: Calibration parameters for Yabus at Yabus Bridge*

| Lmax | Umax | QOF | TIF | TOF | TG | CKOF | CKIF | CKBF | CQOF | CQIF |
|---|---|---|---|---|---|---|---|---|---|---|
| 815 | 40 | 0.7 | 0.5 | .05 | 0.35 | 0.5 | 15 | 65 | 0.3 | 0.1 |
| mm | mm | $m^3/s$ | - | - | - | days | days | days | - | - |

### 7.6.4 Daga at Daga Post

The Jonglei Investigation Team (1954) conducted flow measurements over a four year period (1950 to 1954) in the Daga River at Daga Post, one of the so-called eastern torrents which drains to the Machar Marshes from the Ethiopian Highlands. Unfortunately, it was not possible to obtain the raw time series data. However, from Sutcliffe and Parks (1999), the mean monthly values of the recorded flows were available and used for calibration of the catchment upstream of Yabus Bridge using observed rainfall during the period 1950 to 1954. The results of the comparison between simulated and observed mean monthly flows for the calibration period is shown in Figure 7-7.

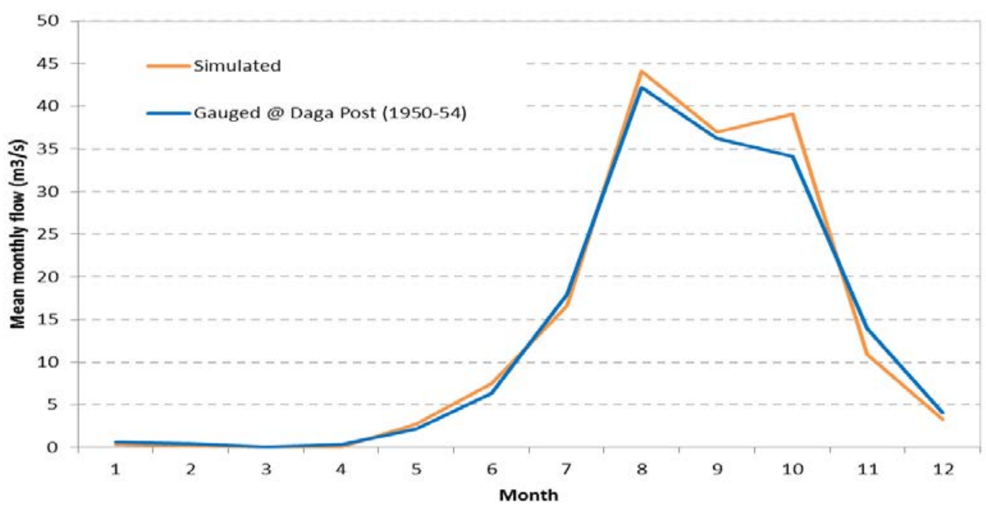



*Figure 7-7: Seasonal flows in Daga River at Daga Post*

The NAM calibration parameters for the Daga catchment upstream of Daga Post are listed in Table 7-6.

*Table 7-6: Calibration parameters for Daga at Daga Post*

| Lmax | Umax | QOF | TIF | TOF | TG | CKOF | CKIF | CKBF | CQOF | CQIF |
|---|---|---|---|---|---|---|---|---|---|---|
| 1000 | 40 | 0.7 | 0.5 | .05 | 0.7 | 0.5 | 10 | 50 | 0.3 | 0.1 |
| mm | mm | $m^3/s$ | - | - | - | days | days | days | - | - |

# 7.7 CONFIGURATION AND VALIDATION OF THE MIKE HYDRO BASIN MODEL

A critical aspect of the water balance model which was configured for the Baro-Akobo-Sobat sub-basin relates to the accurate representation of the interaction between the main river system, smaller tributaries, spills, floodplains, marshes and wetlands as well as attenuation and evaporation and infiltration losses along floodplains.

## 7.7.1 Model configuration

The configuration of the baseline water balance model for the Baro-Akobo-Sobat sub-basin entailed four key elements:

- Constructing the model network in MIKE HYDRO Basin using a combination of model components
- Generating flow sequences for specific validation periods in all of the model sub-catchments using the calibrated NAM rainfall runoff model.
- Refining the model network in an iterative manner through the representation of wetlands, floodplain storage, inter-catchment links and spills onto the floodplains and marshes, including attenuation and losses due to evaporation. This process was informed by remote sensing data and information from maps, previous study reports and literature
- Validation of the model

Using the NAM rainfall-runoff model along with catchment rainfall files, evaporation estimates and calibration parameters for each model sub-catchment, monthly flow sequences for specific periods were simulated for each sub-catchment. The Gambella NAM parameters were transferred to all of the sub-catchments in the upper Baro sub-basin, the upper Akobo and the upper Gilo sub-catchments, while the Alwero parameters were employed to simulate runoff in the lower Gilo, Alwero, lower Akobo, lower Sobat and Pibor sub-catchments. The Yabus and Daga parameters were used to simulate runoff from the Machar eastern torrents. Annex 5-D provides information about the NAM parameters which were transferred to each model sub-catchment.

Inter-catchment spills were modelled using bifurcation nodes and link channels. Bankfull channel capacities and spill locations were based on information from literature and by interrogating maps and historical satellite images of the study basin. In order to accommodate lags, evaporation and infiltration losses and attenuation in the wetlands, marshes and floodplains, dummy dams were introduced and modelled as rule-curve reservoirs to represent storage in these areas. In some cases, the outlet capacities of these dams were set equal to the downstream river channel capacities. Coarse storage-elevation-area relationships for wetlands and marshes in the basin were estimated based on historical inundation extents from satellite images, previous study reports and various global inundation datasets. Historical observed inundation areas during specific flood events were used to refine the assumptions regarding channel capacities, spill locations and spill volumes.

Annex 5-E provides a summary of the information and sources that were used to refine the model structure in terms of floodplains, inter-catchment links and spills.

A schematic of the conceptual representation of floodplain links, spills, wetlands and storage areas in the Baro-Akobo-Sobat sub-basin is shown in Figure 7-8.

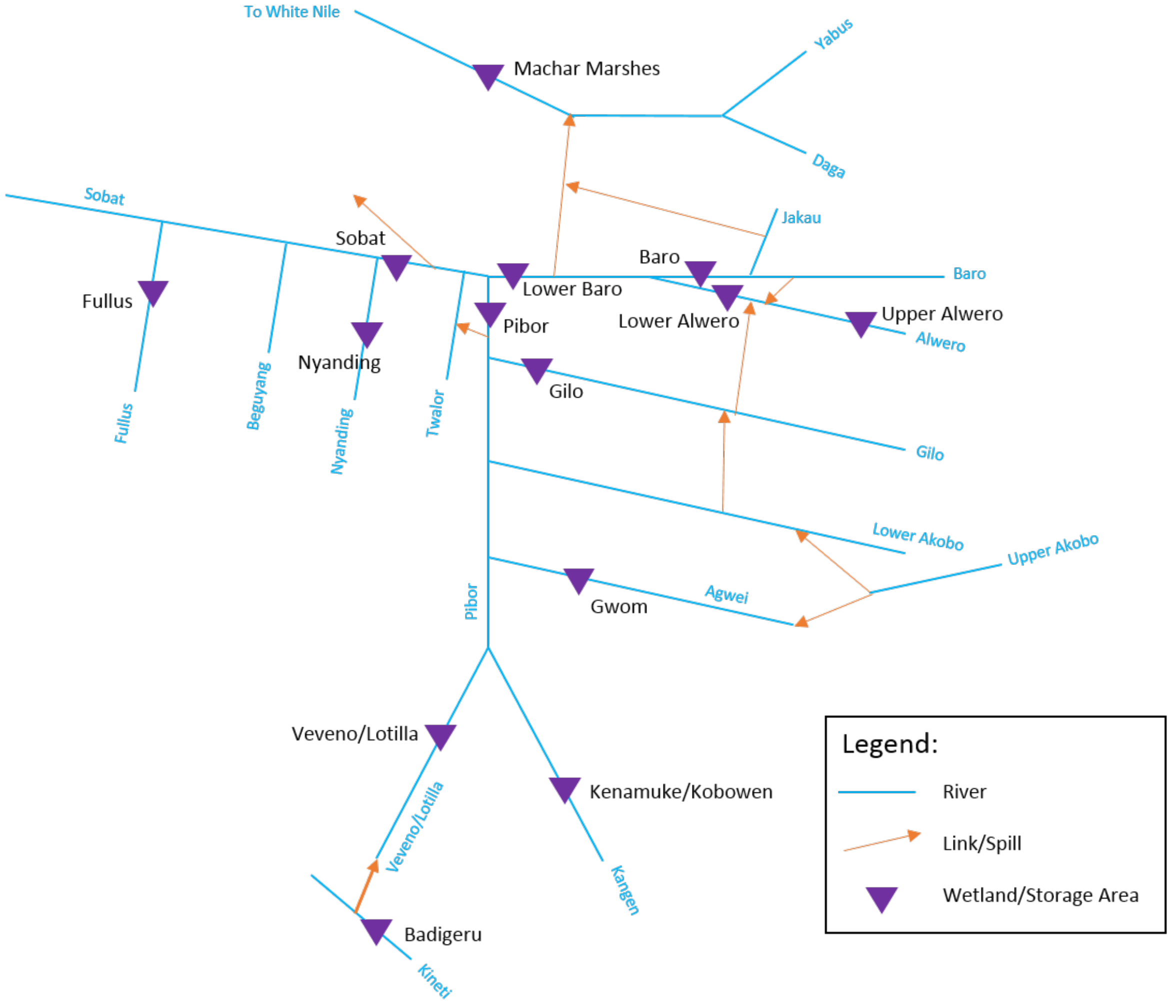



*Figure 7-8: Conceptualisation of floodplain dynamics in lower Baro, Pibor and Sobat catchments*

The final MIKE HYDRO Basin baseline model for the Baro-Akobo-Sobat basin is shown in the figure next page. The existing Abobo Dam on the Alwero River was included in the baseline model.

The Abobo Dam was completed in 1997, and was therefore modelled to be effective from 1997 onwards. A minimum environmental flow release from Abobo Dam of about 45 million m$^3$ per year was also included in the model configuration. Due to the relatively insignificant (from a water balance perspective) current day water requirements by other users in the basin e.g. livestock, domestic and very limited small scale irrigation, coupled with the fact that these users make use of groundwater to a large extent, these water demands were not included in the baseline model.

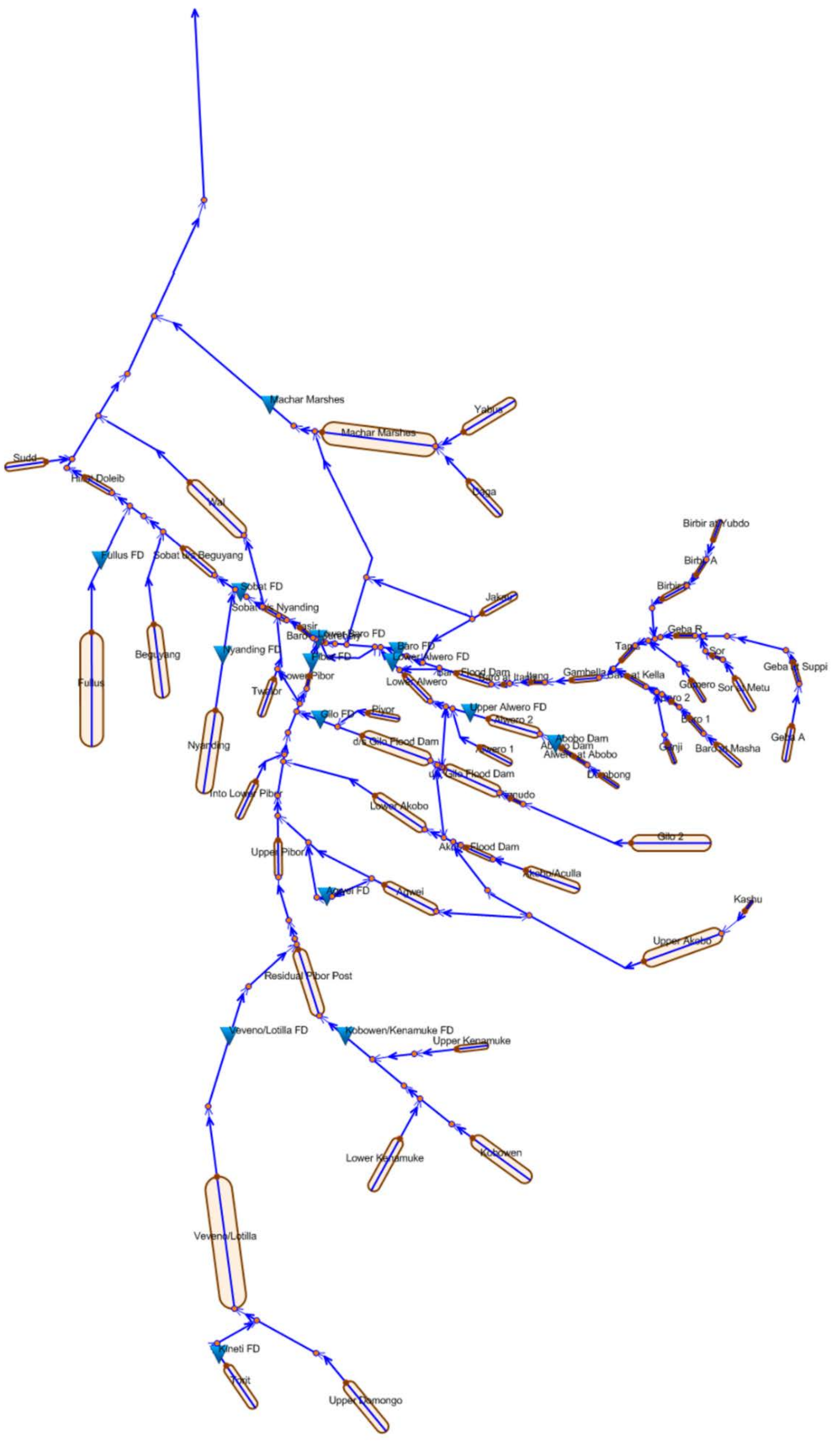



*Figure 7-9: Final baseline MIKE HYDRO Basin model network*

### 7.7.2 Model validation

The Sobat and Hillet Doleib gauges on the Baro River were identified as key validation gauges - specifically with regard to the assumptions related to the spills, evaporation and infiltration losses modelled along the extensive floodplains upstream of these gauges. In addition, a validation of the simulated model flows was done at Gambella based on the summation of all of the incremental upstream model subcatchment flows, while the limited flow record on the Baro River upstream of its confluence with the Pibor River also provided a useful check on the validity of the model. Unfortunately, the paucity of good quality flow records along the lower Pibor River catchment, meant that the model could not be validated in this part of the basin.

#### Baro at Gambella

Flows were simulated for a validation period of 1970 to 1989. The observed and simulated flows for the validation period are shown in Figure 7-10, and display a high coefficient of determination of 0.95. The seasonality of the observed and simulated flows as shown in Figure 7-11 also show a good fit. The validation statistics for Gambella are presented in Table 7-7. The 11.1% difference between the observed and simulated MAR is largely due to the difference in observed and simulated peak flows of 1988. There was a recorded flood at Gambella in 1988, which agrees with the large simulated peak flow for this year, which may not have been measured accurately by the gauge at Gambella.

*Figure 7-10: Validation of simulated flows at Gambella*

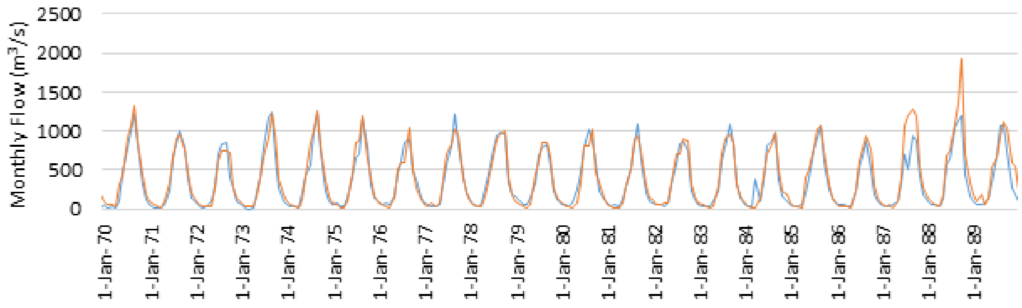



*Figure 7-11: Validation of seasonality of flows at Gambella*

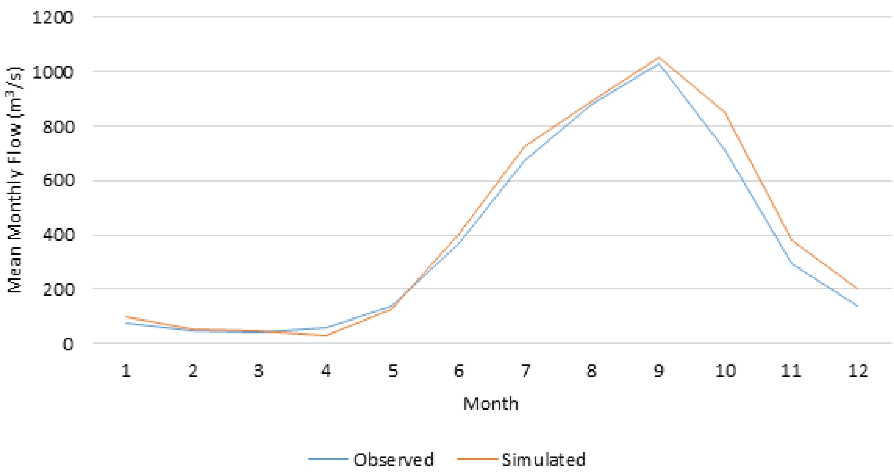



*Table 7-7: Validation statistics at Gambella*

| | Observed | Simulated | Difference |
|---|---|---|---|
| Mean Annual Runoff (million $m^3$/a) | 11 788 | 12 868 | 9.2% |
| Standard Deviation of Monthly Flows ($m^3$/s) | 358 | 384 | 7.6% |
| $R^2$ | 0.95 | | |

## SOBAT AT NASIR

Flows were simulated for a validation period from 1929 to 1963. The observed and simulated flows for the validation period are shown in **Erreur ! Source du renvoi introuvable.**, and display a high coefficient of determination of 0.94. The seasonality of the observed and simulated flows as shown in Figure 7-12: Validation of simulated flows at Nasir

also displays a good fit. The validation statistics for Nasir are presented in Table 7-8. The simulated and observed MARs show a very good fit, with only 0.1% difference.

*Figure 7-12: Validation of simulated flows at Nasir*

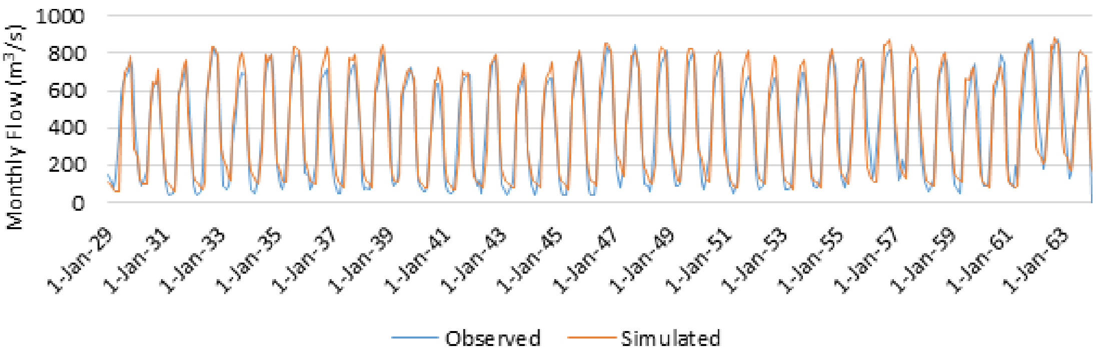



*Figure 7-13: Validation of seasonality of flows at Nasir*

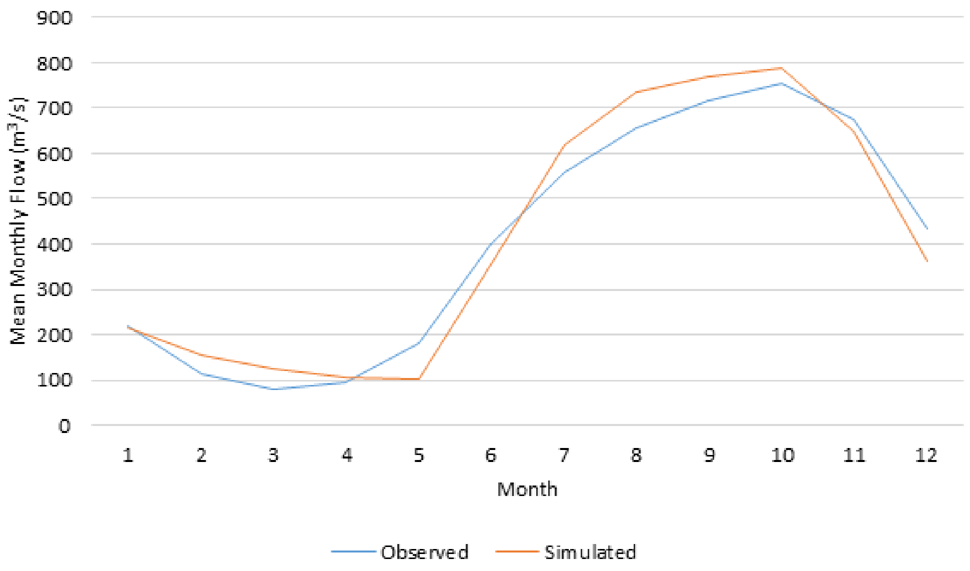



*Table 7-8: Validation statistics at Nasir*

| | Observed | Simulated | Difference |
|---|---|---|---|
| Mean Annual Runoff (million $m^3$/a) | 12 885 | 13 136 | 1.9% |
| Standard Deviation of Monthly Flows ($m^3$/s) | 262 | 276 | 5.4% |
| $R^2$ | 0.95 | | |

## SOBAT AT HILLET DOLEIB

Flows at Hillet Doleib were simulated for a validation period from 1929 to 1963. The observed and simulated flows for the validation period are shown in Figure 7-14 and display a high coefficient of determination of 0.87. The seasonality of the observed and simulated flows as shown in Figure 7-14: Validation of simulated flows at Hillet Doleib

also shows a relatively good fit. The validation statistics for Hillet Doleib are presented in Table 7-9.

*Figure 7-14: Validation of simulated flows at Hillet Doleib*

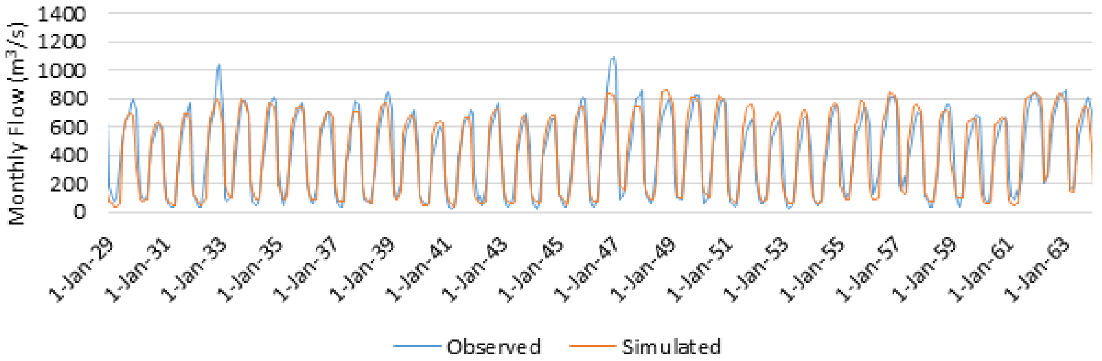



*Figure 7-15: Validation of seasonality of flows at Hillet Doleib*

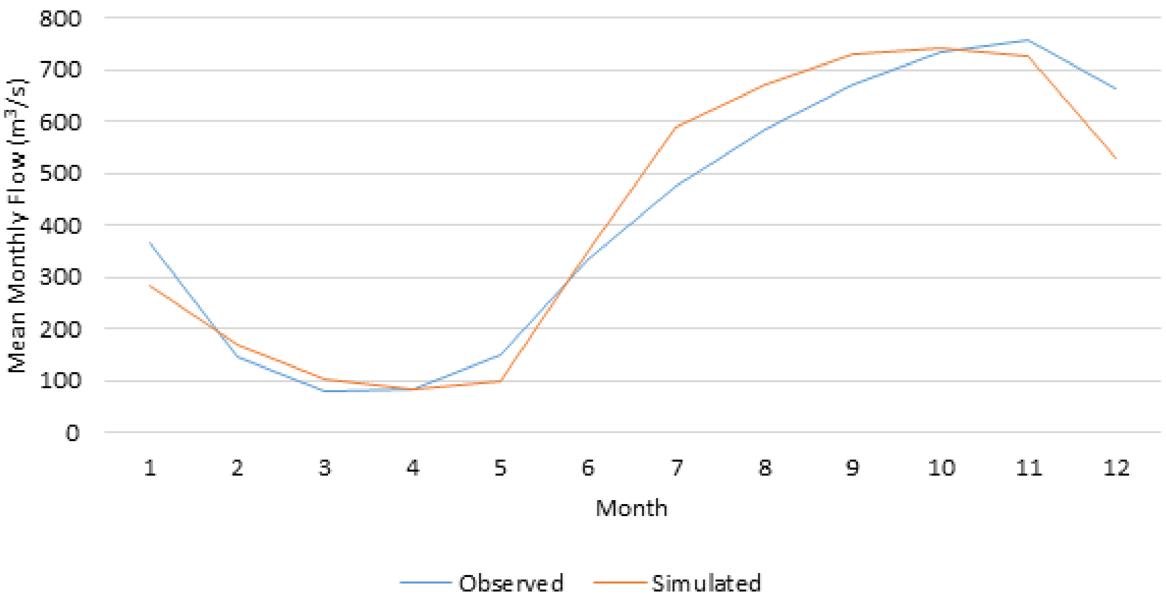



*Table 7-9: Validation statistics at Hillet Doleib*

| | Observed | Simulated | Difference |
|---|---|---|---|
| Mean Annual Runoff (million $m^3$/a) | 13 324 | 13 392 | 0.5% |
| Standard Deviation of Monthly Flows ($m^3$/s) | 277 | 286 | 3.3 % |
| $R^2$ | 0.93 | | |

## BARO AT ITS MOUTH INTO SOBAT

Flows were simulated for a validation period from 1929 to 1932. The observed and simulated flows for the validation period are shown in Figure 7-16, and display a high coefficient of determination of 0.94. The seasonality of the observed and simulated flows as shown in Figure 7-17, shows a good fit. The validation statistics for Baro at its mouth into Sobat are presented in Table 7-10.

*Figure 7-16: Validation of simulated flows at Baro at its mouth into Sobat*

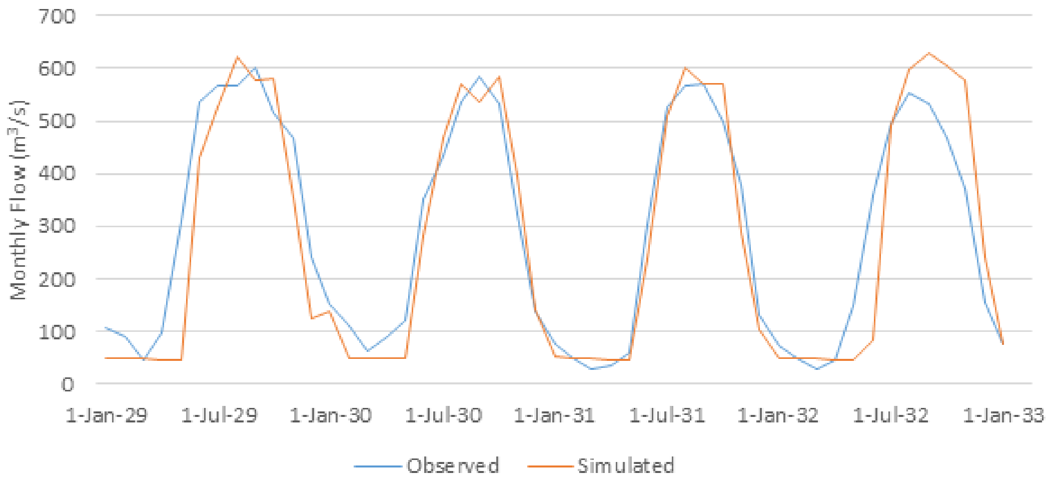



*Figure 7-17: Validation of seasonality of flows at Baro at its mouth into Sobat*

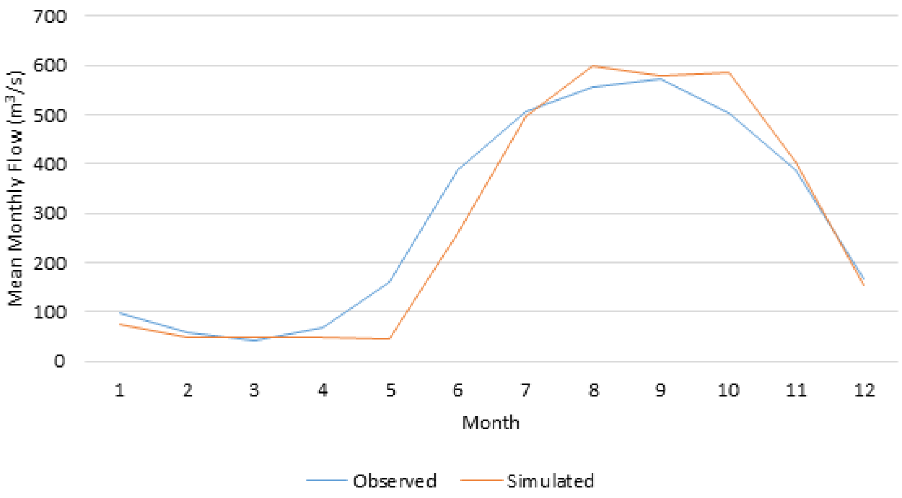



*Table 7-10: Validation statistics for Baro at its mouth into Sobat*

| | Observed | Simulated | Difference |
|---|---|---|---|
| Mean Annual Runoff (million $m^3$/a) | 9 339 | 8 883 | -4.9% |
| Standard Deviation of Monthly Flows ($m^3$/s) | 211 | 235 | 11.5% |
| $R^2$ | 0.94 | | |

## PIBOR AT ITS MOUTH INTO SOBAT

Flows were simulated for a validation period from 1929 to 1932. The observed and simulated flows for the validation period are shown in Figure 7-18, and display a high coefficient of determination of 0.90. The seasonality of the observed and simulated flows as shown in Figure 7-19, shows a good fit. The validation statistics for Pibor at its mouth into Sobat are presented in Table 7-11.

*Figure 7-18: Validation of simulated fows at Pibor at its mouth into Sobat*

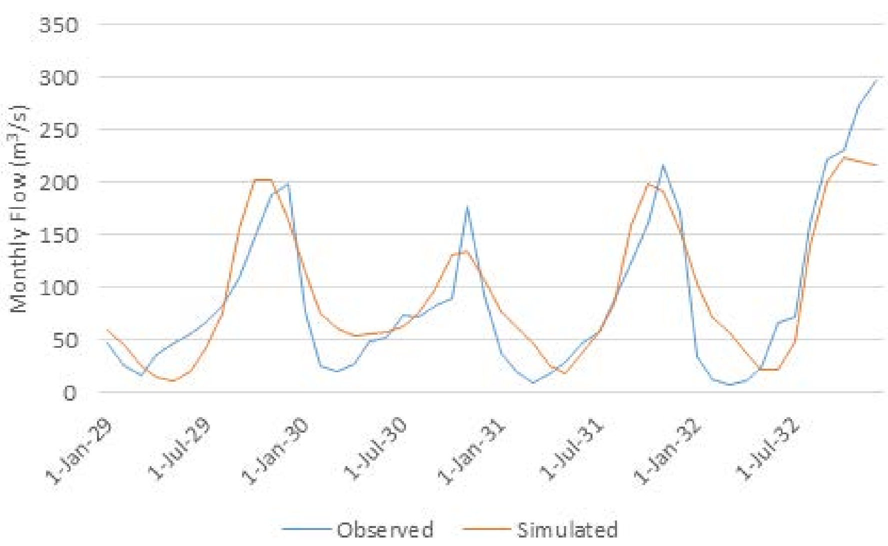



*Figure 7-19: Validation of seasonality of flows at Pibor at its mouth into Sobat*

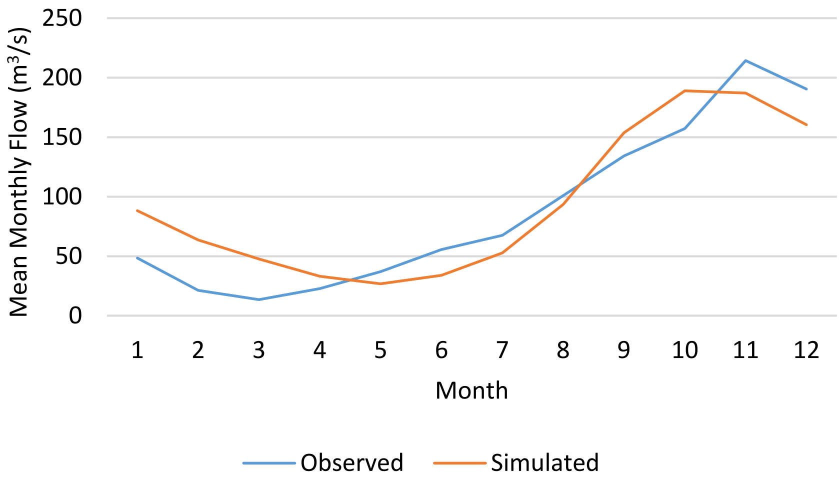



*Table 7-11: Validation statistics at Pibor upstream of Sobat*

| | Observed | Simulated | Difference |
|---|---|---|---|
| Mean Annual Runoff (million $m^3$/a) | 2 806 | 2 976 | 6.1% |
| Standard Deviation of Monthly Flows ($m^3$/s) | 76 | 65 | -14.0% |
| $R^2$ | 0.90 | | |

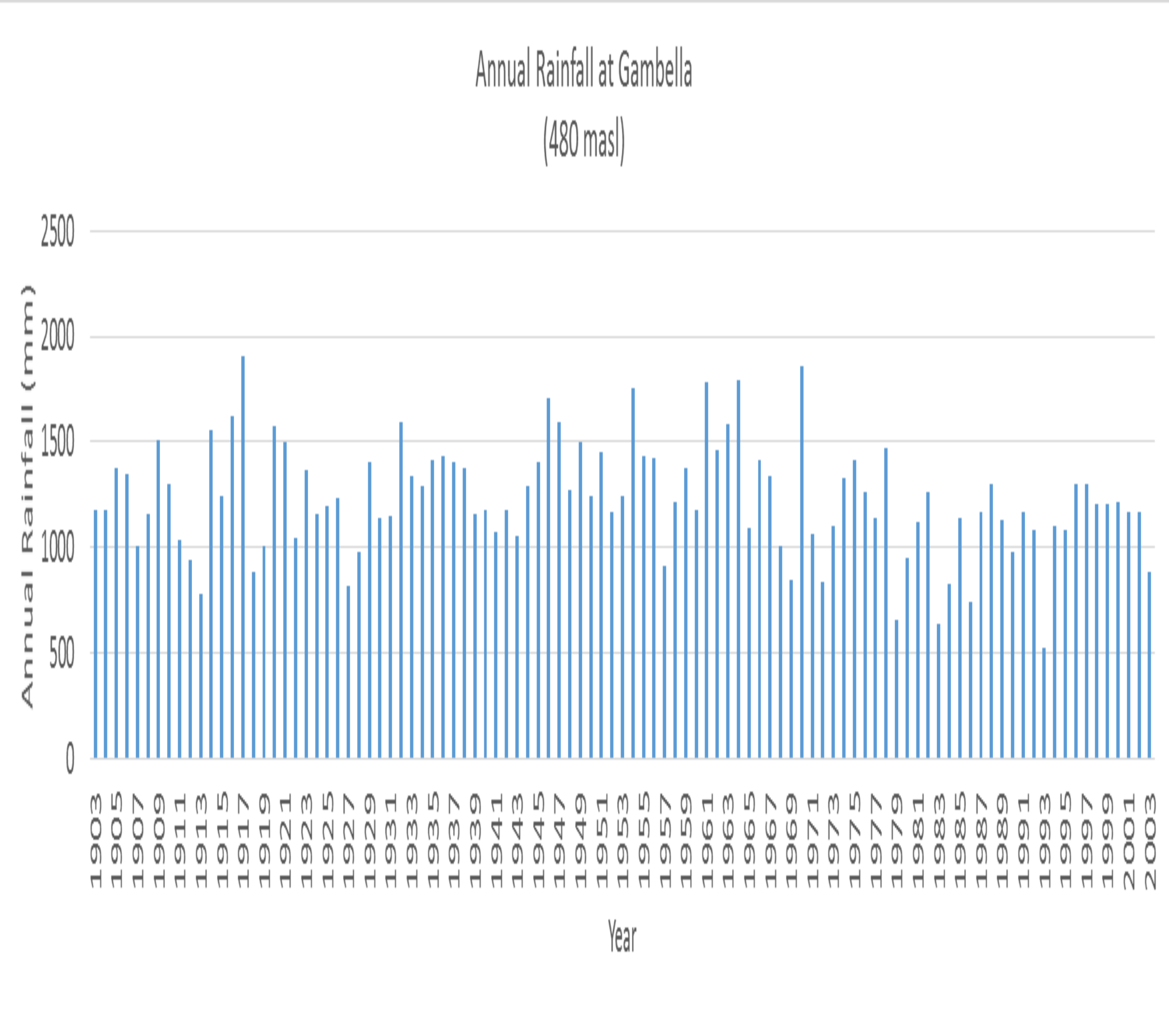
## 7.8 SIMULATION OF LONG-TERM FLOW SEQUENCES FOR THE BASELINE SCENARIO

Using the calibrated rainfall runoff model in conjunction with the validated MIKE HYDRO Basin model, long-term flow sequences were simulated at key locations across the basin. The simulation period, which extended from 1905 to 2014, was dictated by the length of the catchment rainfall files.

Annex 5-D summarises the Mean Annual Runoff (MAR) in million $m^3/a$ per model sub-catchment and also lists the runoff coefficients as calculated for each sub-catchment. Annex 5-F provides a long-term water balance of the basin in terms of inflows, spills, gross evaporation and precipitation.

Figure 7-20 displays a schematic representation of the simulated study basin, and provides information on the mean annual runoff volumes along main rivers, in key tributaries, and at spill locations and inter-catchment links along the floodplains.

*Figure 7-20: Mean annual flows in the Baro-Akobo-Sobat sub-basin*



# 8. MAIN CONCLUSIONS FOR THE BASELINE

Determination of the key social and environmental issues

As emphasized in the introduction, the baseline report aims at providing a clear view on the current situation in the basin in terms of bio-physical, socio-economic and legal/institutional environments. From this **baseline study**, the **key social and environmental issues** have been identified and are summarized below:

- Social issues
  - Poverty and Food Insecurity
  - Low level of well-being
  - Lack of peace and security
  - Low level of provision of social services
  - Vulnerable groups
  - Gender inequality
  - Scattered settlements
  - Poor agriculture extension and poor credit facilities
  - Recurrence of various forms, intensity, duration and impacts of conflicts
  - Potential for influx of people
  - Risks
  - Flood and drought
  - Land security/land tenure issues
  - Basin population dynamics place heavy pressure on natural resources
  - Climate change
  - Weak institutions, poor coordination and cooperation among existing institutions
- Environmental issues
  - Stress on Wetlands
  - Loss of biodiversity
  - Unsustainable hunting of wildlife
  - Loss of natural forest
  - Soil erosion
  - Scattered settlements
  - Poor agriculture extension and poor credit facilities
  - Flood and drought
  - Lack of peace and security
  - Poor physical and social infrastructure
  - Climate change
  - Lack of knowledge

Analysis of the current development of water resources

The analysis of the current development of water resources in the basin is particularly important to take into account the projects already implemented in order to build the IWRDMP on the basis of what already exists. This analysis is the foundation of Part 2: "Potential developments in the Baro-Akobo-Sobat sub-basin" which looks at opportunities to develop water resources in the basin, based on the needs and potentials of the different sectors.

Key issues, opportunities and strategic objectives

The key issues identified in the baseline analysis (Part 1) and the sectoral opportunities (Part 2) are further developed in Part 3 “Key issues and objectives” of this report and integrated to propose the strategic objectives for the basin. It should be noted that these objectives will be discussed during the baseline workshop as they must be agreed by all the key stakeholders.

Way forward

Once the strategic objectives will have been agreed by all during the workshop, the SSEA will study different development scenarios to reach the objectives. The SSEA will be based on social and environmental indicators that will also be discussed during the baseline workshop.

# PART 2: POTENTIAL DEVELOPMENTS IN THE BARO-AKOBO-SOBAT SUB-BASIN

# 1. INTRODUCTION

A sectoral approach has been chosen to identify the potential developments of water resources in the basin. As introduced in the scoping report, interventions can be the development of **already identified projects** (from masterplans, existing studies etc.) or the **result of identified needs and/or a potentials**. It should be noted that the consultation and engagement of a wide range of stakeholders has been crucial during the baseline phase to identify these needs and potentials.

Identification of water resources development projects has therefore been focused on two areas:

- Already identified projects and their importance to answer the needs in the basin
- Identification of needs & potentials and, proposition of development projects. Indeed, some developments are more related to potential (hydropower) and other to needs (water supply for instance).

As already mentioned in this report (Part 1, Section 6), the development of water resources has been divided into three main categories:

- **Economic sectors related to water resources**: Agriculture (rainfed and irrigated), Hydropower, Livestock farming, Fisheries and aquaculture, Ecotourism.
- **Service sectors related to water resources**: Potable water supply and sanitation, Navigation, Flood and drought mitigation
- **Cross cutting sectors and themes**: Livelihood-based watershed management, Biodiversity, habitats and landscape conservation, Climate change mitigation

Results of Part 2 “potential developments” will feed into Part 3 “Key issues and objectives”, especially to identify the opportunities related to water resources development in the basin. It should be noted that the results have also been integrated to propose the seven short term projects developed in the concept note (see separate report).

# 2. POTENTIAL DEVELOPMENT FOR ECONOMIC SECTORS

## 2.1 RAINFED AGRICULTURE

As emphasized before in this report, rainfed agriculture is widely practised in the basin. However, in some areas there is a major untapped potential. This is especially the case for South Sudan in both the upland lowland areas, but there is also a large potential for (large-scale) mechanised rainfed agriculture in the lowland areas in Ethiopia.

The potential for large-scale mechanised agriculture in the flat areas of Gambella Region has already been recognised and there have been efforts to develop it. These have been largely uncoordinated and poorly planned, and have generally failed due to flooding problems.

### 2.1.1 Existing development projects in the basin

#### ETHIOPIA

Development projects for small-scale rainfed agriculture are generally part of watershed management projects and are discussed as part of these in Section 4.2.5.

As observed and discussed with stakeholders during field missions, many thousands of hectares have already been leased by private investors in and around the Gambella floodplains. In general, the intention to use much of this land for irrigation has been expressed. However, it is also recognised that rainfed agriculture (with or without some supplementary irrigation) could be economically viable. Indeed large-scale cropping (more than 10,000 ha) has already been carried out with varying degrees of success.

#### SOUTH SUDAN

A number of projects for rainfed agriculture have been identified and these are listed in the main volume of the CAMP (2015). A 25 year programme for the crop sector (costing 194 million USD) has been provided. The vast majority of intervention are aimed at supporting the subsistence and/or rainfed sector and is aimed at setting up a solid base covering all the key issues and challenges facing the sub-sector.

### 2.1.2 Identification of new projects for areas in need

Opportunities for development and improved performance in the rainfed agriculture sector do have direct and indirect linkages with development in other sectors. The development of hydropower can be a driver for the acceleration of livelihood-based watershed management in the highland source areas and a key part of this would be the improved performance of rainfed farming in these areas. The development of large-scale rainfed farming can be supported by the parallel development of irrigated agriculture since both require and encourage the development of agro-processing, transport logistics and the access to markets.

## 2.2 IRRIGATED AGRICULTURE

### 2.2.1 Existing development projects in the basin

#### ETHIOPIA

Large scale Irrigation Scheme-Gambella Alwero Rice Project (GARP)

Alwero Irrigation is the only ongoing large scale irrigation scheme in the Baro-Akobo basin. It is located in Gambella Regional State. According to the official project document for the project from the MWIE, Alwero Agricultural Development Enterprise, (Alwero Agricultural Development Enterprise, 2007) and (WRDA, 1987) the feasibility studies at Alwero irrigation project areas that includes 10,000 ha land development and the construction of the Abobo/ Alwero dam were commenced in 1984 by the Russian team together with the Ethiopian counterparts and its implementation phase started in 1987 by the then Water Resources Development Authority and the Ethiopian Water Works Construction Authority. The scheme was initiated as public enterprise for-commercial cotton production. The project implementation was planned to be carried out in two phases, the first phase was designed to include the construction of Abobo dam, the first 18.3 km of the main canal and the 1000 ha land development works. The second phase was designed to include the reaming 7 km part of the main canal and the 9000 ha land development works including the construction of other infrastructure for the farm. Out of the planned first phase works, the dam was completed and only about 40% of the excavation work for the first 18.3 km reach of the main canal that stretches from the intake structure at the dam to the head of the irrigable land was completed. The remaining works could not proceed as envisaged owing to the various factors that impeded the implementation of the project.

The scheme was under public enterprise in the past but, the command area of Alwero irrigation project was presently transferred to private company, and Saudistar in early 2011to develop the 10,00ha land area that could be irrigated from Alwero Dam. Based on the studies prepared by SNC Lavalin. Ghulam Rasool & Company, a Pakistani Work Contractor is in charge of implementing the works.

The overall goals of the project are:

- To develop irrigated farm land on 10 000 ha for farming of rice and other crops
- To establish post-harvest treatment for rice (crops protection, drying, husking, polishing grading and packing) for rice and other crops

A rice mill with a capacity of 100 000 ton/year has been built and is presently operational. Rice would be grown in the rainy season under complementary irrigation, followed by mainly irrigated leguminous crops in dry season.

A 21 km concrete lined main canal connects the dam with the rice farm. Works were interrupted at the end of 2013. At that time,

- 315 ha were irrigable by a temporary pump station situated on a diversion canal of the river, downstream the dam.
- Most earthworks of the main canals were completed and about 20% of the canal lined;
- Part of the supply and distribution system of about 3,000 ha was under implementation.
- About 500 ha of land was laser levelled.

The per ha cost of the scheme is estimated at 16 000 USD, exclusive costs of management, studies and work supervision.

A base map showing Abobo town, and the Main Canal connecting the Alwero dam with the scheme is shown in Figure 2-1 below.

- Achieve another 1,500 ha in 2016 for irrigation;
- Finalise the whole by 2020;
- Implement a new sugar cane factory of 4,000 Ton/day capacity, which would require another 10,000 ha to be irrigated;
- Assist other private investor in bush clearing and land preparation.

In that regard it should be mentioned that end 2015 a site of 10,000 ha near the Gambella airport has been subject of a new handover and intends outsourcing the land preparation to Saoudistar.

As important issues in this new development we can mention:

- Bush clearing, land levelling and building an irrigation scheme is time consuming and costly
- Difficulties in finding qualified human resources as it is a remote area
- Tensions with local population around land tenure
- Insufficient roads, marshy lands say access problems

*Figure 2-1: Base map Gambella Alwero Rice Project*

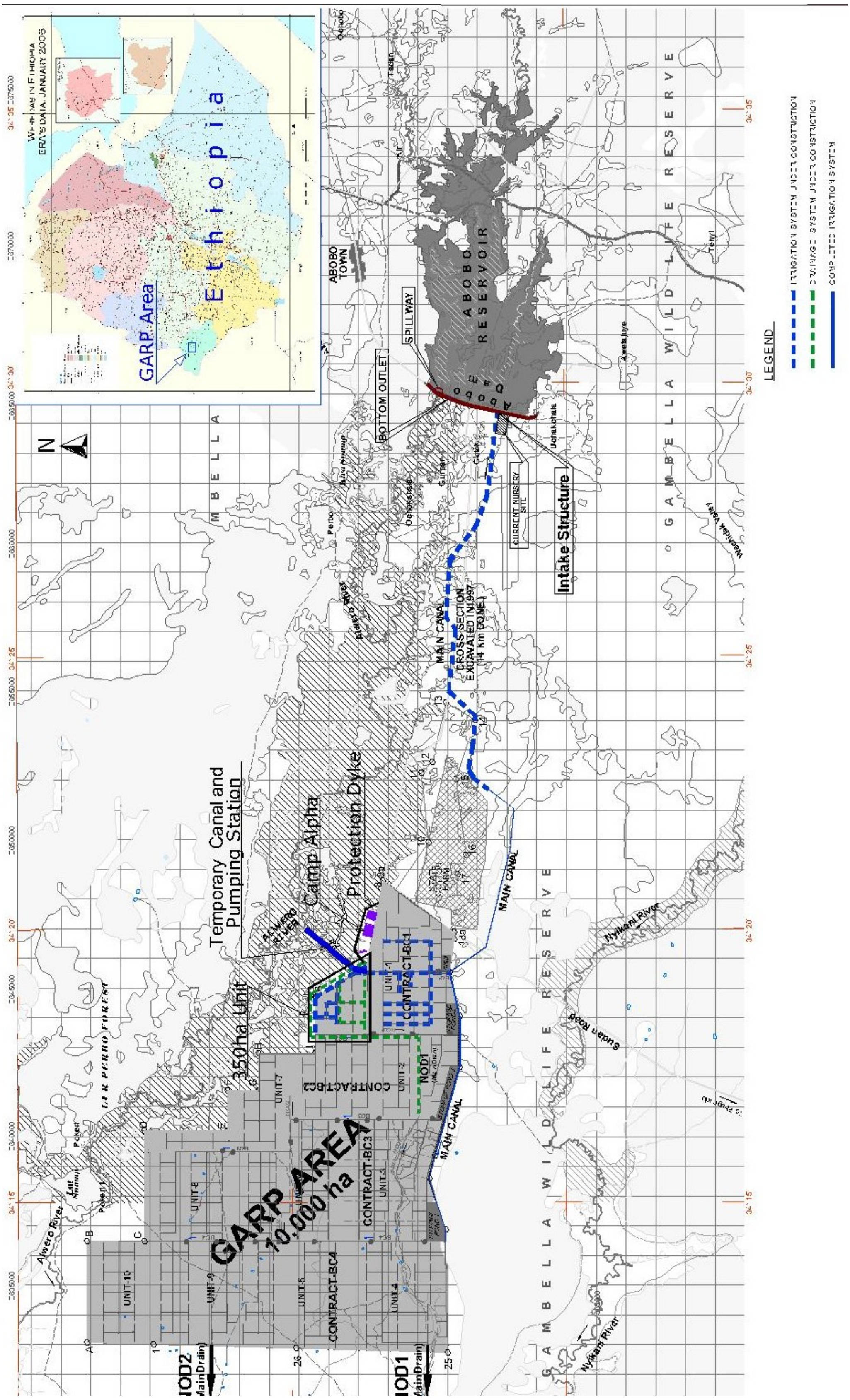


Figure 2-2: Alwero dam with security spill

Figure 2-3: Laser land levelling

Figure 2-4: Transplanting paddy in laser levelled fields

Small Scale Irrigation Scheme Under Construction

There are fourteen (14) small scale irrigation schemes under construction. Total command areas for the schemes under construction are 1,270ha. The construction of the schemes are planned to be finalized in 2016. The three schemes in Gambella are all pumped diversion while the eleven schemes in SNNPR and Oromia are weir diversion headwork. The highest number of schemes under construction is found in SNNPR. Table 2-1 presents the number of schemes under design and those under construction in each region at the time of baseline survey.

*Table 2-1: Small Scale Irrigation scheme projects in the basin/planed and under construction*

| No | Region | Area (Ha) | | | | |
|---|---|---|---|---|---|---|
| | | Under construction | | Under Study & Design | | Planned for 2016 to 2020 |
| | | Qt | Area Ha) | Qt | Area (Ha) | Area (Ha) |
| 1 | Gambella | 3 | 600 | | | 1400 |
| 2 | SNNPR | 8 | 1200 | 3 | 190 | 3402.6 |
| 3 | Oromia | 5 | 345 | 4 | 185 | 45,596.97 |
| | **Total** | **16** | **2145** | **7** | **375** | **4950,596** |

*Source: Ibid*

Planned Small Scale Irrigation Schemes

Currently, the sub-sector is getting due emphasis in a way of enhancing the food security situation in the project area. Accordingly, the assessment and planning of irrigation development has been continued at different levels aiming at Improving food security and living standard of the user communities.

To this end, several schemes with total land areas of 50,399.57ha have been planned for implementation in the coming five years (2016-2020). The planning focused on needy areas where land and water resources, as well as, cultivation of crops existed. Priority is given to areas where traditional irrigation schemes already developed and basic skill in irrigation techniques as well as adequate level of awareness exist. Table 5 above shows total land areas planed in each region. The extent of planned area reflects, the potential of basic resources existing.

Planned Large Scale Irrigation Schemes

As part of country's Growth & Transformation Plan II (GTP-II), a second five years development program for irrigation sub sector has been launched. The target during GTP II is to raise irrigated agriculture from the current 6.16 % of the potential irrigable lands to 25%. To achieve this, during the plan period, study and design of 915,881 ha and construction 954,000 ha of land for irrigation will be carried out during the same period, out of which thirteen projects with total land area of 678,630 ha land areas are in Baro - Akobo River Sub - basin.

*Table 2-2: List of Potential Irrigation Development Sites Identified for GTP-II*

| S. No | Site | **Current Status** | **Basin** | Planned area (ha) |
|---|---|---|---|---|
| 1 | Alwero –Abobo Dam | Master Plan level | Baro- Akobo | 11,364 |
| 2 | Baro RB Itang dam | | | 50,900 |
| 3 | Baro-RB Itang pumping plus re lift | | | 57,495 |
| 4 | Baro RB Gambella dam plus high lift | | | 67,740 |
| 5 | Baro LB Itang dam | | | 61,900 |
| 6 | Baro LB pumping | | | 15,832 |
| 7 | Baro LB Gambella dam | | | 57,018 |

| S. No | Site | **Current Status** | **Basin** | Planned area (ha) |
|---|---|---|---|---|
| 8 | Alwero Cheru and Dumbong Dam | | | 34,665 |
| 9 | Gillo RB, Gillo Dam 1 | | | 81,346 |
| 10 | Gillo LB Gillo dam 1 | | | 79,652 |
| 11 | Gillo LB Gillo dam 2 | | | 33,855 |
| 12 | Gillo River LB pumping | | | 65,538 |
| 13 | Gillo RB Gillo dam 1 | | | 61,325 |
| | **Total** | | | **505,992** |

*Source: (MWIE, 2016)*

### SOUTH SUDAN

The Ministry of Electricity, Dams, Irrigation & Water Resources (MEDIWR) has prepared Irrigation and Drainage Master Plan (IDMP) to address irrigation infrastructure issues and requirements of the agriculture sector in relation to water resources. Accordingly, the master plan identified and proposed nine medium scales schemes with total land area of 72,000ha in Unity and Joglei states and prepared implementation plan for the schemes. Table 2-3 below presents list of the identified medium scale irrigation schemes. The schemes are planned to be implemented over a period of 2015 to 2027 during the midterm of the program implementation plan.

*Table 2-3: List of Proposed Irrigation Schemes*

| No | Name | Status | State | Country | Area (Ha) | Source of Water |
|---|---|---|---|---|---|---|
| 1 | Nakdeir | Detail Assessment | UN | Panyikang | 11,000.00 | R. Sobat |
| 2 | Baliet | Detail Assessment | UN | Baliet | 9,000.00 | R. Sobat |
| 3 | Abong | Detail Assessment | UN | Baliet | 3,000.00 | R. Sobat |
| 4 | Khorfulus | Detail Assessment | J | Feji | 4,000.00 | R. Sobat |
| 5 | Pultruk | Detail Assessment | J, UN | Khorfulus | 3,000.00 | R. Sobat |
| 6 | Doma | Detail Assessment | UN | Olang | 5,000.00 | R. Sobat |
| 7 | Utang | Detail Assessment | UN | Nasir | 10,000.00 | R. Sobat, R. Nyanding |
| 8 | Nasir East | Detail Assessment | UN | Nasir | 19,000.00 | R. Sobat |
| 9 | Nasir west | Detail Assessment | UN | Nasir | 8,000.00 | R. Sobat |
| | Total | | | | 72,000.00 | |

*Source: (MEDIWR, 2015)*

## 2.2.2 Identification of areas with potential for irrigation

### 2.2.2.1 Large & medium scale Irrigation potential

In Ethiopia, the Baro-Akobo Sub-basin covers approximately a total land area of 75,912 $km^2$. The basin is divided into two major landscape units of roughly equal size. The western lowlands (Lower basin) and the eastern highlands (Upper basin), are separated by an escarpment and areas of severely dissected highlands. The Gambella catchments in the Ethiopian portion gently slope to almost flat plains that continue into the South Sudan crossing the border. The plains are abruptly terminated in the east by a well defined north-south escarpment (ENTRO, 2009).

Assessments of land and water resources potential of the Baro-Akobo Basin were carried out at different times by Ethiopian Valley Development Study Authority: on the lower and upper part of the basin (EVDSA, 1990) and (EVDSA, 1995), respectively, and by Ministry of Water Resources on the entire basin in Ethiopia (MoWR, 1997).The land resources that have been identified together with potential water resources in the basin have used in identification of areas with potential for irrigation development. Potential area identification was based on the physiographic of the land and availability of surface.

#### Lower Basin

The Baro-Akobo Integrated Development River Basin Master Plan Study (1997), by MoWR identified about 631,000ha of gross land area as potentially suitable for irrigation and drainage in the three major watersheds namely; Baro, Alwero and Gillo whereas the net command area in the basin was estimated at 480,000ha..

The master plan studies (EVDSA, 1990 and MoWR, 1997) also indicated that the development of this available net irrigable area is possible only if flow is regulated by reservoir. In view of that, the Baro-Akobo Integrated Development Master Plan Study (MoWR, 1997) identified six dam sites and carried out multiple reservoir analysis for all six by considering potential storage in each of the major rivers, in order to find the total maximum area that could be ultimately irrigated under diversified rotation. The maximum irrigable area, considering the environmental release and excluding return flow, was found to be 483,100ha in the three major watershed with the Baro (249,800 ha), Alwero (37,400 ha) and Gillo (195,900 ha).

Furthermore, the study by MoWR formulated 14 large-scale irrigation projects to cover the available 480,000ha in the lower basin. They were all cost ranked and economic analysis was worked out. The projects to be taken forward to the next level by the on-going study were thus identified based on the cost ranking and maximum land area that can ultimately be irrigated based on the reservoir operation study. The following large scale irrigation projects are thus recommended for the plan.

*Table 2-4: Full development potential for large scale irrigation projects in the lower basin*

| System | Description | Source | Gross area (ha) | Net area (ha) |
|---|---|---|---|---|
| **I** | **Baro River** | | | |
| 1 | Right bank, Itang Dam, gravity conveyance | Itang Dam | 66,600.00 | 50,949 |
| 2A | Scheme 2 + re lift p/station + additional canal | Itang Dam | 57,495.00 | 43,984 |
| 3A | Scheme 3 + low lift p/station + additional canal | Gambella Dam | 41,016.00 | 31,377 |
| 4 | Scheme 3 with Baro River p/station instead of Gambella Dam | Baro River | 17,338.00 | 13,264 |
| 5 | Baro River, left bank, Itang Dam, gravity conveyance | Itang Dam | 61,900.00 | 47,354 |

| System | Description | Source | Gross area (ha) | Net area (ha) |
|---|---|---|---|---|
| 6 | Baro River, left bank, Itang Dam p/station, canal | Itang Dam | 15,832.00 | 12,111 |
| 7 | Baro River, left bank, Gambella Dam, gravity conveyance | Gambella Dam | 57,018.00 | 43,619 |
| | **Subtotal for Baro sub basin** | | **317,199.00** | **242,658** |
| **II** | **Alwero River** | | | |
| 9 | Alwero, Abobo Dam, gravity | Abobo Dam | 13,600.00 | 10,404 |
| 10 | Alwero River, Chiru Dam, gravity conveyance | Chiru Dam | 17,054.00 | 13,046 |
| 10A | Alwero River, right bank, Dumbong Dam, gravity conveyance | Dumbong Dam | 23,192.00 | 17,742 |
| | **Subtotal for Alwero** | | **53,846.00** | **41,192** |
| **III** | **Gillo River** | | | |
| 11 | Gillo River, right bank, Gillo 1 Dam, gravity | Gillo 1 Dam | 81,346.00 | 62,230 |
| 2 | Gillo River, left bank, Gillo 1 Dam, gravity | Gillo 1 Dam | 79,652.00 | 60,934 |
| 13 | Gillo River, left bank, Gillo 2 Dam, gravity | Gillo 2 Dam | 33,855.00 | 25,899 |
| 14 | Gillo River, right bank, Gillo 2 Dam, gravity | Gillo 2 Dam | 61,325.00 | 46,914 |
| | **Subtotal for Gillo** | | **256,178.00** | **195,976** |
| | | **Total** | **627,223.00** | **479,811** |

***Source:-*** *MoWR, 1997*

## UPPER BASIN

A study by EVDSA, 1995 identified 109,300ha of gross land area and a net area of 27,022ha**.** The methodology used to arrive at the net irrigable area by ARDICO-GEOSERV was not clear from the report. Hence, the net irrigable area was re-calculated by assuming and deducting 10% as non-irrigable due to being occupied by streams, road, towns, and rocky areas. This resultant area was further reduced by 15% to account for irrigation and other infrastructure in the irrigated areas (Table 2-5below).

*Table 2-5: Potential large and medium scale irrigation projects in the Upper basin*

| S. No | Potential Project site | Watershed | Off-take Coordinate | | Altitude | Area (ha) | |
|---|---|---|---|---|---|---|---|
| | | | North | East | (m) | Gross | Net |
| 1 | Koji | Birbir | $8^0 44'$ | $34^0 18'$ | 475 | 6,000 | 4,590 |
| 2 | Sako Guda | Birbir | $8^0 19'$ | $34^0 47'$ | 550 | 4,600 | 3,519 |
| 3 | Bako | Gillo | $7^0 16'$ | $35^0 32'$ | 1150 | 6,000 | 4,590 |
| 4 | Kilu | Gaba | $6^0 32'$ | $34^0 46' 49''$ | 1050 | 5,600 | 4,284 |
| 5 | Lafo Kotu | Birbir | $8^0 54'$ | $34^0 16'$ | 550 | 9,000 | 6,885 |
| 6 | Baro | Baro | $8^0 12'$ | $35^0 56'$ | 475 | 2,000 | 1,530 |
| 7 | Birbir | Birbir | $8^0 44'$ | $35^0 09'$ | 1150 | 8,000 | 6,120 |
| 8 | Fani | Birbir | $8^0 03'$ | $35^0 07'$ | 1250 | 1,200 | 918 |
| 9 | Alwero | Alwero | $7^0 35'$ | $34^0 58'$ | 650 | 5,500 | 4,208 |
| 10 | Guy | Gillo | $7^0 09'$ | $34^0 53'$ | 550 | 1,800 | 1,377 |

| S. No | Potential Project site | Watershed | Off-take Coordinate | | Altitude | Area (ha) | |
|---|---|---|---|---|---|---|---|
| | | | North | East | (m) | Gross | Net |
| 11 | Godare | Gillo | $7^0 29'$ | $35^0 06'$ | 750 | 3,300 | 2,525 |
| 12 | Achani | Gillo | $7^0 12'$ | $35^0 14'$ | 950 | 4,300 | 3,290 |
| 13 | Awaya | U Akobo | $6^0 48'$ | $34^0 50'$ | 600 | 5,000 | 3,825 |
| 14 | Babaka | Gillo | $6^0 58'$ | $35^0 27'$ | 950 | 6,000 | 4,590 |
| 15 | Guracha | U Akobo | $6^0 26'$ | $35^0 30'$ | 650 | 2,000 | 1,530 |
| 16 | Gumero | Gaba | $8^0 15'$ | $35^0 29'$ | 1600 | 4,000 | 3,060 |
| 17 | Akobo I | U Akobo | $6^0 26'$ | $35^0 29'$ | 850 | 5,000 | 3,825 |
| 18 | Akobo II | U Akobo | $6^0 30'$ | $35^0 15'$ | 650 | 30,000 | 22,950 |
| | **Total** | | | | | **109,300** | **83,615** |

*(Source: EVDSA, 1995)*

*Table 2-6: Potential large and medium scale irrigation projects in the Upper basin – summary by watershed*

| No | Watershed | Gross are | Net Area |
|---|---|---|---|
| | | (ha) | ha |
| 1 | Birbir | 28800 | 22,032 |
| 2 | Gaba | 9600 | 7,344 |
| 3 | Gillo | 21400 | 16,371 |
| 4 | Upper Akobo | 42000 | 32,130 |
| 5 | Alwero | 5500 | 4,208 |
| 6 | Baro | 2000 | 1,530 |
| | **Total** | **109300** | **83,615** |

*Table 2-7: Identified Full Development Potential for Large and Medium scale Irrigation in the Upper and Lower Basin*

| **Gross** | **Gross (ha)** | **Net (ha)** |
|---|---|---|
| Upper Basin | 109300 | 83,615 |
| Lower Basin | 627,223.00 | 479,811 |
| **Total (ha)** | **109927,223** | **563,426** |

## Recession Farming (South Sudan)

No data was available on the extent of the recession farming in the South Sudan. Areas with potentials for the development of irrigation were identified by the Irrigation Development master Plan (MEDIWR, 2015) around Akobo, Poshala and Pipor in the Sobat River basin. Assumed water resources for the developments are from River Akobo, residual moisture and ground water.

#### 2.2.2.2 Small Scale Irrigation

The 678,63ha of large-scale irrigation mentioned in Section 2 page 8 of the baseline survey report was planned area by the MoWIE and the 50,399.57ha is the small-scale irrigation planned area by the regions (Gambella, Oromia and SNNPR) for implementation in the coming five years (2016-2020). These were not reported as potential.

Neither the previous master plan studies nor the current study identified the potential irrigable land area for small-scale irrigation. The current study only identified areas under production, construction, study & design and planned to be implemented up to 2020 instead.

*Table 2-8 Summary of the Small Scale Irrigations Schemes Identified During the Baseline Survey (Ethiopia)*

| *No* | *Region* | *Area under production* | *Under construction* | *Under Study & Design* | *Planned (2016-2020)* | *Total* |
|---|---|---|---|---|---|---|
| | | Ha | | | | |
| 1 | **Gambella** | 3052 | 600 | | 1400 | 5,052.00 |
| 2 | SNNP | 8016.17 | 1200 | 190 | 3402.6 | 12,808.77 |
| 3 | Oromia | 53705.98 | 345 | 185 | 45596.97 | 99,832.95 |
| | **Total** | **64774.15** | **2145** | **375** | **50399.57** | **117,693.72** |

*Table 2-9: Distribution of the Schemes over the Sub Watersheds*

| *No* | *Sub Watershed* | *Area (ha)* | *Region* |
|---|---|---|---|
| 1 | Gaba | 39,018.60 | SNNP and Oromia (Illu Ababor zone ) |
| 2 | Birbir | 73,622.95 | Oromia (Qelem and West Wollega) |
| 3 | Baro, Alwero, Gillo | 5,052.17 | GMB |
| | **Total** | **117,693.72** | |

### 2.2.3 Enabling environment

#### ETHIOPIA

Institutional, legal and policy frameworks

Ethiopia follows the decentralized system of governance. At the federal level, the Ministry of Agriculture and Natural Resources Development (MoANRD) has the mandate of promoting the expansion of small scale irrigation schemes.(planning, design, implementation, and operation and maintenance) including advisory services on irrigated agriculture.

The powers and duties to prepare plans that help to properly utilize water resources for development purposes and supervise their implementation upon approval is that of the MoWIE. In addition, the Ministry is responsible for overall supervision and policy issues related to large and medium scale water resource developments and trans-regional and trans-national rivers. The Ministry is also in charge of conducting trans-boundary and trans-regional river basin master plan studies and the preparation, detailed design and construction and implementation of large scale water resources projects based on the identification of the master plan

By proclamation, the Ministry of Water, Irrigation and Electricity is responsible for the study, design and implementation of medium and large scale irrigation schemes (with sizes greater than 200 ha) whereas, the Ministry of Agriculture is responsible for the development of small scale irrigation schemes (sizes less than 200ha).

At regional level, there is independent agency responsible for planning, study and design and implementation of irrigation schemes in Oromia and SNNP regions. In Oromia region, scheme development as well as operation and maintenance including irrigation advisory service are mandated to Oromia Irrigation Development Authority (OIDA) whereas in SNNPR scheme study, design and implementation is the mandate of Irrigation Construction and Scheme Administration Agency and the Advisory service is the responsibility of Regional Bureau of Agriculture. Unlike Oromia, in Gambella region development and management of small scale irrigation scheme is the responsibility of regional agricultural bureau.

Water Sector Policy, Strategies and Development Plan

***Water Policy***

Water policy in Ethiopia was prepared and adopted since 2000. The overall goal of the national water resources management policy is to enhance and promote all national efforts towards efficient, equitable, and optimum utilization of the available water resources of Ethiopia for significant socio-economic development on a sustainable basis.

In order to realize the overall goal and the fundamental principles, the water resource management policy has spelled out Irrigation sub sectoral policies which covers small-scale, medium-scale and large- scale irrigation activities

The overall objective of irrigation policy is to develop the huge irrigated agriculture potential for the production of food crops and raw materials needed for agro industries, on efficient and sustainable basis and without degrading the fertility of the production fields and water resources base.

The detailed objective of the irrigation policy states development and enhancement of small-scale irrigated agriculture and grazing lands for food self sufficiency at household level as one of its objectives while the principal objective of the irrigation development strategy is to exploit the agricultural production potential of the country to achieve food self sufficiency at the national level, including export earnings, and to satisfy the demand for raw material by the local industries, but without degrading the fertility and productivity of the land and water resource bases of the country.

### *The Ethiopian Water Resources Strategy*

The principal objective of the water resources strategy is to translate the national water resources management policy into action. More specifically, this strategy sets the road map as how to make meaningful contributions towards:

- Improving the living standard and general socio-economic well being of the Ethiopian people.
- Realizing food self-sufficiency and food security in the country.
- Enhancing the contribution of water resources in attaining national development priorities.
- Promoting the principles of integrated water resources management.

More specifically, the objective of the irrigation development strategy is to exploit the agricultural production potential of the country to achieve food self sufficiency at the national level, including export earnings, and to satisfy the raw material demand of local industries, but without degrading the fertility and productivity of country's land and water resources base. More specific objectives of the strategy are to: expand irrigated agriculture, improve irrigation water-use efficiency and thus the agricultural production efficiency, develop irrigation systems that are technically and financially sustainable, and address water logging problems in irrigated areas

### *Irrigation Development Strategy*

The principal objective of the irrigation development strategy is to exploit the agricultural production potential of the country to achieve food self sufficiency at the national level, including export earnings, and to satisfy the raw material demand of local industries, but without degrading the fertility and productivity of country's land and water resources base. More specific objectives of the strategy are to: expand irrigated agriculture, improve irrigation water-use efficiency and thus the agricultural production efficiency, develop irrigation systems that are technically and financially sustainable, and address water logging problems in irrigated areas.

### *Small Scale Irrigation Capacity Building Strategy*

The strategy was prepared and adapted in 2011 as a 15 years road map to guide the government and its development partners to address the capacity constraints and improve the efficiency of smallholders irrigated agriculture. The overall objective of the Small-Scale Irrigation (SSI) capacity building strategy is to undertake infrastructure, institutional and human resources capacity building which will help the country to optimize its natural resources use efficiency for small-holder irrigated agriculture development and contribute to food security and alleviate poverty.

### *Growth and Transformation Plan II (GTP II)*

As the first growth and transformation plan finalized during the mid 2015, the country has now launched its second Growth and Transformation Plan (GTP II) covering the period from 2016-2020. The overall objectives of the plan for irrigation sub sector are (1) To develop and expand sustainable ,effective and feasible irrigation medium and large scale irrigation schemes with the ultimate view to ensure food security at national level ,secure foreign currency supply of raw materials to “agro-processing industries “ and (2) to carry out studies and designs of medium and large scale irrigation projects, thereby ensuring that such projects are readily available for investors or public economic development when required

Under this plan, institutional transformation is also taken as one of the major components to ensure the successful implementation of the plan and to maintain sustainable development and management of the water sector. It includes creating an enabling environment by formulating necessary regulatory frameworks, and establishing the necessary institutions like independent regulatory body which regulates the performance indicators and benchmarks and will allow the ministry to focus on policy issues. It was also planned to promote and strengthen small-scale irrigation schemes, and improve water use efficiency, including strengthening water harvesting and utilization practices through provision of appropriate technologies. Accordingly, 1,743,000 ha and

915,881 ha of land are planned to be cultivated by the use of small scale and large scale irrigation respectively. The extension and training programs will receive particular attention to enhance farmers' capacities to use water resources efficiently, and help to build the community-level institutional structures necessary for effective irrigation and water resource management.

## SOUTH SUDAN

The South Sudan's policies and institutional frame work in relation to the development of irrigation sub sector are well reviewed and presented in the Comprehensive Agricultural Master Plan (MAFCRD & MLFI, 2015) and Irrigation Development Master Plan , (MEDIWR, 2015) documents. This baseline study also summarizes related policies and institutional framework as follows.

Policies:

***South Sudan Development Initiative (SSDI):***

The SSDI identifies Water and Sanitation as one of five sectors in its scope of work. Within the Water and Sanitation sector, there are 28 priority programs. One of these, "Water Resources Development and Management Plans and Interventions", is of primary concern. The IDMP would provide basic input for this program. The Water Resources Potential Assessment carried out under IDMP will be a basis for water resources development and utilization

***Water Policy:***

The South Sudan Water Policy was issued in November 2007. The purpose and scope of the Water Policy is stipulated as "to provide a framework for optimal allocation of available water resources in South Sudan on an equitable and sustainable basis". The Policy remarks that, "it is important to note that policy should be dynamic and continuously evolving" and therefore, periodically re-assessed to meet the future changing needs. The Policy addresses specific issues in three (3) sub-areas, namely Water Resources Management (WRM), Rural Water Supply and Sanitation (RWSS) and Urban Water Supply and Sanitation (UWSS).

Irrigation is not categorized as a single topic. It recognizes irrigation as an important component of future strategy for achieving food security and agriculture-based economic growth and single biggest user of water in South Sudan. The policy also expected agriculture as the single biggest user of water in South Sudan in the future and suggested to establish policies and strategies to promote efficient and responsible water use and mitigate potential conflicts between competing water users as demand for irrigation grows. Furthermore, the policy suggests cost recovery through fees and levies charged to water users for specific services such as delivery of irrigation water and operation of dams/reservoirs

***Water, Sanitation and Hygiene (WASH) Sector Strategic Framework:***

The Water Sanitation & Hygiene (WASH) Sector Strategic Framework was formulated in August 2011 with the purpose of operationalizing the Water Policy of 2007 and ensuring its implementation through effective and technically sound strategic approaches, improved capacity and involvement of all stakeholders. In relation to irrigation, the WASH Strategic Framework noted the requirement for a separate policy and regulatory establishment for irrigation development. This is due to the fact that "MWRI‟s mandate is to allocate and deliver bulk water to irrigated agricultural schemes; but at the on-farm level, it is the responsibility of the Ministry of Agriculture and Forestry (MAF) to distribute and manage that water among farmers on their plots and in crop fields. MWRI realizes that the shared responsibility between the two Ministries calls for a separate policy and regulatory framework for irrigated agriculture and other productive uses, to be adopted enacted, so as to fully realize the potential of this sub sector.

***Draft Water Bill:***

Although it is still a draft and doesn't explicitly deal with irrigation but has stipulations that may affect its implementation. It provides legal framework for water resources management, by legalizing the establishment of the Water Resources Management Authority (WRMA), and under it the Basin Water Boards and Catchment/Sub-catchment Committees. Provision of water users association is also given in the draft Act and is governed by the administrative structure of WRMA. Facilitation of the establishment of irrigation boards has also been mentioned under powers of the Minister.

***Agricultural Sector Policy Framework:***

Agriculture Sector Policy Framework (2012-2017) with its setting vision of "Food security for all the people of the Republic of South Sudan, enjoying improved quality of life and environment", has addressed some key issues, for example acceleration of food and agricultural production through commercial smallholder and large scale agriculture, using mechanized and irrigation technology. The document sets policy guidelines, one of which states to promote sustainable irrigation infrastructure and flood management system to contribute to improved agricultural productivity and food security enhancement. The guideline further describes its implementation strategy as: 1) collaborate with then MWRI in developing a National Irrigation and Drainage Policy and Strategy (NIDPS) to ensure IWRM, 2) build institutional and human capacity in irrigation and drainage development, 3) support and promote private sector participation and 4) support and collaborate with the then MWRI in implementing the Water Policy and implementing various water resource development activities and 5) promote water harvesting technique in arid and semi-arid areas for boosting irrigation agriculture

The Agriculture Sector Policy Framework (ASPF), of 2012-2017) document has stipulated national targets by 2017 regarding crop land expansion, increase of crop production and yield, and poverty reduction. The plan was to increase crop land from 3.8% (2.7 m ha) to 14.3 % (9.2 m ha) of total land area in the next five years by 2017.

***Environmental Policy:***

The environmental policy of South Sudan maintains that any projects involving wetlands, rivers or lakes consider environmental protection. And any irrigation development program should consider this when formulating the irrigation projects..

***Land Policy:***

The South Sudan land policy does not explicitly mention the facilitation of use of water for irrigation based agriculture but calls for equitable access to land resources for all.

Institutional Frameworks:

National, State and Local Governments: The State Ministry of Agriculture in each state has vital role in promoting irrigated agriculture, while MEDIWR (Ministry of Electricity, Dams, Irrigation and Water Resources) is in charge of allocating the budget for projects through the National Ministry of Finance and Economic Planning (MoFEP).

Training, Research and Education Institutes/Institutions: Out of a number of higher level institutions in South Sudan, University of Juba provides the Civil Engineering courses necessary for irrigation application. The first trainees were planned to be available by 2015's end.

### 2.2.4 Conclusion: water related opportunities for irrigated agriculture

For irrigation development, the physical resources such as water, land, climate, and the human working force form the most essential inputs. Marketing opportunity and conducive policy environment are also the basic opportunistic consideration regarding irrigation development. There are numerous opportunities in the basin for the development of irrigated agriculture as presented bellow.

#### ETHIOPIA

Opportunities for irrigation development

***Land and water resources for Irrigation***

Taking the land and water resources together; Baro-Akobo has the largest irrigation potential and is the most important basin in the country. The Baro-Akobo Integrated Development Master Plan Study (MoWR, 1997) estimated total irrigable area of 483,100 ha which is considerable potential that offer opportunity for irrigated agriculture.

***Climate***

The entire area is characterized by a single monsoon wet season that runs from late May or early June to the end of September/early October. The annual precipitation in the area varies from 750mm in the lowlands to over 2000mm in the highlands. 80% to 90% of this rainfall occurs in the wet season (MoWR, 1997). The wet season is followed by a long dry season indicating high moisture deficits for crop production during this period. Above all high priority is accorded to irrigation by the government, due to increased variability both in temperature and rainfall patterns.

Marketing Opportunity

The existing highway and additional planned all-weather roads that extend from the center to Gambella through Nekemte and Jima provides opportunity to transport products to large market centers. The Gambella airport within the region also offers air way link to the centers.

***Policy***

The free market economic policy offers a good opportunity for development of irrigation. The policy offers opportunity for participation of the private sector in irrigation by attracting both local and international investors. Moreover, emphasis and priorities are given to irrigation in the growth and transformation plan of the country.

## SOUTH SUDAN

Opportunities for irrigation development

***Physical resources***

- Abundant Water Resources

  The basin is endowed with abundant water from River Sobat and its tributaries. However, despite the abundant water resources, 97% of the lands used for farming are not irrigated, as this is not equipped with appropriate facilities and technologies (MAFCRD & MLFI, 2015). According to Sutcliffe et al., as quoted by the MEDIWR (2015), the total annual average discharge of the Sobat sub-basin at Hillet Dolieb is 13.5 billion m3/yr, with the daily discharge fluctuating between 8.7 million m3/day in a month of April to 64.7 million m3/day in a month of November

- Vast Unutilized Land Resources

  South Sudan is endowed with abundant land resources with flat topography suitable for irrigation. Over 95% of its total area (658,842 km2) is considered suitable for agriculture, 50% of which is prime agricultural land where soil and climatic conditions allow for production of a variety of crops and livestock. It is also reported that more than 70% of South Sudan's land area has a Length of Growing Period (LGP) longer than 180 days and is therefore suitable for crop production. However, the FAO land cover data show that most of the land that is suitable for agriculture is still under natural vegetation. Only 3.8% (2.5 million ha) of the total land area (64.7 million ha) is currently cultivated, while the largest part of the country (62.6%) is under trees and shrubs The ratio of cropland to total land is very low in South Sudan compared to Kenya and Uganda, where despite less favourable LGPs, cropland accounts for 28.3% and 7.8% of total land area, respectively. Most of the cropland in South Sudan is rain-fed. The irrigated area is limited to only 32,100 ha, mainly in Upper Nile State. Flood land used for rice production is also limited, at about 6,000 ha, and is located primarily in Northern Bahr el Ghazal, (MAFCRD & MLFI, 2015)

***Policy***

The South Sudan Water Policy recognizes irrigation as an important component of future strategies for achieving food security and agriculture-based economic growth. It also expects irrigated farm as the single biggest user of water in country in the future, and calls for establishing policies and strategy to promote efficient and responsible water use and mitigate potential conflict between competing water user.

***Marketing***

Significant market opportunities for agricultural commodities exist both within South Sudan and in neighbouring countries. The East African Community (EAC) is a market of 130 million people with a GDP of USD75 billion. East African countries are already responsible for 80% of South Sudan's trade, and merchants from Uganda and Kenya are coming to Juba in large numbers. Juba can assist in strengthening regional integration, which will help local and foreign companies to participate in the regional economy (MAFCRD & MLFI, 2015).

## 2.3 HYDROPOWER AND INTERCONNECTION

### 2.3.1 Existing development projects in the basin

In the BAS sub-basin in Ethiopia, there is currently one small HPP in service, Sor described in section 6.2.3 with an installed capacity of 5 MW and eight HPPs that have been identified, studied at various levels of details and proposed in various generation planning studies as candidates for future additions to the power generation pool. The latest published characteristics of these HPPs are presented in the following table.

*Table 2-10: Characteristics of existing and planned Hydropower Plants in Ethiopia*

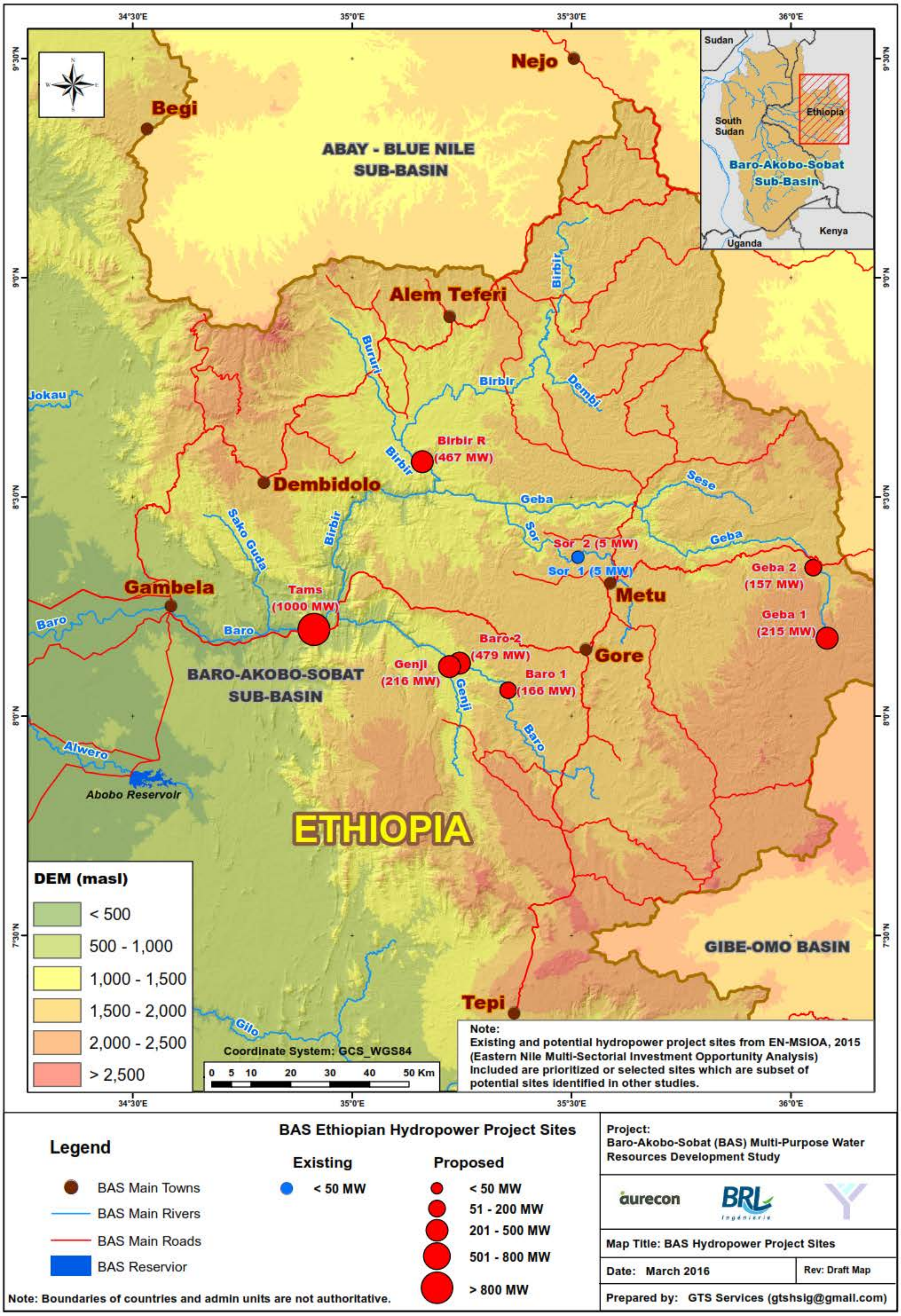
| Name | Status | Installed Capacity (MW) | Storage capacity (Mm$^3$) | Type |
|---|---|---|---|---|
| Sor | Existing | 5 | 0 | R-o-R |
| Sor 2 | Project | 5 (additional 5 compared to existing Sor) | 310.5 | Reservoir |
| Baro 1 | Project | 166 | 1,137 | Reservoir |
| Baro 2 | Project | 479 | 73.3 | Pondage |
| Genji | Project | 216 | 1.5 | Pondage |
| Birbir R | Project | 467 | 2,700 | Reservoir |
| Geba 1&2 | Project | 372 | 860 | Reservoir |
| Tams | Project | 1,700 | 10,000 | Reservoir |

For Geba 1 and Geba 2, a feasibility study was completed in 2005 (Norplan & Norconsult, 2005). For Baro 1 and Baro 2 including Genji, a full feasibility study was completed in 2006 (Norplan, 2006). Tams feasibility study was completed in 2015 with an installed capacity of 1,700 MW according to a presentation done on October 21, 2015 in London, UK by Mr Azeb Asnake, CEO, Ethiopian Electric Power. Birbir has only been studied at the reconnaissance level.

The Sor existing small hydropower plant has the potential to be expanded by an additional 5 MW. A feasibility study was undertaken in 1992 and another study conducted with the support of the United Nations Development Programme (UNDP) also calculated the same results. The Supervisory Review and Evaluation Process (SREP) Strategic Draft Report plans to implement this development between 2012 and 2014 by updating the existing feasibility study; design and tender document preparation; installation of additional penstock and additional 5 MW third unit, construction of a rock-fill dam, construction of annexed hydraulic structures (spillway, bottom out late and connection structure at the headrace tunnel) and finally refurbishment of the existing two units (UNIDO & ICSHP, 2013).

Figure 2-5 presents the location of these HPPs.

*Figure 2-5: Location of existing and planned HPPs in Ethiopian part of BAS*



It should also be noted that the TAMS BAS 1997 study also identified a number of HPPs that have not been retained in more recent studies, particularly generation and transmission planning studies.

In South Sudan, the Kinyeti HPP feasibility study has been completed for an installed capacity of 5 MW (Sinohydro, 2012). In 2013, an agreement was signed between the republics of China and South Sudan to finance the construction of Kinyeti (Gurtong, 2013).

An interconnection is planned between Ethiopia and South Sudan whose first phase goes directly through BAS territory. This interconnection will consist of two separate routes:

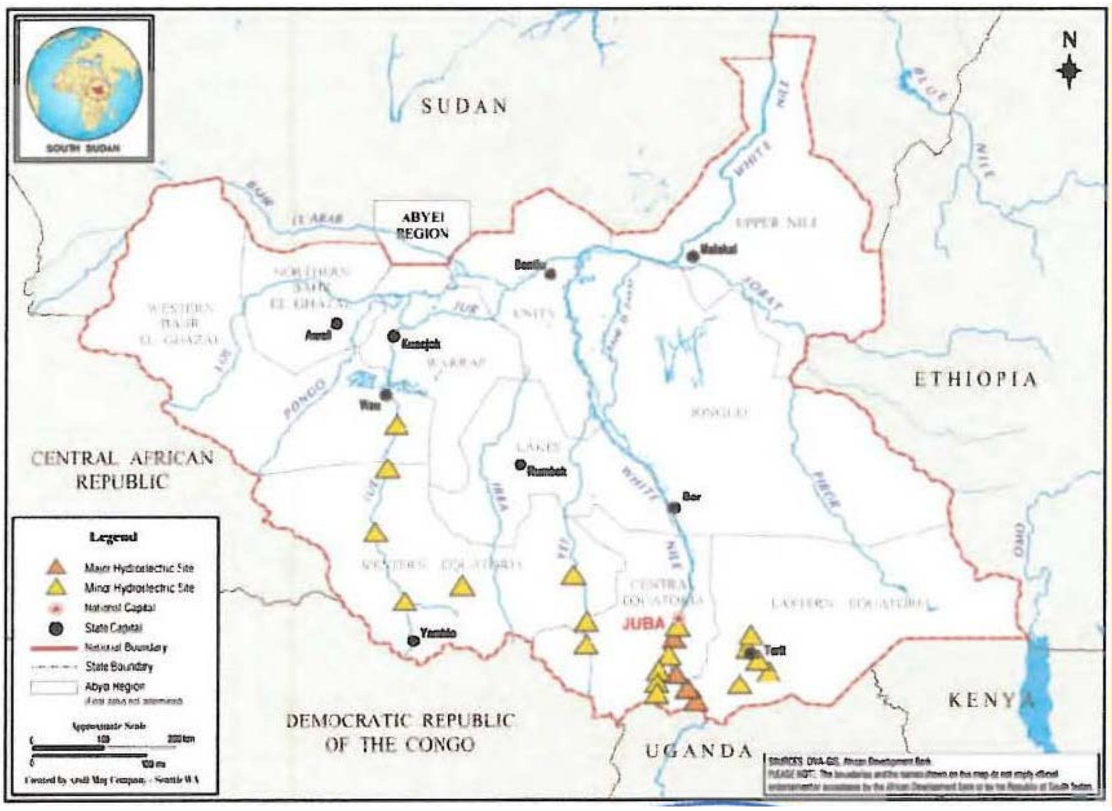
- Phase I: 230 kV transmission line from Gambella in Ethiopia to Malakal in South Sudan. The distance from Gambella, South Sudan to the border in Ethiopia is around 105 kilometers and from border to Malakal is around 230 kilometers. The total distance of phase I is 335 kilometers. This is the continuation of the line recently constructed up to Gambella.
- Phase II: 500 kV transmission line from the proposed Dedesa substation in Ethiopia to Tepi and from Tepi to South Sudan border and to Juba. From Dedesa South Sudan to South Sudan Border is around 300 kilometers and from the South Sudan border to Juba is around 400 kilometers. The total distance of phase II is 700 kilometers.

It is expected that the project will interconnect Ethiopia and South Sudan, Juba and Malakal cities. The Inter-Governmental and Inter-Utility Memorandum of Understandings have been signed (COMESA, undated).

## 2.3.2 Identification of suitable sites to produce hydropower in South Sudan

In South Sudan, small HPP sites have been identified near the town of Torit at the Western edge of the BAS sub-basin as shown in the following map extracted from a document published by the Ministry Of Electricity, Dams. Irrigation. and Water Resources of South Sudan (RSS, MoEDIWR, Directorate of Renewable Energy, 2014) .

*Figure 2-6: Location of potential hydropower sites in South Sudan*



### 2.3.3 Enabling environment

In Ethiopia, the institutions responsible for the energy sector are:

- The Ministry of Water and Energy of Ethiopia, a federal organization established to undertake the management of water and enegy resources of Ethiopia . This involves development, planning and management of water and energy resources, development of polices, strategies and programs, develop and implement water and energy sector laws and regulations, conduct study and research activities, provide technical support to regional water and energy bureaus and offices and sign international agreements.
- Ethiopian Electric Power (EEP) responsible for generation and transmission.
- Ethiopian Electric Utility (EEU) responsible for the power distribution network. Currently EEP is responsible for rural electrification but this function is to be transferred in the short term to EEU.

With respect to the policy and regulatory framework in the Ethiopian power sector, a number of documents have been obtained such as the council of ministers regulation to provide for the regulation of energy operations. Recently Ethiopia has opened up its electricity generation and distribution sector to private investors Now private power companies looking to invest in the industry can compete with EEP. In this respect, a sample PPA (Power Purchase Agreement ) of Large Hydro Facility Developed as a joint venture between IPP (Independent Power Producer) and EEP has been drafted (May, 2015).

Currently, the electricity network of South Sudan consists of three decentralized generation plants, each with a localized distribution network, serving the capital city of Juba and the state capitals of Malakau and Wau. Approximately 1% of the population had access to electricity services in 2011, the majority of these being in Juba, The electricity sector is under the responsibility of the Ministry of Electricity and Dams currently looking for a private company to operate the existing generation and distribution system. The country's energy sector context is summarized in a recent document expressing interest to participate in the scaling up renewable energy program in low income countries (SREP).

In addition to national agencies, the Nile region is moving towards regional integration of the electricity sector with organizations such as NBI, East Africa community (EAC) and East Africa Power Pool (EAPP). It should be mentioned that in September 2015, the five EAC members pulled out of a regional power sharing pool to avoid duplication of the intentions of the larger EAPP which becomes the driving force behind the integration of the electrical sector of the Nile countries.

With respect to capacity building, the electricity sector is monitored by several organizations, regional power pool, World Bank and regional banks, assistance funds from developed countries

### 2.3.4 Conclusion: opportunity to develop hydropower in the basin

It is clear that the development of hydropower can and should fit into the overall context of multipurpose development. Hydropower schemes will generally rely on significant reservoir storage and this storage can support a number of purposes in addition to hydropower generation including:

- Regulation of flows, supporting the development of **irrigation** schemes downstream,
- Providing the irrigation schemes (and other beneficiaries) with protection from floods through **flood attenuation**.
- providing a source of gravity-fed **water supply** to settlements downstream and opportunities for other developments
- Supporting the development of **fisheries**, especially capture fisheries within reservoirs, but also through providing a reliable supply of water for aquaculture.
- Catalysing **watershed management** activities in the source areas of the reservoirs (in order to reduce the risk of sedimentation)

Critical to the successful development of these reservoirs as multipurpose storage is a cross-sectoral collaborative approach to their planning and design. There are many examples of how this approach has not been possible because one sector has dominated the planning and design of infrastructure towards their own interests.

## 2.4 LIVESTOCK DEVELOPMENT

### 2.4.1 Existing development projects in the basin

#### SOUTH SUDAN

**The Republic of South Sudan Draft Water Bill of September 2013** contains the following clauses which stress the importance of water for livestock:

- Clause 4 Interpretation
  - a "essential water uses shall mean those uses that are required for:

i. for health or safety reasons;

ii. by regulation;

iii. for the production of food;

iv. for the maintenance of livestock: or

v. to meet the core functions of business" etc

- Clause 138 Water Pollution
  - **"Any person who pollutes water sources (ground and surface water) to such an extent as to be likely to cause injury directly or indirectly** to public health, **to livestock** or fish, to crops, orchards or gardens which are irrigated by such water or to any products in the processing of which such water is used commits an offence and shall be liable on conviction to a fine of not less than XXXX but not more than XXXX, or imprisonment for a term not exceeding XXXX but not more than XXXX" etc.

An Assessment of Livestock Water Harvesting Structures in Eastern Equatoria, Western Equatoria and Lakes States by the Food and Agriculture Organisation of the United Nations states that the main sources of water for livestock during the dry season are perennial rivers and streams, swamps, locally known as toic, community ponds and recently haffirs and to a lesser extent water yards.

Large scale construction of ponds in the greater Upper Nile area of South Sudan was started by the former Sudanese Government during the early seventies. These ponds were intended to provide water for human consumption but were used by both livestock and human populations. Most of these quickly became non-functional owing to siltation and design problems.

In 2005 construction of proper/standard water harvesting facilities was started by the Government and other development partners in Jonglei and Eastern Equatoria using funds from MDTFs (Multi Donor Trust Fund). This has continued to date using additional funds such as the SSRF (South Sudan Recovery Fund), PBF (PeaceBuilding Fund), and Canadian funds.

**The Ministry of Rural Water Supply and Sanitation and the Ministry of Animal Resources and Fisheries** are working together to select suitable areas for livestock, taking account of water and pasture availability, and have identified several sites in Eastern Equatoria and Jonglei. The considerations taken into account include:

- The availability of seasonal streams.
- Security – where people feel safe.
- Existing patterns of tribal movement.
- Areas subject to flooding and areas where ponding occurs during the rainy season.
- The need to consult the chiefs.
- The availability of community water supplies which could also supply livestock.
- The practice of keeping cattle for milk.
- Livestock routes to market on the hoof (2007-2008 map).
- Flooding which can affect the grass and cause stomach problems for cattle.
- Recent droughts in Jonglei and Upper Nile.
- Cattle raiding which is a practised by some tribes.

The longer term aim of the Ministry of Animal Resources and Fisheries is to change the pastoral people to semi-pastoral and to change tribal holdings of cattle to commercial holdings which are affected by:

- The need to change the mind-set of the people as documented in the Strategic Plan 2012-2017.
- The possibility of improving pastures and providing water so as to increase production.
- The need to work with engineers to determine where water is available.
- The experience gained from the borehole project that was implemented in Jonglei**.**

Some studies of livestock watering have been undertaken in Eastern Equatoria, Jonglei and Upper Nile, and technical guidelines have been prepared. Information on pastures and water availability have also been prepared.

The Technical Guidelines for the Planning, Construction and Operation of Water Harvesting Structures in South Sudan prepared by the Food and Agricultural Organisation of the United Nations for the MEDIWR dated 2015 focus on the design of haffirs (Arabic word for a pond) for livestock watering and also mention the possibility of also utilizing haffirs for potable water supply.

The Guidelines document the technical considerations to be taken into account for the planning, design and construction of haffirs all of which require sound engineering skills including supervision during construction.

The Guidelines also stress the importance of the following for the successful operation and maintenance of haffirs:

- The establishment and functionality of a management committee;
- The establishment of a user fee;
- The need for fuel and spare parts; and
- The need for regular maintenance and repair.

### ETHIOPIA

Pilot Villagization project to improve understanding of the relationships between pastoral people a Livestock in Ethiopia

The Government of Ethiopia is planning to implement a villagization policy to reduce the movement of the pastoralist communities in search of water within the basin, which has been a cause for conflict. The cost of villigization would be high on account of the costs of developing water sources and of constructing cattle troughs for livestock watering in the affected Woredas.

Currently there is a plan and budget from Sustainable Development Goals (SDG) to construct cattle troughs for 7 Agro pastoral woredas/districts. This presents an opportunity to implement a pilot project in to in order to assess and if necessary improve the policy.

The daily water requirements of livestock and people in the Gambella region are as follows:

- Cattle and camel: 30 l/h/day
- Goats, sheep: 3 l/ h/day.
- Average Human water demand: 20l/c/day

One of the Woredas that has the lowest water supply coverages in the Gambella region is the Akobo Woreda. During the dry season cattle from the remote areas in this Woreda are brought to the Baro and Akobo Rivers where they also consume grazing, which frequently results in tribal conflict. The estimated daily water requirements of the villagers and livestock in the remote areas of the Akabo Woreda which villagization would retain in these areas are indicated below:

*Table 2-11: Estimated daily water requirements of the villagers and livestock in the remote areas of the Akabo Woreda*

| Description | Woreda | |
|---|---|---|
| | Population | Water Demand in $m^3$/day |
| Cattle | 19,450 | 583.5 |
| Sheep | 10.550 | 31.65 |
| Goat | 13,450 | 49.35 |
| Overall livestock demand in $m^3$/day | | 655.50 |
| Human population | 34,555 | 691.1 |

Note that villagization of the migrants and their livestock may also require the development of fodder banks for the dry winter months.

### 2.4.2 Identification of new projects for areas in need

#### SOUTH SUDAN

Pastoral communities and their migration patterns

A number of political and social changes have taken place since previous studies were undertaken and it is necessary to determine the current distributions and numbers of permanent livestock and of the seasonal locations and migration patterns of pastoral people and their livestock. If possible the quality of the stock should be determined and whether the stock are owned for commercial or traditional purposes.

Therefore it is proposed that a study is undertaken to determine the distribution and quality of permanent livestock and the seasonal distributions, and migratory patterns of pastoral people and their livestock.

Livestock routes on the hoof to market should also be determined.

The study should include the identification of all existing water sources used for livestock watering.

Pilot project to improve the provision of facilities for pastoral communities

There is a need to consult with the Ministry of Rural Water Supply and Sanitation and the Ministry of Animal Resources and Fisheries concerning the following:

- The typical migratory patterns and livestock ownership of pastoral communities.
- The existing water utilization by pastoral communities, the permanent communities from whom they obtain water and the facilities provided.
- Possible improvements of the water supply facilities, their operation and maintenance and the cost thereof as well as arrangements for payment.

The proposed pilot project should comprise the following:

- Ongoing consultation with three or more pastoral communities and with the permanent communities from whom they obtain water for their stock
- Monitoring of these pastoral communities over an extended period with GPSs and perhaps with satellite imagery to identify grazing cover and surface water sources.
- The implementation of improved water supply facilities for the pastoral communities in consultation with both the permanent and pastoral communities, the ongoing operation and maintenance thereof and payment for the water.
- Further monitoring of the interactions between the pastoral and permanent communities and the use of the facilities
- The preparation of or amendment of guidelines.

This work should be undertaken in conjunction with existing donor agencies that are actively developing water supply facilities in the areas.

# 2.5 FISHERIES AND AQUACULTURE

## 2.5.1 Potential development

### *2.5.1.1 Existing development projects in the basin*

**ETHIOPIA**

There is no existing commercial fisheries industry in the region. The fishing activity is artisanal and uses low technology. There are some activities and efforts by local Non-Government Organizations to organize the fishermen into cooperatives and equip them with essential facilities for production and processing of fishes and fishery products.

The existing and forthcoming agricultural projects, hydroelectric and irrigation projects could potentially benefit the development of the fisheries sector. The rice farm fields being developed by Saudi Star and other investment firms in Gambella Region are potentials for integrated rice-fish farming. The canals that are intended to be developed for the commercial farms are again potential sites where fishes, especially catfishes, could grow.

**SOUTH SUDAN**

There is no report on organized fisheries development projects in the basin, although the potential for such projects in the BAS region is very high.

### *2.5.1.2 Potential to develop fisheries in the basin*

**ETHIOPIA**

The basin is the most appropriate place in the country for development of the fisheries industry. However, its potential is not fully utilized. This is largely associated with problems in getting and using high technology fishing gears as well as poor availability and access to market. Therefore, the capture fisheries are not fully utilized and require some scaling up of efforts. Provided that the essential infrastructures (landing sites, sheds, storage facilities) are in place and market availability is facilitated, the capture fisheries can further be developed and contribute to improving the livelihood of the community and also support the GDP of the country.

The more than 50 natural ponds found in Gambella region (largely in Agnwaa Zone), the Alwero Reservoir and reservoirs of other planned dams, the large and productive rivers (Alwero, Gillo and Baro (Openo/Kir) are potential sources of high production of capture fisheries in the region.

**SOUTH SUDAN**

There is high potential to increase the catch from capture fisheries in South Sudan, although some localities are already overfished. Given the situations of the capture fisheries, it is essential to properly apply management measures to protect the fish stocks from overfishing. It has been reported that the value of the catch could be raised by increasing the proportion of the existing catch that is marketed fresh. Fresh fish generates more income for fishermen and fish traders than smoked or dried fish. Fresh fish marketing requires ice, training, and insulated boxes for transport. Dried fish, however, will remain important for food security, as it requires no refrigeration for transport or marketing and few consumers have refrigerators. Future investments in infrastructures are expected to add value to the catch and get appropriate market to the products. There are potential export markets in Sudan and Ethiopia.

According to the CAMP Investment plan there are various projects designed to be implemented in the fisheries and aquaculture sector Nation-wide and in the BAS region. These include:

Nation-wide projects:

- Fisheries and aquaculture law project
- Fisheries information and fisheries resources management systems development project
- Development of urban fish market infrastructure project
- Private sector establishment of ice production facilities
- Private sector promotion of value adding for local and export markets
- South Sudan national fisheries competent authority project
- Private sector fisheries and aquaculture technical training project
- Regional fisheries and aquaculture research project
- States aquaculture training project
- States fisheries services capacity development project

Upper Nile and Jonglei Projects:

- Private sector promotion of large scale commercial aquaculture
- Strengthening of fisheries and aquaculture research project
- Private sector establishment of feed mills for aquaculture
- Micro credit for fishing communities project
- Prevention of HIV infection in fishing communities project
- Development of fish landing site infrastructure project
- Fishers and fisheries communities training project

Jonglei Project:

- Establishment of fisheries training and research institute project

### *2.5.1.3 Need and potential to develop aquaculture in the basin*

#### ETHIOPIA

There is a great need to develop aquaculture in the country, as the capture fisheries is very much limited as compared to the ever increasing population and demand for fish and fish products. The current per capita production of fish from the natural systems (capture fisheries) is less than half a kilogram/person/year. In order for an Ethiopian fellow to consume a kilogram of fish per year the country has to produce over 100,000 tons of fish per year (the current production stands at about 38,000 tons per year).

Gambella Region is one of the most appropriate regions of the country for the development of the fisheries sector. There is also great potential for integrated aquaculture in the rice fields by agriculture investors in the region.

Aquaculture requires land with some degree of slope and not prone to flooding and identifying areas in the region that could not be affected by flood at the rainy seasons would be vital. These criteria should be properly formulated for analysis of the region’s suitability for subsistence and commercial aquaculture and the areas that are properly identified should be mapped.

The development of aquaculture will require the development of feed industry, hatchery facilities and fish processing and packaging industries. There is also the need to train specialists and the local people in the different skills of aquaculture production, maintenance and management.

The fish species which are appropriate for aquaculture and which are indigenous in the Gambella Region include, but not limited to, Oreochromis niloticus (Nile tilapia), Clarias gariepinus (African catfish), Heterotis niloticus (Milk fish) and Polypterus bichir (African Bichir).

The following parameters should be examined and suitability analysis have to be performed in order to identify and map appropriate sites in the basin: Topography of land (% slope); Soil texture; Annual rainfall (in mm); Distance from perennial river or lake or reservoir (in km); Temperature (inoC); Economic suitability; Distance from available market; Infrastructure (access to all-weather road and electric source); Population density (per km2); and Land cover.

### SOUTH SUDAN

A very large potential for aquaculture development exists in South Sudan, particularly in the Greenbelt zone, which has permanent water and an ideal climate. Huge promises exist both in large-scale commercial farming near the main population centers and subsistence type agriculture/aquaculture systems in rural areas, although this great potential is yet to be realized. The main species to be cultured, the African Catfish (*Clarias gariepinus*) and the Nile Tilapia (*Oreochromis niloticus*), are both technologically suitable and native species to South Sudan.

In Central and Western Equatoria States efforts have been made to introduce subsistence aquaculture near Yei and Yambio. In these states some 80 ponds were prepared for aquaculture and less than half are operational and less than 3 tons of fish is produced per year.

According to FAO (2006), aquaculture development may have vast potential in the Eastern Equatoria State in the BAS region. However, there is no report, so far, on the existence of any type of aquaculture practices in the BAS region in South Sudan. For aquaculture to flourish there needs to be investment, both in subsistence and small scale commercial aquaculture, and also in high-intensity large scale commercial aquaculture. Credit, tax, and other incentives will make a big difference, but most of all there has to be some security of land tenure where fish ponds are established.

Aquaculture requires skilled staff, and for this reason a National Aquaculture Training and research Centre must be established to act as a training institution to provide the trained manpower that the sector requires, and also a research institute for basic investigations into aquaculture development in South Sudan.

Aquaculture also requires land with some degree of slope and not prone to flooding and identifying areas that could be affected by flood at the rainy seasons would be vital. These criteria should be properly formulated for analysis of the region’s suitability for subsistence and commercial aquaculture and the areas that are properly identified should be mapped.

The development of aquaculture will also require the development of feed industry, hatchery facilities and fish processing and packaging industries. There is also the need to train skilled manpower and the local people in the different skills of aquaculture production, maintenance and management.

The following parameters should be examined and suitability analysis have to be performed in order to identify and map appropriate sites in BAS Region of South Sudan: Topography of land (% slope); Soil texture; Annual rainfall (in mm); Distance from perennial river or lake or reservoir (in km); Temperature (in $^oC$); Economic suitability; Distance from available market; Infrastructure (access to all-weather road and electric source); Population density (per $km^2$); and Land cover.

#### 2.5.1.4 Enabling environment

**ETHIOPIA**

Recently Ethiopia has formulated the five year Growth and Transformation Plan (GTP II) that promote agricultural growth through adoption of improved technologies and encouraging private sector investment. In these plans, there are some descriptions of activities to promote fisheries and aquaculture such as strengthening existing fish stocking program following the water harvesting system, promoting and developing farmers-based demonstration fish ponds, establishing fish-zone and regional/federal-administration based fish culture centers for breeding and distribution of fingerlings; and training of fish farm technicians. Research will also be strengthened in the areas of developing farming technologies, food and feeding. Promotion and development of commercial aquaculture is also emphasized in complementary with rural aquaculture and other agricultural development interventions.

The main legal bases in the fisheries sector at national level in Ethiopia is the Fish Resources and Utilization Proclamation no. 315/2003 and Fish product standards produced by the Ministry of Agriculture and Natural Resources (MoANR) and the Ethiopian Quality and Standards Agency (EQSA), respectively. The proclamation provides the legal framework within which the fisheries sector operates. Together, it is expected to regulate access to fisheries, distribution and consumption of fish, sanitary and hygiene conditions, and fisheries management to utilize the fish resources in a sustainable manner.

Gambella Region has no legislation on fishes so far; however, it has been reported that a draft legislation, which has been adapted from the Federal legislation has been submitted to the Regional State for ratification (Hussien Abegaz et al, 2010).

**SOUTH SUDAN**

The main constraints to fisheries development in South Sudan are the absence of policy incentives, lack of storage facilities due to weak or total absence of power supply and the absence of effective processing technologies. In addition, inadequate transport infrastructure which limits producer's access to market is a deterrent to fisheries development in South Sudan.

In South Sudan, there is no active fisheries management carried out by the national or state governments. There is no existent routine data collection system on the fisheries and nor are there monthly or annual reports on the same.

It appears that there are already signs of overfishing near the larger towns on the Nile and Sobat Rivers. Both the national and state fisheries administrations are reportedly very weak at all levels, with under qualified staff, meager or non-existent budgets, minimal equipment, unmotivated leadership and low morale.

There is no research being carried out in aquaculture or in capture fisheries at all levels. Although policies for the sector are laid out in the 'MARF Policy Framework and Strategic Plan 2012-16' and in a separate 'Fisheries Policy 2012-16' (the latter produced under an EU-funded project), it has been impossible to implement these policies due to the reported weaknesses of the administration.

Associations and co-operatives exist in areas where donors or Non-Government Organizations have and continue to fund interventions. In other areas fishermen have formed associations, but these associations collapsed in the absence of sustainable support for them.

According to the report by the Ministry of Agriculture, Forestry, Cooperatives and Rural Development, the Fisheries Training Centre at Padak near Bor is now inoperative, having been damaged in 2014. There is no other organization offering technical training in fisheries, though some of the universities offer undergraduate and graduate courses with options in fisheries. There is no Aquaculture Training Centre and there is no technical institute offering vocational qualifications in fisheries related subjects.

A draft Fisheries Law was prepared in 2012, which is reportedly inefficient and doesn't cover all essential components and there are no fisheries regulations enacted. A serious and widespread problem is 'informal taxation', which weighs heavily on the fisheries sector and is a disincentive to activity and investment.

It has to be mentioned, however, that the recently developed CAMP (Comprehensive Agricultural Master Plan) for the fisheries sector is a well designed, well articulated and exhaustive plan of activities that need to be adhered to and implemented.

#### *2.5.1.5 Conclusion: opportunity to develop fisheries and aquaculture in the basin*

**ETHIOPIA**

The conditions necessary for the development of fisheries and aquaculture in the Baro-Akobo-Sobat sub-basin within the limits of Ethiopia are very much favorable. If fisheries and aquaculture are to develop in Ethiopia, it is the Gambella region that could provide the greatest opportunity. The water systems are quite adequate in terms of quantity and quality. The capture fisheries potential, especially in the floodplains, the natural ponds and reservoirs is very high. The aquaculture potential of the region is immense and need to be properly identified and mapped.

In order to realize and tap these potentials Government, Non-Government organizations and the private sector need to work together. There needs to be proper investment in improving the fishing and post-harvest technologies, organizing the fisher communities, and also provide proper, relevant and adequate trainings. The development of road and power infrastructures is an important prerequisite for the development of the fisheries in order to access potential markets and also to present the products without and before spoilage.

**SOUTH SUDAN**

The capture fisheries could remain viable as source of nutrition and income for the foreseeable future in the BAS Region of South Sudan so far as it is exploited in a sustainable manner. Therefore, the management of the fishery resources needs to be strengthened by the concerned authorities.Probably unstoppable rise of catch to well beyond the Maximum Sustainable Yield is to be expected in the coming years without proper management measures. Therefore, essential policy, proclamations and regulations should be in place for sustainable management of the resources.

The aquaculture sector has to be developed for large scale commercialization of fishery products and to meet the ever increasing demands of the society. The potential for the development of intensive aquaculture practices is immense as many of the criteria for the development of aquaculture can easily be met in the BAS region in South Sudan.

The role of the Government, Non-Government Organizations and the private sector should be identified and each should play its role appropriately both in the capture and culture fisheries for sustainable and profitable exploitation of the resources. Importantly, land issues have so far precluded investment into commercial aquaculture and need to be considered seriously. The private sector is quite capable of improving production and maximizing post-harvest returns in capture fisheries and investing in aquaculture and feed for aquaculture. Private sector investments should include ice machines, processing plants, refrigerated vehicles, ice boxes and retail and wholesale premises; and for fish farms, hatcheries, ponds, feed mills and service industries.

It is, of course, incumbent upon GOs and NGOs operating in the region to construct the essential infrastructures (landing sites, sheds, storage facilities) to reduce both harvest and post-harvest losses now facing the fishery industry. Transport and power facilities are central for proper maintenance of the products and these have to be seriously considered by all concerned (especially by the Government agencies). Market availability and accessibility are bottlenecks for the development of the sector and they need be addressed properly. Fishermen have to be organized in cooperatives so that they could receive the essential support (material, knowledge and skills) in an organized manner.

There is a need for a research and training center to produce the necessary manpower at all levels. Priority research areas have to be identified and research need to be conducted at the center, which would be helpful for the effective use of the capture and culture fisheries. For proper fisheries management a data collection system must be established. It is impossible to actively manage a multispecies fishery without understanding the dynamics of the species assemblage within it, and the spatial distribution and volumes of catches. Additionally, the Fisheries Training Centre must concurrently be refurbished and revitalized, as there is no other institution designed to provide the necessary technical and vocational training at states and community level, and for private sector development.

## 2.6 ECO-TOURISM

### 2.6.1 Existing development projects in the basin

The existing initiatives are going in several areas of the BAS:

- Gambella region, including Gambella national park, through IGAD BMP project. Beyond wildlife observation in the national park, the main attractions currently promoted by the Gambella region related to water resources and include brigdes on the Gilo and Baro rivers, lakes and waterfalls.
- Development of management and business plan for ecotourism and edition of a visitors' guide in Kafa Biosphere Reserve, Bonga, Ethiopia. Current activities include bird watching, walk through coffee forest, waterfalls, visits of tea plantations, etc. Infrastructure such as hiking trails with picnic huts, wildlife observation towers and camping site have been set up as part of 2009-2014 NABU 1$^{st}$ forest and climate protection in Kafa.
- Social empowerment through group and nature interaction in Sheka zone, organized by MELCA offering the following activities: camping in the forest, trekking, night watch, …
- Preparation of brochures by each regional state to be used by tourists and to advertise the available tourism potentials and attractions of their respective regions. These brochures contain valuable information about protected areas, list of wildlife species found in the protected areas and wildlife parks, landscapes, lakes, traditions, etc.

The existing initiatives are located exclusively in the Ethiopian part of the BAS. However, there is a large potential to further develop this sector, both in the Ethiopian and South Sudan parts of the BAS (see next section).

The map presented in Figure 2-7 sums up the existing eco-tourism attractions and initiatives.

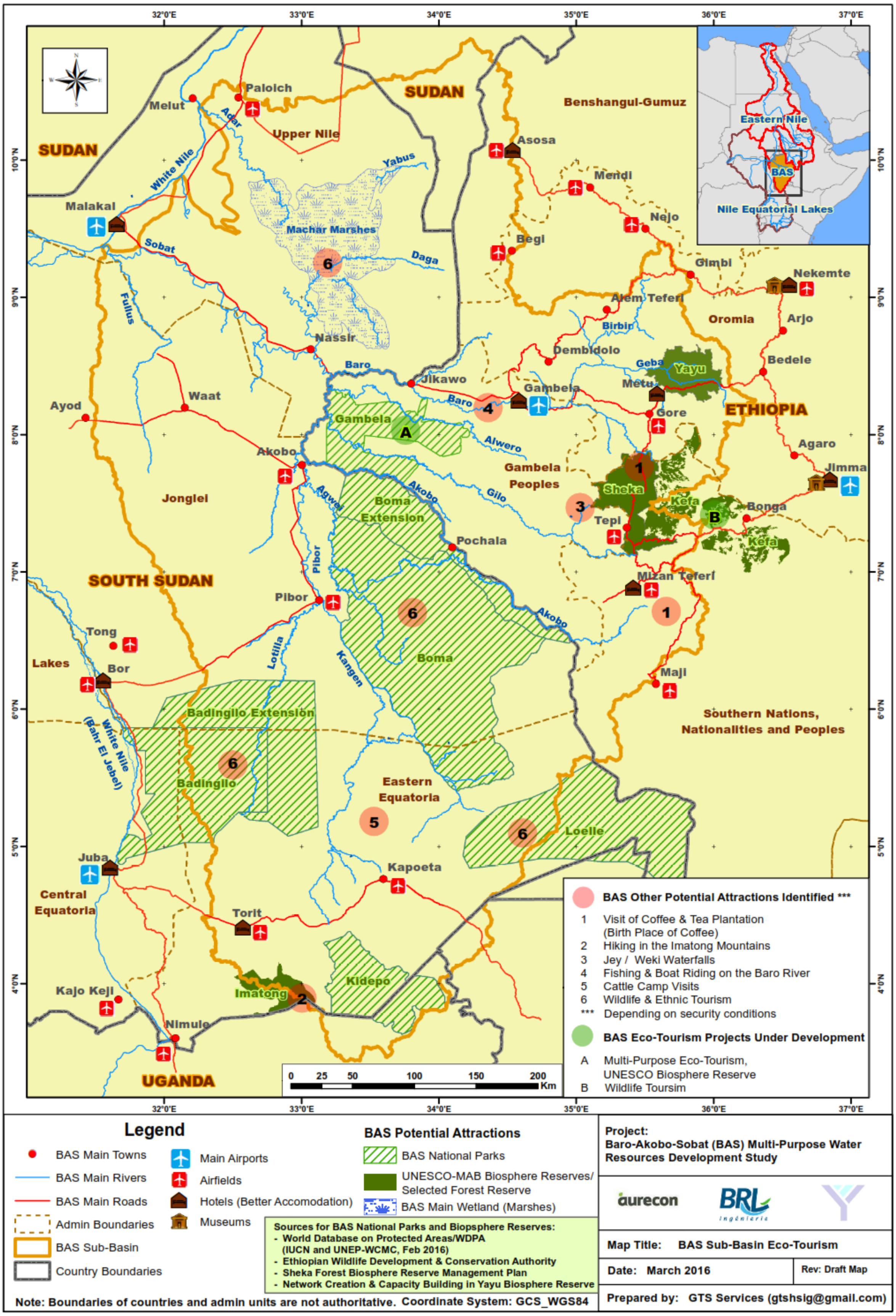
### 2.6.2 Potential to develop ecotourism in the basin

As already stated, the potential for ecotourism development in the basin is huge, considering the current level of development and the natural assets of the basin. The variety of ecosystems of the basin, its quite pristine character and the importance of mammals and birds migration offer a huge potential for natural-resources based tourism.

Wildlife experts consider that the mammal migration of the BAS is equal to the Massai Mara – Serengeti one. The mamal migration occurs in the lowlands areas (biophysical area 4) both in South Sudan (in and around Badingilo and Boma National Parks) and in Ethiopia (mainly in and around Gambella National Park) The total annual numbers of visitors to this transboundary protected areas vary from 300,000 to 400,000. This is more than the currently most visited national park of Ethiopia (Nechisar national park) and offers interesting perspectives for complementary sources of income for the communities.

The main potential ecotourism development identified in Ethiopia and in South Sudan through consultations and literature review are presented in the map below.

*Figure 2-7: Main existing and potential tourism development in the BAS*



### 2.6.3 Enabling environment

The two following facts illustrate the willingness of the two countries to further develop tourism and ecotourism:

- The Government of Ethiopia is currently “implementing a number of strategic measures to further develop the country’s tourism sector, including investment in infrastructure and capacity building on destination management and product development, through the recently established Tourism Transformation Council” (UNWTO, 2014).
- The Government of South Sudan, through (but not limited to)“ The Eastern Equatoria State Local Government and Wildlife Conservation Minister Charles Lokonoi Ambrose vows to improve the sector with prime objective to boost economy especially in protected areas of wildlife conservation and tourism as key target to realize sightseeing attractions of wildlife both flora and fauna in the state” (Nakimangole, 2013).

The major impediment for ecotourism development is the localized instability and the related security issues, especially in South Sudan.

### 2.6.4 Conclusion: opportunity to develop ecotourism in the basin

The BAS basin offers huge natural and cultural assets. Conservation and valorization of these assets could lead to the sustainable development of eco-tourism. This willingness to develop ecotourism has been largely mentioned during the consultations and few local and regional initiatives have been identified.

It should be noted that, on the short term, for security reasons, the opportunities to develop ecotourism are higher in the BAS highlands and escarpments. On the mid and long terms, there are huge opportunities to develop ecotourism in a large part of the basin.

# 3. POTENTIAL DEVELOPMENT FOR SERVICE SECTORS

## 3.1 POTABLE WATER SUPPLY AND SANITATION

### 3.1.1 Introduction

The situation and development of water supplies and sanitation facilities in the South Sudan and Ethiopian portions of the catchment area of the BAS have been presented in section 6, Part 1 of this report.

### 3.1.2 Potable Water Supply and Sanitation in South Sudan

#### *3.1.2.1 Identification of New Projects for Areas in Need*

The Republic of South Sudan Urban WASH Sub-sector Investment and Implementation Plan 2013-2018, November 2013 of the Ministry of Electricity Dams, Irrigation and Water Resources (MEDIWR) identified a number of projects to improve water supply coverage in the urban areas of South Sudan. The aim of this investment plan is to supply 1.8 million people of South Sudan (approximately 20% of the population) with safe and reliable water and sanitation services.

The Plan proposes the rapid extension of water supply services in urban areas by focussing on kiosks and yard taps followed by household connections. Private sector involvement is being encouraged. Table 3-1 lists the towns to be served within the catchment area of the BAS and Figure 1 indicates the locations of these towns within the BAS catchment area.

*Table 3-1 List of towns for rapid extension of water supply services 2013-2018*

| Town | State | County | Population | Investment US$ (2013-2018) |
|---|---|---|---|---|
| **Major Towns** | | | | |
| Torit | Eastern Equatoria | Torit | 30,100 | 224,821 |
| Akobo | Jonglei | Akobo | 15,172 | 8,561 |
| Pibor | Jonglei | Pibor | 8,648 | 5,671 |
| Nasir | Upper Nile | Luakpiny/Upper Nile | 17,915 | 9,777 |
| **Minor Towns** | | | | |
| Kapoeta | Eastern Equatoria | | 10,705 | 5,880 |
| **Small Towns** | | | | |
| Kato | Eastern Equatoria | Kapoeta South | 12,449 | 6,425 |
| Narus | Eastern Equatoria | Kapoeta East | 9,383 | 4,937 |
| Imehejek | Eastern Equatoria | Lopa/Lafon | 4,246 | 2,444 |
| Riwoto | Eastern Equatoria | Kopoeta North | 3,463 | 2,064 |
| Uror? | Jonglei | Uror | 4,684 | 2,656 |
| Mareng | Jonglei | Duk | 761 | 753 |
| Boma | Jonglei | | 6,516 | 3,546 |
| Wedakona? | Upper Nile | Manyo | 9,659 | 5,071 |
| Mathiang? | Upper Nile | Longochuk | 9,070 | 4,785 |
| Pagak | Upper Nile | Maiwut | 2,223 | 1,463 |
| | | **TOTALS** | **144,994** | **288,854** |

SMEC International's report titled Detailed Design: Torit Town – Eastern Equatoria State for the Ministry of Water Resources and Irrigation was funded through the Multi Donor Trust Fund (MDTF) and was printed in March 2013. This report provides preliminary designs for upgrading the water supply to Torit in Eastern Equatoria but recommends that the existing water supply system is refurbished and operated until 2022 when a new water supply system should be commissioned, either based on groundwater, if this proves to be feasible, or on surface water from the Bahr el Ghazal River.

**In July 2015 the Director General of Housing and Public Utilities, Ministry of Physical Infrastructure of Eastern Equatoria** advised that the existing supply system in Torit is to be taken over by a public Water Corporation which will sell water at 10 pounds/kl to pay for operation and maintenance costs. This is the first such corporation in South Sudan and a Water Committee has been appointed. The lessons learned from this development could be extended to other towns and communities.

The 3 year **Water for Eastern Equatoria State (WEES) Project** commenced in November 2013 and will end in November 2016. The project is funded through the Dutch Multiannual Strategic Plan 2012-2015 for South Sudan. The WASH component of the project is designed to improve ongoing awareness and understanding of WASH rather than focussing on the emergency responses provided by most NGOs to the various rainy-season-related disease epidemics and to drought stress, two phenomenon that are frequent occurrences in South Sudan. The Project's WASH component is designed to address this gap.in the developmental perspective of WASH which is lacking in the work of many NGOs. Geographically, the WASH component covers five counties in Eastern Equatoria: Torit, Lopa/Lafon, and Kapoeta North, East and South.

**There is a need to improve WASH awareness** throughout the BAS basin and the lessons learned from the WEES Project could be valuable.

The Technical Guidelines for the Planning, Construction and Operation of Water Harvesting Structures in South Sudan prepared by the Food and Agricultural Organisation of the United Nations for the MRDIWR focus on the design of haffirs (Arabic word for a pond) for livestock watering but also mention the possibility of utilizing haffirs for potable water supply, provided that the water sources are protected from pollution and that the water is treated to an acceptable standard including disinfection. If haffirs are utilised for potable supplies then it is likely that it will be necessary to provide chemical dosing followed by sedimentation and filtration to remove suspended matter. This would normally be followed by chlorination for disinfection. This would require and would the ongoing purchase of chemicals and testing to optimise the dosing requirements. This may require the appointment of a trained permanent operator. Therefore sound engineering advice would be necessary for implementing haffirs which are to serve as potable supplies.

### *3.1.2.2 Enabling environment in South Sudan*

The Government of South Sudan relies on donors for the provision of infrastructure and on the communities for undertaking the operation and maintenance. Therefore it is essential that donors consult communities regarding any new water supply infrastructure or major refurbishment of existing water supply infrastructure for which communities must take responsibility and provide training in operation and maintenance. Communities must also be educated in the financial management of their facilities. The well-established approach in Ethiopia could serve as a model for South Sudan.

Assuming that the formation of a public corporation in Torit is successful, this should serve as a model to be extended to other towns and communities.

Well-equipped water quality monitoring laboratories have been set up by the government in the capitals of each state, however these laboratories frequently experience problems with outdated reagents and with transport. Therefore measures should be implemented to improve this monitoring that is vital for the health of all communities.

The management and maintenance of water supply infrastructure was previously undertaken by government departments but will in future vest with communities and public corporations. Therefore it is essential that the operators are trained. It is also necessary that a strong cohort of local contractors is trained and established to undertake the maintenance of water supply facilities and that public corporations are well trained and know where and how to access maintenance contractors should these be required.

### 3.1.2.3 Conclusion: opportunities to improve potable water supply and sanitation in the BAS basin in South Sudan

Many urban and rural communities in the BAS basin of South Sudan do not have access to basic water supplies and in some instances favour using water from unprotected sources on account of the taste or hardness of the water mostly from protected borehole sources. Therefore it is essential that community consultation and WASH education in respect of both water supply and sanitation should go hand in hand with the provision of new water supplies.

South Sudan has limited capital resources and currently relies on donor funds for the development of new sources of supply. There are a number of donors that are operating drilling rigs and are actively developing new supplies for towns and communities. It seems that some of these may not be providing sufficient training of communities to operate and maintain their facilities. Therefore there may be a need for ongoing training and guidance of operators.

The collection of payments for water by communities and water corporations is essential to enable these organisations to operate and maintain their water supply infrastructure. The training of local maintenance contractors is also essential including training in the procurement of spares.

Given the groundwater potential (see sections 3.2.4 and section 4.15 “water security” – Part 1), the development of groundwater will be an important catalyst to achieve better access to water resources in the BAS.

## 3.1.3 Potable Water Supply and Sanitation in Ethiopia

### *3.1.3.1 Identification of new projects for areas in need in Ethiopia*

Although capacity limitations and high staff turnover are affecting progress in meeting planned targets in Ethiopia, there are implementation guidelines and procedures for WaSH interventions and better coordination, joint planning and evaluation amongst the development partners and stakeholders in Ethiopia. Even though significant progress has been made in the last decade in improving access to water supply and sanitation, some of the woredas within the basin particularly in Gambella (Akobo and Jor) still have the lowest water supply and sanitation coverage. As noted above these woredas receive finance from OWNP-CWA fund, however little or no progress has been made to improve their accessibility by road. There is also a huge gap in the finances required to meet the water supply and sanitation needs in these woredas.

### *3.1.3.2 Enabling environment in Ethiopia*

The WASH (water supply, sanitation and hygiene) sector in Ethiopia is developing rapidly and is moving towards a sector-wide approach. This has been facilitated by the several important policy, coordination and implementation mechanisms that have been developed in recent years. These include rural and urban water access plans (UAPs), the WASH Implementation Framework (WIF), the national WASH sector programme, and the One WASH National Program (OWNP). The OWNP is the main instrument for achieving the goals set out for the WASH sector in Ethiopia's poverty reduction strategy of the "Growth and Transformation Plan 7/2015 – 6/2020 (GTP)". While the basic principles and strategies of the institutional and policy framework governing drinking water supply, hygiene and sanitation in the country have remained the same, over the last ten years the framework has undergone a number of reforms aimed at improving the delivery of water supply and sanitation services.

In compliance with its policy the GoE is enhancing decentralized decision-making; promoting the involvement of all stakeholders; adopting a demand driven approach with communities contributing towards capital and O&M costs; integrating water supply, sanitation and hygiene promotion activities in project woredas, and creating a favourable environment for the promotion of appropriate sanitation services.

### *3.1.3.3 Conclusion: opportunities to improve potable water supply and sanitation in the BAS basin in Ethiopia*

Many of the Districts particularly in the BAS basin of Ethiopia are areas where access to safe water supplies is lowest. Many factors contribute to this including accessibility, the need for more investment to develop sources, and lack of local human capacity.

The lowering of ground tables due to excessive water abstraction requires that surface water sources are developed to supply water to multi villages (communities) for both human and livestock consumption.

Given the groundwater potential (see sections 3.2.4 and section 4.15 "water security" – Part 1), the development of groundwater will be an important catalyst to achieve better access to water resources in the BAS.

## 3.2 NAVIGATION

### REQUIRED PROJECTS TO IMPROVE NAVIGABILITY, ESPECIALLY ON THE BARO AND THE SOBAT RIVERS

The following projects are required in order to improve navigability, especially on the Baro and Sobat rivers:

- The rehabilitation of the port infrastructure in Gambella along the Baro River to develop the traffic: construction and/or rehabilitation of vertical quay walls and jetties, mechanical equipment for loading, and discharging operations, mobile cranes and rail cranes, equipment with mooring rings, etc.
- Increase the number of fleets for barge operation and the carrying capacity.
- The improvement of water regulation and the increase of the level of dredging, in order to make river navigation in dry season possible.

When looking at the potential for navigation it is necessary to look beyond the potential in the existing (or historical) context of (river) transport in the area. One of the strategic conclusions of the Eastern Nile countries in the recent Multisector Investment Opportunity Analysis (MSIOA, 2014) was that there should be a move towards a regional approach to food security. According to the MSIOA, a regional approach to security would imply "*a regional approach to markets and the entire logistic chain getting produce to principal regional market centres. Maximising food production should be achieved from a regional perspective rather than a national one, with a focus on the most efficient use of the available water resources within the system as a whole*".

Bearing this in mind, on a regional perspective, the place for navigation in the transport sector would be crucial. To connect Ethiopia to South Sudan and through to Sudan, the target areas are the rivers which go from Gambella to Khartoum:

- The Baro River: reaches from Gambella to the Sobat, at the confluence with the Pibor;
- The Sobat Corridor: stretches between Nessir and Malakal;

## 3.3 THE WHITE NILE: STRETCHES BETWEEN MALAKAL TO KHARTOUM.FLOODS AND DROUGHTS MITIGATION

Several interventions proposed in the frame of this study will have direct benefits on floods and droughts mitigation. The most important ones are summarized below:

- **Reservoirs associated to hydropower production**: Reservoirs can supply potable water during the dry season and water for small scale irrigation, aquaculture and livestock. This will help to face severe droughts. They can also retain water during heavy rains thus limiting floods during the rainy season. However, it should be noted that the regulation of the flow should not deregulate wetland ecosystems downstream as wetlands have a significant role in water retention during heavy rains. Damaging these wetlands could increase floods in downstream areas.
- Small reservoirs with a focus on livestock watering and potable water supply: these reservoirs will have a direct benefice in case of severe droughts.
- **Protection of wetlands**: the conservation of wetlands will ensure water availability during dry periods but also retention and storage of floodwaters.
- **Conservation of the highland forests / reforestation**: these forests play an important role in flow regulation and, mitigation of the floods downstream in the basin. The conservation of the forests and wetlands through livelihood based watershed management is a key element to retain water during heavy rains and mitigate floods in the lowlands. It increases also aquifers recharge and help to mitigate the droughts.
- **Hydrological and meteorological monitoring**: a reliable and long term monitoring in key areas of the basin will improve knowledge on the hydrological functioning in the basin and thus risk prediction.
- **An improved land use planning** and the effective implementation of the plan can have an significant role in limiting permanent settlements in floodplains and other areas with high flood risks
- Implementing measures to increase water productivity and efficiency, especially for irrigation to face severe droughts

# 4. POTENTIAL DEVELOPMENT FOR CROSS-CUTTING SECTORS AND THEMES

## 4.1 LIVELIHOOD-BASED WATERSHED MANAGEMENT

### ETHIOPIAN UPPER CATCHMENTS

The upper catchments of the sub-basin in Ethiopia are located in highlands and escapments (biophysical areas No1 & 2) and to a lesser extent in the foothills and Piedmonts (biophysical area No 3). In terms of administrative areas, it comprises Southern Nations and Nationalities and Peoples, Oromia (Illubabor and West Wellega) and Gambella (Majang zone) Regional States. They show a distinct and similar agro-ecological condition and farming systems dominated by coffee production and mixed farming on steeper slopes. The potential and hotspots areas of the sub-basin have been identified and prioritized for watershed management interventions during the reconnaissance survey of the Ethiopian highlands. The two field reconnaissance trips to the area have clearly indicated the high potential in terms of natural resources and favourable climatic condition for farming and livestock production. However, these areas have become prone to degradation as a result of population growth, resettlement and people's in migration from other areas as well as expansion of private commercial farms. In a recent study, upstream of the Gilo-Akobo sub basin, a large water resource supply area for downstream it was noted that it is being deforested for tea production without proper consent of the regional or local government. In addition no EIA of the proposed commercial farm has or is being undertaken. The effect of this intervention will be to reduce groundwater and surface water recharge in the lower reaches of the sub-basin, downstream of Gambella and beyond.

The livelihood zone of the Ethiopian part which characterize the selected watersheds of the sub-basin for livelihood development fall in two major zones (Refer to Livelihood Map of the Sub-Basin, Figure 4-9, part 1);

- Bench-Keffa Cereal and Enset in Bench Maji zone, Southern Nations and Nationalities and People's Region
- Wellega Coffee, Maize and Sorghum in West Wellega Zone, Oromia Region

### SOUTH SUDAN UPPER CATCHMENTS

The upper catchments of the sub-basin in South Sudan are located in highlands and escapments (biophysical areas No1 & 2) and to a lesser extent in the foothills and Piedmonts (biophysical area No 3). In terms of administrative areas, these areas are included within the Eastren Equatoria state.

The South Sudan positioning survey for the Dutch water sector identifies opportunities, product market combinations, strategies and approaches for the Dutch water sector in South Sudan (Aidenvironment, 2015). One identified product is climate proofing through, among others, watershed management for preventing drying up of rivers and wetlands.

Based on the Joint Assessment of the Agriculture Sector of South Sudan in 2014, the main livelihood zones of the sub-basin part of South Sudan fall into three zones,

- Highland Forest and Sorghum mainly in Central and Eastern Equatoria State
- Eastern Semi-Arid Pastoral in Central Equatoria
- Eastern Plains Sorghum and Cattle and Northeastern Maize and Cattle in Jongley State.

In terms of watershed management relevance to the sub-basin, the Highland Forest and Sorghum livelihood zone is the most important with the greatest potential to improve existing livelihoods and minimize downstream effects of sediment loads in rivers and other water resources development projects. This zone is characterized by a population density of 16.88/km$^2$ (higher than most other livelihood zones), an average precipitation of 937 mm/annum and a land use of dominantly shrubland followed by wood/forest and grasslands. The main occupation of the people is crop and livestock production with minimal crop production (2% of the livelihood zone is under crop production).

The three most frequently perceived shocks by rural households are 1) drought or floods, 2) death or theft of livestock and 3) crop disease or pests which is followed by illness or death of household members. Rural households are averse to these shocks since all of the shocks negatively affect their livelihood and agricultural production. The difference in their coping capacity in different Livelihood Zones is significant. The major coping mechanisms for this particular livelihood zone are reduced food consumption, help received from others and the sale of animals.

#### SUDANESE UPPER CATCHMENTS

Main sources of livelihood in rural areas of Sudan, specifically in the Hills and Mountains zone are with 79% crop farming, 7% animal husbandry and 4% wages and salaries. Thus, there is a need to focus on sustainable and improved productivity of crop production through an integrated livelihood based watershed management based on the previous experiences in the sub-basin.

### 4.1.1 Existing development projects in the basin

#### IN ETHIOPIA

There are 3 SLMP 2 woredas in the BAS basin: Semien Bench and Meinit Goldiya in Bench Maji Zone of SNNPR and Masha woreda in Sheka Zone. The only other watershed management intervention that came to light during the reconnaissance field trip was the NGO Mekane Yesus in Bench woreda. However since 2011 there has been a surge of interest by zone and woreda staff and land users themselves in undertaking soil and water conservation measures through Mass Mobilisation following the example of Tigray. Many woredas have planned interventions through mass mobilisation usually starting in the most degraded micro-watersheds or kebeles in the area. In some cases the plans have been too ambitious with a major constraint of a paucity of suitable trained technical staff and limited funding for supporting implementation on a regular basis. However people report a high level of interest in mass mobilised soil and water conservation with land users able to appreciate the benefits. Allied to watershed management, Farm Africa/SOS Sahel have been implementing an EU-funded project (Strengthening Sustainable Livelihoods and Forest Management) in (inter-alia) the forest areas of Gesha, Chena, Gewata and Yeki woredas, parts of which are in the BAS. The project promotes participatory forest management, developing non-timber and forest-based enterprises in these forests for forest-adjacent communities. Moreover, there are two active local NGOs, MELCA and NABU, operating in the Sheka and Keffa zones respectively. They are involved in supporting the sustainable of natural forests including wet lands through community awareness, rehabilitation and promotion of livelihood opportunities.

Wetlands in the south western part of the sub-basin is being managed through an indigenous NGO (Civil Society Organization), “Ethio Wetlands of Ethiopia”. The NGO mainly had embarked on research in Illubabor zone of Oromiya region supported by EU and Addis Ababa University for three and a half years. It was established to disseminate research results of the wetlands and provide information for awareness raising and help protect the wetlands of Ethiopia. It is also involved in participatory forest management of Sheka, Bench Maji and Illubabor and Kefa zones covering 12-13 woredas. Furthermore, the NGO is involved in micro-watershed management of the wetland areas in Mettu areas of Illubabor zone of Oromia. Main activities include forest development, soil and water conservation and wetland management.

The main challenges affecting wetland management are conversion of wetland areas to agricultural lands mainly for maize production, overgrazing during the dry season and large irrigation investment projects in the floodplains.

### 4.1.2 Identification of new projects in areas in need

Potential watershed management projects in the BAS basin are likely to be linked to dam construction and downstream irrigation development. The Eastern Nile Multi-Sectoral Investment Opportunity Analysis (EN-MSIOA) has identified 13 potential irrigation projects fed from 5 dams and reservoirs (Gambella, Itang, Abobo, Gilo 1 and Gilo 2), the development of which could well drive the implementation of soil and water conservation and watershed management interventions upstream.

Both the cooperative regional assessment and the reconnaissance field trip highlighted potential hotspot areas that may well prove to be corroborated during the master plan. The cooperative regional assessment identified ‘the northeast in the Upper Baro catchment, and in the southeast in the catchments of the Upper Gilo and Duna’ (part of the Akobo by an assessment of the extent of soil degradation while the reconnaissance field trip also identified slightly different areas in the northeast and southeast of the basin with the woredas of Yubdo, Ayra, Guliso, Haru and Genji in West Wellega Zone, part of the upper basin and Meinit Goldiya and Meinit Shasha woredas in Bench Maji Zone in the Kilu, Bilang and Olmu river sub-basins in the upper Akobo sub-basin.

The Ethiopian side of the sub-basin specifically the upper catchments, suffer from various factors affecting land degradation and the overall livelihood system of the local community. As farmers rely on rain fed agriculture for crop and livestock production, the natural resources are highly affected by continuous shifting cultivation of the steep slopes which can expose- large parts of the cultivated areas to soil erosion by water. Additionally, the Bench Maji zone agriculture office indicated that soil acidity has become the most alarming land degradation problem that requires amelioration through is the application of lime to vast areas of the cultivated lands. The zonal office in general suggested the following activities to be considered for implementation in the identified watersheds of Menit Shasha and Menit Goldia based on the agro-ecology and the land degradation problem.

- Focus on livelihood activities related to agro-forestry and fruit production in order to minimize pressure on the natural forests of the upper catchments by meeting the livelihood needs through increased income and rely on multipurpose trees for using as energy sources.
- Provision of alternative energy sources and technologies such as coffee husks and fuel efficient stoves;
- Construction of soil and water conservation and water harvesting technologies in the uplands and low land areas of the watersheds for improved land productivity and reduction of soil erosion.
- Application of lime ($CaCo_3$) on lands affected by soil acidity, which is the major problem of the soils in the sub-basin.
- Flood control and improved drainage
- Fertility management and Biological Soil Conservation
- Gully Control measures

### 4.1.3 Enabling environment

**INSTITUTIONAL, LEGAL AND POLICY FRAMEWORKS**

In Ethiopia Watershed Management has developed through a desperate need to address soil erosion and land degradation. The Soil Conservation Research Project (SCRP) and the Ethiopian Highlands Reclamation Study (EHRS) were the precursors to current thinking carrying out research into farming practices and soil erosion in the 1980s and 1990s. Soil and water conservation projects however were not particularly successful. This changed in the late 1990s to mid-2000s with the WFP (World Food Programme) supported MERET (Managing Environmental Resources to Enable Transitions to more Sustainable Livelihoods) programme within the Ministry of Agriculture and Rural Development. Traditionally, watershed management focused on soil and water conservation (SWC) measures such as bunds, terracing and drainage ditches, aimed at reducing the speed at which water flows downslope by breaking up the slope thus promoting infiltration and trapping sediment. Parallel to this were measures to safely dispose of excess water in high rainfall areas and measures aimed at gully control. This reflected a tradition of soil and water conservation imposed from above with technological fixes to technological problems. However over the last twenty years or so there has been an awakening to the fact that these problems are not, first and foremost, technical problems but socio-economic problems. More recently soil and water conservation has been integrated with other technical measures, typically agronomic and agroforestry measures such as contour ploughing, row seeding, mulching, improved seeds, hedgerow planting, increased use of inputs, etc. Area closure of grazing areas and reforestation is also typically part of the mix. Traditionally farmers were seen as part of the problem (poor land management was often quoted) who needed to be changed through awareness raising, training and capacity building. Results from this approach were often less than satisfactory.

As the MoARD Guideline (2005) states: “Watershed Development has been problematic when applied in a rigid and conventional manner … when applied without community participation and using only hydrologic planning units … resulted in various failures or serious shortcomings difficult to correct”. Within the context of the present study the current thinking in Ethiopia is for ‘integrated watershed management’ projects epitomized by the MERET project that has been running since 2002 and followed on from previous projects supported by the WFP such as the Land Rehabilitation Project. The project is concerned at farm level with conservation, intensification and expansion of cultivated, and diversification of income opportunities. The main thrust of the project is to enhance the productivity and sustainability of the farming system by introducing conservation measures and improved technological packages that use the same land area. Some interventions are also aimed at reclaiming degraded land and bringing it back into cultivation or as community forestry. (WFP 2005).

MERET undertook a cost-benefit analysis of its interventions (WFP 2005) in chronically food insecure woredas. In the absence of baseline data, reliance was made on farmer perceptions of change, as assessed in 66 sample catchments in eleven Woredas and theoretical calculations (e.g. application of the USLE). Both financial (farmer) and economic (impacts on the national economy) analyses were undertaken, with a 25 year time horizon. The aggregate Economic Rate of Return (ERR) was assessed at 13.5% over 25 years, indicating economic viability (assuming a 10% discount rate), without accounting for downstream benefits and intangibles. This was largely attributed to the moisture effect of soil and water conservation.

Since 2009 MERET experience has opened the door for the design of SLMP (Sustainable Land Management Programme) under the framework of the Ethiopian Strategic Investment Framework (ESIF) as the main driver of watershed management in Ethiopia. SLMP 1 ran from 2009 to 2013 in 45 woredas in mainly food secure or/and food self-sufficient woredas of the country and comprised three main components: Watershed Management, Rural Land Certification and Administration and Project Management. SLMP-2 supports the ESIF aim of scaling up SLM and will be implemented between 2014 and 2018 in an additional 90 woredas through four components: Integrated Watershed and Landscape Management; Institutional Strengthening, Capacity Development and Knowledge Generation and Management; Rural Land Administration, Certification and Land Use; and Project Management.

Mass mobilization for natural resources management following the experience of Tigray has gained popularity and had been scaled up to other regions in the last five years with some successes being advocated by the Government. Though well accepted and realized for its benefit to the environment, the program has suffered from the lack of technical expertise and gaps in planning and implementation of watershed management at large. However, the Ethiopian government would like to follow this approach for implementation of soil and water conservation and watershed management at large.

#### AVAILABILITY OF CAPACITY AND CAPACITY BUILDING OPPORTUNITIES

Capacity has been identified as a limitation at zone, woreda and kebele levels, particularly for planned mass mobilisation interventions where a major constraint is the lack of suitably trained technical staff. Moreover, the existing Land Administration office has limited capacity at zonal and woreda level to ensure land certification through GIS mapping and this has delayed issuance of land certificates to land users which delays ensuring an enabling environment for initiating investments for longer term benefits. Technical capacity is not perceived as a constraint in SLMP selected woredas since technical expertise is imported and local staff are trained. The opportunity for capacity building is high given the level of interest in soil and water conservation and watershed management through mass mobilization with woreda staff, DAs and land users able to appreciate the benefits.

The areas identified for watershed management in the sub-basin would benefit from the experience of the nearest watershed management projects implemented through SLM 1 and SLM 2 as well as from other, specifically MERET, project sites that have demonstrated successes in mostly food insecure woredas of the country.

### 4.1.4 Conclusion: watershed management opportunities in the basin

The sub-basin specifically from the Ethiopian side has rich natural resources and favourable climatic conditions that favours the implementation of livelihood based watershed management provided that local capacity and resources are available. The existing initiatives in managing the natural resources of the upper catchment through various projects and regulatory policies (bio-sphere protected areas linked with livelihood enhancement of local communities) will be helpful in strengthening the implementation of the proposed watershed management projects.

The regional sectoral institutions' readiness and concern for the environment and natural resources is an opportunity to embark on livelihood based watershed management that would address in-situ watershed issues such as land degradation and low productivity and the cumulative effects of the upper catchment treatment on reduced sedimentation of downstream rivers and potential irrigable areas.

A key principle of livelihood-based watershed management is that it should be sustainable though a "win-win" approach with environmental sustainability supported by land use and farming practices that result in improved livelihoods and wealthier farmers. However, experience has shown that there are usually some significant "start-up" costs ("seed financing") and efforts are required to promote and accelerate the implementation of livelihood-based watershed management. Accessing this financing and capacity building expertise can sometimes be a challenge since the beneficiaries are many and the benefits relatively intangible, at least in the short-term. The efficient development of downstream projects such as reservoirs for hydropower and/or irrigation, or diversion weirs and water treatment plants for water supply will benefit from a less silt-laden river. These developments can therefore catalyse the implementation of watershed management interventions upstream. Their design should make allowance for the required design and seed-financing of such watershed management intervention programmes.

## 4.2 BIODIVERSITY, HABITATS AND LANDSCAPE CONSERVATION

### 4.2.1 Existing development projects in the basin

The following on-going conservation projects have been identified :

- Improving South Sudan's Livelihoods and Ecosystems Through Water Management in the Imatong mountains

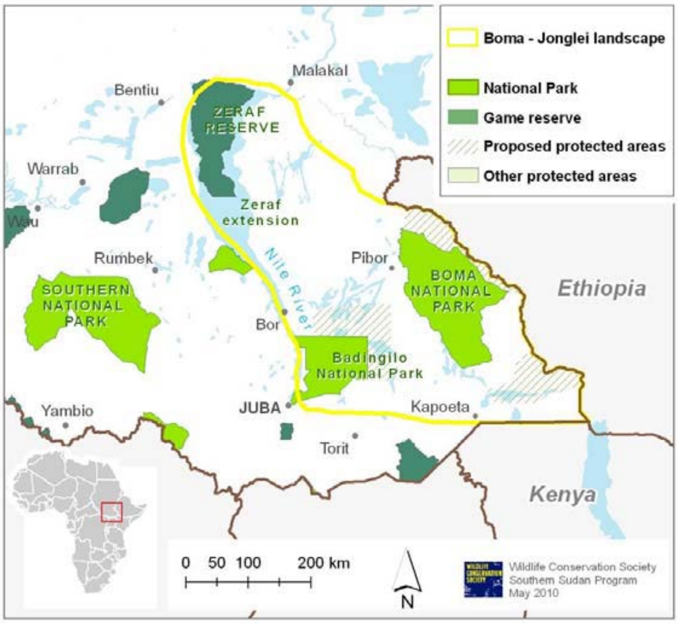
  The African Wildlife Foundation has received a five year project grant from the Netherlands to secure the Imatong Mountains Water Tower in Equatoria State (African Wildlife fundation, 2014a). The projects aims at ensuring that the water tower of the Imatong Mountains, and particularly the catchment area of the Upper Kinyeti River are protected and sustainably managed, to ensure long-term water access to communities and ecosystems down river (African Wildlife Foundation, 2015). So far, a comprehensive socio-economic survey of the area has been conducted and published in 2014 (AWF, 2014b). Interventions in the middle part of the watershed should relate more to management of water use as well as agriculture (crop & livestock) use. By ensuring that water continues to permanently flow in the Kinyeti River, this project should contribute to securing livelihoods and food security around Torit for agricultural development and food security as well as safeguarding drinking water extraction for Torit town which will otherwise be in jeopardy. Furthermore, it should contribute to containing water related conflicts between farmers and pastoralists in the lower watershed and around Kinyeti's mouth (African Wildlife Foundation, 2015).

- Boma-Jonglei landscape project

  This project was initiated in 2009 through a financial support from EU in order to promote trans-boundary, sub-regional interventions to respond to emerging issues and the environmental challenges through a financial support from EU (SSNCO, 2014). The program focuses on "strengthening institutional capacity, participatory land-use planning and resource management, establishing protected area management, improving community livelihoods, promoting ecotourism, and developing other incentives for sustainable land use to conserve this remarkable ecosystem and its magnificent wildlife migrations for the benefit of the people of Sudan and the world" (USAID, 2010a).

  So far, integrated land-use and conservation plan for the Boma-Jonglei Landscape was developed through a fund from USAID/Sudan in 2010 and the Boma-Gambella Landscape has been identified as a pilot project (SSNCO, 2014).

*Figure 4-1 : Location of the Boma-Jonglei landscape*




*Source: USAID (2010_a); Demetry (?)*

- Protected Area Network Management and Building Capacity in Post-conflict South Sudan

  This UNDP program planned for the period 2012-2016 aims at "laying the foundations for effective protected areas management by firstly, reassessing the present protected area estate to ensure the identification of key migratory routes and wildlife corridors within the protected area network and secondly, building the capacity of the Ministry of Interior and Wildlife Conservation to effectively manage and sustainably develop South Sudan's key protected areas" (UNDP, 2015).

  It include specific activities in the BAS, such as socio-economic surveys, consultations with local representatives, demarcation and awareness raising on parks boundaries in Boma and Badingilo national parks (UNDP, 2015)

- IGAD Biodiversity Management Programme (BMP)

  The Biodiversity Management Program (BMP) is a four-year (2015-2018) program implemented by the IGAD and funded by the European Commission (EC) (ICRAF, 2015).

The Boma-Gambella landscape is one of the 3 demonstration sites of the program. It should help to enhance the biodiversity management of the Boma-Gambella landscape whilst improving the livelihoods of the people of Gambella (IGAD, 2015). The activites performed include:

- Improvement of Gambella park administration and infrastructure,
- Development of an integrated Land use and development plan for the Gambella region,
- Wildlife movements monitoring,
- Value chain development (honey and shea butter).
- NABU Conservation and sustainable use of the last wild coffee forests of Ethiopia project in the Kafa forest Biosphere Reserve

The project is planned to run for 3 years (2014-2017), is part of the International Climate Initiative (ICI) and is supported by the German Federal Ministry of Environment, Nature Conservation, Building and Nuclear Safety. It aims to continue and expand former NABU programmes such as reforestation, participatory forest management and energy saving stoves, while introducing new components such as biodiversity protection and community based management strengthening. From 2009 to 2014, almost 1,600 ha of degraded forest and agricultural land have been reforested and 10,000 ha of natural forest was integrated into Participatory Forest Management (NABU, 2015).

- Kafa wetlands strategy

In 2008, a wetlands strategy for the Kafa has been established in order to reduce wetlands degradation, "fill the gap created in wetland management in Kafa zone and also to promote similar efforts all over the country by learning from this" (EWNRA, 2008). The main objectives of the strategy are listed as follows :

- "To integrate wetland management in to watershed or river basin management
- build data base on the wetlands of Kafa Zone and disseminate information on wetlands
- To secure support and promote relevant development and management studies/research for better wetland management" (EWNRA, 2008)

## 4.2.2 Identification of new projects in areas in need

he following key areas for potential development have been identified:

### WETLANDS MONITORING

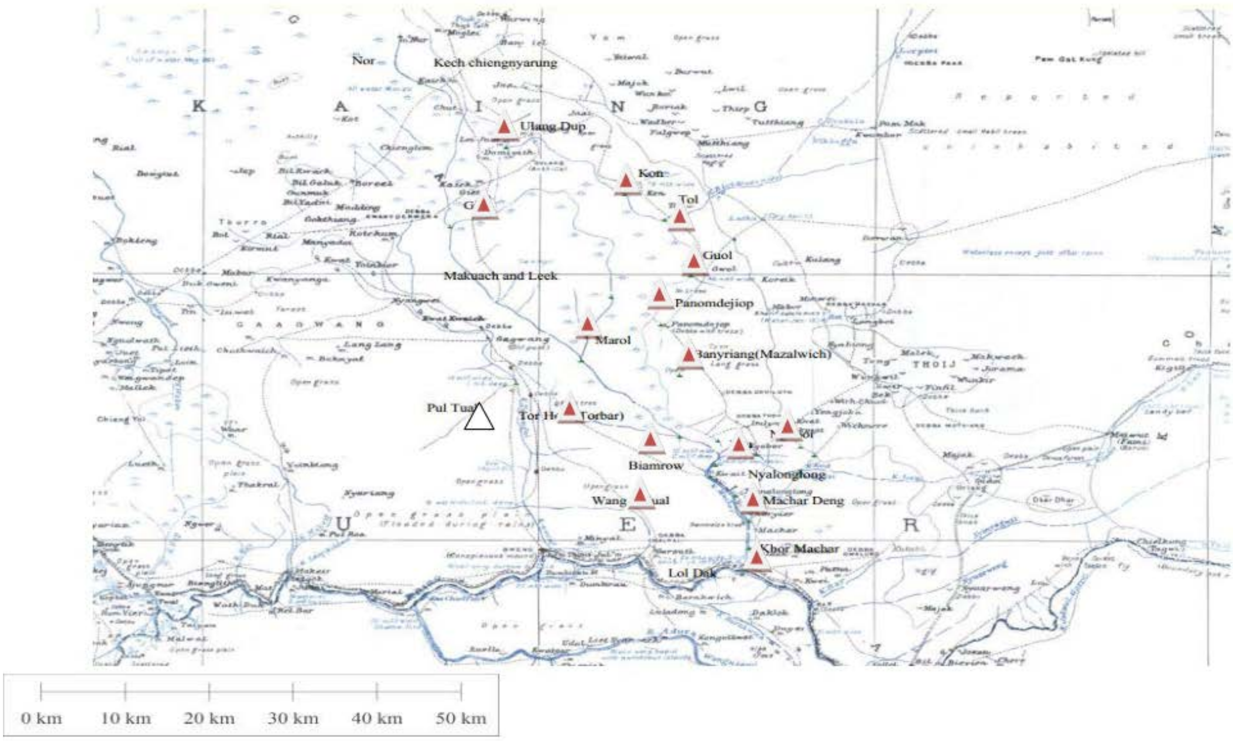
Literature review and stakeholders consultations have shown that wetlands knowledge is very low, especially on hydrological aspects.

This represents a key knowledge gap at the basin scale and is a key priority that should outstrip future water developments.

This idea is to create and monitor new water level and flow measurement sites in main wetlands in addition to the proposed measurement network.

During a field mission commissioned by ENTRO in 2012 water level and flow measurement sites in *Machar marshes* have been proposed (see figure below):

*Figure 4-2: Proposed water level and flow measurement sites in Machar Marshes*




Source: (ENTRO, 2012b)

Socio-economic and updated fauna and flora survey should also be conducted in parallel as per proposed by (ENSAP-ENTRO, 2012).

### DESIGNATION OF THE BAS MAIN IMPORTANT WETLANDS AS RAMSAR SITES

Designation of the BAS main important wetlands as Ramsar sites such as Badingilo, Gwom, Gambella plains and Marchar marshes. These wetlands have the potential to be recognized of international importance. Ramsar designation and related management plan implementation can be considered as an interesting tool to both protect wetlands ecosystems and improved livelihoods.

The following table illustrate the benefits of ramsar designation on wetlands condition.

*Table 4-1: Benefits of designation of Ramsar sites in Asia*

| | % of Asian Contracting Parties reporting | |
|---|---|---|
| | **Condition improving** | **Condition deteriorating** |
| **Ramsar Site** | **41 %** | **12 %** |
| **Other wetlands** | **12 %** | **47 %** |

*Source: (Ramsar Convention Secretariat, 2013)*

According to their spatial distribution, two potential Ramsar sites have been identified:

- Badingilo floodplains and marshes
- Marchar marshes, Gambella plains and Boma wetlands (Gwom)

The designation involves the following main activities:

- Engagement of the local community through awareness raising on the importance of the site to ensure their support and involvement in site designation, management and monitoring;
- Establishment of a broad-based ‘site management committee’
- Elaboration and implementation of a management plan
- Periodic assessments of the management effectiveness focused on the effectiveness of conservation and on the benefits to the local community (Ramsar Convention Secretariat, 2013).

These activities should take into account existing management plans and landuse plans and rely on exiting management authorities in Boma, Badingilo and Gambella National Parks. Activites will have to be developed from scratch in the *Machar marshes*. Difficulties of acees during the wet season and security issues are potential obstacles to the development of such initiatives.

### REFORESTATION AND REHABILITATION OF DEGRADED FOREST AREAS

The main current initiatives (mainly through biosphere reserves) concerning the forest ecosystems in the basin mainly deal with natural forest conservation and occur where the forest coverage is still dense. Already highly degraded land also need attention in order to offset the effect of deforestation such as erosion, soil loss, siltation in the river and climatic and hydrological impacts. Target areas could be highlands and escarpments cultivated ecosystems of

- The north-east head catchment of the Baro sub basin;
- The head catchment of the Akobo sub basin
- Torit area.

*Figure 4-3: Highlands cultivated ecosystem in the Ethiopian part of the BAS*

*Source: This study*

Activities could include afforestation, tree nurseries, catchment management, agroforestry, plantation of fruit trees, management of grazing in the forests, but also development of alternative energy sources like small hydropower, use of fuel conserving stoves, solar energy; creation of awareness among the local people, development of mechanisms to use dry grass for household energy purposes…

Tools such as Participatory Forest Management (PFM), revitalisation of National Forest Priority Areas, development of forest management plans and land use plans in sensitive areas (currently lacking in the Imatong Mountains for instance) could be involved.

The ongoing Ethiopian forest inventory could bring interesting information to specifically document the targeted area as soon as it will be published.

### DEVELOPMENT OF SOLID AND LIQUID WASTE MANAGEMENT

According the stakeholders consultations, urban pollution by solid and liquid waste is becoming a concern in some parts of the basin. So far, little has been done in this field, which open a significant potential for improvement. Development of solid and liquid waste management should be associated with water quality monitoring.

### 4.2.3 Enabling environment

The ongoing trend which consists of formalising the existing protected areas network (boundaries demarcation, official designation) and designating management authorities (NGO in cooperation with environmental authorities) is a progress which bring a start of a fertile ground for the above identified potential developments. Moreover, the following strategic documents are under review:

- South Sudan draft environmental policy of the country is submitted to the parliament for review and endorsement,
- Boma management plan,
- Badingilo management plan,
- Gambella region land use plan.

Their endorsement should contribute to strengthen the legislative and strategical environmental framework in the basin.

In parallel, the ratification of the Ramsar convention by Ethiopia could benefit to the identified development projects.

### 4.2.4 Conclusion: conservation opportunities in the basin

Despite a large network of protected areas in the BAS basin, the effective protection is very low. Important programs and projects are currently ongoing and should significantly improve the conservation situation if they succeed in achieving their goals.

Complementary initiatives are necessary, especially in areas which are not covered by existing initiatives such as the *Machar marshes* and the already high degraded land north-east of the Baro catchment, on the head catchment of the Akobo and around Torit.

## 4.3 CLIMATE CHANGE MITIGATION

Resilience to climate change will be a critical component to be integrated in the SSEA. As illustrated in the SSEA framework (separate report), several indicators will allow a compared analysis between different proposed projects in terms of resilience to climate change. The proposed indicators are the following:

- Change in availability of water for riparian users: domestic consumption, subsistence agriculture and livestock
- Change in water storage capacity of the basin
- Reduction of floods risks
- Modification of spatial extent of marshes
- Modification of spatial extent of floodplains

Cross-sectoral interventions, crucial for climate change mitigation will be integrated in the IWRDMP. These proposed interventions are similar to the proposed interventions for floods and droughts mitigation as these issues will be exacerbated by climate change[18].

[18] For more information, refer to section 3.3 Floods and Droughts mitigation of Part 2

# 5. KEY WATER RELATED OPPORTUNITIES IN THE BAS BASIN: CONCLUSION

## 5.1 INTRODUCTION

Identification of the potential developments in the Baro-Akobo-Sobat sub-basin serves three related purposes:

i. The potential developments are based on needs and potentials identified for the different sectors. This has been particularly important to define the key water related opportunities in part 3 of this report. Identification of these opportunities was then integrated with the key issues and challenges to propose strategic objectives to be discussed during the baseline workshop.

ii. The potential developments will be screened through the SSEA in order to propose medium and long term projects that will help achieve the desired vision for the basin, agreed during the baseline workshop.

iii. The identification of the seven short term projects proposed in a separate report is based on the potential developments identified in this report.

## 5.2 SUMMARY OF THE MAIN FINDINGS PER SECTOR

The key findings per sector are illustrated on the map here after. The map identifies the existing development projects in the basin and the projects proposed as part of this study. Some of these projects have been selected as part of the short term projects.

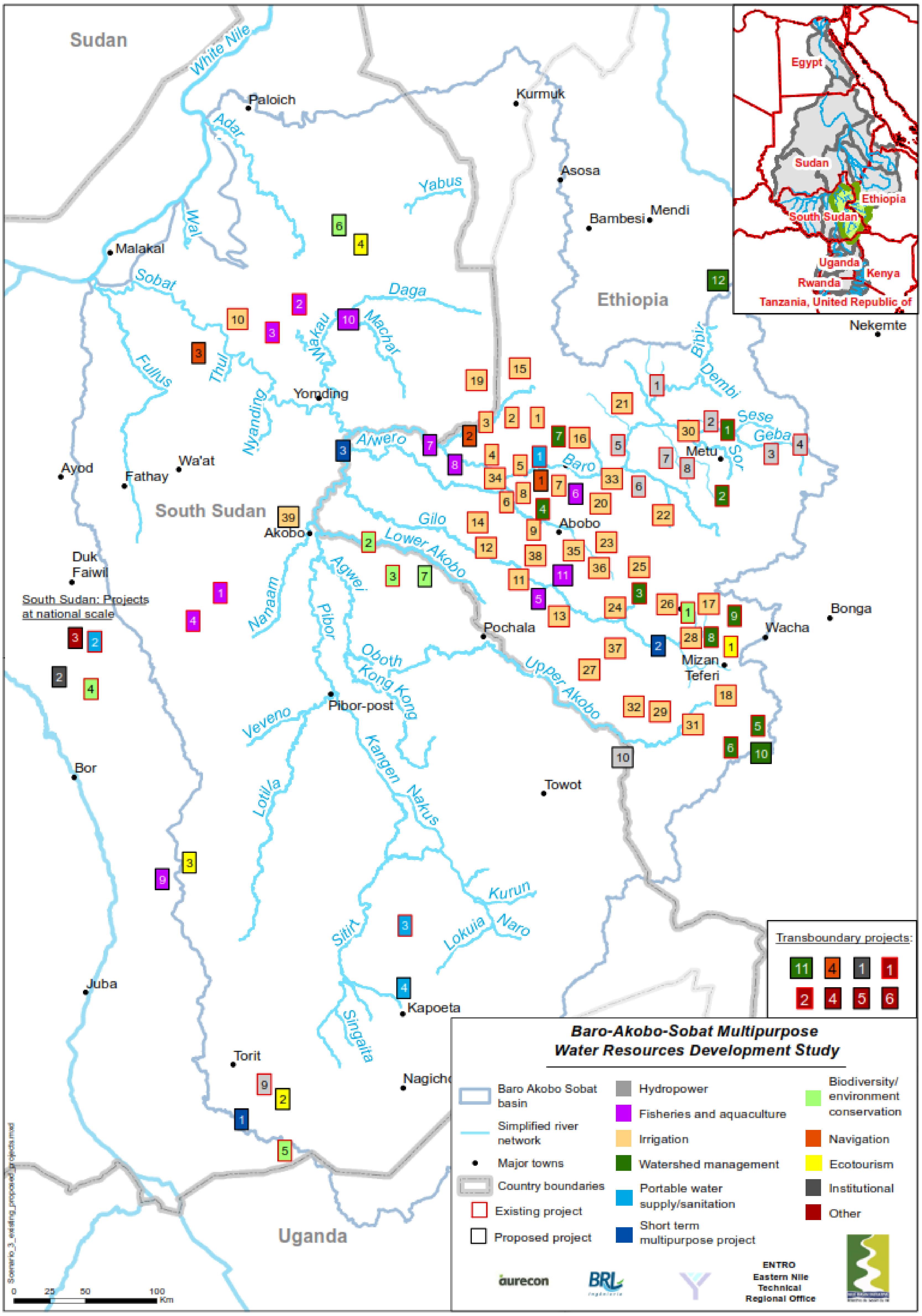
## 5.3 OPPORTUNITY TO DEVELOP MULTIPURPOSE PROJECTS

It is widely recognised that multipurpose projects usually cost more that single sector oriented projects. However, if well designed and implemented, the projects can generate higher incomes and thus have a more significant impact on poverty reduction and development of the economy.

The projects proposed in this report are mostly single sector oriented. They aim at representing the numerous development opportunities in the basin but it should be stressed that these projects can often be turned into multipurpose projects. This exercise has been realised in the concept note for the short term projects (separate report): the proposed infrastructure or development plans have been designed in such a way that it/they can be shared by a number of development sectors (potable water supply, livestock watering, small scale irrigation, fisheries, hydropower, etc.).

An important task of the SSEA and further elaboration of the IWRDMP will be to integrate the projects into medium and long term multipurpose projects, in order to propose different development scenarios to reach the desire vision for the basin.

*Figure 5-1: existing and proposed development projects – summary of the key findings*



## Existing development projects

### Hydropower

1. BirBir (capacity 467 MW)
2. Sor 2 (capacity 5 MW)
3. Geba 2 (capacity 157 MW)
4. Geba 1 (capacity 215 MW)
5. TAMS (capacity 1700 MW)
6. Genji (capacity 216 MW)
7. Baro 2 (capacity 479 MW)
8. Baro 1 (capacity 166 MW)
9. Kinyeti (capacity 1 MW)

### Fisheries and aquaculture

1. Microcredit for fisheries projects in Joglei States
2. Microcredit for fisheries projects in Upper Nile
3. Promotion of large scale aquaculture in Upper Nile
4. Promotion of large scale aquaculture in Jonglei State

### Irrigation

1. Baro Right Bank (Gambela Dam / River Pumping) (potential area : 68000 ha)
2. Baro Right Bank (Itang Reservoir Pumping) (potential area : 58 000 ha)
3. Sako Guda
4. Baro Left Bank (Itang Dam) (potential area : 62 000 ha)
5. Baro Left Bank (Itang Reservoir Pumping) (potential area : 16 000 ha)
6. Baro Left Bank (Gambela Dam / River Pumping) (potential area : 57 000 ha)
7. Upstream Alwero Project (Abobo Area) (Chiru / Dum) (potential area : 42 000 ha)
8. Alwero Left Bank (Abobo dam) (potential area : 9000 ha)
9. Gilo Right Bank (Gilo 1 dam) (potential area : 81 000 ha)
10. Northern area (Sobat irrigation-South Sudan) (potential area : 816 000 ha)
11. Gilo Left Bank (Gilo 1 dam) (potential area : 72 000 ha)
12. Gilo Left Bank (Gilo 2 dam) (potential area : 34 000 ha)
13. Gilo Left Bank (Gilo 1 dam) (potential area : 9 000 ha)
14. Gilo Right Bank (Gilo 2 Dam) (Ubela-Pashala area)
15. Koji small scale irrigation project (potential area : 6 000 ha)
16. Sako Guda small scale irrigation project (potential area : 4 600 ha)
17. Bako small scale irrigation project (potential area : 6 000 ha)
18. Kilu small scale irrigation project (potential area : 5 600 ha)
19. Lafo Kotu small scale irrigation project (potential area : 9 000 ha)
20. Baro small scale irrigation project (potential area : 2 000 ha)
21. Birbir small scale irrigation project (potential area : 8 000 ha)
22. Fani small scale irrigation project (potential area : 1 200 ha)
23. Alwero small scale irrigation project (potential area : 5 500 ha)
24. Guy small scale irrigation project (potential area : 1 800 ha)
25. Godare small scale irrigation project (potential area : 3 300 ha)
26. Achani small scale irrigation project (potential area : 4 300 ha)
27. Awaya small scale irrigation project (potential area : 5 000 ha)
28. Babaka small scale irrigation project (potential area : 6 000 ha)
29. Guracha small scale irrigation project (potential area : 2 000 ha)
30. Gumero small scale irrigation project (potential area : 4 000 ha)
31. Akobo I small scale irrigation project (potential area :5 000 ha)
32. Akobo II small scale irrigation project (potential area : 30 000 ha)
33. Gambella dam
34. Itang dam
35. Chiru dam
36. Dumgong dam
37. Gilo 1 dam
38. Gilo 2 dam

### Watershed management

1. Metu: Sustainable Land Management Programme (SLMP) 1
2. Masha: SLMP 2
3. Godere: SLMP 1
4. Abobo: SLMP 1
5. Bench Maji Zone: SLMP 2 for two woredas (Semien Bench and Meinit Goldiya)
6. Watershed Management Programme implemented by Farm Africa/SOS Sahel in the forest areas of Gesha, Chena, Gewata and Yeki woredas
7. Gambella Town: SLMP 1
8. Sustainable development of forest products operated by MELCA and NABU in Sheka and Kafa zones
9. Micro watershed management by Ethiowetlands of Ethiopia in Sheka,

### Potable water supply/sanitation

1. Gambella Town and woreda: water supply and sanitation programmes
2. National investment plan for the WASH sector in South Sudan
3. Water for Eastern Equatoria State to improve understanding

### Biodiversity/environment conservation

1. Majang forest: application to the biosphere reserve classification
2. Boma-Jonglei landscape project: promotion of trans-boundary and sub-regional interventions to address the environmental challenges of the area
3. IGAD Biodiversity Management Programme (BMP) to put in place the necessary policies and practices to sustainably manage natural resources, conserve biodiversity, and secure the livelihoods of local people of the BomaJonglei Landscape
4. UNDP launching protected area network management and building capacity in post-conflict South Sudan
5. Sustainable water management in the Imatong mountains by AWF

### Ecotourism

1. Ecotourism development in Kafa, Majang and Sheka biosphere reserves

### Other

1. 230 kV transmission line from Gambella to Malakal
2. 500 kV transmission line from Dedesa to Tepi then Juba

## Proposed development projects

### Hydropower

10. Upper Akobo

### Fisheries and aquaculture

5. Fisheries development in the Gilo river
6. Fisheries development in Alwero reservoir
7. Fisheries development in the Alwero river
8. Fisheries development in the Baro river
9. Fisheries development in the Badingilo floodplains
10. Fisheries development in the Mashar Marshes
11. Opportunity to develop aquaculture in the rice fields in Gambella region

### Irrigation

39. Akobo (South-Sudan)

### Watershed management

10. Watershed management potential in Meinit Goldiya and Meinit Shasha woredas
11. Livelihood-based watershed management - taking to scale for a basin wide impact
12. Potential watershed management projects in the woredas of Yubdo, Ayra, Guliso, Haru and Genji

### Potable water supply/sanitation

4. Combined water supply and cattle watering for Kapoeta counties

### Short term multipurpose project

1. Kinyeti river multipurpose project - multipurpose reservoir for hydropower, irrigation, potable water supply, fisheries, aquaculture
2. Majang multipurpose project - developement of hydropower, irrigation, aquaculture, watershed management
3. Akobo-Gambella flood plain transboundary project - solar pumping for potable water supply, vegetable gardening, aquculture development

### Biodiversity/environment conservation

6. Machar marshes integrated water resources management plan
7. Boma Gambella transboundary national park - biodiversity conservation and ecotourism development

### Navigation

1. Rehabilitation of the port infrastructure in Gambella along the Baro River to develop the traffic
2. Baro river: improvement of water regulation and dredging, to make river navigation in dry season possible
3. Sobat river: improvement of water regulation and dredging, to make river navigation in dry season possible
4. Regional transport and navigation development project

### Ecotourism

2. Hiking in the Imatong mountains
3. Badingilo national park: bird watching, recreational fishing
4. Mashar marshes: bird watching, recreational fishing

### Institutional

1. Establishment of the BAS basin authority
2. Water tariff structure: setting of tariffs and charges for use by Local Government Authorities and Service Providers, in accordance with South-Sudanese policies

### Other

3. Borehole Supplies - South Sudan national programme to improve collection and monitoring of data on yields and water quality
4. Transboundary hydro-meteorological and environmental monitoroing system and environmental flows assessment
5. Integrated BAS Hydropower, irrigation and multipurpose development programme - phase 1: Baro/Sobat component
6. Flood-risk mapping and early-warning system

# PART 3: SUMMARY OF THE FINDINGS – KEY ISSUES AND OBJECTIVES FOR THE BARO-AKOBO-SOBAT SUB-BASIN

# 1. INTRODUCTION

The purpose of this Part of the overall Baseline, Development Potentials, Key Issues and Objectives Report is to move forward from an appreciation of the key issues and development potential within the BAS basin towards the development of a vision and the strategic objectives that will underpin the IWRDM Plan. The process, showing the three different parts of the overall report is illustrated in Figure 1-1.

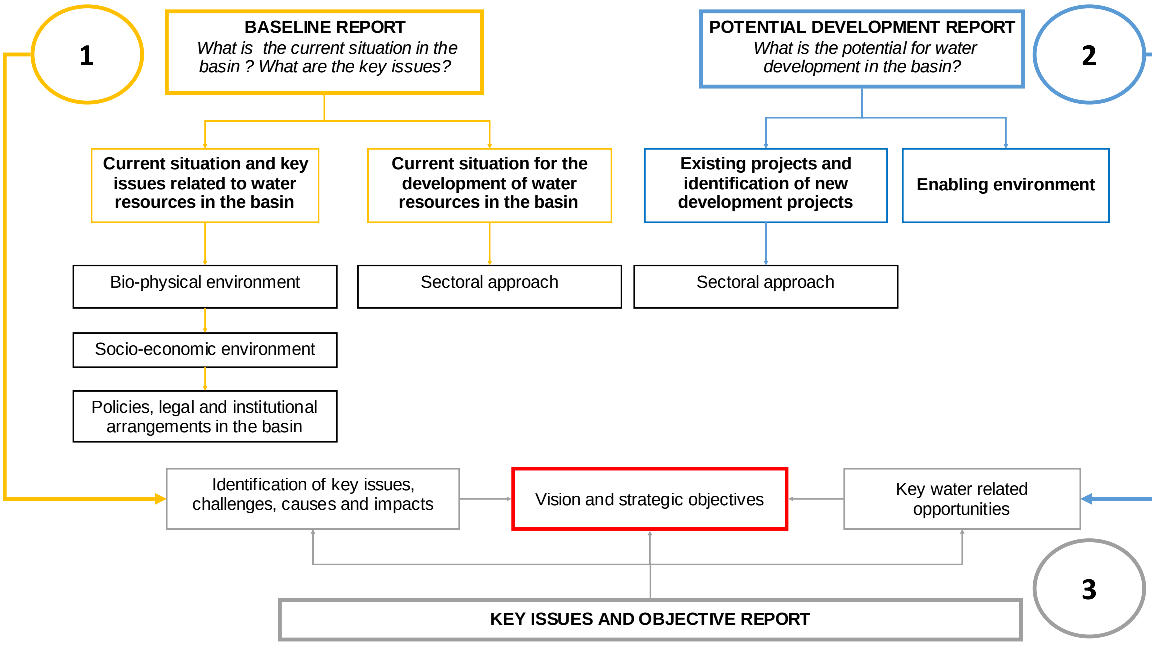



*Figure 1-1: Development of Vision and Strategic Objectives*

This report starts with a rapid overview of the key issues, challenges, cause and impacts and then summarised the key water-related opportunities that can support development within the basin. It is understanding of these two opposing aspects that leads to the development of the vision. The vison is a picture of a future state of what the basin will look like after implementation of the IWRDMPlan.

# 2. IDENTIFICATION OF KEY ISSUES, CHALLENGES, CAUSES AND IMPACTS

## 2.1 INTRODUCTION

A key aim of the baseline work has been to understand the status of the basin from a number of perspectives, and to appreciate the relayed issues and challenges. The issues are grouped into environmental, socio-economic and institutional issues. The issues of availability of water is also relevant but this can be considered as something that cuts across environmental, social and institutional areas. Similarly, “technical issues” can be seen as cross-cutting in nature.

As indicated in Figure 1-1, organizing and understanding the key issues is a first step towards defining a vision for the basin in the future and for defining the strategic objectives that need to be achieved to move towards this vision. Getting this right is a key part of the logical framework behind the details of the eventual IWRDMPlan.

## 2.2 IDENTIFICATION OF KEY ISSUES

In the following pages the key environmental, social and institutional issues, as identified in the baseline work, are summarized. It is clear that some of the apparently environmental issues, are also social issues and vice versa. This should not be seen as a problem in itself. In fact it will help focus on what are really the key challenges. It is also clear that key issues are interlinked.

### 2.2.1 Bio-physical environment: Key issues identified

The key issues identified are summarized in Table 2-1.

*Table 2-1: Summary of environmental issues*

| Issues | Explanatory details | Worst affected areas |
|---|---|---|
| **Stress on Wetlands** | ***Existing Issues***<br>Loss of wetlands in upper sub-basin due to wetland drainage, over cultivation, over exploitation. This is the result of both misguided policy/strategy and poor management. These wetlands are home to *cyperus latifolius* (epiphytic flatsedge), which is used for thatching. | Ethiopian highlands |
| | ***Issues related to potential change in hydrological regime.***<br>A reduction in the inflow (through abstraction or regulation) of river water into the Machar Marshes and other wetlands (by abstracting or regulating water at pick rivers flow) would reduce the size and function of these wetlands. This would have a negative effect on the climate , ecosystem and social fabrics of the basin. Without due care, this would have a dramatic impact on wildlife, livestock and fish through reduction of dry season grazing, spawning areas etc | Mainly Gambella plains (Ethiopia) and Machar marshes (South Sudan) |

| Issues | Explanatory details | Worst affected areas |
|---|---|---|
| **Loss of biodiversity** | ***Existing Issues***<br>Despite a historic attention paid to conservation in Ethiopia, the countries protected areas are increasingly degraded. Land is being converted for subsistence and commercial agriculture, timber use, fuel wood and construction, protected grasslands used for livestock grazing. The loss of forests and other protected land is underpinned by a growing population, unsustainable natural resource management, poor enforcement of existing legislation, uncertain land tenure and very low public awareness of the impact of climate change and the importance of biodiversity and ecosystems.<br>***Potential Issues***<br>In South Sudan, the situation is much better with many areas in a relatively pristine condition. The potential for rapid development and the risks that go with it if not properly managed are there. These risks have already showed themselves with pollution issues around oil exploitation. | Ethiopian highlands, escarpments and piedmonts /foothills<br>Around South Sudan towns and dens settlements.<br>Around oil fields in the Upper Nile State |
| **Unsustainable hunting of wildlife** | The civil war and continuing insecurity has seen a proliferation of firearms among the communities in the South Sudan part of the basin. The proliferation of arms allows hunters to kill more wildlife with less effort. In the context of insecure tenure, wildlife has become an open access resource and well-armed hunters are rapidly depleting wildlife populations. Lack of livelihood options for internally displaced people (IDP) and returning refugees in South Sudan has resulted in an overdependence on natural resources as a source of income, causing a rapid spread of unsustainable trade in bush meat across the basin. The sale of endangered species such as chimpanzees as pets is a growing concern in South Sudan.<br>Livestock grazing pressure, access to water and the transmission of wildlife-livestock diseases (e.g., bovine TB, rabies, rinderpest, cooties) are important factors affecting local wildlife, livestock and human communities as well as natural resource management (USAID, 2010c). | All over the South Sudan part of the BAS |
| **Loss of natural forest** | ***Existing and potential Issue***<br>The dominant environmental change in the Baro-Akobo sub-basin is the loss of forest cover, most marked in the southern and eastern part of the upper sub-basin. Estimated annual loss of forests and other wooded land in South Sudan is 277,630 hectares. In the high forest areas of Ethiopia (Dima, Godere, Gog, Akobo and Gambella woredas) deforestation estimated at 2.23% caused by expanding population. Annual destruction of the woody biomass from the high forest areas for agricultural expansion in BAS basin of Ethiopian side was estimated at about 4,287 ha per annum in 1995 but will will increase exponentially and it is estimated that Gambella Regional State could lose 32% of its high forest resources by 2020. Some 68 per cent of the loss will occur in Godere and Dima weredas.<br>***Drivers of deforestation***<br>Deforestation rate driven by national and foreign demand for tree products. Without significant improvement of protection will increase at faster rate than population growth. As a result of market extension (Kenya, Uganda and Sudan)/ Specific drivers of deforestation include:<br>• Clearing for cultivation: The most important factor responsible for total forest clearing in BAS basin is cultivation | Ethiopian and South Sudan highlands, escarpments and Piedmonts/ foothills. |

| Issues | Explanatory details | Worst affected areas |
|---|---|---|
| | • Clearing for roads and settlements: To create space for roads, settlements and other social and economic infrastructure<br>• Charcoal burning: The main fuel used in urban centres of the BAS basin is charcoal<br>• Brick making in South Sudan: In the past, houses were made of sun-dried bricks. Nowadays more and more baked bricks are used<br>• Construction and fire wood; demand has increased due to the construction of new settlements and population growth<br>• Unsustainable levels of livestock grazing/browsing<br>• Fires (by farmers, pastorlists and hunters, natural)<br>• Population growth and resettlement<br>• Allocation of forest land to state fams and investors | |
| **Soil erosion** | Soil erosion is a serious problem particularly on sloping areas with coarse soil texture and poor vegetation cover. Erosion is more prominent in the highlands of the BAS basin due to higher human pressure, steeply sloping land and/ or generally coarser soil types. This in turn impedes water infiltration and groundwater recharge and leads to siltationo the lowlands of the BAS (and its associated social and environmental impacts.<br>***Drivers of erosion***<br>• Cultivation, in particular using poor farming practices. Lack of soil conservation mesures and cultivation close to stream edges<br>• Deforestation (see previous issue which includes many specific drivers)<br>• Over-grazing | Ethiopian (and South Sudan to a lesser extent) highlands, escarpments and Piedmonts/ foothills. |
| **Scattered settlements** | The settlement pattern of the communities, where many rural communities are scattered along the river banks increasing susceptibility to flooding and reducing accessibility, thus making dissemination of best management practices and technology more difficult. | All over the BAS sub-basin |
| **Poor agriculture extension and poor credit facilities** | Agricultural extension programs which are not designed to address the complex socio cultural farming systems and agro – climatic conditions of the basin.<br>Lack of or no rural credit facilities, agricultural input supply and market facilities, inadequate linkage between research – extension farmers and cooperatives, Prevalence of livestock diseases and crop pests, inadequate market infrastructure and marketing information system and traditional farming techniques (hand tillage) are among the constraints limiting agricultural productivity in the basin. This in turn leads to loss of soil (due to inadequate agricultural practices) and to deforestation. | All over the BAS sub-basin |
| **Flood and drought** | While flood and drought are parts of the natural cycle, the social impacts often result in exacerbation of environmental issues. | Floods: in the Gambella area and in the South Sudan lowlands<br>Droughts: Mostly in low lands even if highlands can also face severe droughts |

| Issues | Explanatory details | Worst affected areas |
|---|---|---|
| **Lack of peace and security** | Unpredictable conflict between tribes and ethnic groups within the region and cross border conflict with ethnic groups from the South Sudan as well as cattle raid impose instability in the border areas. In these areas, pressure on natural resources is exarcabated and leads in turn to increasing conflicts over natural resources between refugees and host communities, especially over land, livestock and wood.. | In the South Soudanese part of the BAS and in the border area in Ethiopia |
| **Poverty & Poor physical and social infrastructure** | Poor physical and social infrastructure and communication (poor access to health and education services, poor animal husbandry and animal health services, poor market outlet, absence of roads and information, etc. are among the constraints of the basin development and this can also have impacts on the environment when increased population levels requires adaptation of traditional management of natural resources. | All over the BAS sub-basin |
| **Climate change** | Effects of climate change are still uncertain but are likely to lead to an increased occurrence of extreme events such as flood and drought (see flood and drought above). Without adaptation of natural resources management practices, climate change can result in environmental degradation. | All over the BAS sub-basin |
| **Lack of knowledge** | A important issue which effectively constrains management of the environment is the lack of knowledge with respect to water and natural resources around the basin. Even if the use of remote sensing can help to fill some gaps, there is a critical need for improving knowledge. This is especially true for South Sudan where the conflict situation and a lack of resources has meant that few hydrological and environmental data have been collected for decades. The biggest knowledge gap in the basin concerns the Machar Marshes. | All over the BAS sub-basin |

### 2.2.2 Socio-economic environment: key issues identified

The key socio-economic issues identified are summarized in Table 2-2.

*Table 2-2: Summary of Socio-economic issues*

| Issues | Explanatory details | Worst affected areas |
|---|---|---|
| **Poverty and Food Insecurity** | Poverty in the basin is both pervasive and deep, but is also differentially distributed across the basin. Poverty can be seen as a root cause for many other social and environmental issues and challenges. Poverty levels are high despite the relative abundance of natural resources and relatively low population density in many parts of the basin. The alleviation of poverty must be a central objective of any future development and investment plan for the basin. | Rural areas in Gambella Region, Part of Benishangul-Gumuz Region, eastern and northern Jonglei, southern and western Upper Nile and Eastern Equatoria states in the BAS sub-basin in areas affected by communal conflicts with large numbers of IDPs and refugees. |
| **Low level of well-being** | The basin area has low levels of wellbeing and the development options will consider ways of enhancing the basin's population wellbeing | Levels of wellbeing are generally low throughout the BAS sub-basin, particularly in areas in Gambella and Benishangul-Gumuz regions and eastern and northern Jonglei, southern and western Upper Nile and Equatoria states affected by recurring communal and political conflicts. |
| **Lack of peace and security** | The ongoing security in many parts of South Sudan is the single largest constraint to development and social upliftment in the basin.<br>Unpredictable conflicts between tribes and ethnic groups within the region and cross-border conflict with ethnic groups from the South Sudan as well as cattle raiding impose instability in the border areas. Such activities are obstacles to development and growth efforts exerted by the people.<br>Since July 2016, the security situation has significantly deteriorated in the parts of the sub-basin in Eastern Equatoria State, which now form a new frontline of communal and political conflicts. Longstanding local conflicts between Dinka and non-Dinka increase the risk of widespread inter-ethnic violence in this part of the sub-basin. | Gambella Region, part of Benishangul-Gumuz Region, eastern and northern Jonglei and southern and western parts of Upper Nile states and Eastern Equatoria State in the BAS sub-basin. |
| **Low level of provision of social services** | Access to services within the basin is very low. Within the Ethiopian part of the basin it is lower than elsewhere in the country. Gambella is in the process of being connected to the national grid, but outside of urban centres levels of electrification are low throughout the basin.<br>Access to improved water sources is lower than the national averages in both countries, and access to improved sanitation is very low. Most of the basin is poorly served in terms of basic social services.<br>Poor physical and social infrastructure and communication (poor access to health and education services, poor animal husbandry and animal health services, lack of market outlets, absence of roads and information, etc. are among the constraints to basin development. This can also have impacts on the environment when increased population levels require adaptation of traditional management of natural resources. | Gambella Region, parts of Benishangul-Gumuz Region, Oromia SNNPR regions and all areas in South Sudan in the BAS sub-basin. Rural areas have even lower levels of social services than urban areas. |

| Issues | Explanatory details | Worst affected areas |
|---|---|---|
| **Vulnerable groups** | There are many sizeable vulnerable groups in the basin including pastoral groups, women and children, conflict and war displaced people, internally-displaced persons, refugees, etc.): Much of the basin is marginalized from the mainstream economy of both countries and has experienced various forms of risks (both natural and economic) as well as conflicts which adversely affect vulnerable groups. The issue of protection of vulnerable groups should receive attention in the plan and development options. | Gambella Region and part of Benishangul-Gumuz Region Concentrations of vulnerable groups are found in refugee camps in these regions and among IDPs in Jonglei, Upper Nile and Eastern Equatoria states in South Sudan most affected by communal and political conflicts. |
| **Gender inequality** | Gender inequality is an issue at household, community and national levels, as women have low access to productive resources, education and health services. The work burden for women is also high. The level of legal disenfranchisement is high for women. In most cases they are socially limited and excluded from important economic activities and resources such as property as well as effective political representation. Conditions and opportunities vary among ethnic groups in the basin and between urban and rural areas, but there are a number of common issues.<br>• **Equality in access to education** is still not a reality for many girls in the basin. Women are only half as likely (19%) to be as literate as men. Although the gap is narrowing with higher school enrolment for girls, it is still below the enrolment rates of males, particularly in secondary, vocational and higher education.<br>• **Access to employment** is limited in the formal public and private sectors by a combination of restrictive social norms and lack of formal educational qualifications and skills. Males are also the main beneficiaries of political patronage for government jobs.<br>• **Access to wealth**, measured in ownership of land, shelter, cattle or cash, is severely curtailed for women in the basin. Cattle are owned and controlled by males and represent a means of wealth and social status as well as valuable property for which girls can be exchanged in marriage through the bride price. Women have very few resources that confer social status and political power.<br>• **Inheritance rights** are limited for women. This has disinherited widows (of whom there are inevitably very many) and divorcees, especially those from polygamous relationships, as well as their children. Without access to land, cattle or other forms of wealth, and with little prospect of remarrying outside their late husband's family, widows or divorcees are marginalized and have few opportunities to improve their lives. | Gender inequality is found throughout the BAS sub-basin, but is generally higher in rural and pastoral areas and in areas affected by communal and political conflicts in Jonglei, Upper Nile and Eastern Equatoria states. |
| **Scattered settlements** | The settlement pattern of the communities, where many rural communities are scattered along the river banks increasing susceptibility to flooding and reducing accessibility, thus making access to social services complicated. | Rural areas in Gambella Region, part of Benishangul-Gumuz Region and in rural areas in all parts of the BAS sub-basin in South Sudan. |

| Issues | Explanatory details | Worst affected areas |
|---|---|---|
| **Poor agriculture extension and poor credit facilities** | Agricultural extension programs which are not designed to address the complex socio-cultural farming systems and agro – climatic conditions in the basin.<br>Lack of, or no, rural credit facilities, agricultural input supply and market facilities, inadequate linkage between research – extension farmers and cooperatives, prevalence of livestock diseases and crop pests, inadequate market infrastructure and marketing information system and traditional farming techniques (hand tillage) are among the constraints limiting agricultural productivity in the basin. | All parts of the BAS sub-basin. |
| **Recurrence of various forms, intensity, duration and impacts of conflicts** | A range of conflicts in the basin are the major impediment to future development activities. Conflicts in the basin occur as interrelated and mutually reinforcing layers consisting of three main types of conflicts.<br>• Resource-based conflicts in South Sudan can be a consequence of oil exploration and extraction activities that have potential impacts on water quality. Another potential impact related to these activities results from the management, allocation and control over land and water resources.<br>Resource allocation conflicts between national and state/regional governments and indigenous people over land allocation policies and practices. This includes allocation, leasing or sales of land to local and foreign investors, resettlement, and evictions. Governments in the basin are seen as misallocating land (and water) resources, appropriating land to which local farmers claim property or use rights, and where land lease contracts are not transparent. Unclear land tenure and the lack of effective conflict resolution mechanisms mean that there is high potential for conflicts.<br>• Historical pastoralist conflicts: cattle raids, communal clashes, revenge attacks and selective violence in the Jonglei and Upper Nile areas in South Sudan and in the Akobo area bordering Gambella in Ethiopia. The frequency and intensity of these conflicts have increased since independence, and there is no clear prospect for resolution in sight.<br>• Political conflicts in the basin take two forms. In the area of the basin in South Sudan, there are political rivalries between the President and former Vice President accompanied by armed conflicts, occurring in Jonglei and Upper Nile states and more recently in Easter Equatoria State. (See also under Lack of peace and security above.) In the area of the basin in Ethiopia, the fault lines are between the national Government and Oromo people in Oromia Region and the Anurak people in Gambella.<br>In the case of Gambella Region, active conflicts are the result of a series of migrations and | Gambella Region, parts of Benishangul-Gumuz Region, Oromia region in the sub-basin in Ethiopia. Conflicts can occur in most parts of the sub-basin in South Sudan, but the worst affected areas are central and eastern Jonglei State, and southern and western Upper Nile State and northern and western parts of Eastern Equatoria State. |

| Issues | Explanatory details | Worst affected areas |
|---|---|---|
| | encroachments, including cross-border incursions of the Nuer from South Sudan, mainly for the purpose of cattle raiding, but also include the taking of food from stores and even kidnapping and fatalities. These conflicts are exacerbated by the Government's policy of allocating large tracts of land to outside investors for agricultural development and relocation of the local population.<br>Another source of tension in Gambella Region is between the local inhabitants and refugees from South Sudan who also compete for living space, firewood, water and other resources. Increasing dependency on food aid with the arrival of the South Sudan refugees, accompanied by a host of international aid agencies provide humanitarian assistance. This also includes food aid, which contributes to the disruption of agricultural production and markets.<br>The breakdown of customary means of conflict resolution means that governance structures on managing and allocating land and water resources need to be strengthened and applied equitably if a fair distribution of resources and benefits is to be achieved. Legal and institutional frameworks to address issues such as land tenure, water rights and conflict resolution need to be developed and implemented in a consultative and transparent manner at all levels. | |
| **Potential for influx of people** | There are various forms of migration into the basin following ongoing and planned development initiatives and interventions. The likely consequences of the various development options/alternative on influx of people into the basin areas is an issue to be addressed. In addition, there is the issue of the potential effects of population increase, resettlement, increasing investment (commercial farm leaseholds) etc. | Gambella Region, part of Benishangul-Gumuz Region in the sub-basin that experience the influx of refugees from communal conflicts in South Sudan and settlers from the highlands in Ethiopia. |
| **Risks** | Risk is high in many areas. Conflicts, flooding, disease outbreaks, economic shocks, insecurity etc. are common in the area. | These risks exist throughout the BAS sub-basin, and are particularly high in areas along the border between Ethiopia and South Sudan and in areas in parts of the sub-basin in South Sudan affected by communal and political conflicts. |
| **Floods and drought** | Flooding is a real challenge for many communities living in many areas around Gambella and elsewhere. It is also a challenge for the development of agriculture in flood-prone areas. Drought is also a risk in many parts of the basin and has an impact on food security. | Gambella area and the South Sudan lowlands are worst affected by floods.<br>The worst effects of droughts occur in the lowlands, but highlands can also face severe droughts. |
| **Land security/ land tenure issues** | There are significant land security and tenure issues with respect to the rights of indigenous people. These rights and land tenure issues are relevant when designating land for any type of development (commercial farms, large scale irrigation, hydropower, national parks, protected areas). | Gambella Region, part of Benishangul-Gumuz Region and all parts of the BAS sub-basin in South Sudan. |

| Issues | Explanatory details | Worst affected areas |
|---|---|---|
| **Basin population dynamics place heavy pressure on natural resources** | Under normal conditions, in areas that are largely rural and agrarian it can be expected that there would be a natural tendency for the population to move from areas of high population density to areas of lower density in search of new land for cultivation or grazing. However, in the present situation in the basin, conflicts and accompanying insecurity in the western part of the basin, primarily in South Sudan, inhibit such movement.<br><br>The relatively sparsely populated area of the basin in southwestern Gambella Region along the border with South Sudan is attracting new settlers from the highlands to the east, primarily from Oromia and SNNP regions, which increases pressure on land and water resources as well as increasing tensions with the indigenous people in the receiving area. This is also the area where large areas of land are being leased to outside investors for agricultural development.<br><br>The most common types of mobility in the basin are migration from the eastern highlands to the lowlands in Gambella Region and internal displacement due to ethnic and political conflicts. Over 250,000 people in the basin have been affected by internal displacement since the outbreak of political conflicts in South Sudan in December 2013.<br><br>The areas most affected by displacement due to political and ethnic conflicts are Jonglei and Upper Nile States and more recently in Eastern Equatoria State in South Sudan, and Gambella and parts of Benishangul-Gumuz regions in Ethiopia. | In the highlands of Oromia and SNNPR region in the Ethiopian part of the basin, in areas in western and southern Gambella and Benishangul-Gumuz regions where there are large numbers of IDPs and refugees and in peri-urban areas throughout the BAS sub-basin. |
| **Climate change** | Effects of climate change are still uncertain but are likely to lead to an increased occurrence of extreme events such as floods and droughts (see floods and drought above). Without adaptation of natural resources management practices, many social issues will be further exacerbated. | All areas the BAS sub-basin, particularly in areas that depend on subsistence farming in the central and northern parts of the BAS sub-basin in South Sudan and all areas in the BAS sub-basin in Ethiopia. |
| **Weak institutions, poor coordination and cooperation among existing institutions** | There are varying levels of capacities and resources in the basin countries and the BAS sub-basin. Therefore, the issue of capacity building for coordinating and implementing development programs and plans is important for planning and implementing basin development activities. | All areas in the BAS sub-basin are affected. |

### 2.2.3 Institutional issues

*Table 2-3: Summary of Institutional Issues*

| Issues | Explanatory details |
|---|---|
| **Transboundary Cooperative framework** | The Cooperative Framework Agreement has not yet been put into force. This is certainly a gap in itself and beyond this situation, it appears that very little institutional organization has been developed since 2010. This situation is not counterbalanced by other mechanisms such as possible bilateral agreement relating to development based on water resources, nor future management and operation of activities having transboundary effects |
| **Security and instability** | The ongoing security situation in many parts of South Sudan is the single largest constraint to institutional development at all levels, but especially at the local level.<br>Within the Ethiopian portion of the basin there are also security issues, especially in Gambella Region, but also in part of Oromia. These also have an impact on the effectiveness of regional and local level institutions<br>The security situation has a knock on effect on other institutional aspects indicated further in this table. |
| **Lack of capacity/ experience in (MPP) project implementation** | The planning, development, implementation and management of multipurpose projects are relatively new concepts. Although ENTRO has experience in planning, the development and implementation of projects is something that has to be largely done at the national and local levels. ENTRO's role can only be limited. Capacity and experience at the national levels is limited, largely because implementation tends to take place along sectoral lines. There is a gap with respect to multipurpose project implementation and especially operation and maintenance, bearing in mind that there will be a high level of sectoral inter-dependence in terms of shared infrastructure, water resources management etc. |
| **Capacity of local government institutions and Water Users** | The capacity of local government institutions within both countries is weak. This represents one of the major issues when it comes to implementation |
| **Lack of inter-sector coordination and cooperation** | Sectoral developments including the required associated water resources development are currently being conceived planned almost independently. There is a lack of inter-sector coordination which is necessary right at the beginning of the project cycle. This is a hindrance to the most efficient use of water resources and the early identification and planning of multipurpose projects which could build on cross-sectoral planning and capitalise on shared spending from the earliest possible time |
| **Planning based on limited consultation** | Due, among others, to the security challenges in South Sudan in recent years, there is little preparedness for large developments based on water in general. Despite progress in drawing up master plans at national scale (agriculture, irrigation…), it is doubtful that adequate grass roots level consultation of stakeholders was possible. |
| **Inadequate water resources data/monitoring** | One major weakness is relating to data, for water resources and many other items. A lot of data are old or totally missing and the literature references often cross quote each other. This is first a technical issue, but not only. This is also an organizational issue when considering that developing a much more extensive and reliable monitoring network should be put at the top of the list of priorities (hydro-meteorology especially). As an example, the Machar marshes are almost not known at all, except from qualitative description, most often old. Due to the extreme value of this ecosystem, of international importance, which is also a source of livelihood for many people, any large hydraulic infrastructure will need very careful evaluation (ESIA, possibly resettlement action plan…). This can only be envisaged in the frame of a close cooperation between the two countries, through: exchange of data, water information system, global ESIA (not case by case) etc. This is an institutional and policy matter |
| **Land security/land tenure issues** | There are significant land security and tenure issues with respect to the rights of indigenous people. These rights and land tenure issues are relevant when designating land for any type of development (commercial farm; large scale irrigation, hydropower, national parks, protected areas). |

## 2.3 DEVELOPMENT OF WATER RESOURCES IN THE BASIN: CURRENT SITUATION

The status of development of water resources in the basin has been presented in Part 1 of the baseline. Table 2-4 is based on this assessment.

*Table 2-4: Water resources development on the basin*

| Water-related sector | Current status |
|---|---|
| ***Economic sectors*** | |
| Rainfed agriculture | ***Large-scale rainfed agriculture***<br>• This activity occurs in South Sudan but in Renk County, Upper Nile State outside of the BAS basin. in the Eastern Flood Plains Zone and outside of the BAS basin.<br>• There are some medium-scale commercial farmers, especially in the greenbelt zone of South Sudan. They use modern methods and have access to tractor services and modern inputs.<br>• Large-scale rainfed farming has been attempted in recent years in the flood plains around Gambella. In most case, crops have been lost to flooding.<br>***Small-scale rainfed agriculture***<br>• These are mainly subsistence farmers and represent the large majority of crop farmers in both countries.  Average yields (1t/ha) are low and the areas harvested (2feddans) per household in South Sudan.  Challenges include lack of financial resources, scarcity of labour, outdated farming methods, large post-harvest losses and security concerns<br>• Development projects for small-scale rainfed agriculture are generally part of watershed management projects. These are ongoing in the Ethiopan highlands in a number of areas and in the Imatong Mountains in South Sudan supported by NGOs. |
| Irrigated agriculture | ***Large-scale***<br>• Abobo scheme on Alwero River under construction (10,000ha) for commercial large-scale irrigation. Other recent attemps around Gambella have largely failed<br>• Information on South Sudan was not available<br>***Small-scale***<br>• A total of 64;774ha are under small-scale irrigation in Gambella, Southern Nations and Oromia region producing around 840,000 t of produce and 180,000 beneficiary households. This includes around 50,000ha as traditional irrigation, 10,000 from pumped groundwater and 1,372ha from modern schemes.<br>• A further 64,000ha of cultivation is wetland valley bottom cultivation in Gambella and Oromia Regions<br>• Information on the South Sudanes portion of the basin was not available. |
| Hydropower and interconnection | ***Interconnection***<br>• Extension of the 230 kV network to the south west has been completed along the route Gilgel Gibe-Jimma-Agaro-Bedele-Metu-Gambella and is currently being commissioned.<br>***Hydropower***<br>• Sor HPP with installed capacity of 5MW. Run of river scheme. Now linked to national grid. |

| Water-related sector | Current status |
|---|---|
| Livestock | • Three production systems, pastoral, agro-pastoral and mixed farming systems<br>• BAS population of 10million cattle, 6.5 million sheep, 9 million goats<br>• Trading of livestock products (milk and butter virtually non-existent<br>• No significant formal livestock watering projects are in place<br>• Current annual water demand for livestock is estimated ar nearly 80 million $m^3$ |
| Fisheries and aquaculture | • No significant fisheries activities in upland rivers. Limited fishing on Lake Buri.<br>• Artesanal fisheries in Gambella Region. Numbers fishing not monitored and it is largeky subsistence with limited marketing. Production potential is estimated at 15-17,000 t. Current catchment levels are a fraction of this (3 – 5%)<br>• Total catch from capture fisheries in South Sudan is around 150,000t but most comes from outside the BAS. The potential of Machar Marshes is largekly untapped. |
| Ecotourism | • Tourism within the basin is largely undeveloped. The security situation in South Sudan has halted tourism development. Within Ethiopia there are some eco-tourism initiatives associayted with the forest biosphere projects but numbers are very small despite the significant growth of Ethiopia as a tourist destination. |
| ***Service sectors*** | |
| Water supply and sanitation | Figures for South Sudan (2011) indicate:<br>• Access to sanitation was 14.6% one of the lowest worldwide<br>• Rural Water Supply average consumption was 6 l/capita/day, between 20% and 50% of water points were not operational<br>• Urban Water Supply technology only exists in some parts of Juba and a few regional capitals<br>Figures for Ethiopia available by woreda indicate:<br>• Access to improved water supply is generally between 76 and 100%. Akobo in Gambella only 2.9%. Access to put latrine very low in Nuer and Majang Zones, low in Dima and Jo (Gambella) and in Keffa, Sheka and Bench Maji Zones in SNNP Region, low in Dima and Jor. Otherwise relatively high. |
| Navigation | • Four minor ports in Gambella Region, Gambella (accessible July-October); Itang (July-November), Matar (July-December), Burbe (al year and 185 km from Gambella).<br>• Navigable water ways from Khartoum to Juba. |
| Flood control | • No significant flood control projects in place. Some efforts have taken place to protect planned irrigation projects in the Gambella region without success |
| ***Cross cutting sectors and themes*** | |
| Livelihood based watershed management | • Total soil eroded in the Baro-Akobo Catchment is estimated to be 43.7 million tons per annum and that from cultivated land 21.5 million tons per annum<br>• In the Ethiopian part of the basin, a few livelihood-based watershed management projects under SLMP2 (World Bank) and Government funded mass mobilisation<br>• In South Sudan, ogoing livelihood-based watershed managemen projects in the Imatong Mountains (supported by AWF) “Improving South Sudan’s Livelihoods and Ecosystems Through Water Management in the Imatong mountains” |

| Water-related sector | Current status |
|---|---|
| Biodiversity, habitats and landscape conservation | • Improving South Sudan's Livelihoods and Ecosystems Through Water Management in the Imatong mountains aimed sustainable management<br>• Boma-Jonglei Landscape Project; to promote trans-boundary, sub-regional interventions to respond to emerging issues and the environmental challenges<br>• Protected Area Network Management and Building Capacity in Post-conflict South Sudan<br>• Biodiversity Management Program (BMP) is a four-year (2015-2018) program implemented by IGAD and includes Boma-Gambella landscape<br>• Kafa wetlands strategy in Ethiopia |
| Climate change mitigation | • Climate change is high on the agenda and there are mitigation measures ongoing. These are usually integrated into projects. Some examples include:<br>• Water storage and development of activities with the reservoirs such as livestock watering, fisheries, irrigation etc. This helps to face more severe droughts.<br>• Use of climate-resilient crops<br>• Protection measures to limit deforestation and increase water retention during heavy |

## 2.4 IDENTIFICATION OF KEY CHALLENGES, CAUSES AND IMPACTS

The following table presents a preliminary analysis of the key water-related challenges, casues and impacts. It is important to get stakeholder input on this and a workshop session aimed at doing thos is planned for the Baseline Workshop planned for April 2016.

*Table 2-5: Key water related challenges in the Baro-Akobo-Sobat sub-basin.*

| Challenges | Causes | Impacts |
|---|---|---|
| **Environmental degradation** | • Security situation<br>• Expansion of rainfed arable agriculture into marginal areas (steep slopes, areas of poor soil cover, unsuitable soils...);<br>• Poor tillage and soil conservation practices;<br>• Cultivation up to river's edge and trampling of river banks by livestock;<br>• Conversion of forest and woodland into farmland;<br>• Conversion of upland wetlands into agriculture and use as source of material for brick-making;<br>• Unsustainable use of fuel wood due to non-availability or high cost of other sources of energy;<br>• General lack of capacities of the water users;<br>• General lack of agricultural extension services;<br>• Lack of incentives for implementing soil conservation measures;<br>• Lack of sanitation and water treatment;<br>• Low environmental awareness and low level of environmental monitoring;<br>• Uncontrolled hunting<br>• Urbanization;<br>• High/growing population density;<br>• Insufficient funding for the environment.<br>• Poverty. | • High levels of soil erosion and damage to river banks;<br>• High sediment load in rivers;<br>• Risk of sedimentation of reservoirs;<br>• Higher infrastructure costs;<br>• Higher water treatment costs;<br>• Higher risks of breakdown of equipment;<br>• Reduction of productivity (from loss of top soil), reduced income, poorer livelihoods<br>• Ecological damage and loss of biodiversity;<br>• Reduced flood attenuation;<br>• Reduced groundwater recharge;<br>• Reduced stream baseflows,<br>• Higher risk of drought and extreme floods;<br>• Higher risks of water related diseases. |
| **Low level of water resources development** | • Security situation<br>• Various conflicts, including over resources<br>• Insufficient funding across a wide range of sectors;<br>• Remoteness of many potential development projects;<br>• Lack of coherent basin-wide approach to water resources development planning;<br>• Lack of institutional stability;<br>• Lack of water management awareness; | • Continued low level of development of services, infrastructure, livelihood enhancement and employment opportunities;<br>• Wasted expenditure and risk of upstream/downstream conflict of interests;<br>• Investigation, project identification and planning process is slow resulting in reinforcement of slow development; |

| Challenges | Causes | Impacts |
|---|---|---|
| | • Lack of capacities of the decision makers and water users;<br>• Lack of maintenance of existing infrastructure;<br>• Lack of mechanisms to cope with risks (including floods and droughts risks);<br>• Unsatisfactory climate for investment;<br>• Lack of a clear transboundary cooperative framework;<br>• Little experience of MPP project implementation (maintenance and operation);<br>• Inadequate water resources data/monitoring;<br>• High poverty levels possibly directing investments to other sectors (education, health…). | • Duplication of efforts, wastage of limited technical and financial resources;<br>• Higher risks of breakdown of equipment;<br>• Increased poverty;<br>• Higher risk of drought and extreme floods;<br>• Higher risks of water related diseases;<br>• Higher risks of pollution.<br>• |
| **Frequent drought and flood** | • Degraded catchment and wetlands;<br>• Lack of structures/storage for regulation and flood attenuation;<br>• High intra and inter annual variability of rainfall;<br>• Lack of water management awareness;<br>• Climate change;<br>• Insufficient funding for flood and drought management.<br>• Poverty. | • Reduced baseflow during the dry season and absence of flow in some tributaries lead to water shortages for water supply to people and agriculture in many areas;<br>• Floods cause damage to property, agricultural land and loss of life;<br>• Increasing agricultural risks – reduction of incentives for implementing soil conservation measures;<br>• Higher risks of breakdown of equipment;<br>• Increased poverty;<br>• Higher risks of pollution;<br>• Higher infrastructure costs;<br>• No satisfactory climate for investment. |
| **Low level of human and social capital** | • Lack of community level (end-user) organisation promoting norms, rights and/or wishes;<br>• Lack of capacity at community / WUA level and high disparity in capacity between decision-makers and beneficiaries;<br>• Lack of coordinated, need-driven, inter-sectoral approach to water resources development planning;<br>• Low level of environmental awareness;<br>• Lack of incentives for capacity building (e.g. to cope with risks of low harvest);<br>• Conflicts over resources;<br>• Recent government instutitions; | • Increased risks of projects failure;<br>• Increased risks of projects non-appropriation by beneficiaries;<br>• Wasted resources;<br>• Environmental degradation;<br>• Low level of water resources development;<br>• Higher risks of low maintenance and breakdown of equipment;<br>• Increased poverty;<br>• Higher risks of pollution;<br>• Higher infrastructure costs; |

| Challenges | Causes | Impacts |
|---|---|---|
| | • Lack of capacity building services and funding;<br>• Low level of involvement by end-users (communities) in planning decision-making;<br>• High degree of top-down planning and decision-making.<br>• Poverty. | • No satisfactory climate for investment;<br>• Increased risks of conflicts between the various water users. |

# 3. IDENTIFICATION OF KEY WATER RELATED OPPORTUNITIES

Part 2 of this report investigated development potentials for the basin. These are summarized in Figure 5-1of Part 2 of the report. Reference should be made to this map.

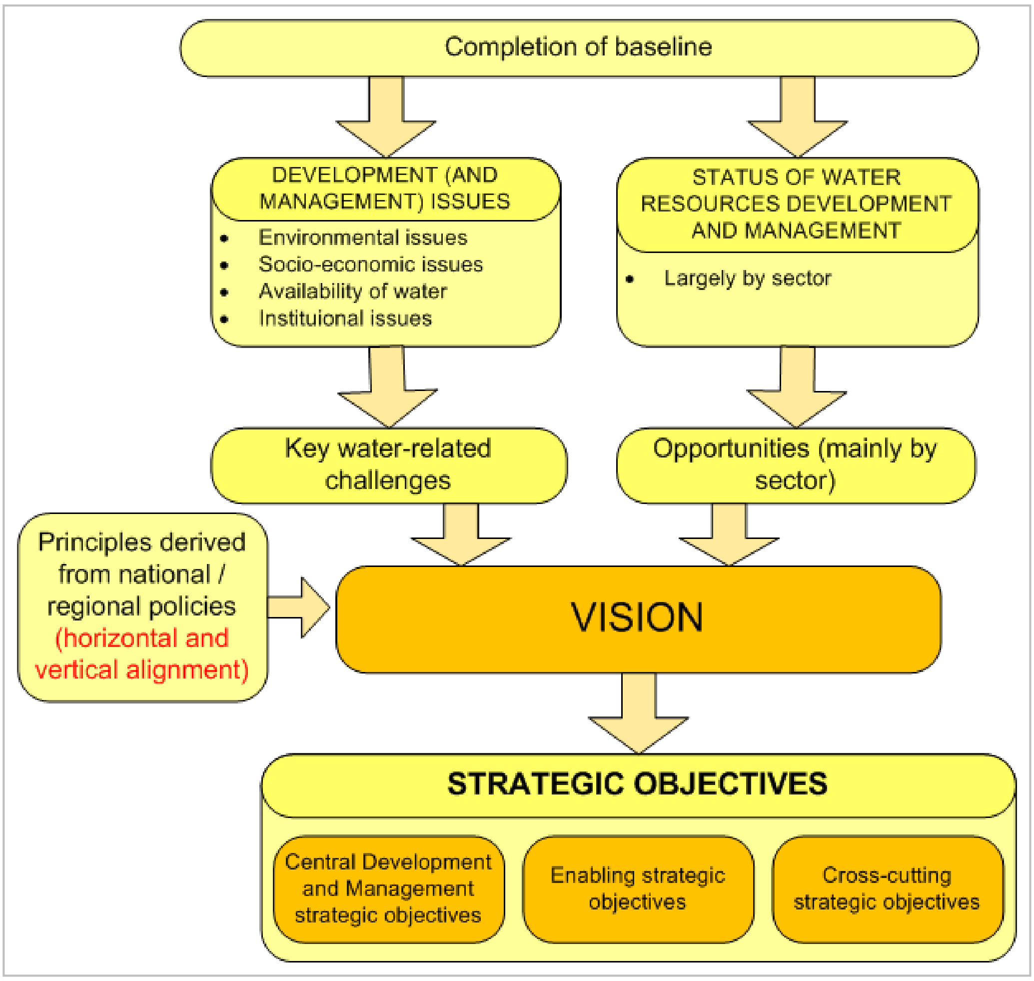
# 4. A VISION AND STRATEGIC OBJECTIVES FOR THE BAS BASIN

## 4.1 INTRODUCTION

The Vison is a picture of a future state of what the basin will look like after implementation of the IWRDMPlan. It should be stressed that the Vision statement **does not aim to state how or what has to be done for the envisioned future state to be achieved.** The identification of those mechanisms will be achieved through consideration of what actions are required to realise the goals that define the vision. These actions are, of course, the actions that will be detailed in the IWRDMPlan and will comprise short-term, medium-term and long-term interventions (aimed at addressing shortcomings in infrastructure, the enabling environment and other areas….).

There is no single way to build a vision but Figure 4-1 provides an overview of the process.

*Figure 4-1: Getting to the Vision and strategic objectives*



## 4.2 NBI SHARED VISION

When it comes to considering the Vision for the BAS, it would seem logical to recall the statement of the shared vision for the Nile Basin, as agreed by the member countries,

> ***"to achieve sustainable socio-economic development through the equitable utilization of, and benefit from, the common Nile Basin water resources"***

## 4.3 DEVELOPING A VISON OF THE BAS BASIN

### 4.3.1 Introduction

As shown in Figure 4-1, development of the Vision will follow on from a clear understanding of the water-related issues and challenges. This has been one of the important roles of the Baseline work which has aimed not only at identifying these, but also understanding their causes.

Developing a vision is not complicated as long as the goals are clearly stated. The preliminary challenges, already introduced in Section 2 are the following:

- Environmental degradation
- Low level of water resources development
- Frequent drought and flood
- Low level of human and social capital

They can be seen as representing the key areas that need to be addressed. Addressing these challenges has to be clearly implied in the Vision, since if these challenges can be overcome, the vision can be achieved. Implementation of the IWRDMPlan should lead to realisation of the Vision.

The Vision should indicate a **timeline** and it should be **verifiable**. This means that **targets** will be required and corresponding **indicators for monitoring and evaluation** will also be necessary. These do not all have to appear in the actual Vision Statement but it will be necessary to develop them fully.

The IWRDM Plan is to be drawn up for the next 25 years. It should be decided whether the Vision should see a future at this time or beyond this. At this stage it is assumed that the vision will correspond to a future view of the basin 25 years. Where this may not be clear or straightforward to define, it is at least important that the targets correspond to the 25 year timeline.

It is essential that the vision of the BAS is one that is shared by the basin stakeholders. It is also important that it fits with other sustainable development visions with which it may overlap. As indicated in the methodology, the Vision for the BAS and the strategic objectives that need to be realised to achieve that Vision, should be developed and agreed during the third (baseline) workshop. The purpose of this section is to provide some background on the elements of the Vision and how they should look.

### 4.3.2 Elements of the Vision

#### INTRODUCTION

The vison comprises the following elements:

- A vision statement for the future state of the basin
- Justification and explanation of the vision,
- A comparison between the current and targeted situation,
- Monitoring indicators

These are briefly discussed in the following sub-sections:

#### VISION STATEMENT

While it is the figurehead of the visioning process, the Vision Statement in itself is not the critical element. A review of visions for river basins in the desired state after the end of IWRM plan implementation shows that they have strong similarities, one of the reasons being that the vision statement should be short, concise but still covering the key elements of the desired-for state. A challenge associated with this is that they risk appearing rather generic.

The following are some examples

- **Orange-Senqu River Basin, Botswana, Lesotho, Namibia, South Africa**
  "A well-managed water secure basin with prosperous inhabitants living in harmony in a healthy environment"
- **Kyoga Basin, Uganda**
  "To ensure that by 2035, water resources development and management investments in the Lake Kyoga basin are integrated and optimized across a wide range of economic sectors leading to poverty reduction and improved livelihoods"
- **Mekong River**
  "An economically prosperous, socially just and environmentally sound Mekong River Basin"

Two of the above are simple straightforward statements of how the basins should be at a future date. For the Kyoga Basin, where the focus was on implementation of multipurpose projects, this specific issue is built into the vision statement. It is arguable whether this is correct since the implementation of multipurpose interventions is just one of the vehicles for reaching the Vision and should probably only be stated as part of one or more of the strategic objectives and then echoed in the strategic actions.

More important in terms of the detail for the IWRDMPlan that has to be developed in order to achieve the vision is the justification and explanation of the vision, a clear understanding of the current situation and the establishment of the targeted situation

While the cited vision statements may seem relatively simplistic, they have been carefully thought out. Stakeholders agreed the vision statement for the Orange-Senqu River basin after several hours of discussion. It had been agreed that key elements of the future state should be:

- <u>Optimised management of the water resources</u> with little wastage (hence "well-managed")
- <u>Minimal water shortages and safe</u> water (hence water secure)
- <u>Support economic development and enhanced livelihoods</u> (hence prosperous)
- <u>Transboundary cooperation over resources utilisation and allocation</u> (hence harmony)
- <u>A protected natural environment</u> (hence healthy environment)

### JUSTIFICATION AND EXPLANATION OF THE VISION

A detailed justification and explanation of the vision should show how the vision represents a situation in which the key issues have been resolved. As already pointed out, it is not the aim of the vision statement to say anything about how this resolution may be achieved. If, for example deforestation is identified as a major issue in the basin, it is important that the Vision reflects an envisaged future in which forests are restored or in which forest cover is maintained. The actions required to ensure that this is done will be developed through technical analysis and stakeholder consultation. Techniques such as the use of causal chains or stakeholder-driven SWOT analyses can be used and the resultant strategic and specific actions will form the framework of the IWRDMPlan.

Elements that should be included in the justification and explanation of the Vision should include:

- Timeline for execution:

  The IWRDMPlan has a plan of 25 years. As one of the Joint Multipurpose Program (JMP) projects this is coherent. The JMP is a "long-term program with a 25-30 year horizon that includes a coordinated set of investments to ensure the sustainable development and management of shared Eastern Nile waters….". It should be clear whether the vision is a state which is expected to be achieved at the end of the timeline or whether or just a certain level of progress towards the vision. Certainly 25 years is a reasonable timeline for strategic planning.

  However, it seems likely that the identification of opportunities and resultant planning of actions and projects will probably be concentrated into the more immediate future. While the principles behind the strategy objectives of the Plan may not change significantly over the next 25 years, it is likely that some of the identified issues may change or at least become more or less important. **It will, therefore, be necessary to revisit and revise the IWRDMPlan on a regular basis.**

- Integration and optimization

  Within the context of IWRM and multipurpose development, it is clear that the concepts of integration and optimization are critical. The vision should capture this concept.

- Ultimate goal: poverty reduction and improved livelihoods

  This ultimate goal is shared by all the existing national / regional / local policies. Moreover, a major underlying cause for almost the key water-related challenge is poverty. Clearly poverty reduction has to be a focus of the vision. At the same time, because so many of the basin's population are subsistence farmers it is important that they have improved sustainable livelihoods, even if in monetary terms they may remain relatively poor. A low level of livelihood sustainability is a result of key water-related challenges in the basin including*:*

  - Environmental degradation:
  - Low level of water resources development:
  - Frequent drought and flood:
  - Low level of human and social capital:

### COMPARISON BETWEEN THE CURRENT AND THE TARGETED SITUATION

For each of the key elements of the vision it is necessary to understand the current situation and targeted situation which represents the vision, or a certain level of progress towards the Vision..

### MONITORING INDICATORS

Carrying out this exercise is the first step towards the development of a monitoring and evaluation framework for the Plan. Clearly there will be a strong link between these indicators and this developed for the SSEA framework since the chosen Plan will have been supported by application of the SSEA framework.

**STRATEGIC OBJECTIVES TO REACH THE DESIRED VISION**

While the vision is a statement of where we want multipurpose water resources management and development **to take us by 2032, the strategic objectives provide clear direction on how to get there**. The strategic objectives are closely related to the key water related issues challenges and have been carefully developed with the vision in mind. Bearing in mind the 4 preliminary challenges that were summarised earlier, it is straightforward to formulate a strategic objective for each one. For example, they could like:

- To conserve the watershed through sustainable integrated catchment management practices,
- To develop the water resources for socio-economic growth,
- To reduce the frequency and severity of floods and drought through structural and non-structural measures,
- To ensure capacity building and coordination amongst various water users in order to optimize development and management efforts.

## 4.3.3 Workshopping the Vision and Strategic Objectives

### *4.3.3.1 Vision*

As already indicated, it is important that the stakeholders are involved in deriving a vision statement for the BAS as it should look after implementation of the IWRDMPlan. A visioning exercise was carried out at the Baseline Workshop in April 2016, at which the draft version of this report (including the preceding text) was presented. As a first step, time was put over to the workshopping of a potential vision for the basin in 2042 and associated strategic objectives. Three groups, each with representation from Ethiopia, Sudan, South Sudan and ENTRO worked on the tasks of drawing up a vision and associated strategic objectives.

Although the wording of the visions were different, there was general consensus on the key elements of the vision. The key elements of the future status of the basin and its inhabitants, as identified by the groups, can be summarised as follows:

- Sustainable development and management
- Security (in terms of peace, certainty);
- Prosperous (wellbeing);
- Connectivity (integration);
- Co-existence.

The following vision of the basin in 2042 is provisionally proposed:

***"A sustainably managed and developed BAS river sub-basin with prosperous, connected, peacefully and mutually co-existing societies."***

This vision has been taken onto the ongoing work on the SSEA and IWRDMPlan development.

#### 4.3.3.2 Strategic Objectives

As part of the visioning exercise already introduced above, there was a stakeholder-driven effort to derive the draft strategic objectives that would be required to lead towards realisation of the vision. The same three groups that worked on the vision also came up with suggestions for the strategic objectives and then these were discussed in a plenary session.

The following draft strategic objectives were developed based on the stakeholder discussions and the need to develop a coherent and logical set of objectives, the realisation of which will ensure that the vision becomes a reality.

- To contribute to food security, livelihood enhancement, poverty reduction and the protection and conservation of biological resources through stakeholder-driven management of wetlands, watersheds and other important natural resources;
- Taking into account the comparative advantages of the different parts of the sub-basin to sustainably develop water resources for hydropower, irrigation, water supply and sanitation and other sectors with the dual aims of reducing poverty within the sub-basin and generating revenue;
- To ensure transboundary and inter/intra sectoral cooperation and benefit sharing with a view to minimizing resource-based conflicts through optimized management and use of water and associated resources;
- To manage water resources so that disasters associated with flood and drought can be prevented and/or mitigated;
- To enhance human and institutional capacities for sustainable management of the water, land, ecosystems and related resources.

The importance of the strategic objectives cannot be overstated. In view of the fact that SSEA is a stakeholder-driven process, the agreed strategic objectives provide consensus on key issue areas and challenges.

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# ANNEXES

ENTRO
Eastern Nile Technical
Regional Office

NILE BASIN INITIATIVE
Initiative du Bassin du Nil

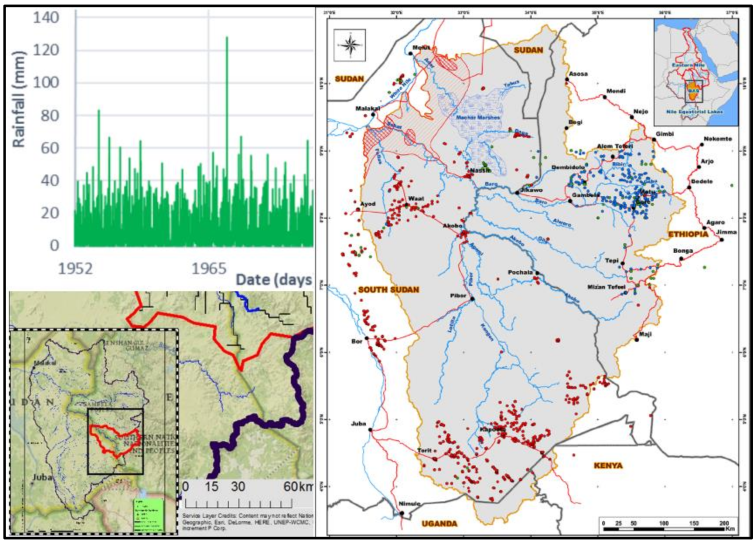
BANQUE AFRICAINE DE DEVELOPPEMENT
AFRICAN DEVELOPMENT BANK

# BARO-AKOBO-SOBAT MULTIPURPOSE WATER RESOURCES DEVELOPMENT PROJECT STUDY

## BASELINE, DEVELOPMENT POTENTIALS, KEY ISSUES AND OBJECTIVES REPORT

## *Annex 1: Physical environment*

*Final version - April 2017*

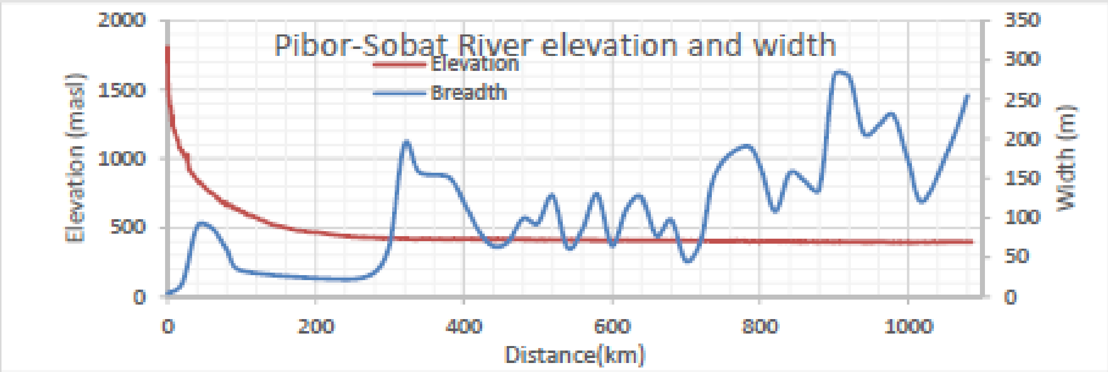


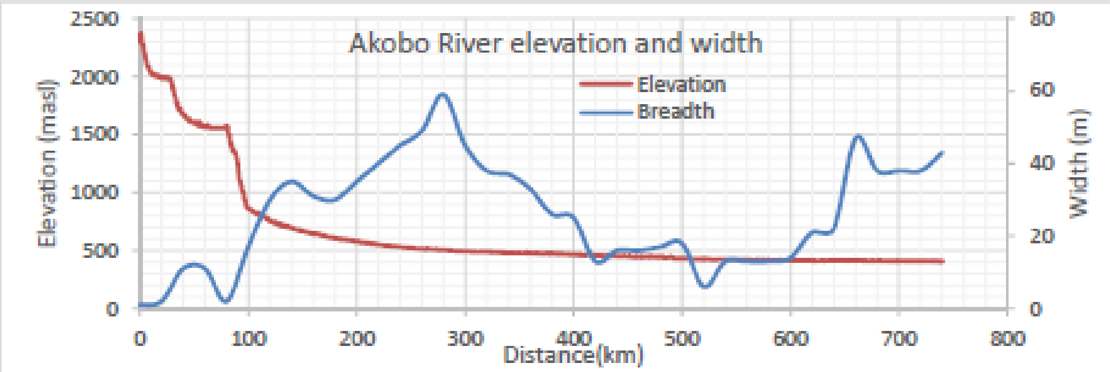

BRL Ingénierie

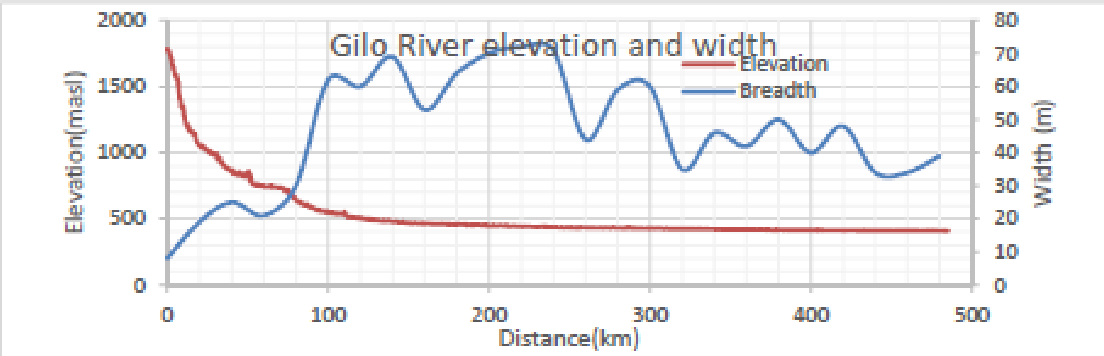
aurecon

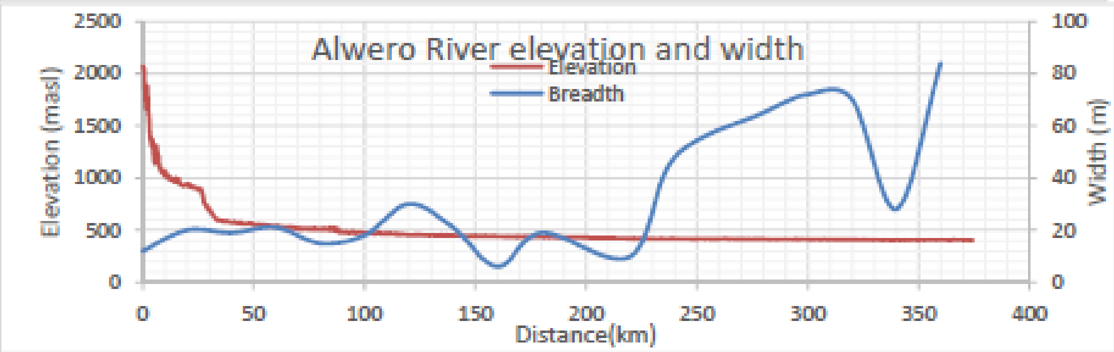
# CONTENT OF ANNEX 1

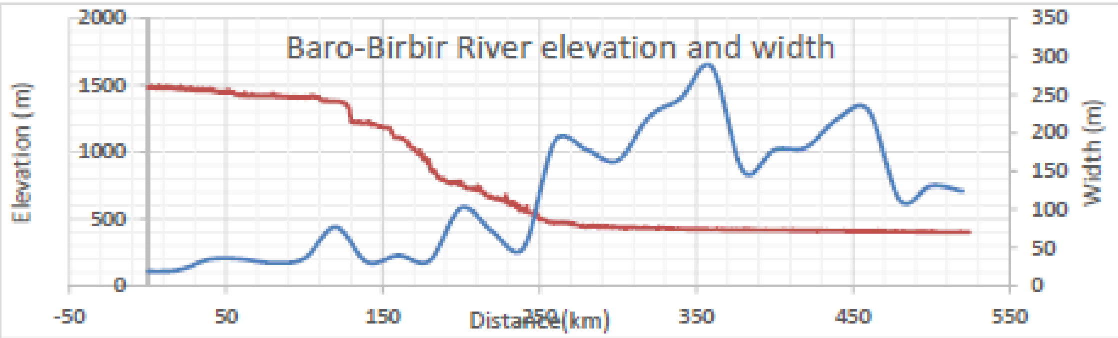
# Annex 1-A: Longitudinal river profiles and top channel widths


Pibor-Sobat River elevation and width
Elevation
Breadth
Elevation (masl)
Width (m)
Distance(km)


Akobo River elevation and width
Elevation
Breadth
Elevation (masl)
Width (m)
Distance(km)


Gilo River elevation and width
Elevation
Breadth
Elevation(masl)
Width (m)
Distance(km)


Alwero River elevation and width
Elevation
Breadth
Elevation (masl)
Width (m)
Distance(km)


Baro-Birbir River elevation and width
Elevation (m)
Width (m)
Distance(km)

# Annex 1-B: Potential sources of water pollution

**Industrial wastewater and impacts**: Concerns have been expressed about oil extraction in the Machar Marshes (ENTRO, 2007). The One System Inventory stated that exploration (cutting of seismic traces, test drilling, access road construction) and drilling and extraction (road construction, new towns, pipelines, oil wells) have already had severe environmental and social impacts. Two potential problems related to oil extraction and transport within the Machar Marshes were identified: The first was that the oil was pumped together with water and the two had to be separated. At this point the water was heavily contaminated and had to be treated before disposal. If this was not done effectively then severe pollution problems would occur. Given the importance of the marshes in terms of water supply and fishing this would have a serious impact on the livelihoods of the local inhabitants. A second potential problem was the construction of all-weather roads without effective drainage and adequate culverts. In these cases a road would acts as a dam and could cause serious flooding on the upstream side and dry conditions on the downstream side. Given the very complex drainage systems within the marshes any disruption in water flow could have very serious impacts on the distribution of the important "toich" grazing areas (ENTRO, 2007). Hydrosult Inc (2007) also concluded that “given the importance of the marshes in terms of water supplies and fishing this would have a serious impact on the livelihoods of the local inhabitants”. Seman (2011) reported that oil exploration and artisanal gold mining occurred in the basin. Both these activities disrupted the natural forest and vegetation in the mining areas, clearing land for the exploration and using wood for timber reinforcement of open pit mines and other construction activities. Artisanal gold mining can lead to severe increases in the suspended sediment loads and chemical contamination such as mercury pollution if this was used in the gold extraction process. Mercury contamination of drinking water sources is a serious concern in countries such as Zimbabwe where artisanal gold mining and mercury extraction methods are in widespread use.

**Domestic wastewater:** ENTRO, 2009) identified dumping of industrial waste and wastewater, and sewage in urban areas as a major concern. The report also identified dumping of domestic waste and wastewater at sub-basin household settlements as greatly affecting the quality of water and the health of populations dependent on river and groundwater for domestic supplies. Merid (2005) concluded that the lack of data about domestic solid waste and effluent volumes constrained the assessment of pollution of water supply sources and, hence, knowledge about domestic waste management was identified as a gap to be filled in the future.

**Agricultural runoff:** Concerns about agricultural runoff are generally associated with fertiliser washoff in the runoff, and pesticide and herbicide residues in the runoff water. Merid (2005) found that there were no data available on pesticide residues in Ethiopia and that Ethiopia had been one of the lowest fertilizers users among ASARECA member states in the region until the mid 1970s (FAO data for the period from 1991 to 2000, cited by Tsedeke, 2004). Ethiopia’s per capita fertilizer consumption for the above period (12.4 kg/ha/yr) was less than that for Kenya (27.4 kg/ha/yr). It was his opinion that the absence of water quality data for fertilizer and pesticides severely constrained an assessment of agricultural impacts and that it was important to establish baselines for such parameters. ENTRO, 2009) expressed the opinion that agricultural runoff was not yet regarded as a serious source of surface water contamination in the Baro-Akobo-Sobat sub-basin.

**Deforestation and land degradation**: In some parts of the basin, especially the highlands, the growing population has led to a high demand for fuel wood and charcoal for energy use resulting in over-harvesting and degradation of forests and woodlands. Conversion of degraded forests into cultivation land often has followed suite. This has resulted in a significant increase in erosion and sediment ingress into watercourses resulting in increased levels of suspended solids, turbidity and sand depositions in riverbeds and floodplains. Deforestation is identified as a major sediment source and the protection and sustainable use of forests and reforestation of degraded forests are regarded as high priority to reduce erosion and sedimentation. This is exacerbated by poor agricultural and land management practices and which leads to erosion and sedimentation.

**Mining and quarrying:** Runoff and leachates from mining activities can have a significant impact on surface and groundwater quality. However, Merid (2005) concluded that there were no large-scale underground and open-cast mining activities within the basin. There was evidence of quarrying which mostly involved extraction of rocks from outcrops. This extraction was done mostly by hand and the crushed stone was used for building and road construction. These activities have resulted in localised impacts on erosion and sedimentation.

**Invasive aquatic plants:** Water hyacinth infestations can have serious impacts on water quality (ENTRO, 2007). In about 1957 water hyacinth (Eichhornia crassipes) appeared in the White Nile in the area of the Sudd, and has since spread north and southwards into the Baro in Ethiopia in about 1976 and also into the Sobat system. The weed has a number of serious negative impacts. The presence of the weed in the river system leads to an increased loss of water via increased evapotranspiration. It also reduces the areas of open water available for fishing, which is an important livelihood strategy for the people of the Sub-basin. It also impedes river navigation along the White Nile. River navigation is an important economic activity on the Nile and sections of the Baro and Sobat rivers. Other impacts relate to low oxygen concentrations below the hyacinth mats and an increase in organic content of the water due to dead and decomposing plants. Reports indicated that the water hyacinth problem was not as serious as it was in the nineteen seventies and eighties and consequently, the water loss would be less than previous estimates. The One System Inventory (ENTRO, 2007) felt that there would still be water lost due to the presence of water hyacinth in the White Nile reaches, and hence an updated investigation was required into the ecological and climatological impacts that could be trigger by a second, even more severe, episode of infestation.

**Seasonal flooding and waterborne diseases:** Most of the lowland areas are susceptible to riverine and rainfall flooding. This has led to an increase in waterborne diseases as bush toilets and animal dung become flooded and mobilising pathogens into water supply systems (Muso, 2011)

# Annex 1-C: Analysis of sediment yields

**BARO-AKOBO-SOBAT MULTIPURPOSE WATER RESOURCES DEVELOPMENT STUDY - BASELINE STUDY**

# Annex 1-C Analysis of sediment yields

# TABLES AND FIGURES

## LIST OF FIGURES

## LIST OF TABLES

# ACRONYMS AND ABREVIATIONS

| | |
|---|---|
| AfDB | African Development Bank |
| ACORD | Association for Cooperative Operations Research and Development |
| ACTED | Agency for Technical Cooperation and Development |
| BAS | Baro Akobo Sobat |
| CAMP | Comprehensive Agriculture Development Master Plan |
| CBA | Cost Benefit Analysis |
| CMA | Catchment Management Association |
| CRA | Cooperative Regional Assessment |
| DEM | Digital Elevation Model |
| EEPCO | Ethiopian Electric Power Corporation |
| EHA | Erosion Hazard Assessment |
| EIA | Environmental Impact Assessment |
| ENID | Eastern Nile Irrigation and Drainage |
| ENCOM | Eastern Nile Committee Of Ministers |
| ENPM | Eastern Nile Planning Model |
| ENPT | Eastern Nile Power Trade |
| ENSAP | Eastern Nile Subsidiary Action Plan |
| ENTRO | Eastern Nile Technical Regional Office (NBI) |
| EPA | Environmental Protection Authority |
| FAO | Food and Agriculture Organization |
| GDEM | Global Digital Elevation Model |
| GDP | Gross Domestic Product |
| GEF | Global Environment Facility |
| GIS | Geographic Information System |
| GTP | Growth and Transformation Plan |
| GWh/y | GigaWatt hour/year |
| HEP | Hydroelectric Power |
| IDEN | Integrated Development of Eastern Nile |
| ILWRM | Integrated Land and Water Resources Management |
| IPCC | Intergovernmental Panel on Climate Change |
| IUCN | International Union for Conservation of Nature and Natural Resources |
| IWMI | International Water Management Institute |
| IWRDMP | Integrated Water Resources Development and Management Plan |
| IWRM | Integrated Water Resource Management |
| JMP | Joint Multipurpose Project |
| MAFCRD | Ministry of Agriculture, Forestry, Cooperatives and Rural Development |
| MASL | Meters Above Sea Level |
| MCA | Multi Criteria Analysis |
| MDG | Millennium Development Goals |
| MEDIWR | Ministry of Electricity, Dams, Irrigation and Water Resources |
| MERET | Managing Environmental Resources to Enable Transitions |
| MLFI | Ministry of Livestock and Fisheries |
| MoA | Ministry of Agriculture |
| MoEN | Ministry of Environment |
| MoWIE | Ministry of Water, Irrigation and Energy |
| MSIOA | Multi Sector Investment Opportunity Analysis |
| MTR&B | Ministry of transport, roads and bridges |
| MW | Mega Watt |
| MWC&T | Ministry of Wildlife Conservation and Tourism |
| NB-DSS | Nile Basin Decision Support System |
| NBI | Nile Basin Initiative |
| NCORE | Nile Cooperation for result project |
| NDVI | Normalized Difference Vegetation Index |

| | |
|---|---|
| NELSAP | Nile Equatorial Lakes Subsidiary Action Program |
| NGO | Non-Governmental Organization |
| Nile-COM | Nile Council of Ministers |
| PIM | Project Implementation Manual |
| PLSPP | Policies, Legislation, Strategies, Plans, and Programs |
| PPP | Private Public Partnership |
| PMU | Project Management Unit |
| PRSP | Poverty Reduction Strategy Program |
| RATP | Regional Agricultural Trade and Productivity Project |
| RPSC | Regional Project Steering Committee |
| RSS | Republic of South Sudan |
| RUSLE | Revised Universal Soil Loss Equation |
| SAP | Subsidiary Action Program |
| SEA | Strategic Environmental Assessments |
| SIS | Soil Information System |
| SLMP | Sustainable Land Management Program |
| SNNPR | Southern Nations, Nationalities and Peoples' Region |
| SRFE | Satellite Rainfall Estimates |
| SRTM | Shuttle Radar Topographic Mission |
| SSEA | Strategic Social and Environmental Assessment |
| SVP | Shared Vision Program |
| SWAT | Soil and Water Analysis Tool |
| SWOT | Strength Weakness Opportunity Threat |
| SWSC | Soil-Water Storage Capacity |
| UNDP | United Nations Development Program |
| UNHCR | United Nations High Commissioner for Refugees |
| UNICEF | United Nations Children's Fund |
| USAID | United States Agency for International Development |
| WaSH | Water Sanitation and Hygiene |
| WB | World Bank |
| WBISPP | Woody Biomass Inventory and Strategic Planning Project |
| WCYA | Women, Children and Youth Affairs |
| WEES | Water for Eastern Equatoria |
| WFP | World Food Program |
| WM | Watershed Management |
| WRMA | Water Resources Management Authority |
| WRMD | Water Resources Management and Development |
| WSS | Water Supply and Sanitation |
| WUA | Water Users Association |

# 1. INTRODUCTION

## 1.1 STUDY AREA

The Baro-Akobo-Sobat-White Nile sub-basin is one of the four major sub-basins in the Eastern Nile Portion of the Nile basin. It is located in the southernmost portion of the Eastern Nile Basin contributing about 26 billion $m^3$ of water every year to the Nile system at Khartoum (ENTRO, 2007). Geographically, it extends from 15° 47' 40'' to the north down to 3° 25' 52'' in the south. Similarly, it extends from 29° 24' 43'' in the west to 36° 18' 27'' in the east, covering a total area of 468,216 $km^2$ (ENTRO, 2007).

The major rivers of Baro-Akobo-Sobat Basin are Baro and its tributaries (Birbir, Geba, Sor and Baro), Alwero, Gilo and Akobo. The general flow direction of the rivers is from east to west originating from the highlands and falling to the Gambela Plain (TAMS_1B, 1997). Figure 1-1 shows the major catchments and rivers in the basin which were evaluated in this study.

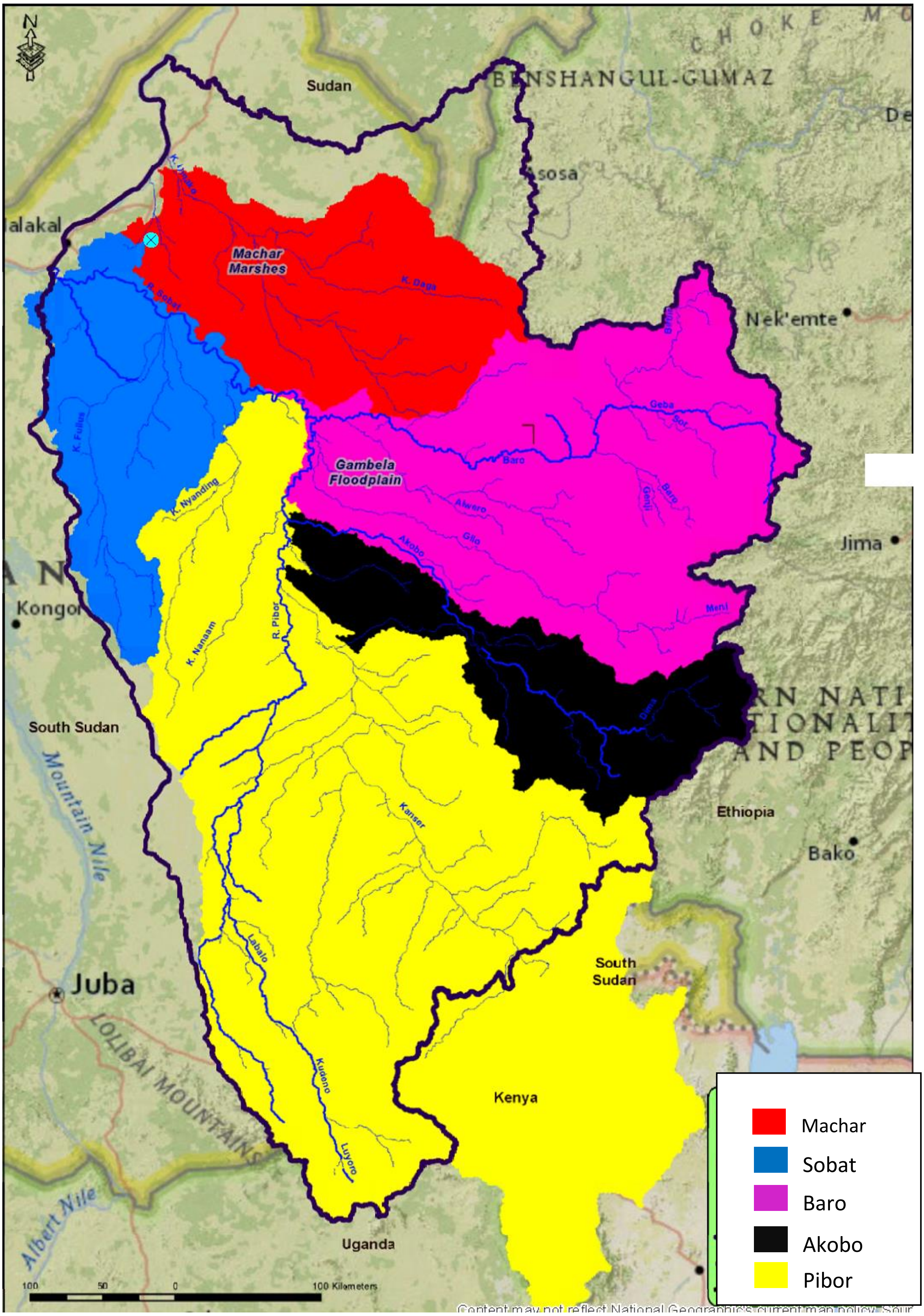



*Figure 1-1: Baro-Akobo-Sobat basin major watersheds as used in this study*

## 1.2 MAIN OBJECTIVE

The main objective of this study is to assist the Eastern Nile Technical Regional Office (ENTRO) to prepare an Integrated Water Resources Development and Management Plan (IWRDMP) based on a Strategic Social and Environmental Assessment (SSEA), and further, develop investment packages for cooperative development in the Baro-Akobo-Sobat sub-basin.

### 1.2.1 Specific objective of this sedimentation task

The specific objective of this study is to develop a sediment yield map for Baro-Akobo-Sobat study area.

## 1.3 STUDY METHODOLOGY

A physical process based model, SHETRAN, was used to simulate the sediment yields and routed sediment loads in the study area. The model was calibrated and validated against flow records and sediment transport data where data was available. The model output was used to generate a sediment yield map.

# 2. SHETRAN MODELLING

SHETRAN is a physically based, spatially distributed model with integrated surface/ subsurface modelling system for water flow, sediment transport and contaminant migration in river basins. The model generates the sediment yield considering rainfall-runoff-erosion processes, and routes the sediment loads along rivers by considering the sediment transport capacity.

The model can accurately describe the physical processes (hydrological cycle) in catchments of less than 2 000 km2. However, the model has successfully been used in large basins of approximately 1 808 500 km2 but it is recommended for basins of about 10 000 km2. Larger catchments are recommended to be subdivided into smaller basins for better accuracy (Shetran, 2013).

## 2.1 MODEL SETUP

To successfully describe the model, various inputs are required:

- Digital elevation model and catchment map.
- Time series of precipitation (mm/hr) and actual/potential evapotranspiration rates (mm/hr)
- Land cover distribution.
- Soil distributions, properties, grading and depth.
- Calibration data

These inputs are discussed further in sections **Erreur ! Source du renvoi introuvable.** to **Erreur ! Source du renvoi introuvable.**.

### 2.1.1 Catchment delineation

A 30 arc DEM was available for the whole catchment but due to the limitation of the SHETRAN model (200 x 200 grid squares), various catchments were delineated with the DEM altered to 1.9 km by 1.9 km spatial resolution. The catchments identified are shown in Figure 2-1 and the flow gauging stations coordinates are enclosed in **Appendix 1**.

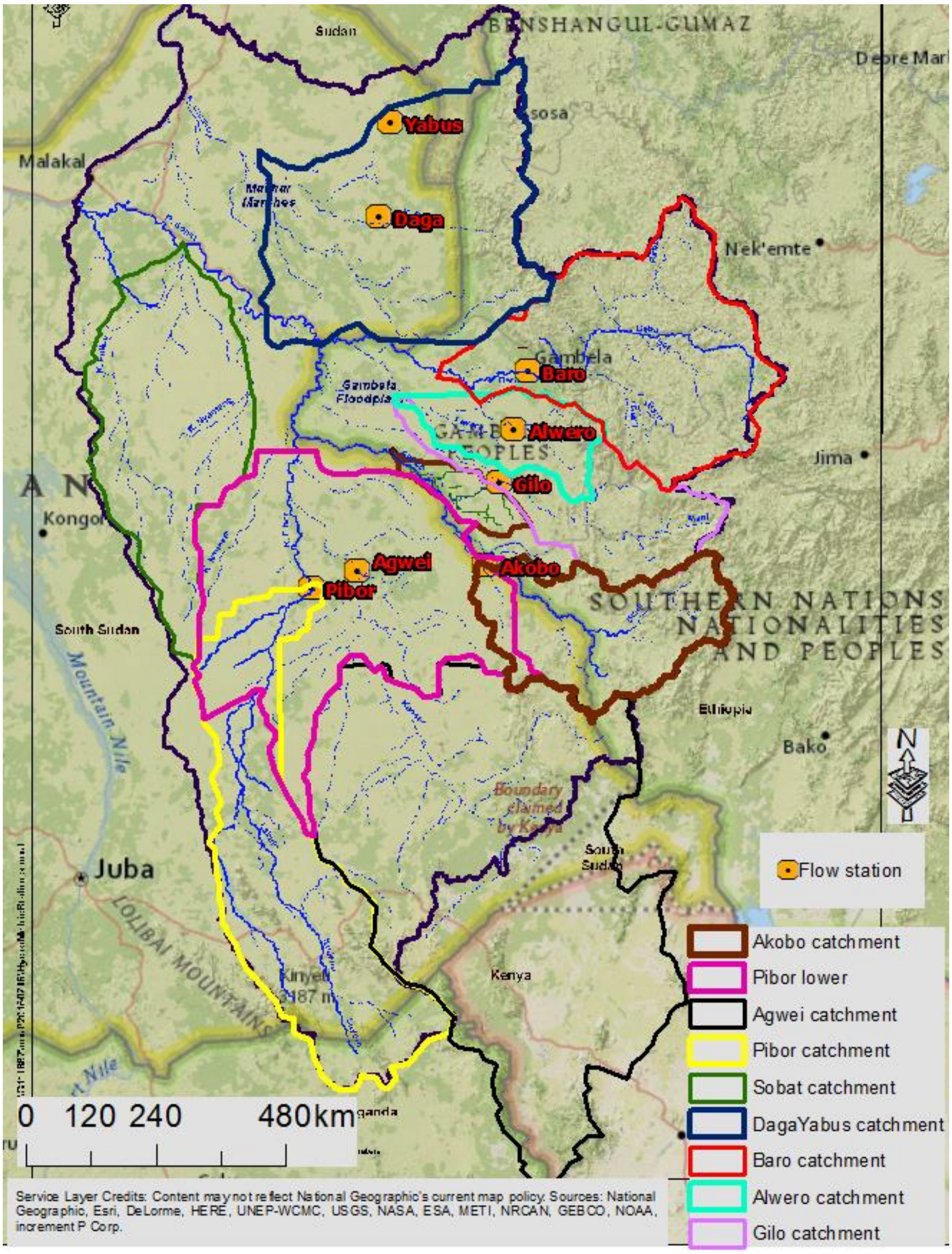



*Figure 2-1: Major delineated catchments and locations of flow gauging stations as used in SHETRAN*

### 2.1.2 Land use and soil distribution

Five main land uses were identified from the ENTRO (2007) report and are shown in Figure 2-2. They were limited to five as to conform to the SHETRAN library: shrub, grass, urban, forest and arable land. The evaporation parameters, root density function, canopy and leaf parameters such as canopy drainage, canopy storage and vegetation cover indices were based on the SHETRAN standard values (SHETRAN, 2013). These standard values are tabled in

**Appendix** 2 and

**Appendix** 3.

Two main soils types were identified, vertisols described as silty clay and nitosols described as clay loam to sandy loam. Their distribution is as shown in Figure 2-3.The two soils were set up having two layers for the whole catchment with the top layer having a thickness of 1m and lower layer varying from 5 to 15m.

The different soil parameters such as saturated water content, residual water content and vanGenuchte values were based on standard SHETRAN values. The saturated conductivity of the top 1m layer varied between 5 to 15 m/day and the lower layer between 0.1 to 1 m/day. Default soil parameters are tabled in

**Appendix 4**.

The channel Manning n value was calibrated with initial value selected as 0.04 and overland flow values varying between 0.07 and 0.1.

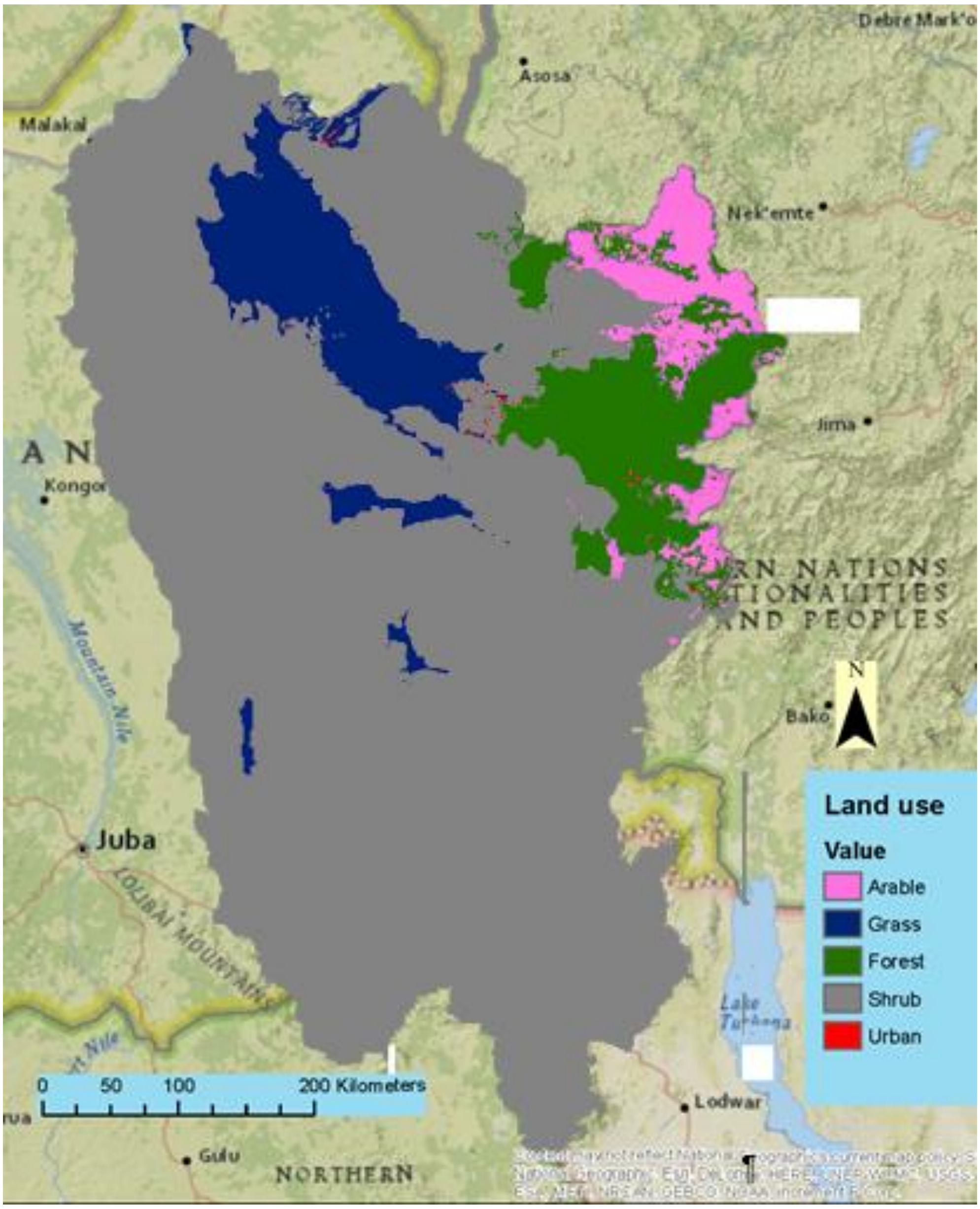



*Figure 2-2: Baro-Akobo-Sobat land use distribution as used in SHETRAN*

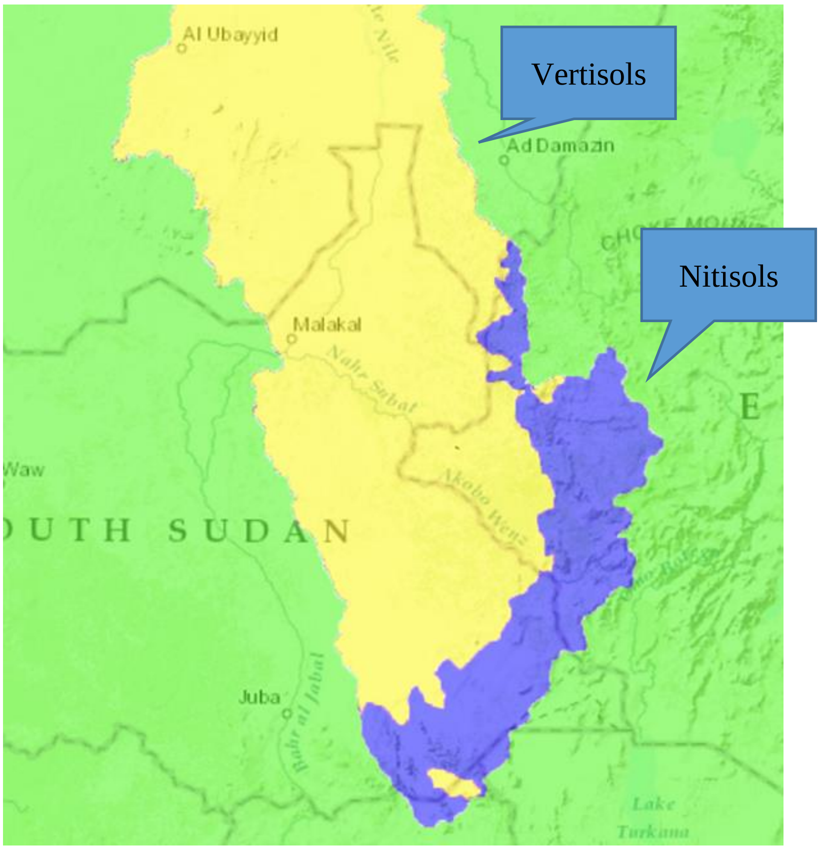



*Figure 2-3: Baro-Akobo-Sobat soil distribution as used in SHETRAN*

### 2.1.3 Rainfall, potential evaporation and flow records

The hydrological year was taken from 1st April to 31st March with all records available for periods between 1952 and 1992. Monthly  and simulated flows (MIKE HYDRO Basin) at eight locations as shown in Figure 2-4 were used.  The monthly flows records/sequences are shown in Figure 2-5 and Figure 2-6 with their coordinates in Appendix 1.

Time series at the flow gauging stations are shown in Appendix 5 to Appendix 9.

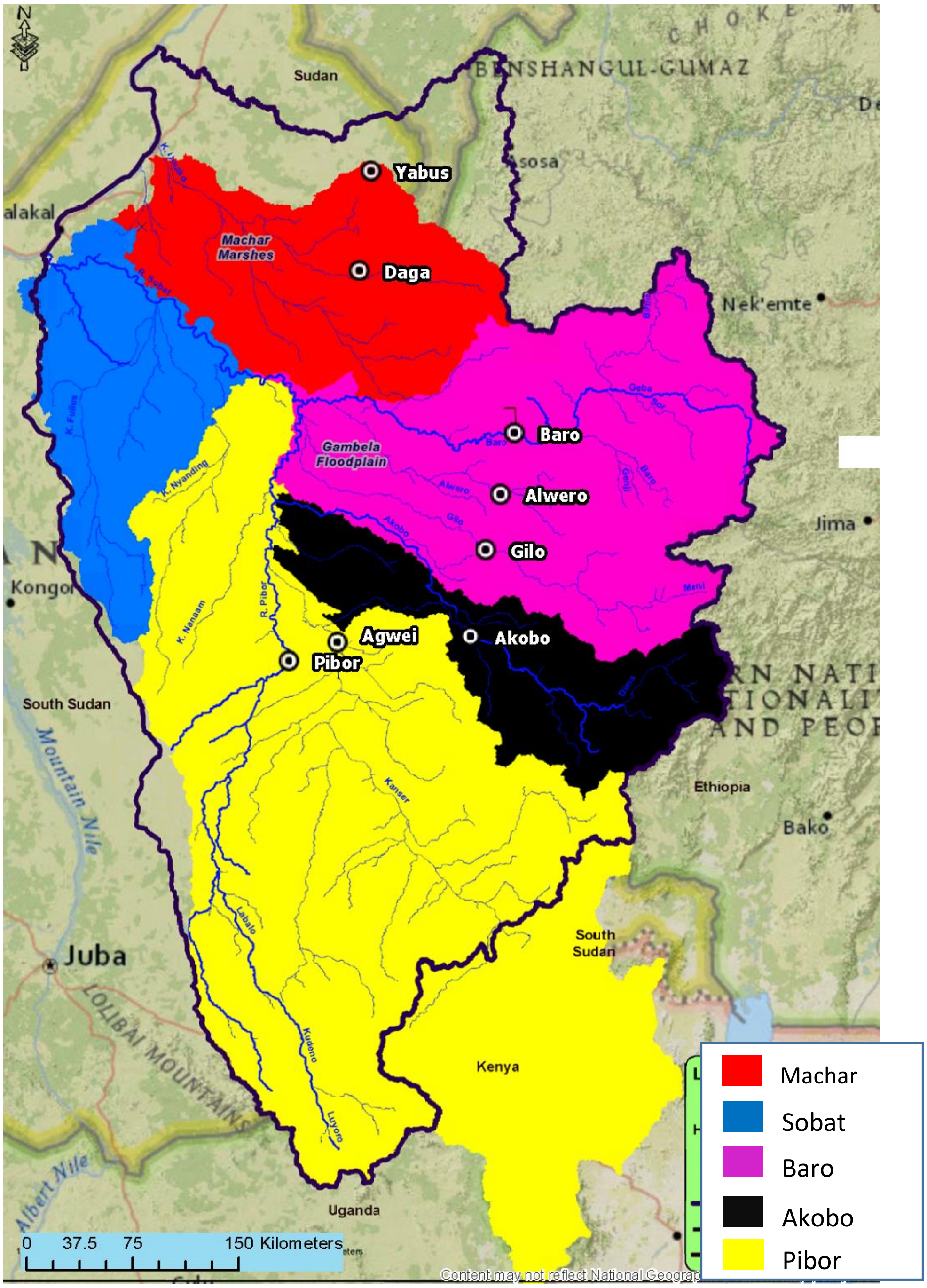



*Figure 2-4: Baro-Akobo-Sobat basin watershed and gauging stations as used in SHETRAN*

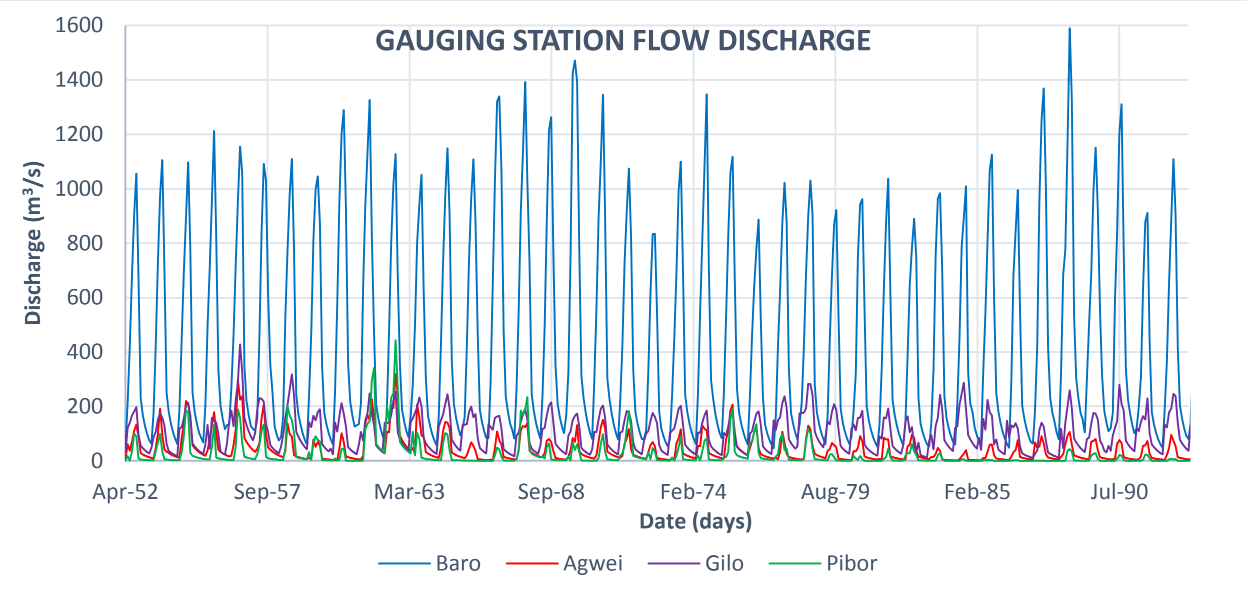



*Figure 2-5: Baro-Akobo-Sobat gauging station flow records (daily data)*

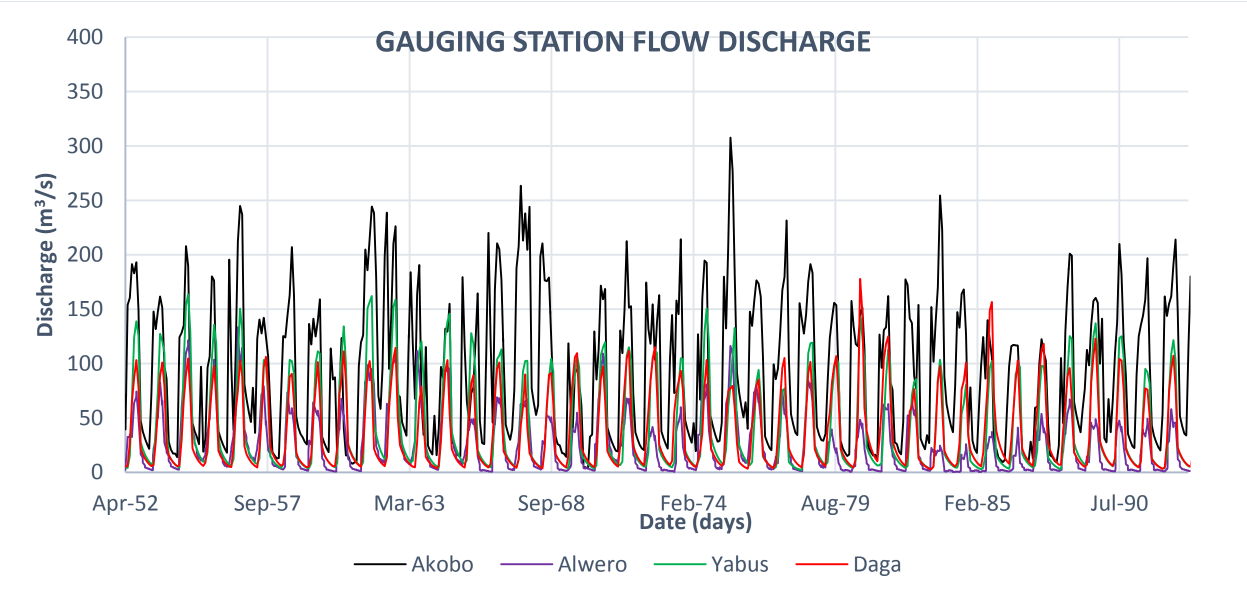



*Figure 2-6: Baro-Akobo-Sobat gauging station flow records*

Nineteen rainfall stations were available for the whole catchment. Their area of influence is as shown in Figure 2-7. Figure 2-8 to Figure 2-10 show a graphical representation of the daily rainfall records.

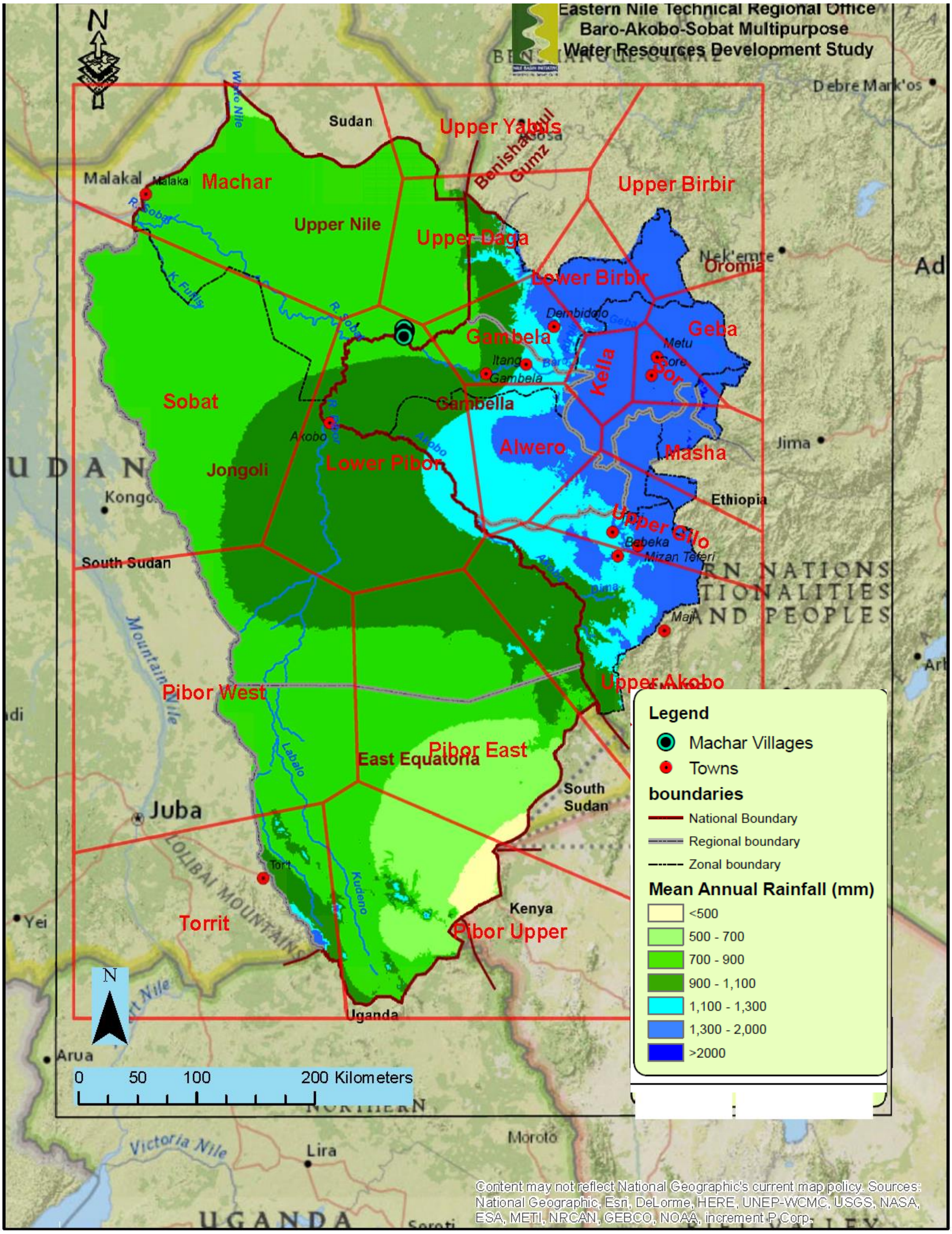



*Figure 2-7: Baro-Akobo-Sobat rainfall Thiessen polygons as used in SHETRAN*

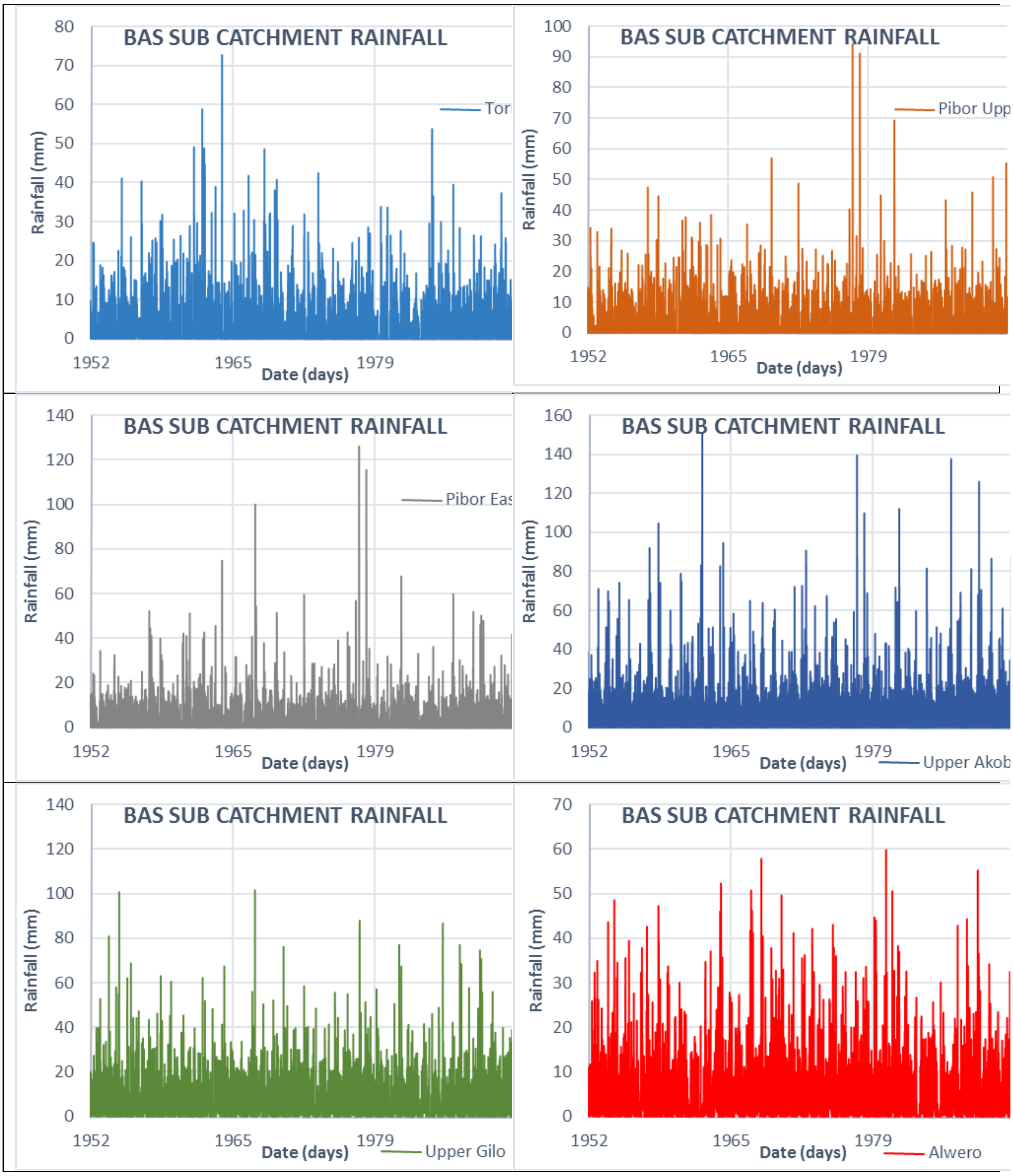



*Figure 2-8: Baro-Akobo-Sobat rainfall records*

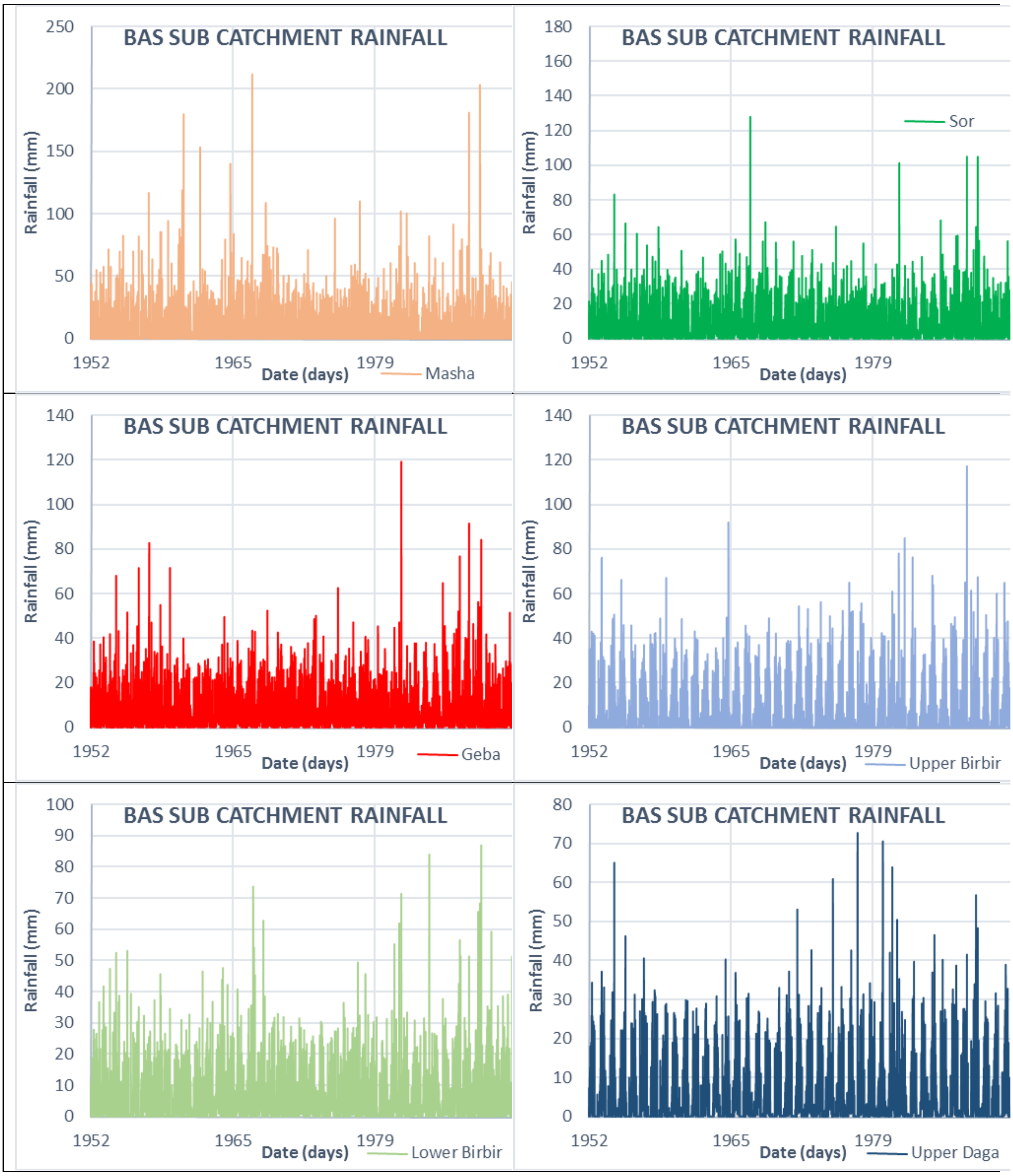



*Figure 2-9: Baro-Akobo-Sobat rainfall records*

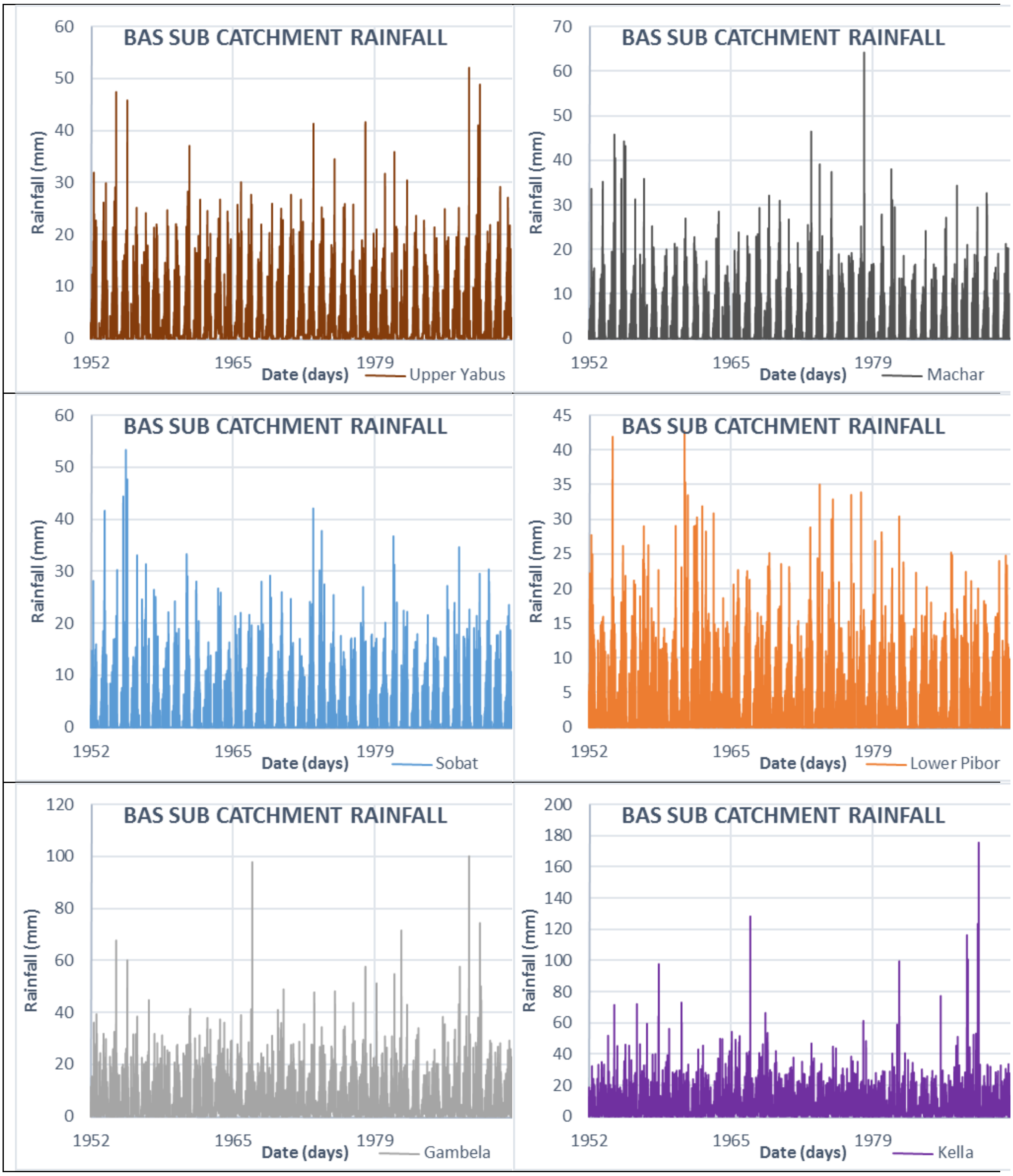



*Figure 2-10: Baro-Akobo-Sobat rainfall records*

Twenty-five evaporation stations are available with their distributions as shown in Figure 2-11. Their monthly evaporation records are as shown in Figure 2-12. Rainfall weather station coordinates are presented in Appendix 10.

Due to the large area of sub-catchments identified the Thiessen polygons of rainfall and evaporation were limited to a maximum of nine in each smaller sub-catchment as not to introduce instabilities in the model, although the model can handle twenty-five polygons.

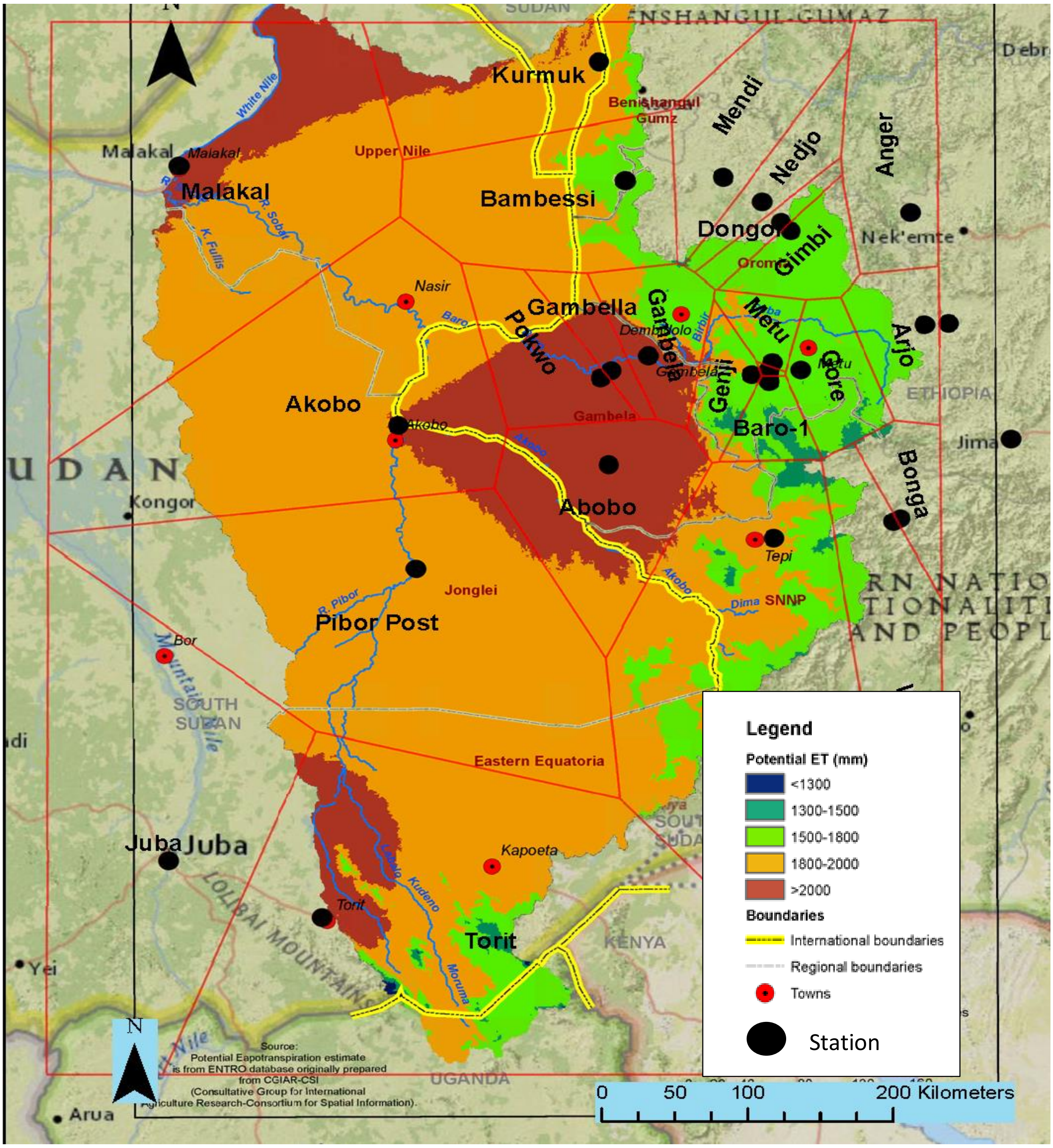



*Figure 2-11: Baro-Akobo-Sabot evaporation Thiessen polygons*

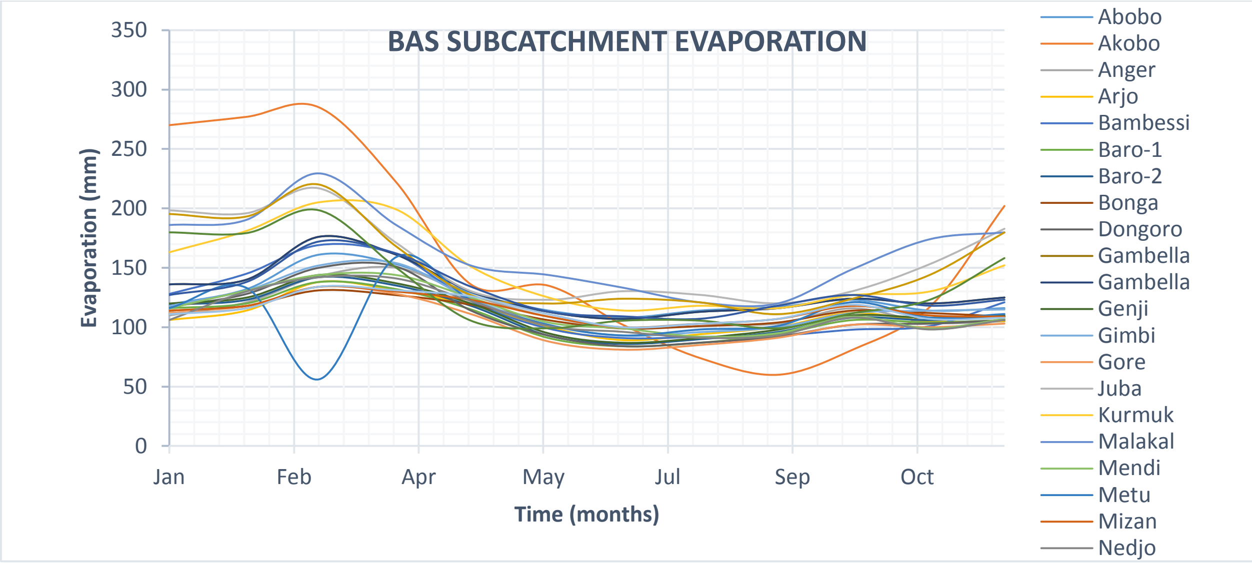



*Figure 2-12: Baro-Akobo-Sobat monthly evaporation records*

## 2.2 SEDIMENT DATA

Table 2-1 and Figure 2-14 show the available sediment yield data for the catchment. There is limited sampling data from the eleven stations in various rivers in the catchment. The data was collected from 1988 to 1990 with 101 samplings done. Based on sediment load, discharge rating curves were obtained. Note that the so-called rating curve given in Table 2-1 is not a standard rating curve from the raw suspended sediment concentrations data-discharge record, but was calculated based on a Mean Annual Flow (MAF) (TAMS_IF, 1997).

*Table 2-1: Average sediment yield (TAMS_1F, 1997).*

| River | Catchment Area ($km^2$) | Mean Annual Flow ($m^3/s$) | Sediment Rating Curve Equation ($t/day.km^2$) and $q = \frac{\text{daily discharge}}{\text{mean annual flow}}$ | | Calculated annual sediment yield ($t/km^2.a$) |
|---|---|---|---|---|---|
| Keto | 1006 | 17.6 | $Qs = 0.01010\ q^{0.974}$ | | 324 |
| Gumero | 106 | 2.05 | $Qs = 0.00372\ q^{0.720}$ | | 35 |
| Ouwa | 288 | 5.75 | $Os = 0.00089\ q^{1.419}$ | | 284 |
| Sor | 1620 | 52.6 | $Qs = 0.00130\ q^{1.189}$ | | 124 |
| Gecheh | 79 | 1.90 | $Os = 0.00056\ q^{1.220}$ | | 63 |
| Begwaha | 125 | 3.33 | $Qs = 0.00110\ q^{1.145}$ | | 85 |

From the Baro 1 and 2 feasibility study, additional studies were done and from seven additional stations the sediment yields were calculated based on discharge-sediment load rating curves, as shown in Table 2-2 (Norplan, 2006). It should be noted these values are just indicative and generally based on short records. The location of these gauging stations is represented in Appendix 11.

*Table 2-2: Average Annual Sediment yield (Norplan, 2006)*

| River Station | #Samples | Area (km²) | Period | Mean Annual Flow (m³/s) | Rating curves (t/day) | Annual Sediment Load (t/km².a) |
|---|---|---|---|---|---|---|
| Sor nr. Metu | 27 | 1622 | 1968-1996 | 50.1 | $Q_s=4.045Q^{1.199}$ $R^2=0.942$ | 169 |
| Geba at Chora | 27 | 1582 | 2003 | 49.3 | $Q_s=3.975Q^{1.239}$ $R^2=0.946$ | 137 |
| Geba nr. Suppi | 14 | 3894 | 1989-1990 | 54.8 | $Q_s=5.346\ Q^{1.214}$ $R^2=0.960$ | 75 |
| Uka at Uka | 18 | 52 | 1988-1996 | 1.3 | $Q_s=6.328Q^{0.781}$ $R^2=0.666$ | 50 |
| Gummero nr. Gore | 15 | 106 | 1988-1996 | 1.9 | $Q_s=6.822Q^{0.728}$ $R^2=0.790$ | 32 |
| Baro nr. Masha | *11+1 | 1400 | 1990-2004 | 56.8 | $Q_s=7.459Q^{1.028}$ $R^2=0.881$ | 155 |
| Genji nr. Gecha | *10 | 115 | 2004 | 4.6 | $Q_s=11.06Q^{0.682}$ $R^2=0.638$ | 88 |

* Norplan measurements 2004

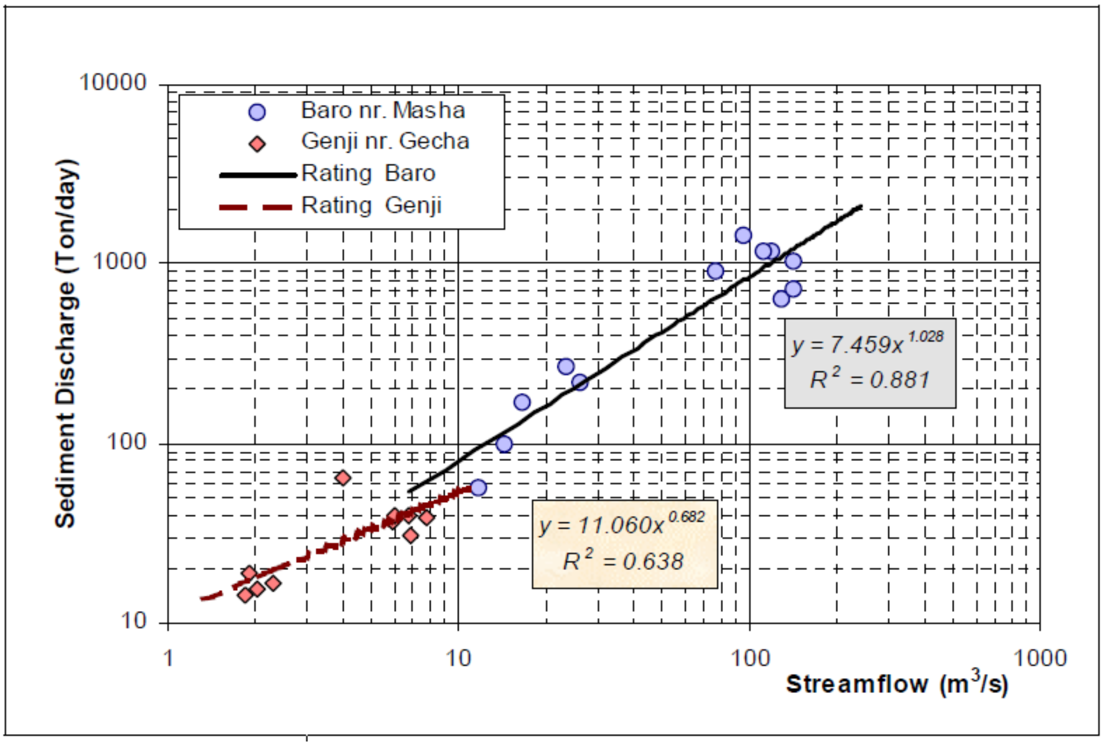



*Figure 2-13: Baro and Genji Rivers sediment rating curves as calculated in Baro 1 and 2 feasibility studies (Norplan, 2006)*

From the 40 years' flow records available in the catchments, it should be noted that the 100 year flood may not be included, thus the sediment yields calculated in this report should be treated with caution.

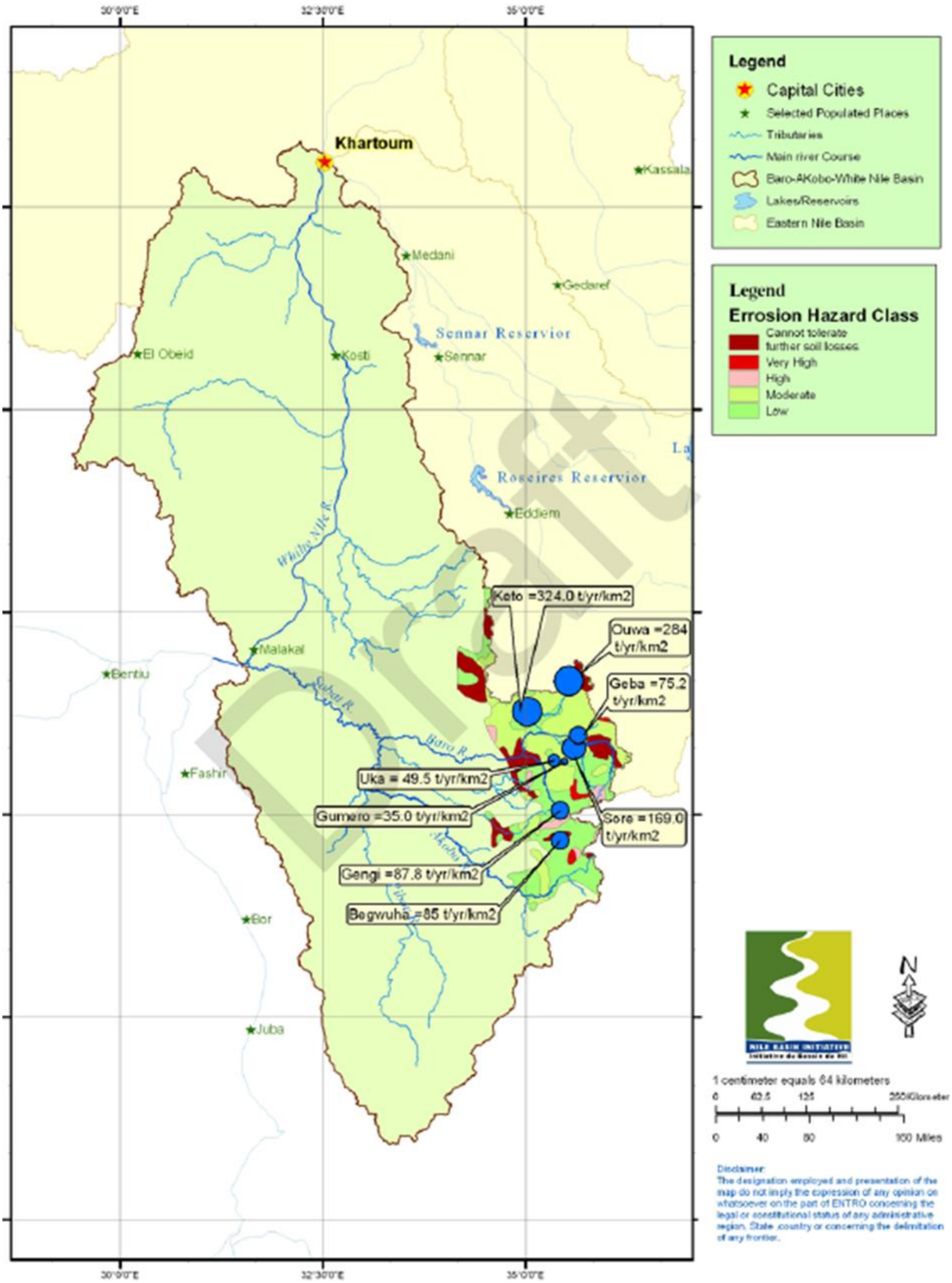



*Figure 2-14: Baro-Akobo-Sobat sediment yield and land erosion potential (ENTRO, 2007)*

## 2.3 MODEL CALIBRATION AND SIMULATION RESULTS

### 2.3.1 Baro catchment

Based on the SHETRAN 200 x 200 grid limitation and 1500 river channel links, a 30 arc DEM was used to delineate the watershed. 130 x 147 grids of 1970 m spatial resolution represented the watershed with a total catchment area of 22364 km$^2$.The watershed formed the model boundary with one gauging station at Baro near Gambela.

Figure 2-15 shows the Baro watershed extent and the river links as calculated by the SHETRAN model.

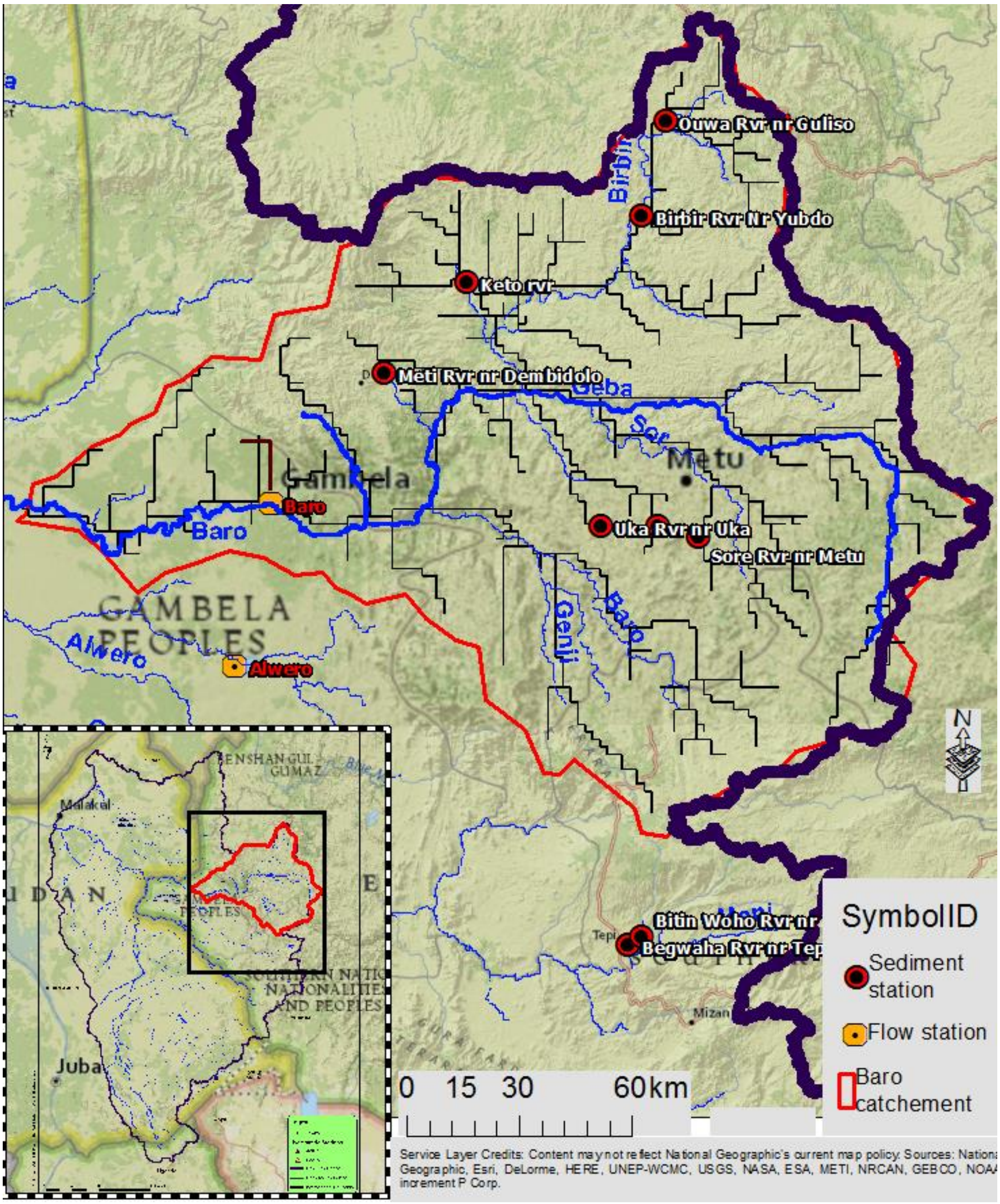



*Figure 2-15: Baro River sub-catchment and SHETRAN river links (black) as used in SHETRAN model*

Land use variation in the Baro model is shown in Figure 2-16 with arable, shrub and forest being dominant.

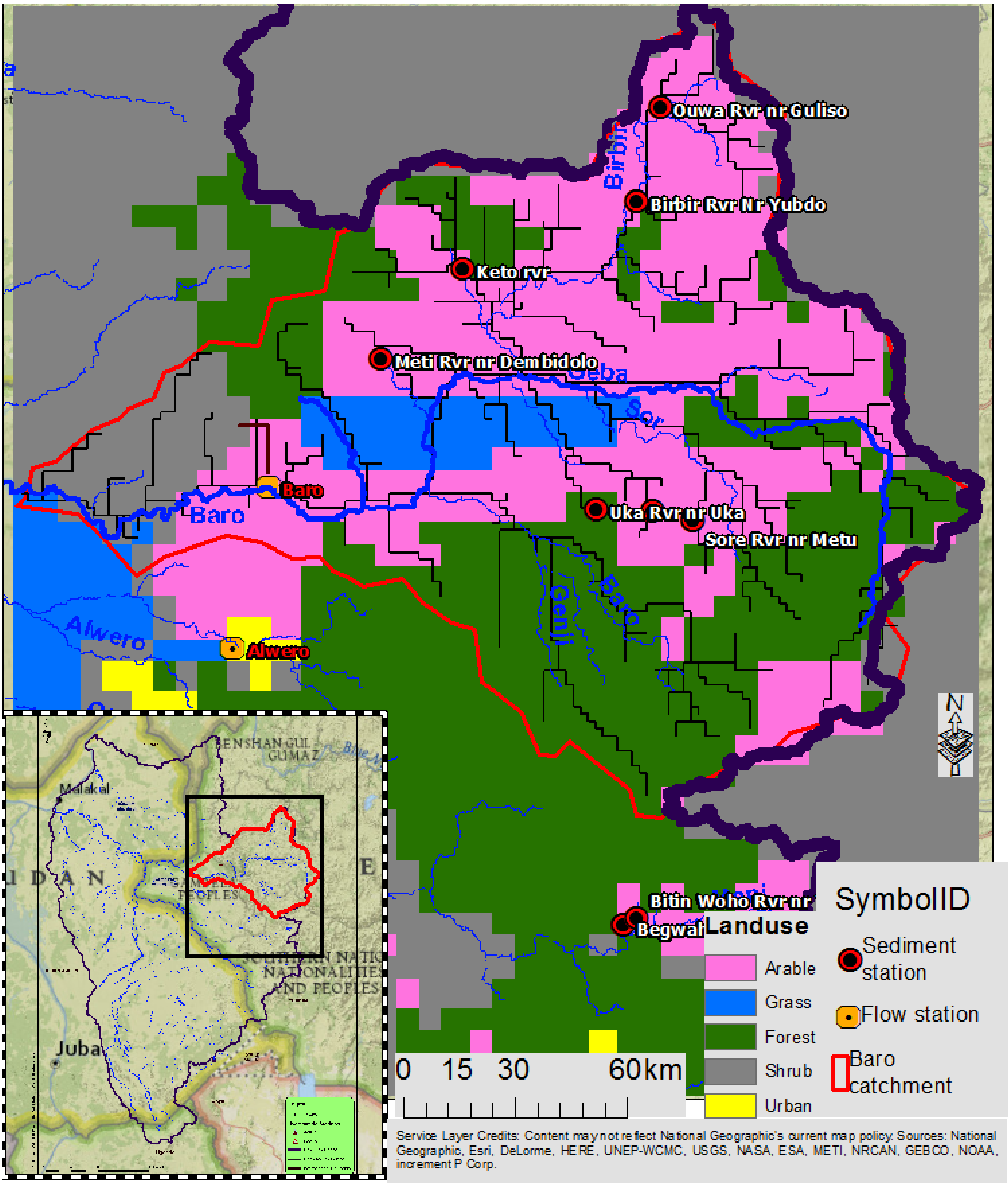



*Figure 2-16: Baro River sub-catchment land use and SHETRAN river links (black) as used in the SHETRAN model*

#### 2.3.1.1 Baro flow calibration

The model was set up and calibrated against flow records for the period between 1952 to 1960 and validated for the period 1989 to 1992. Parameters that varied from the model default are shown in

Appendix 12. The main channel hydraulic roughness was calibrated with a Manning n value of 0.05 and overland value of 0.02 to 0.06, dependent on the vegetation type.

Saturated conductivity was calibrated to 30 m/day for the upper 1m horizon of soil and 5 m/day for the lower 14 m horizon. These values are high but within the acceptable limits.

Figure 2-17 shows calibration flows with the validation graph in Figure 2-18. A r-square of 0.78 was achieved at the Baro-Gambela gauging station for the whole simulation period (1952 to 1992) and the resultant simulation flow graph is shown in Figure 2-19. Note that the model output is daily simulated flows which are plotted as montly flows to compare with the  montly flows.

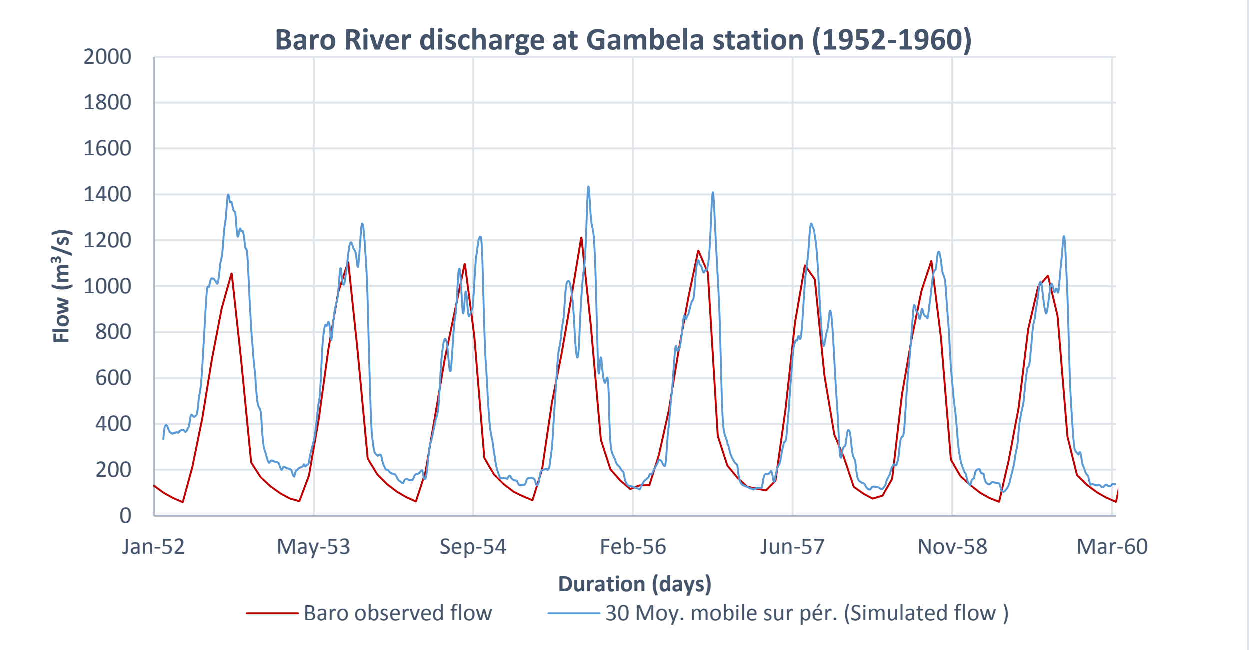



*Figure 2-17: Baro River calibration at the Gambela flow gauging station (plotted as monthly flows)*

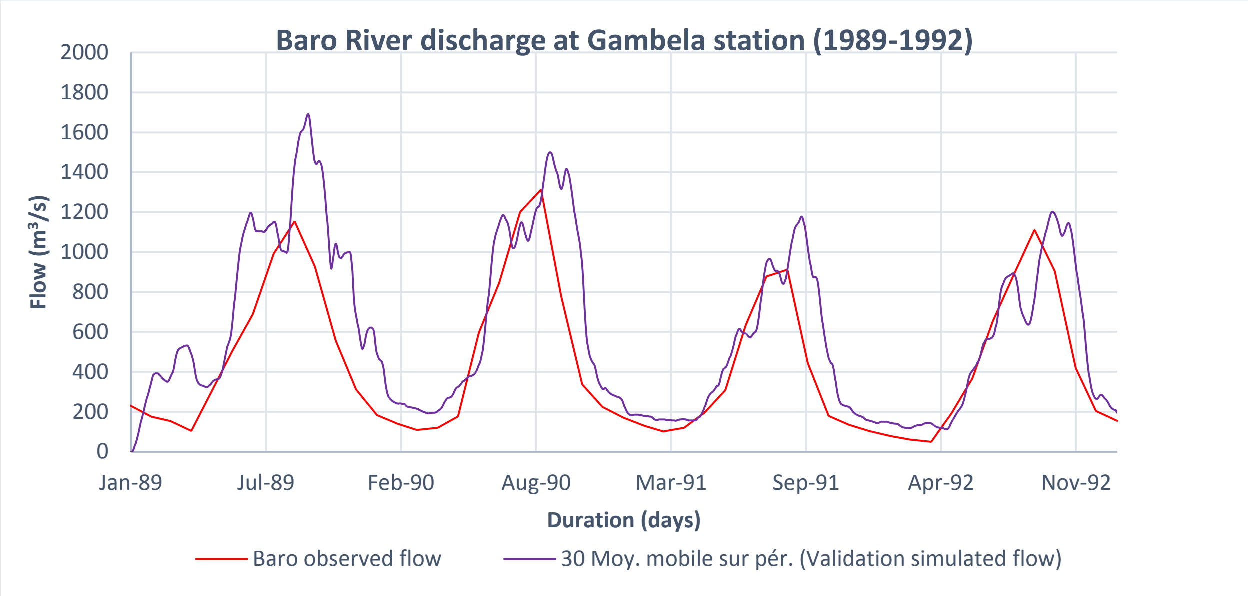



*Figure 2-18: Baro River validation at the Gambela flow gauging station (plotted as monthly flows)*

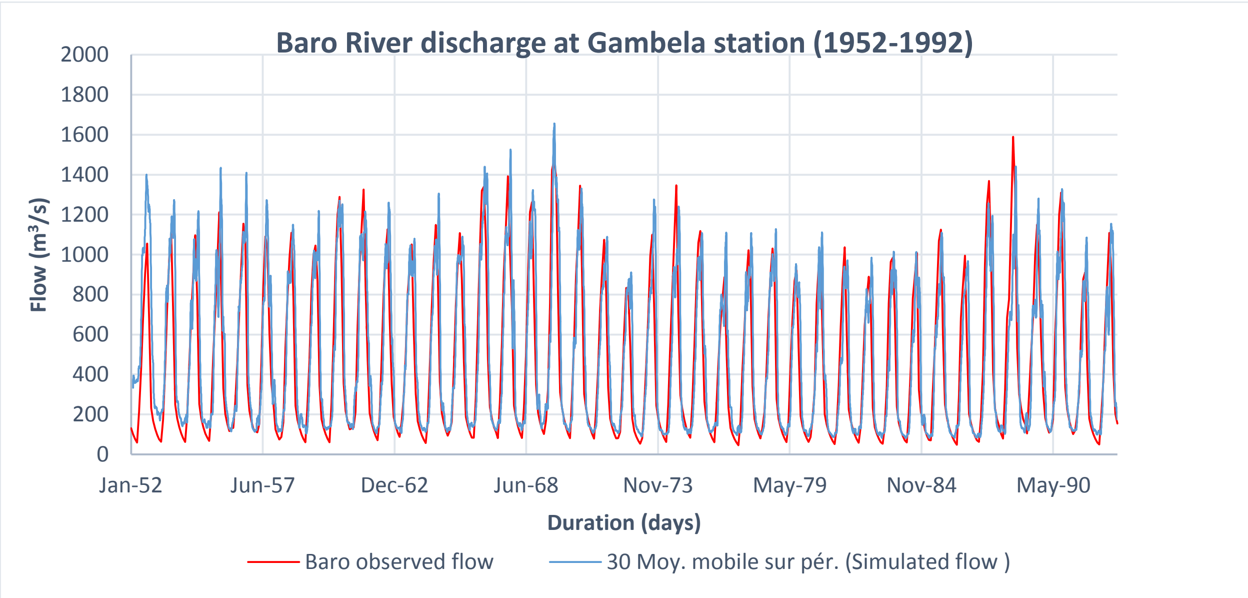



*Figure 2-19: Baro River simulated long term flows at the Gambela station (plotted as monthly flows)*

### 2.3.1.2 Sediment calibration

Seven-grain sizes were used with the initial size composition is as shown in

Table 2-3. The grain size classes were based on the SHETRAN manual while the soil composition values were adopted from the SELKHOZPROMEXPORT (1990) report to conform to clay loam type of soil.

*Table 2-3 Baro River soil composition by size group*

| Grain size (mm) | 0.1 | 0.37 | 0.89 | 1.5 | 2.2 | 3.2 | 8 |
|---|---|---|---|---|---|---|---|
| Soil composition (%) | 60 | 20 | 10 | 5 | 3 | 2 | 0 |

Sediment transport data was available at eight sampling stations in the catchment with their locations shown in Figure 2-16 and their date, flow and sediment load in Appendix 19 (SELKHOZPROMEXPORT, 1990).

Sediment rating curves were plotted for the period where corresponding measured data was available. The model was calibrated and the resulting graphs for each station are shown in Figure 2-20 to Figure 2-27.

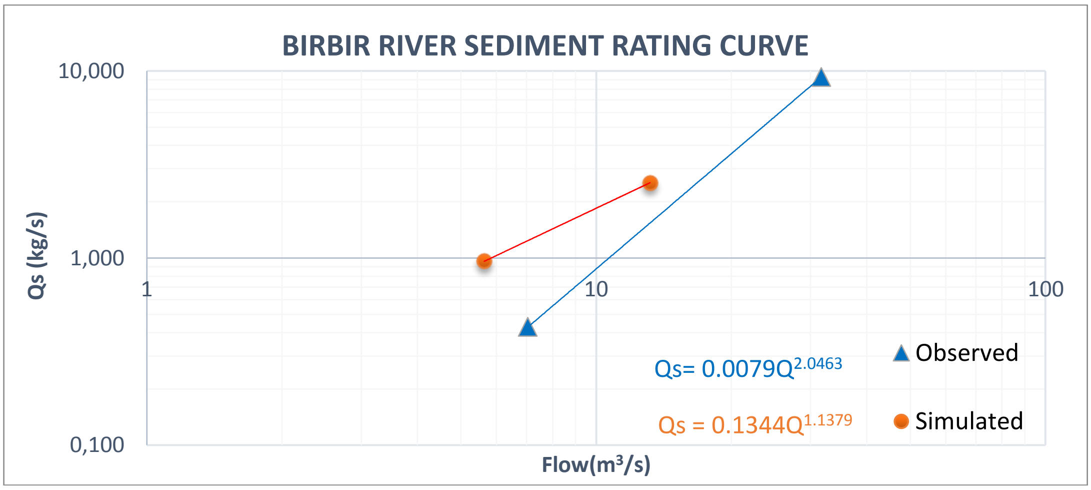



*Figure 2-20: Birbir River sediment rating curve*

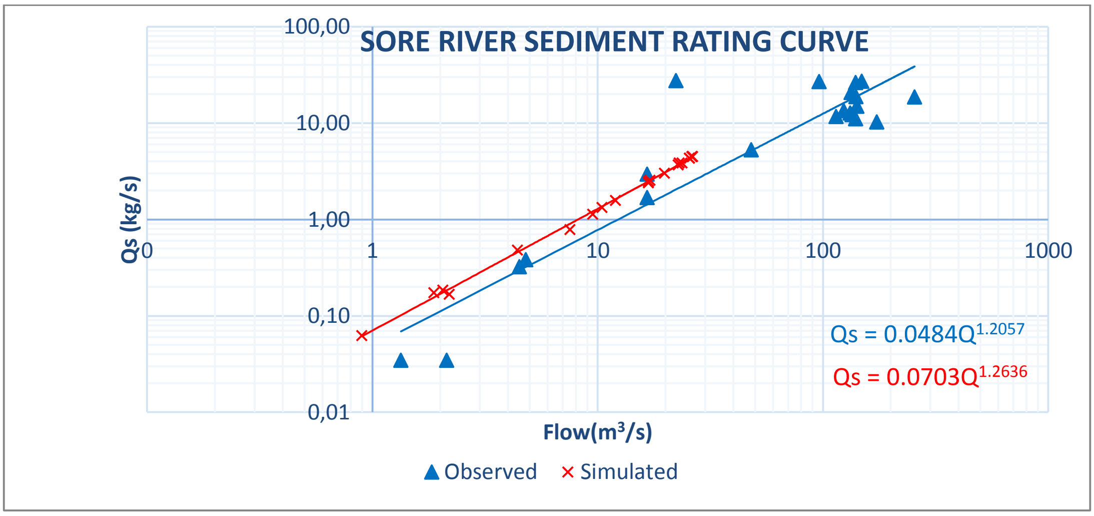



*Figure 2-21: Sore River sediment rating curve*

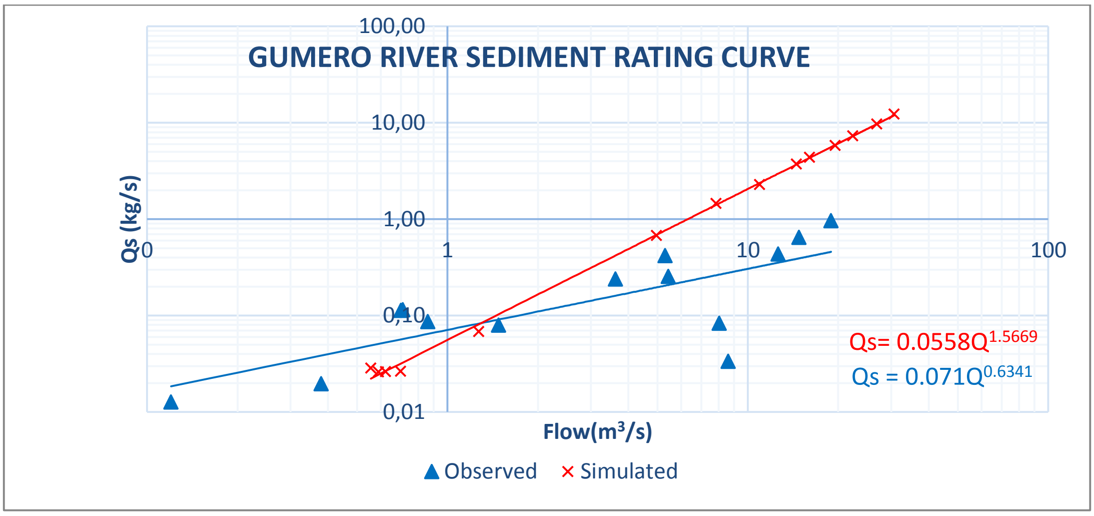



*Figure 2-22: Gumero River sediment rating curve*

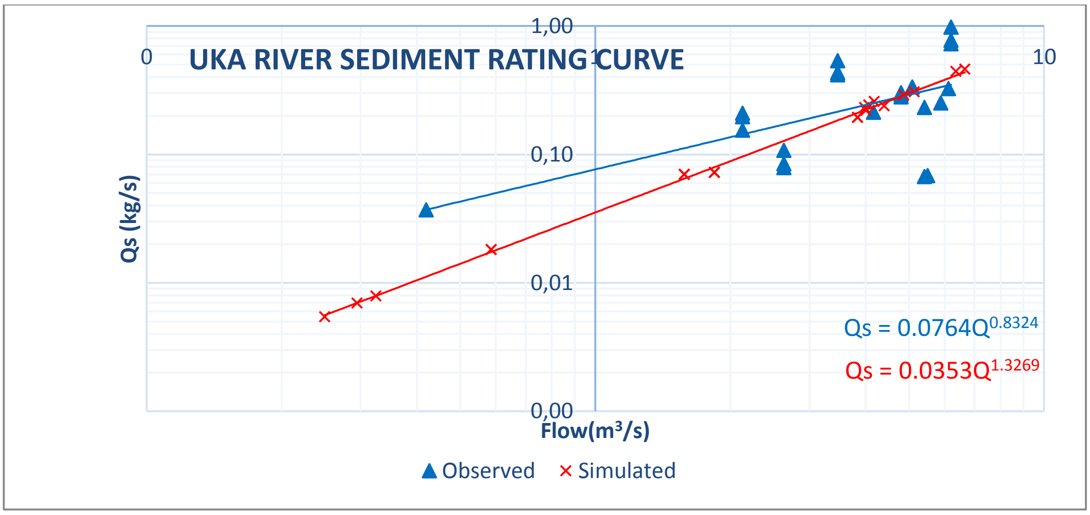



*Figure 2-23: Uka River sediment rating curve*

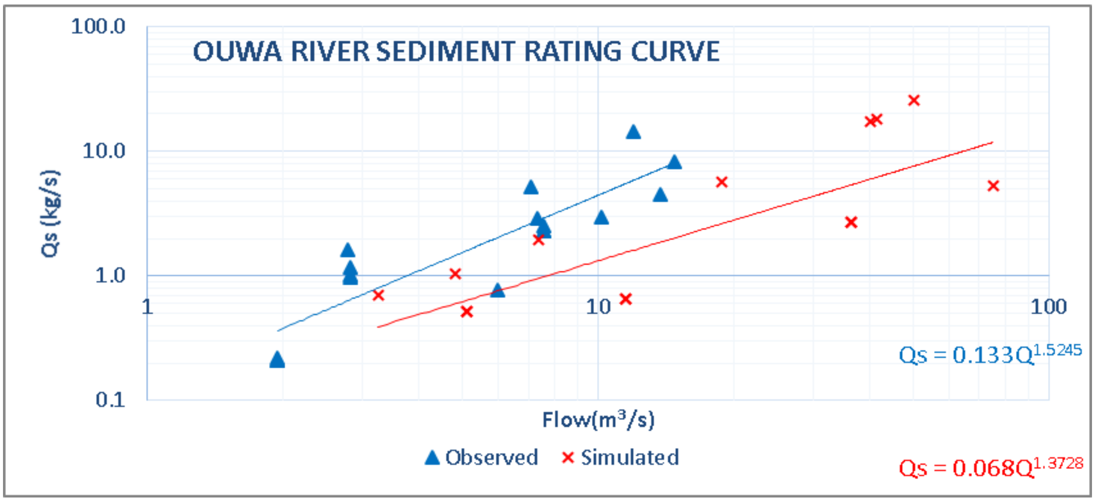



*Figure 2-24: Ouwa River sediment rating curve*

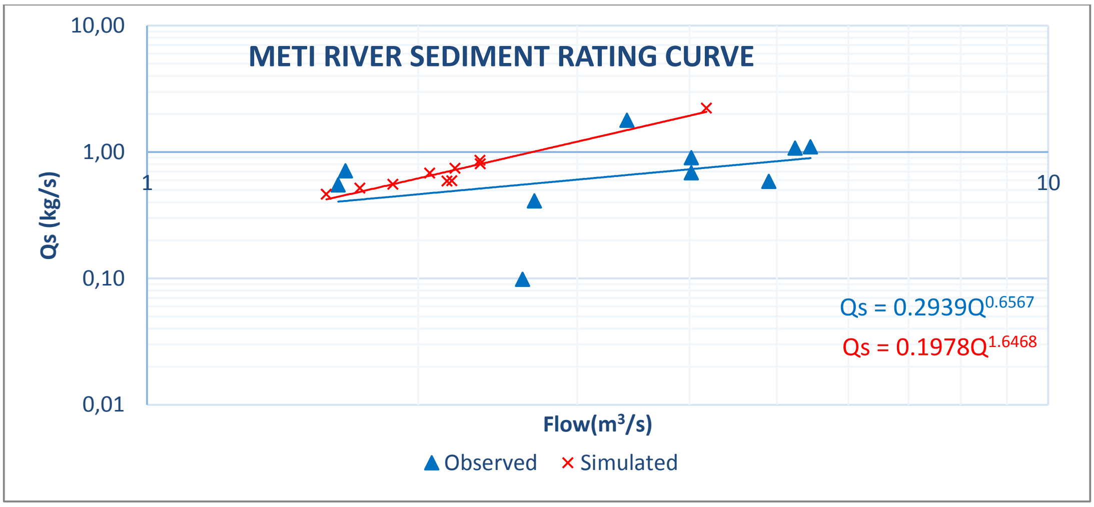



*Figure 2-25: Meti River sediment rating curve*

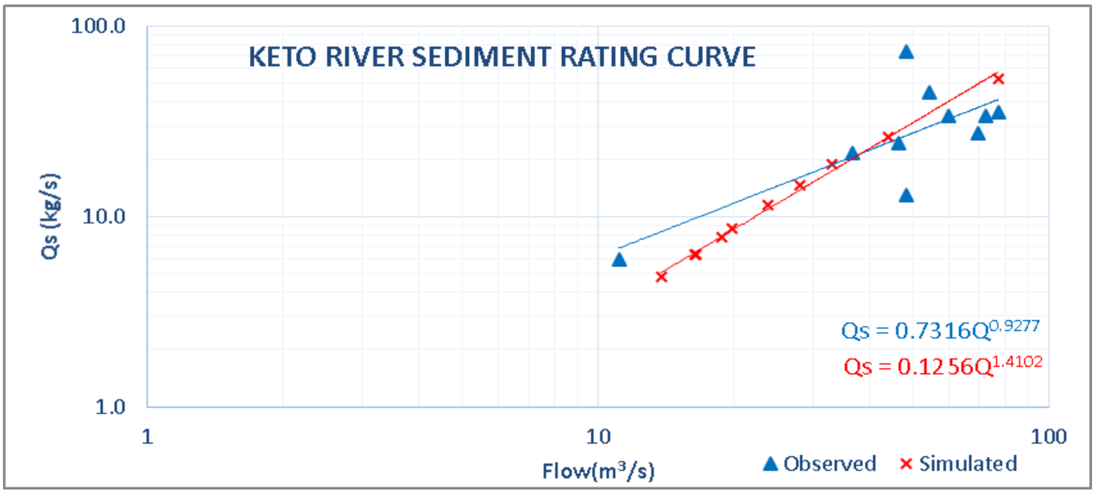



*Figure 2-26: Keto River sediment rating curve*

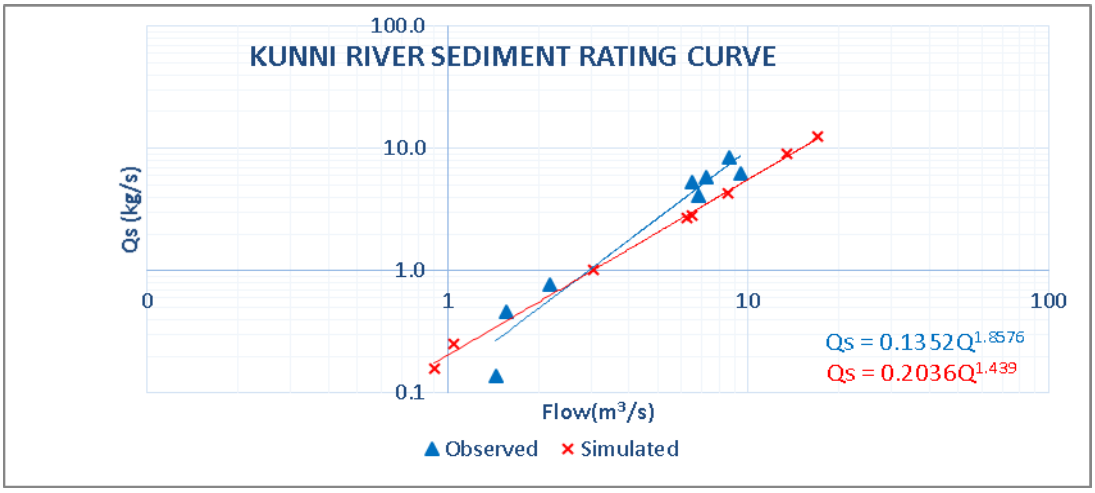



*Figure 2-27: Kunni River sediment rating curve*

The resulting sediment loads simulated at the Baro Gambela station is shown in Figure 2-28.

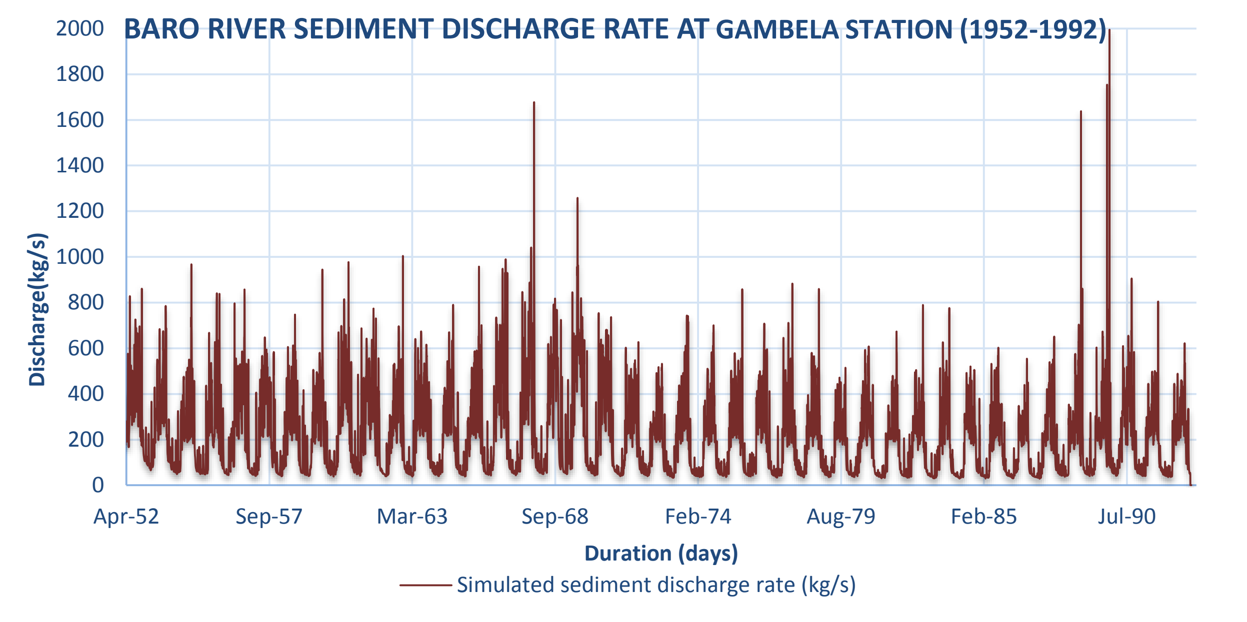



*Figure 2-28: Baro River simulated sediment discharge rate at Gambela gauging station*

Taking April to March as the hydrological year, the catchment sediment yield was calculated and compared to previous study results. This is shown in Table 2-4**Erreur ! Source du renvoi introuvable.**. There is a large difference in the catchment area for the first station, and the MAFs for the first two stations differ significantly. The sediment yields of this study are generally higher than the previous study values for this catchment. The sediment yields of this study were however calibrated against the limited field data and were simulated for a 40 year hydrological period. Therefore the sediment yields of this study are more reliable.

*Table 2-4: Comparison of simulated sediment yields with previous studies*

| | **Previous studies** (SELKHOZPROMEXPORT, 1990) | | | **Simulated** | | |
|---|---|---|---|---|---|---|
| **River Station** | **Area (km2)** | **Mean annual flow (m³/s)** | **Annual Sediment Load (t/km².a)** | **Area (km2)** | **Mean annual flow (m³/s)** | **Annual Sediment Load (t/km².a)** |
| Sor nr. Metu | 1622* | 50.1 | 169 | 276 | 8.5 | 178 |
| Geba nr. Suppi | 3894 | 54.8 | 75 | 3894 | 92.7 | 495 |
| Uka at Uka | 52 | 1.3 | 50 | 70 | 1.4 | 44 |
| Gummero nr. Gore | 106 | 1.9 | 32 | 101 | 4.7 | 385 |
| Baro nr. Masha | 1400 | 56.8 | 155 | 1388 | 40.7 | 507 |
| Genji nr. Gecha | 115 | 4.6 | 88 | 111 | 0.7 | 449 |
| Keto | 1006 | 17.6 | 324 | 1038 | 14.4 | 272 |

Notes: * exact locations of reference not available

### 2.3.2 Alwero Catchment

Based on 30 arc Dem, a 125 x 95 grid of 1980 m spatial resolution Alwero watershed was delineated covering a total catchment area of 6692 km². Figure 2-29 shows the watershed SHETRAN boundary with the basin outlet being the downstream boundary. One gauging station at Alwero with flows record was available to calibrate the catchment. The coordinates of the gauging station are indicated in Appendix 1.

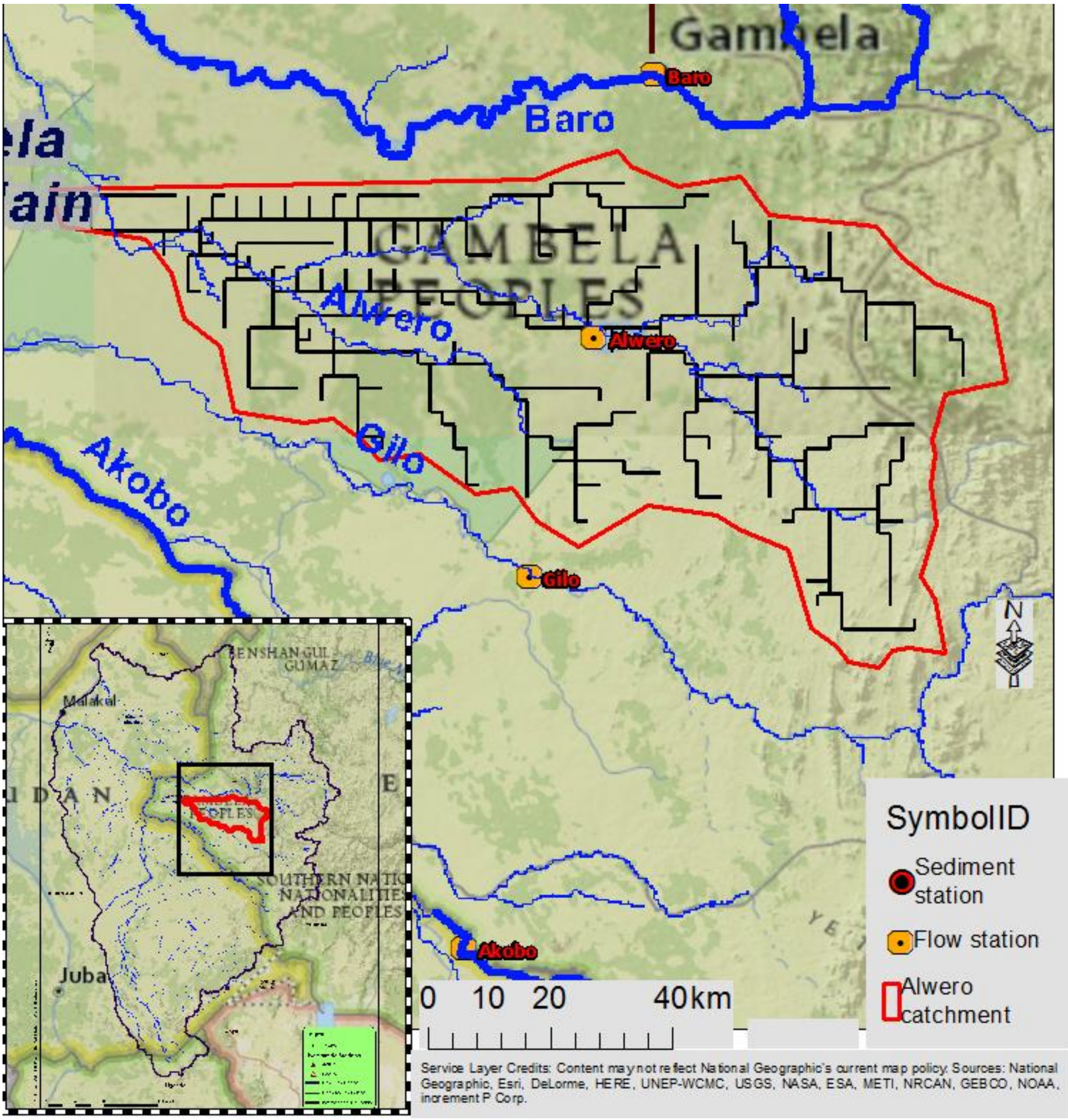



*Figure 2-29: Alwero River sub-catchment and SHETRAN river links (black) as used in SHETRAN model*

The main land uses in the catchment are shown in Figure 2-30 with forest, urban, grassland, and shrub being dominant.

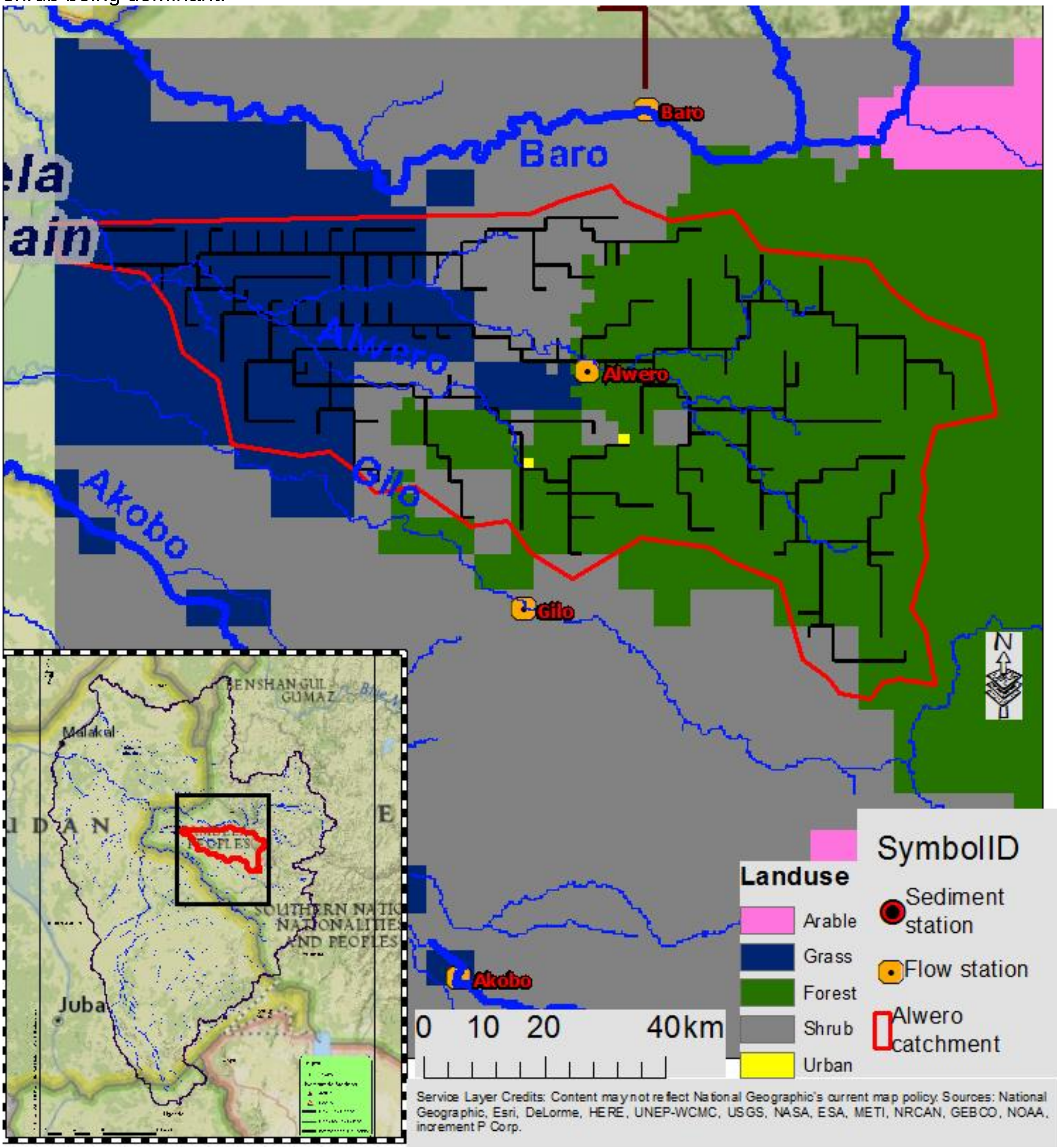



*Figure 2-30: Alwero River sub-catchment land use and SHETRAN river links (black) as used in the model*

### 2.3.2.1 Alwero catchment flow calibration

The model was set up and flow-calibrated for the period 1952 to 1960 and validated for the period 1989 to 1992. Parameters that varied from the model default are shown in Appendix 13.

The main channel was calibrated to a Manning value of 0.033 and overland range of 0.02 to 0.06, dependent on vegetation type. Saturated conductivity was calibrated to 20 m/day for the upper 1m horizon of soil and 5 m/day for 14 m lower horizon.

The calibration graph is shown in Figure 2-31 with the validation graph shown in Figure 2-32. Figure 2-33 shows the simulated long term flows.

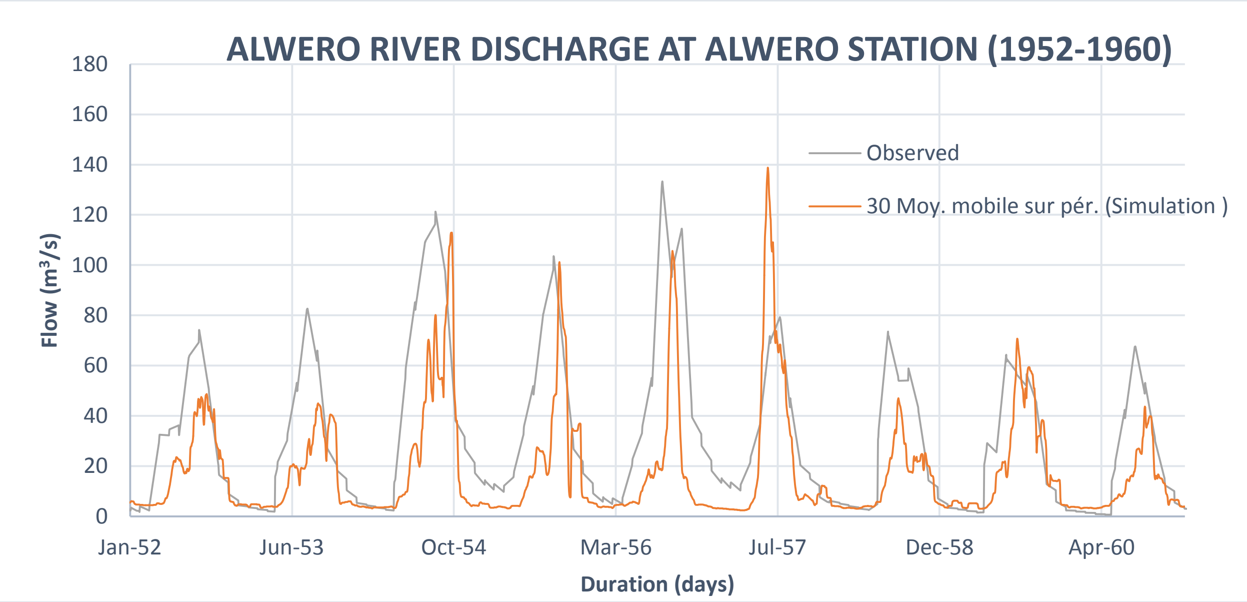



*Figure 2-31: Alwero River calibration at Alwero station (Plotted as monthly flows)*

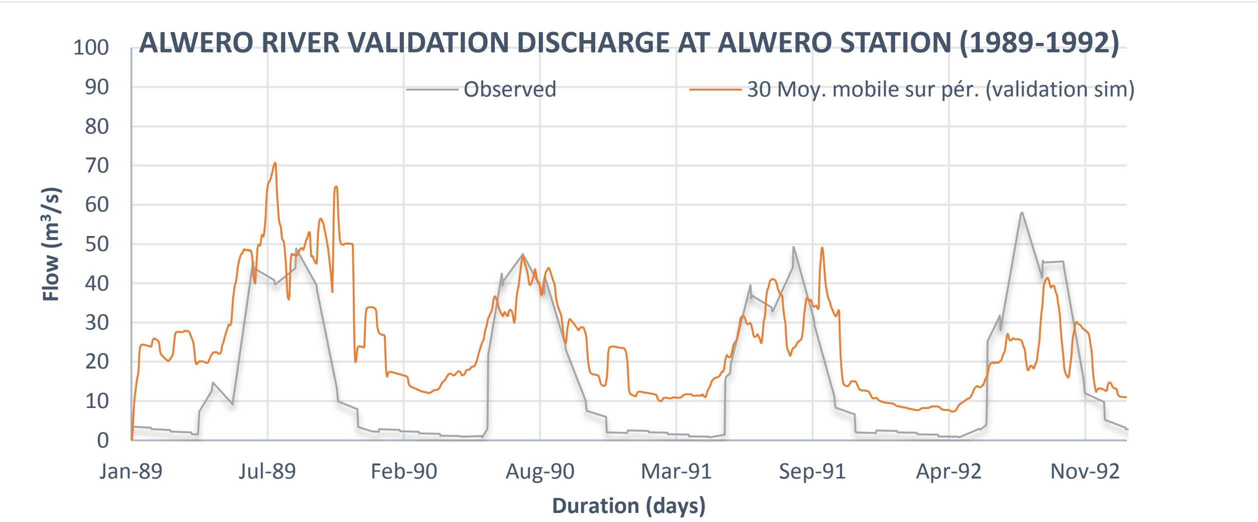



*Figure 2-32: Alwero River validation at Alwero (Plotted as monthly flows)*

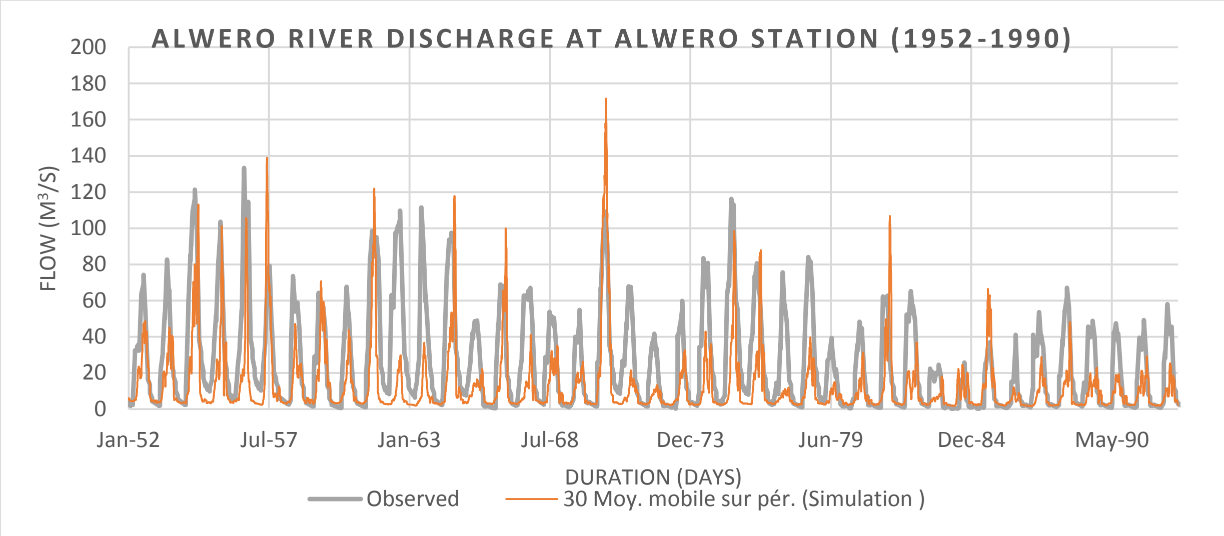



*Figure 2-33: Alwero River simulated long term flows at Alwero station (plotted as monthly flows)*

#### 2.3.2.2 Alwero sediment modelling

No sediment transport data was available for this catchment and therefore the calibrated neighbouring Baro River catchment SHETRAN parameters were used. Figure 2-34 shows the simulated sediment loads at the Alwero gauging station.

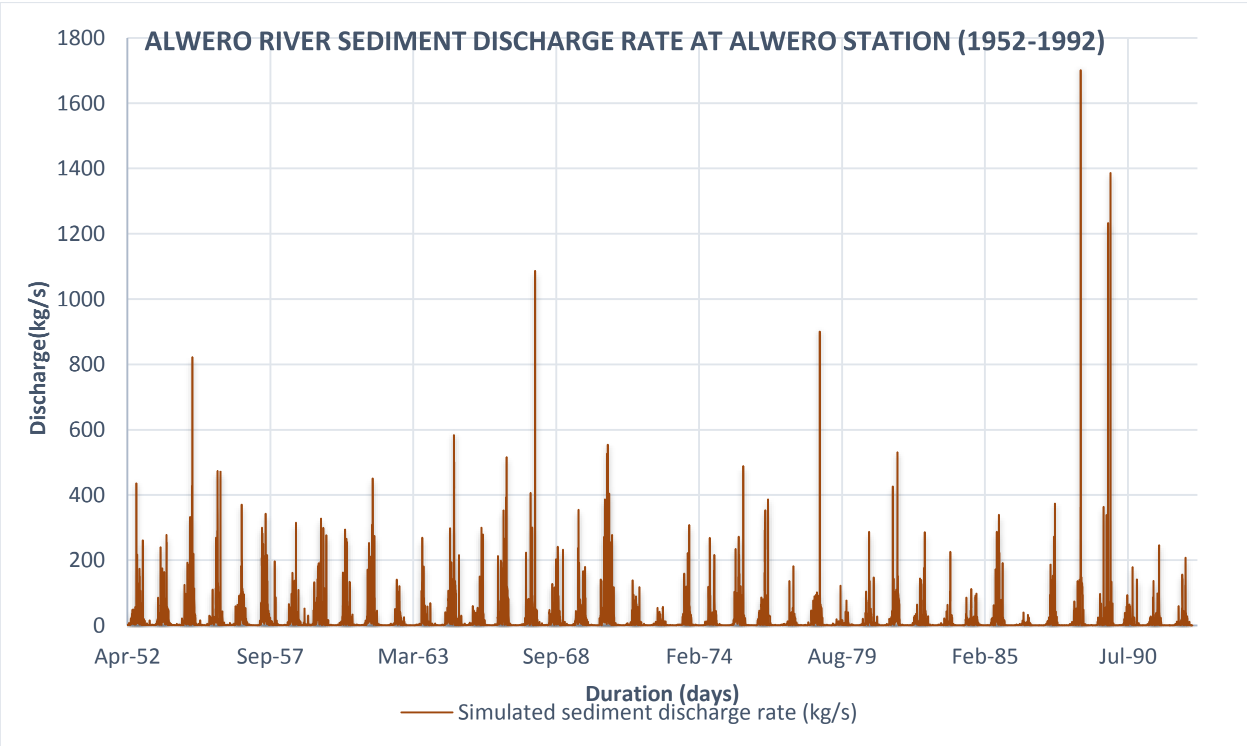



*Figure 2-34: Alwero River simulated long term sediment loads at Alwero*

The simulated discharge-sediment load rating curve at the Alwero station is shown in Figure 2-35.

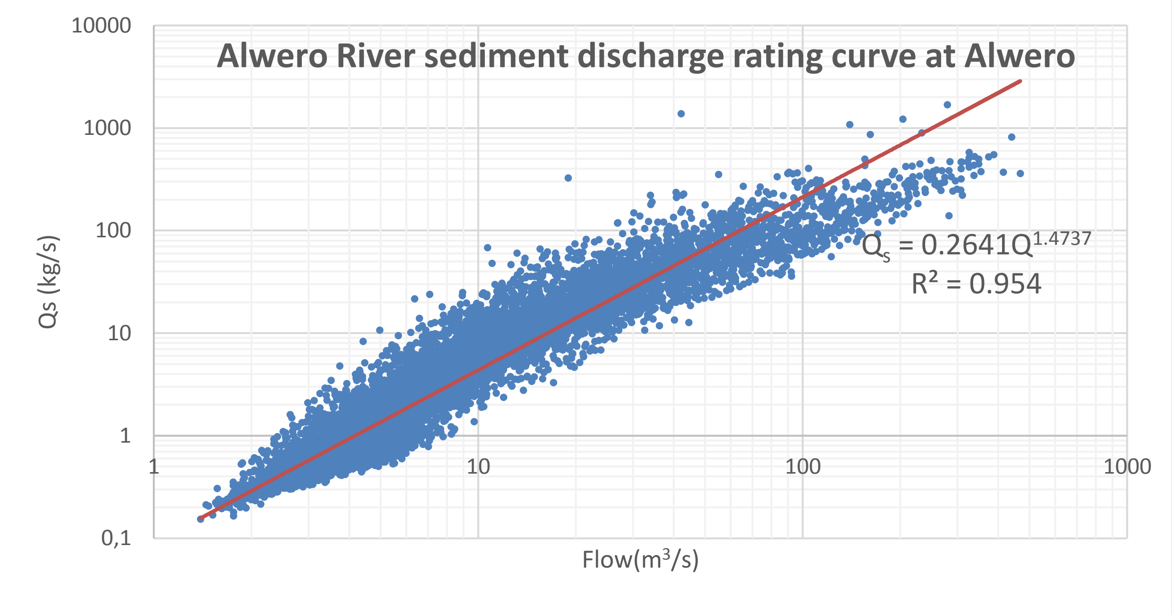



*Figure 2-35: Alwero River simulated discharge-sediment load rating curve at Alwero*

Taking April to March as the hydrological year, the sediment yield at Alwero station was calculated and results are indicated in Table 2-5.

*Table 2-5: Alwero River simulated sediment yield at Alwero station*

| | |
|---|---|
| **Catchment area (km$^2$)** | 2882 |
| **Average Qs (t/day)** | 1185 |
| **Sediment yield (t//km$^2$.a)** | 150 |

## 2.3.3 Gilo catchment

Based on the 30 arc Dem, a 125 x 95 grid of 1980 m spatial resolution Gilo watershed was delineated covering a total area of 10704 km$^2$.The watershed shown in Figure 2-36 formed the SHETRAN boundary with the basin outlet being the downstream boundary. Flow data to calibrate the catchment was available at the Gilo gauging station and sediment transport data was available at the Bitin Woho River near Tepi and Begwaha River near Tepi. Their locations relative to the whole catchment are shown in Appendix 11.

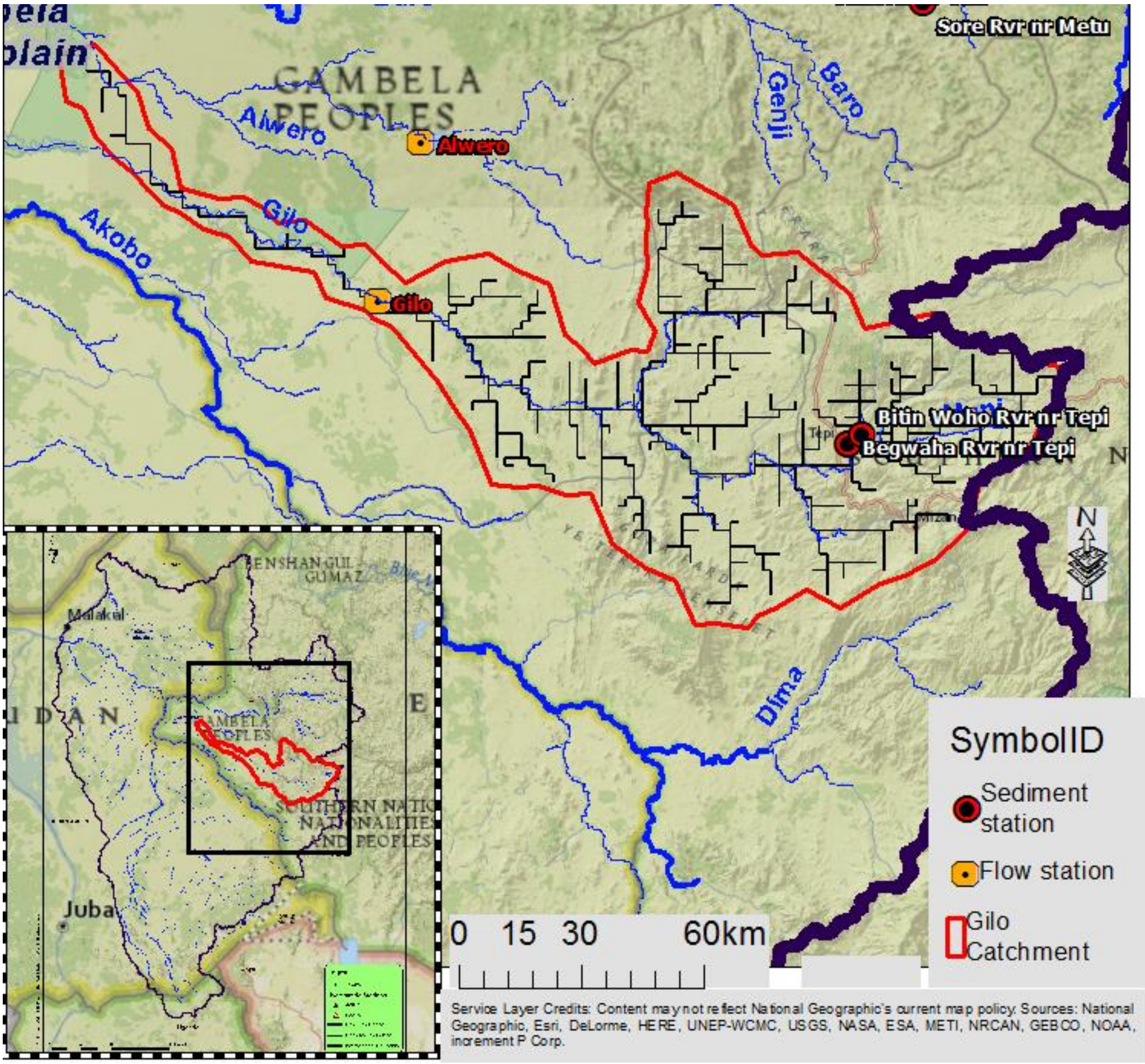



*Figure 2-36: Gilo River sub-catchment and SHETRAN river links (black) as used in SHETRAN model*

The main land uses in the catchment are shown in Figure 2-37 with forest, grassland, arable farming and shrub being dominant.

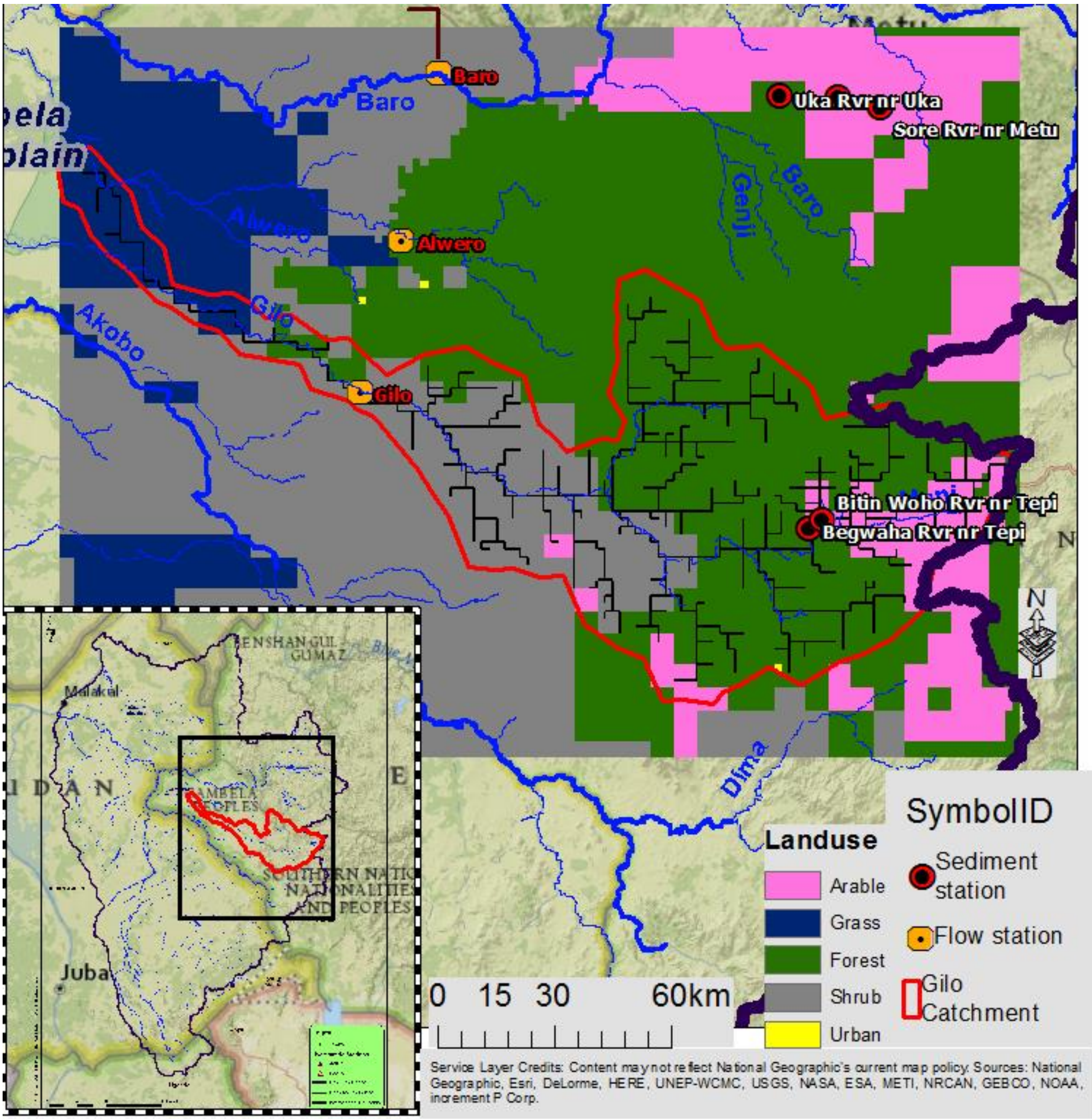



*Figure 2-37: Gilo River sub-catchment land use and SHETRAN river links (black) as used in SHETRAN model*

### 2.3.3.1 Gilo River flow calibration

The model was set up and flow-calibrated for the period 1952 to 1960 and validated for period 1987 to 1992. Model parameters that varied from the model default values are shown in Appendix 14. The main channel was calibrated to a Manning n value of 0.05 and overland values of 0.02 to 0.06 dependent on land use.

Saturated conductivity was calibrated to 15 m/day for the upper 1m horizon of soil and 5 m/day for 14 m lower horizon.

The Gilo gauging station calibration graph is shown in Figure 2-38 while the validation graph is shown in Figure 2-39.

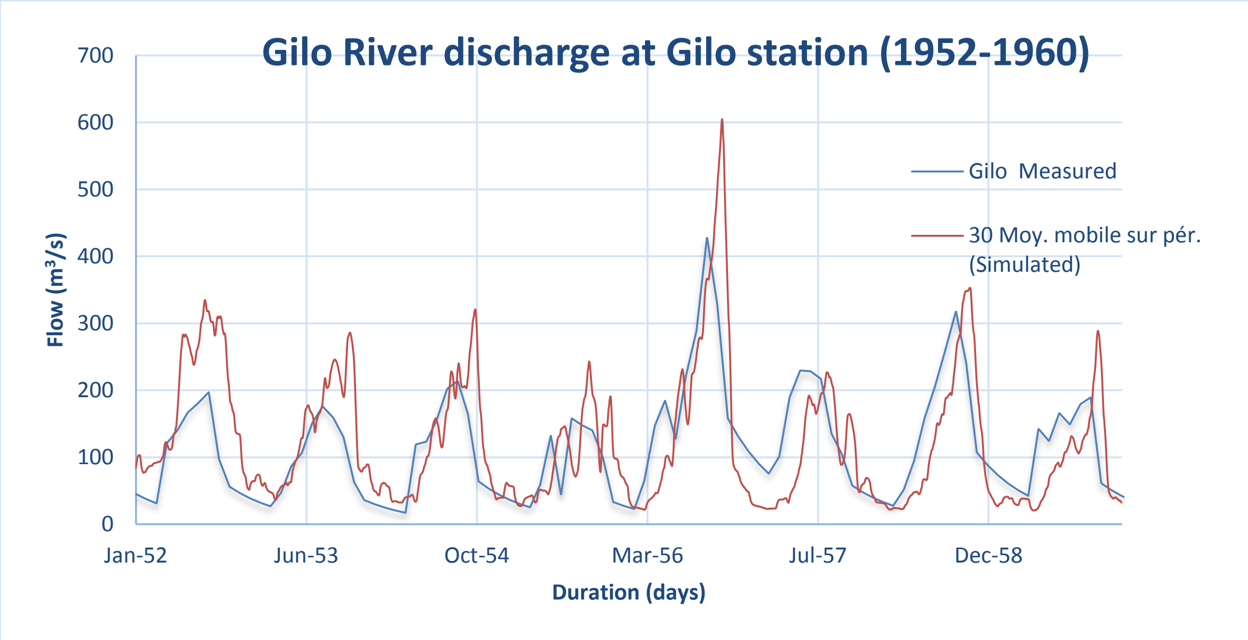



*Figure 2-38: Gilo River calibration at Gilo station (plotted as monthly flows)*

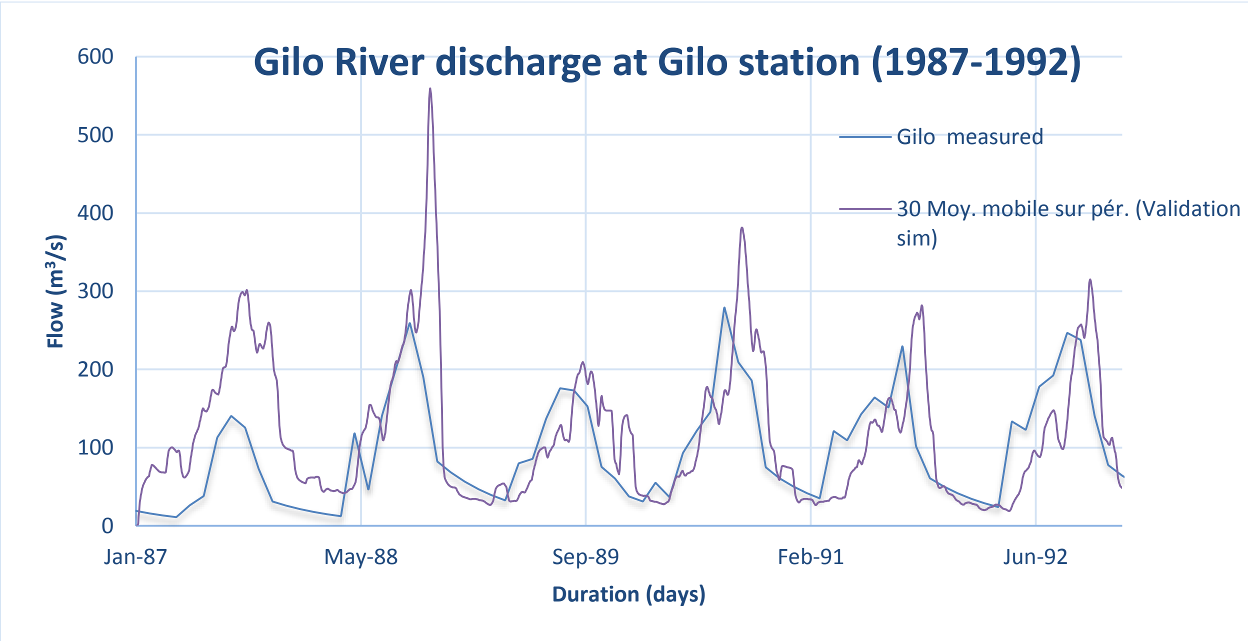



*Figure 2-39: Gilo River validation at Gilo station (plotted as monthly flows)*

The long term simulation flows for the whole period is shown in Figure 2-40.

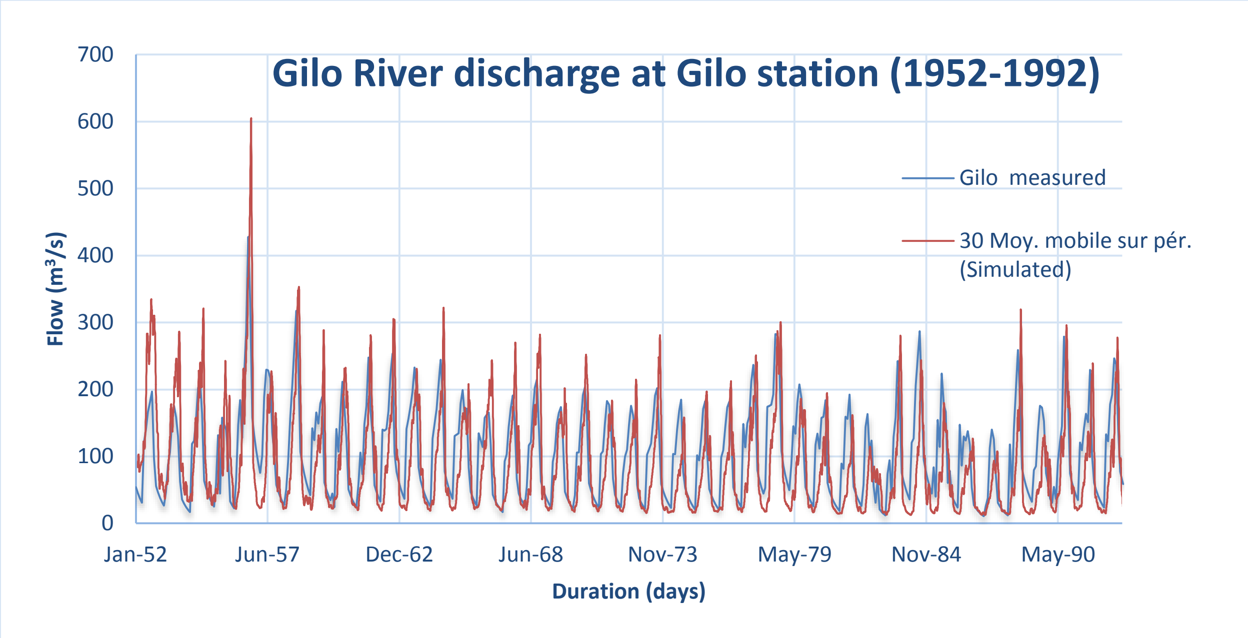



*Figure 2-40: Gilo River long-term simulated flows at Gilo (plotted as monthly flows)*

### 2.3.3.2 Sediment transport calibration

Sediment transport data at Bitin Woho River and Begwaha River near Tepi (TAMS_1F, 1997) were available. Coordinates of these sampling stations were not available, but approximate locations were used.

Seven-grain sizes were used with grains less than 0.1 mm taken as fines. The initial composition is shown in Table 2-6 which was adopted from the SELKHOZPROMEXPORT (1990) report to conform to clay loam type of soil.

*Table 2-6 Gilo River soil composition by size group*

| Grain size (mm) | 0.1 | 0.37 | 0.89 | 1.5 | 2.2 | 3.2 | 8 |
|---|---|---|---|---|---|---|---|
| Soil composition (%) | 60 | 20 | 10 | 5 | 3 | 2 | 0 |

A sediment discharge-sediment load rating curve was plotted for the data and corresponding simulated sediment discharge rate of similar period. This was used to calibrate the model and resultant graphs are shown in Figure 2-41 and Figure 2-42.

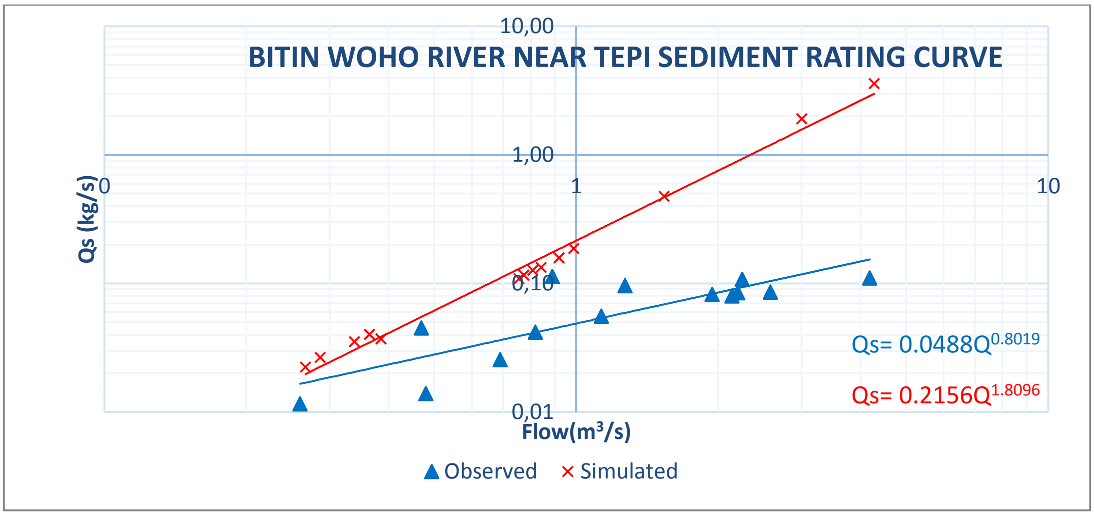



*Figure 2-41: Bitin Woho River near Tepi sediment load rating curve*

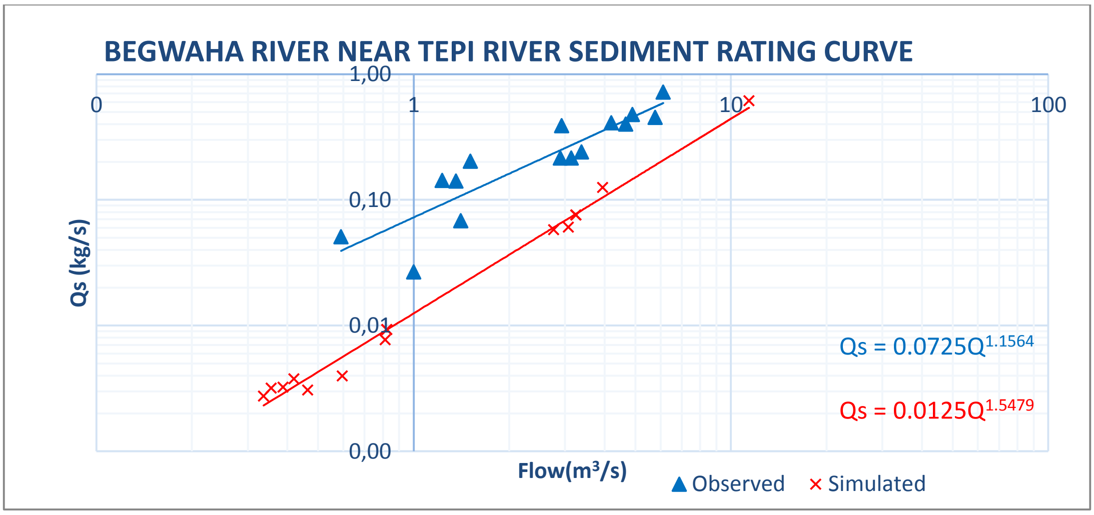



*Figure 2-42: Begwaha River near Tepi sediment load rating curve*

The simulated sediment loads rate at the Gilo station are shown in Figure 2-43.

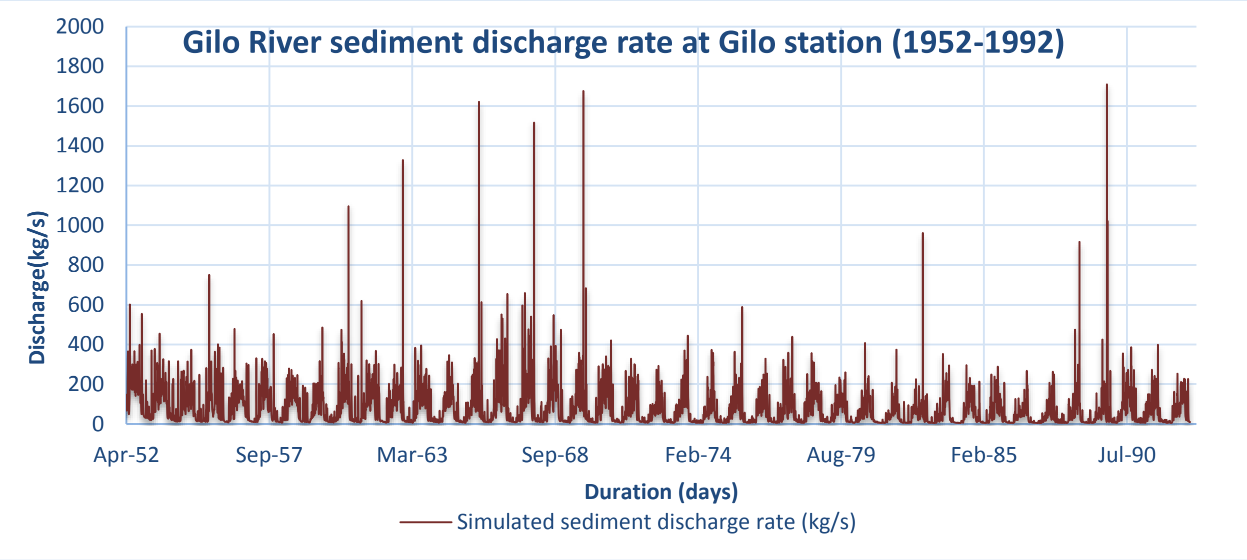



*Figure 2-43: Gilo River simulated sediment loads at Gilo*

The simulated discharge-sediment load rating curve for Gilo station is shown in Figure 2-44.

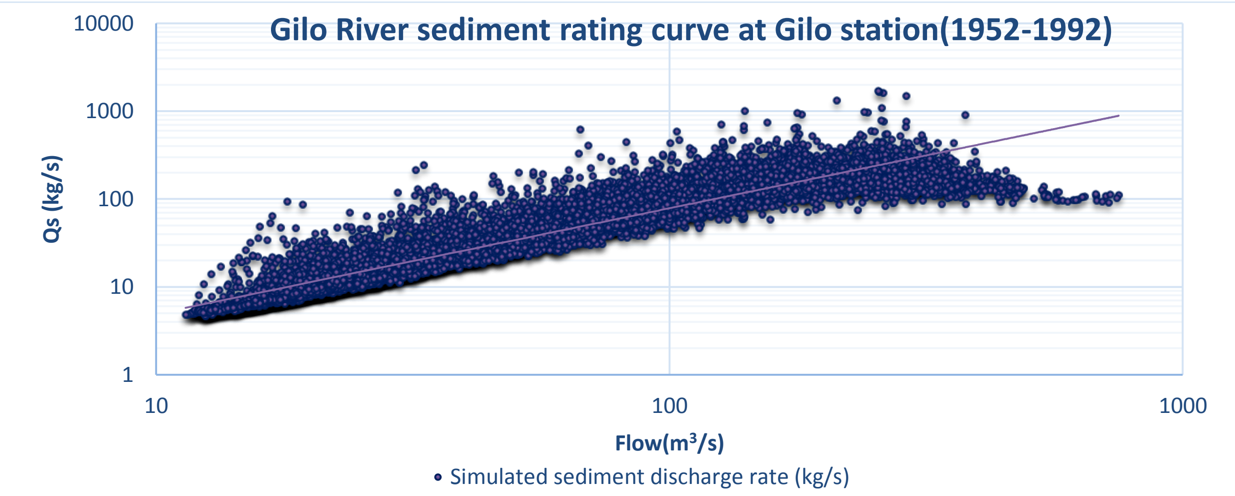



*Figure 2-44: Gilo River simulated sediment rating curve at Gilo station*

Taking April to March as the hydrological year, the sediment yield at the sampling location was calculated and compared to previous studies. Table 2-7 shows the resultant value. The sediment yield calculated for this study is lower than that of the previous study, but is based on a 40 year simulation. Due to the uncertainty of the sampling station location, it is difficult to compare and evaluate the results.

*Table 2-7: Gilo catchment sediment yield comparison with previous studies*

| | Previous studies (SELKHOZPROMEXPORT, 1990) | | | Simulated | | |
|---|---|---|---|---|---|---|
| **River Station** | **Area ($km^2$)** | **Mean annual flow ($m^3/s$)** | **Annual sediment load ($t//km^2/a$)** | **Area ($km^2$)** | **Mean annual flow ($m^3/s$)** | **Annual Sediment Load ($t/km^2.a$)** |
| Begwaha River | 125 | 3.33 | 85 | 77 | 0.41 | 32 |

### 2.3.4 Akobo catchment

30 Arc DEM data was used to delineate the Akobo watershed based on the SHETRAN 200x200 grid limitation and 1500 river channel links. 151x95 grid of 1970 m spatial resolution represented the watershed with a total catchment area of 17809 km$^2$. The watershed formed the model boundary with the river outlet the downstream boundary. Forty years' flow record was available at Akobo gauging station for calibrations purposes, however with no sediment sampling data.

Figure 2-45 shows the Akobo watershed extent and river links as calculated by SHETRAN model.

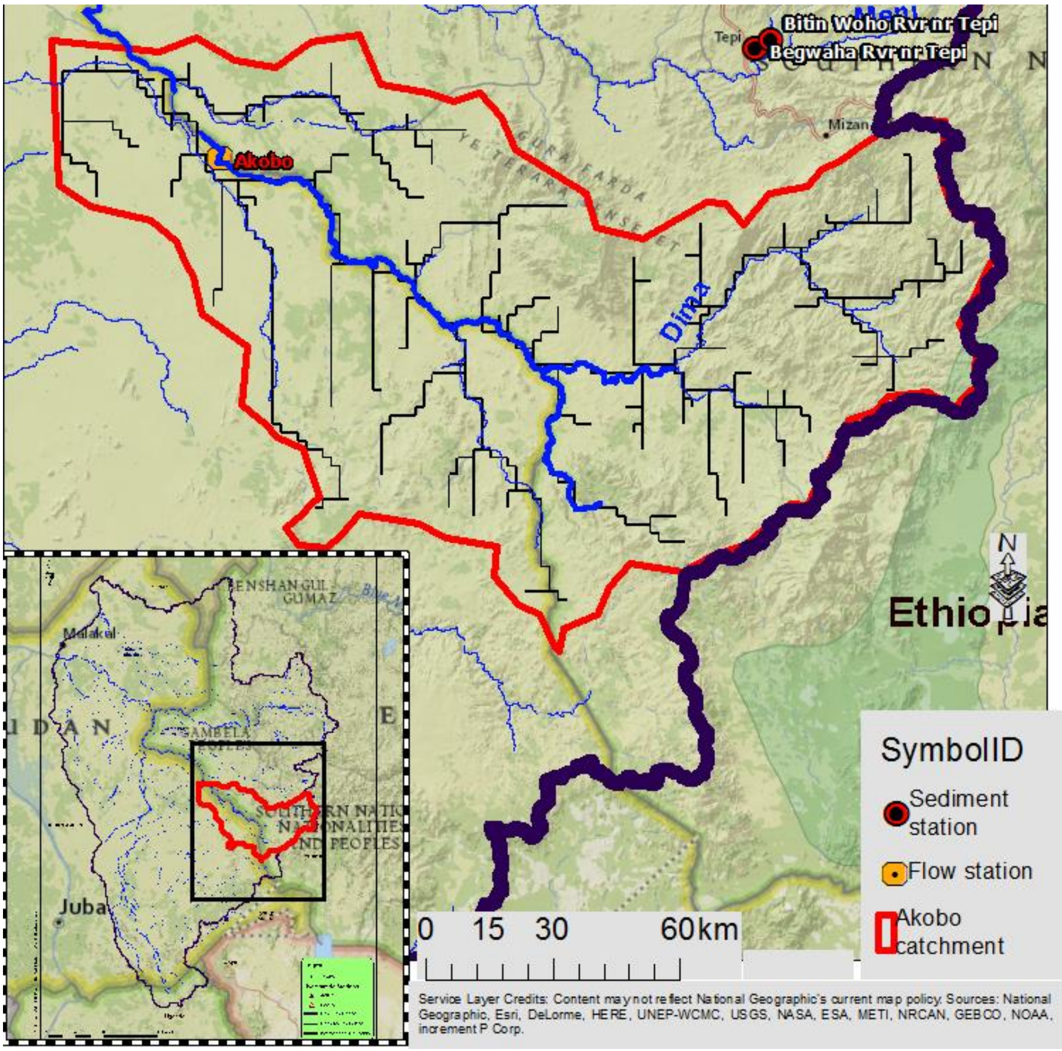



*Figure 2-45: Akobo River sub-catchment and SHETRAN river links (black) as used in SHETRAN model*

To conform to the SHETRAN library five main land uses were identified: arable, forest, grass, shrub and urban. Their variation in the Akobo watershed is shown in Figure 2-46.

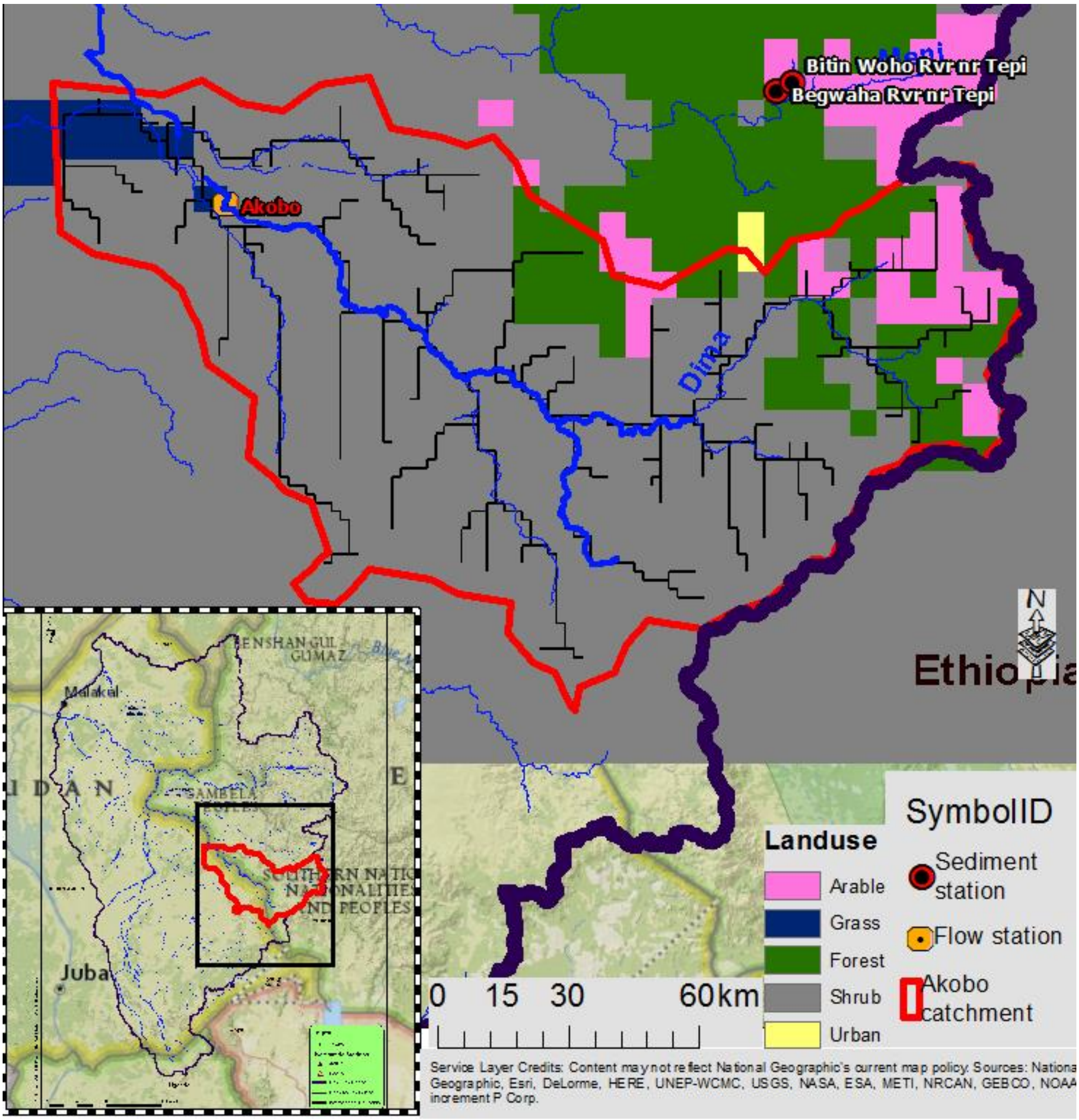



*Figure 2-46: Akobo River sub-catchment (red) land use variation as used in SHETRAN model*

### 2.3.4.1 Akobo catchment flow calibration

The model was set up and flow-calibrated for the period 1952 to 1960, and validated for the period 1987 to 1992. Parameters that varied from the model default values are shown in **Appendix 15**. The main channel was calibrated to Manning n value of 0.03 and overland values of 0.02 to 0.06 dependent on land use. Saturated conductivity was calibrated to 15 m/day for the upper 1m horizon of soil and 5 m/day for 14 m lower horizon.

The Akobo gauging station calibration graph is shown in Figure 2-47 while the validation graph is shown in Figure 2-48. The resultant simulated discharge graph is shown in Figure 2-49.

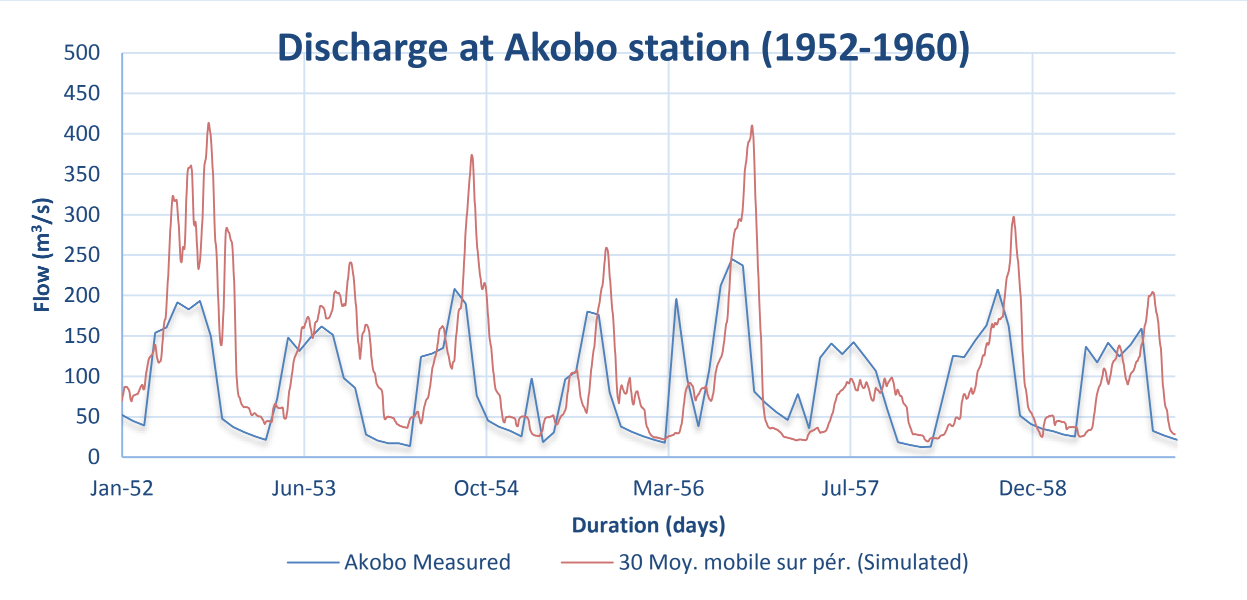



*Figure 2-47: Akobo River calibration at Gilo station (plotted as monthly flows)*

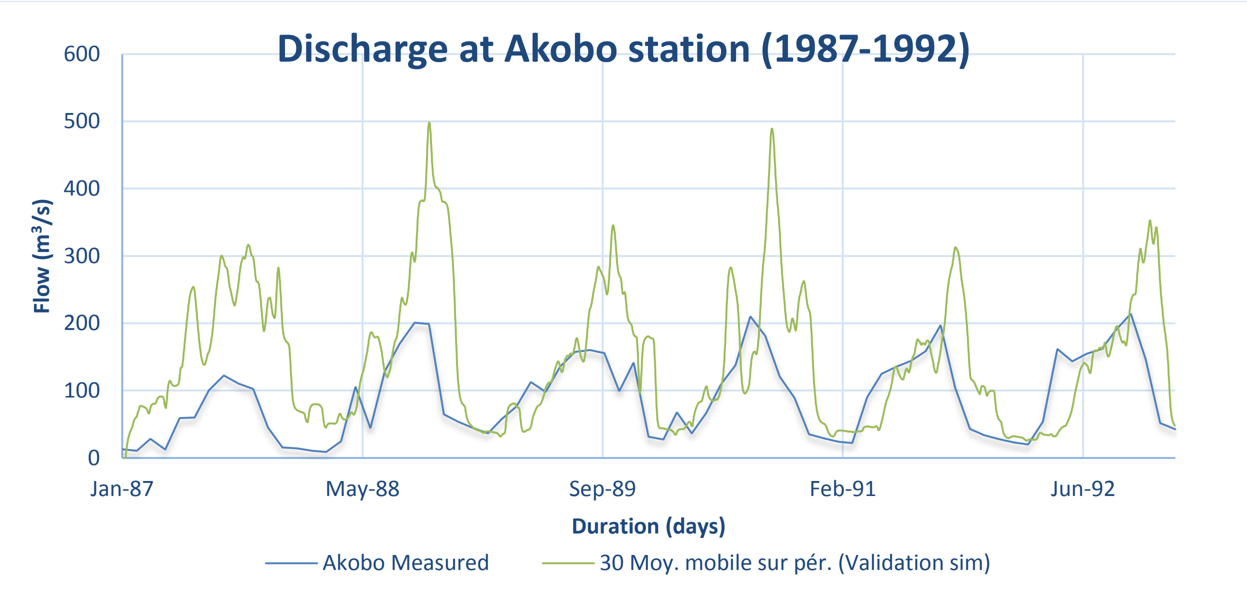



*Figure 2-48: Akobo River validation at Akobo station (plotted as monthly flows)*

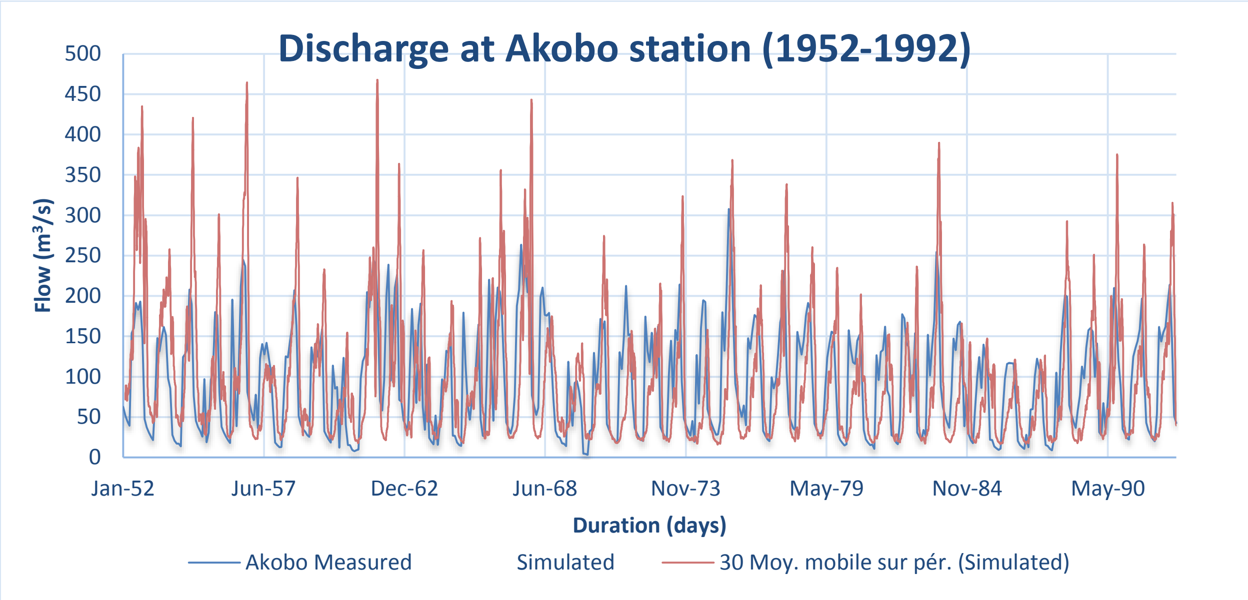



*Figure 2-49: Akobo River long-term simulated flows at Akobo station (plotted as monthly flows)*

### 2.3.4.2 Sediment calibration

There was no sediment calibration data available in this catchment thus SHETRAN parameters from the neighbouring Gilo catchment were used. Figure 2-50 shows the simulated sediment discharge rate at the Akobo gauging station.

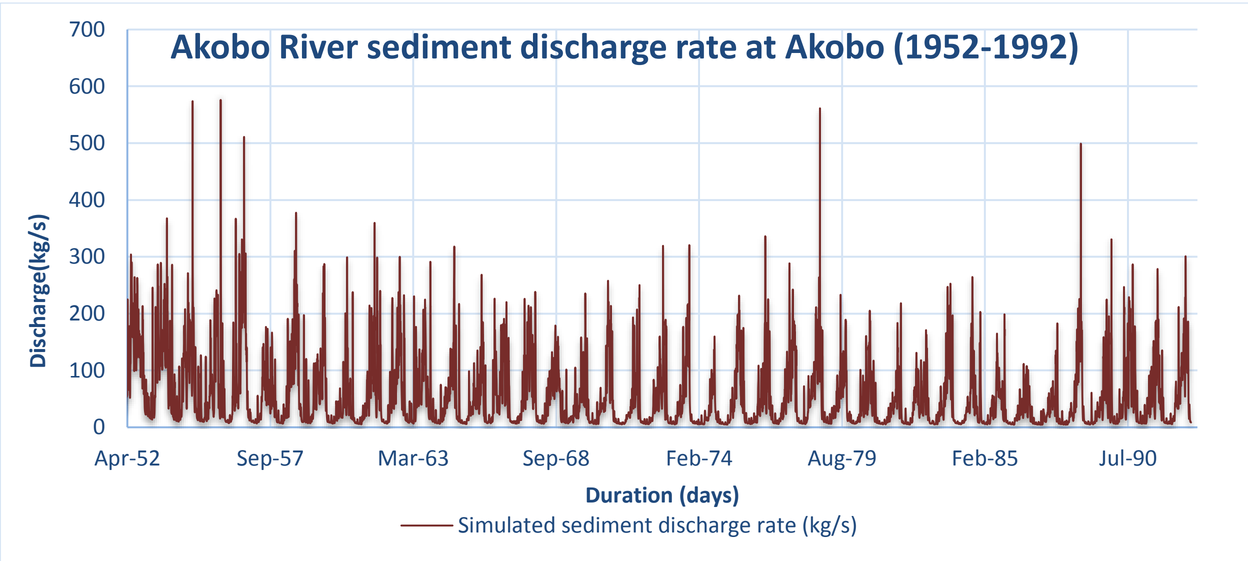



*Figure 2-50: Akobo River simulated sediment loads at Akobo*

The sediment discharge rating curve for the Akobo station is shown in Figure 2-51.

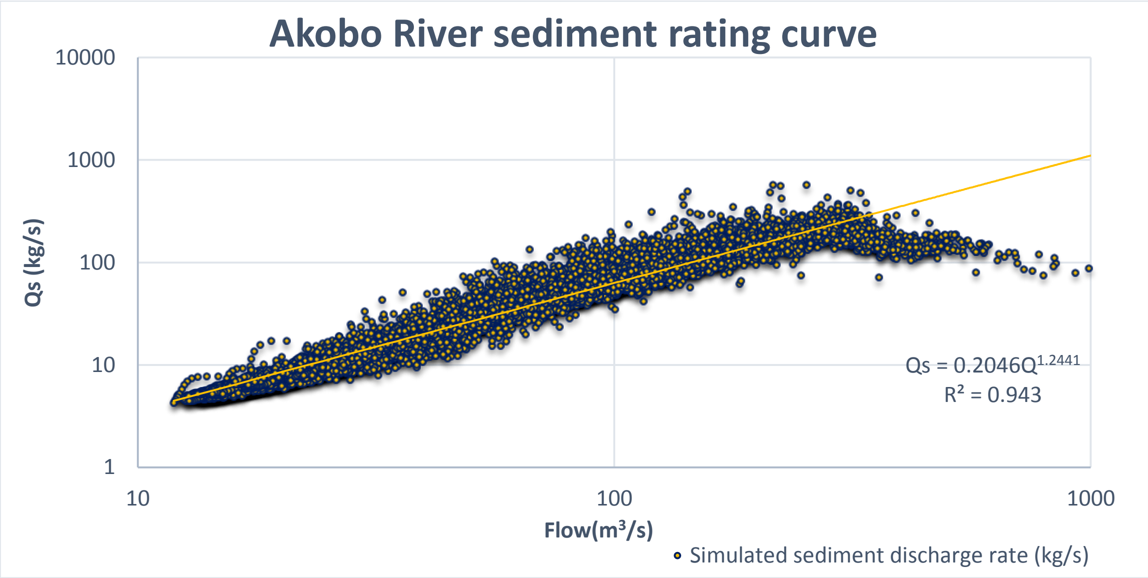



*Figure 2-51: Akobo River sediment rating curve at Akobo*

Taking April to March as the hydrological year, the sediment yields at the gauging station was calculated and the results are shown in Table 2-8.

*Table 2-8: Akobo River sediment yield calculation at Akobo station*

| | |
|---|---|
| **Catchment area (km$^2$)** | 12514 |
| **Average Qs (t/day)** | 4514 |
| **Sediment yield (t/km$^2$.a)** | 132 |

## 2.3.5 Agwei Catchment

Based on 30 arc DEM, the Agwei catchment was delineated within 200x200 SHETRAN grid limitations and 1500 river links limits. Two catchments were delineated, Agwei catchment (196x197 grids) and Lower Pibor (136x144 grids) of 1980 m spatial resolution. These are shown in Figure 2-52. The watershed formed the model outer boundary with the river outlet marking the downstream boundary.

Forty year's flow data record was available at Agwei gauging station for calibration and validation purposes. No sediment sampling data was available for this catchment.

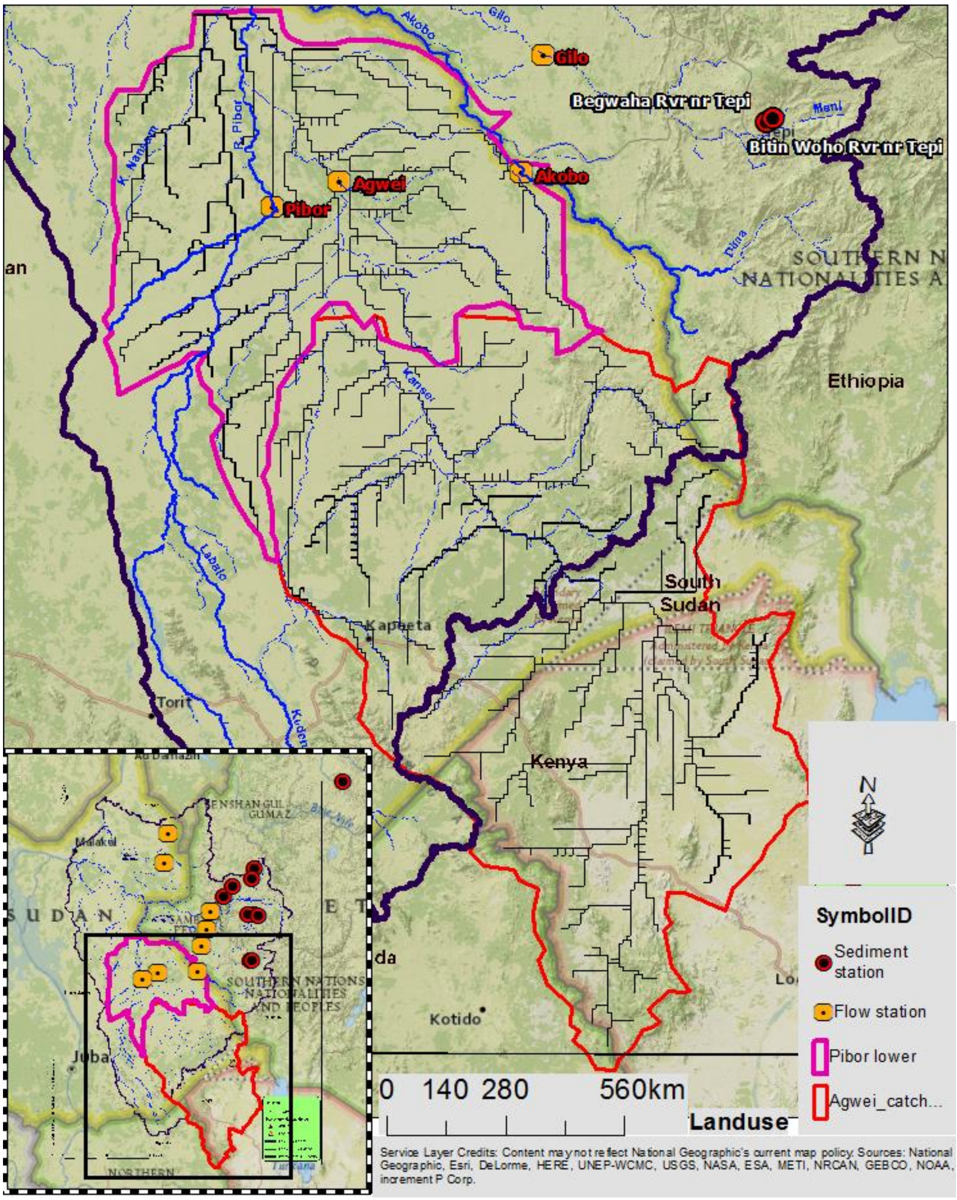



*Figure 2-52: Agwei River sub catchment and SHETRAN river links (black) as used in the SHETRAN model*

To conform to SHETRAN vegetation library two main land uses were identified: shrub and grass. Their variation in the catchment is shown in Figure 2-53.

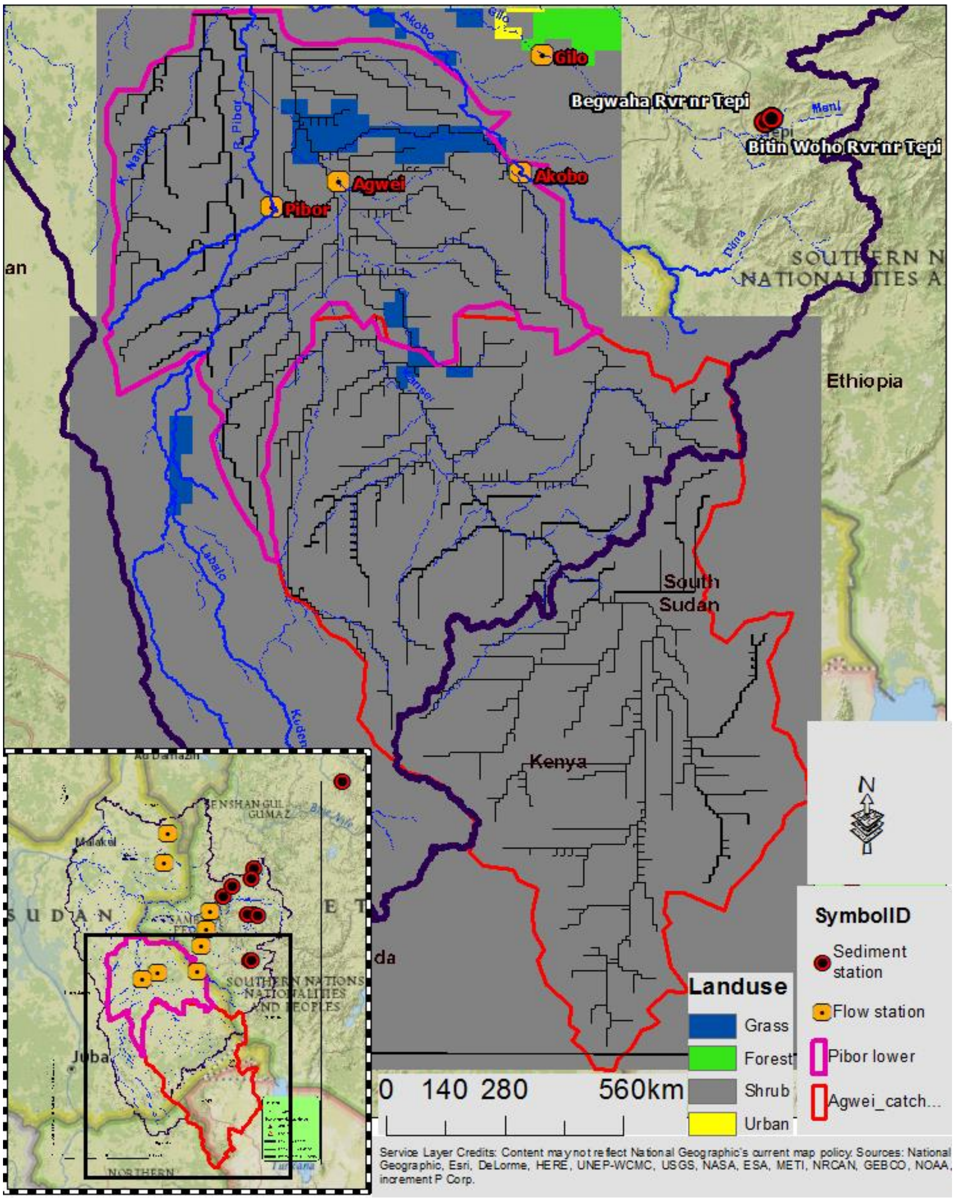



*Figure 2-53: Agwei River sub-catchment land use variation as used in SHETRAN model*

### 2.3.5.1 Agwei catchment flow calibration

The model was set up and flow-calibrated for the periods 1952 to 1960 and validated for the period 1989 to 1992. Due to the gauging station being located in the Lower Pibor catchment, SHETRAN parameters were similar with outlet flow at Agwei being the upstream boundary flows of the Lower Pibor. Vegetation parameters that varied from the model default are shown in **Appendix 17**.

The main channel was calibrated to a Manning n value of 0.04 and overland values of 0.02 to 0.06 dependent on land use. Saturated conductivity was calibrated to 15 m/day for the upper 3 m horizon and 5 m/day for the lower 12 m horizon.

The Agwei station calibration graph is shown in Figure 2-54, while the validation graph is shown in Figure 2-55. The simulated flows for 40 years (1952 to 1992) are shown in Figure 2-56).

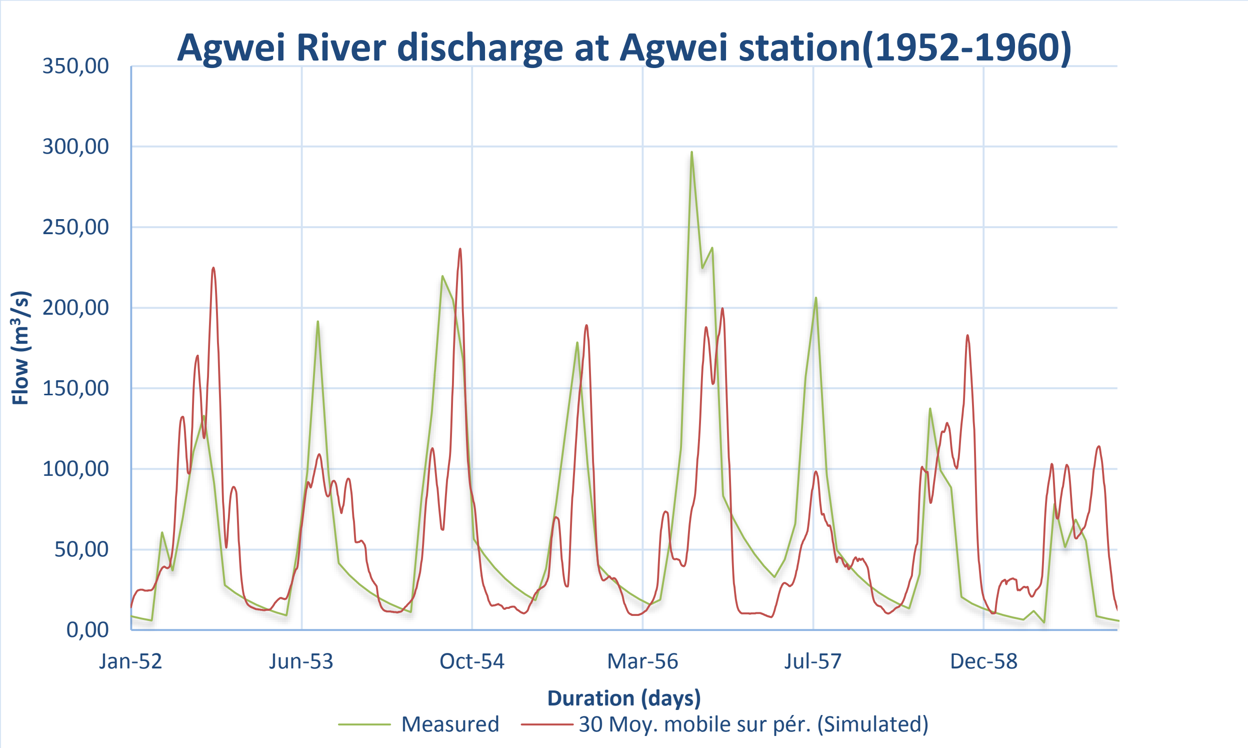



*Figure 2-54: Agwei River calibration at Agwei station (plotted as monthly flows)*

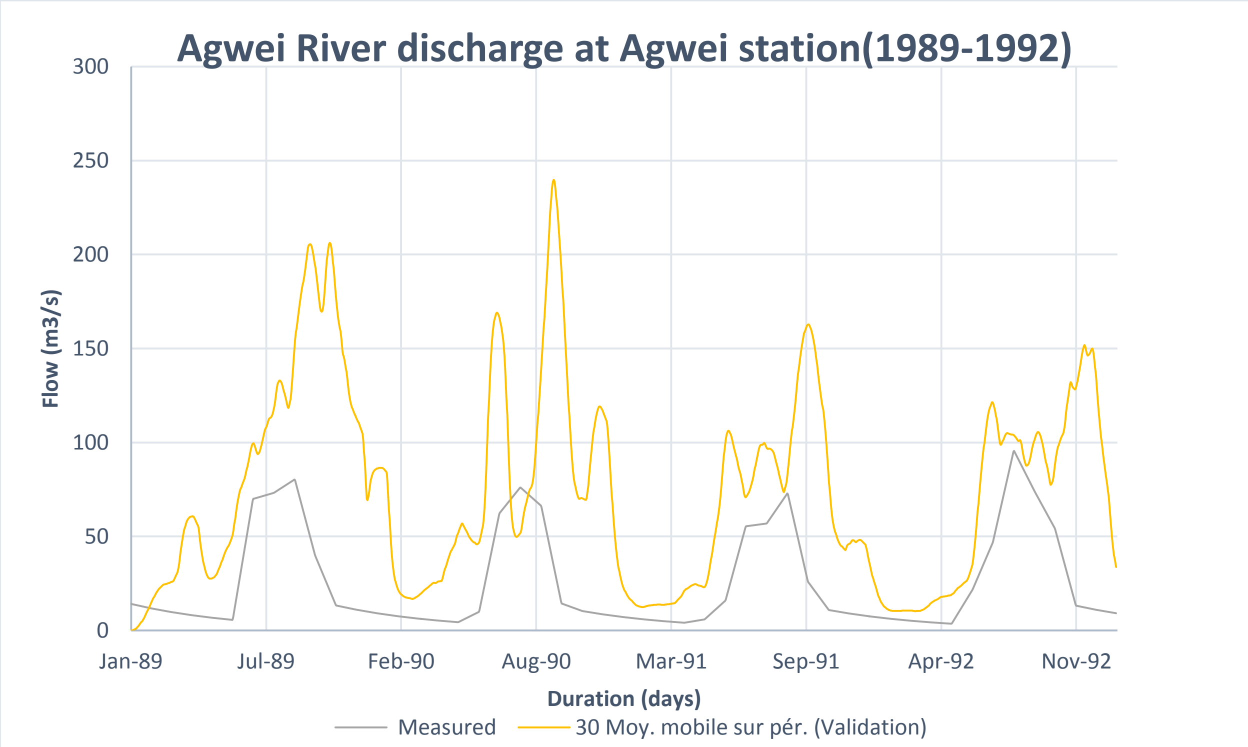



*Figure 2-55: Agwei River validation at Agwei station (plotted as monthly flows)*

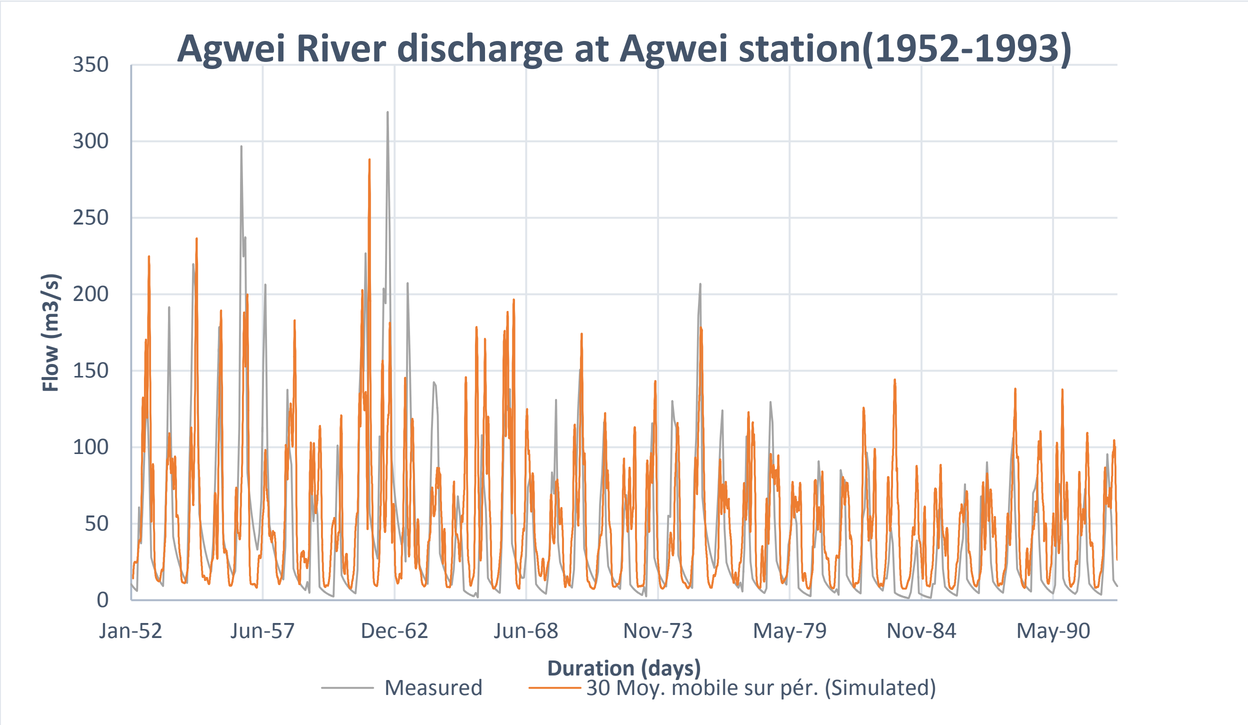



*Figure 2-56: Agwei River simulated flows at Agwei station (plotted as monthly flows)*

### 2.3.5.2 Sediment calibration

No sediment calibration data was available for this catchment thus, SHETRAN parameters from the Gilo watershed were used. The Agwei gauging station simulated sediment loads are shown in Figure 2-57 and the rating curve in Figure 2-58.

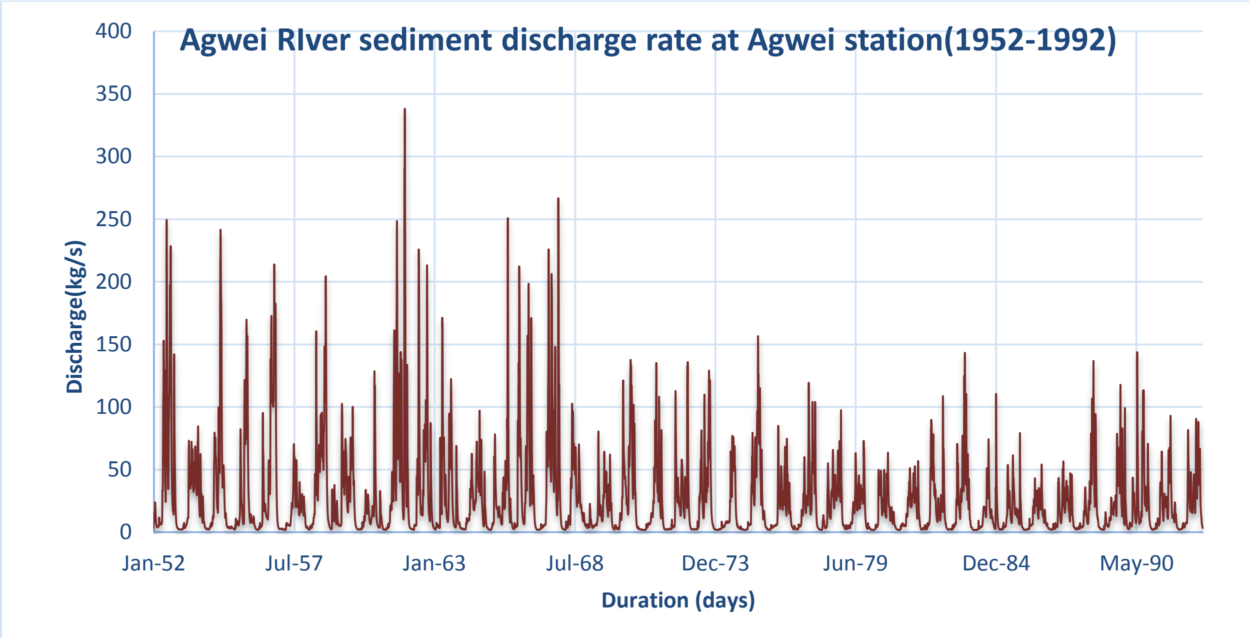



*Figure 2-57: Agwei River simulated sediment loads at Agwei station*

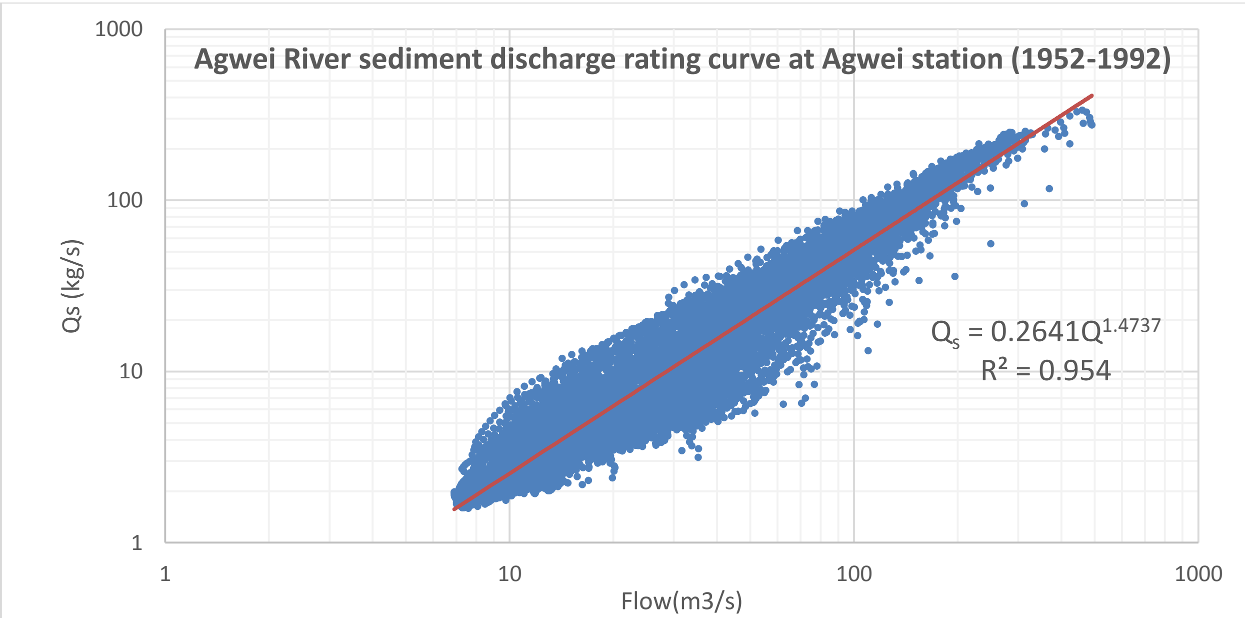



*Figure 2-58: Agwei River simulated sediment rating curve at Agwei station*

The sediment yield at the gauging station was calculated taking April to March as the hydrological year. Table 2-9 shows the resulting sediment yield calculation.

*Table 2-9: Agwei River sediment yield calculation at Agwei station (1952-1992)*

| | |
|---|---|
| **Catchment area (km$^2$)** | 81479 |
| **Average Qs (t/day)** | 2276 |

| | |
|---|---|
| **Sediment yield (t/km².a)** | 10 |

### 2.3.6 Pibor catchment

Based on 30 arc DEM, the Pibor catchment was delineated within 200x200 grids limitations and 1500 river channel links. 111x153 grid of 1980 spatial resolution represented the Pibor catchment of 28254 $km^2$.The catchment formed the model boundary with the outlet being the downstream boundary. Forty years' flow record data was available at the Pibor gauging station with no sediment sampling data available for this watershed.

Figure 2-59 shows Pibor River catchment extent, the location of gauging stations and river links as calculated by SHETRAN model.

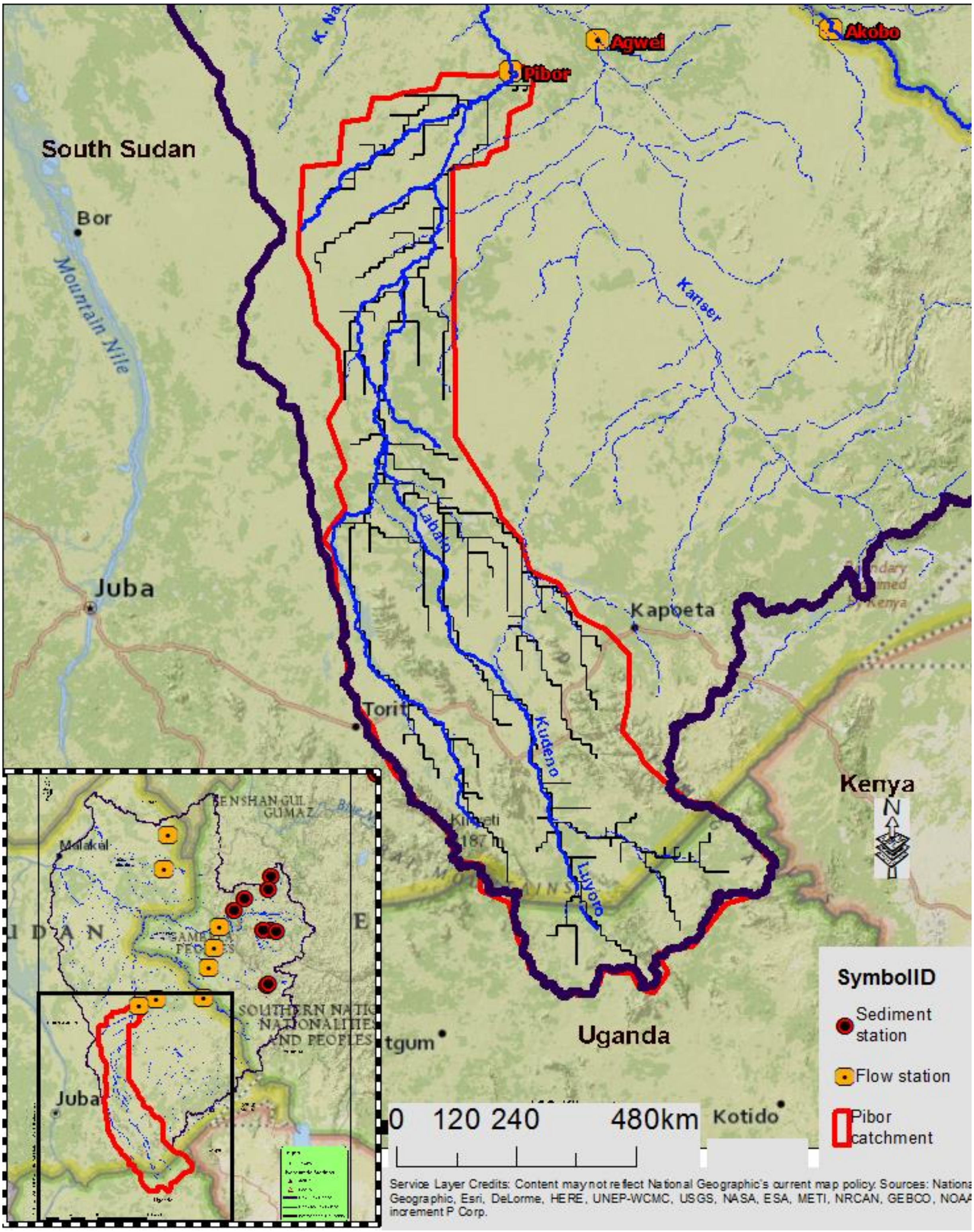



*Figure 2-59: Pibor River sub-catchment and SHETRAN river links (black) as used in the SHETRAN model*

To conform to the SHETRAN land use library, two main land uses were identified: grass and shrub. Their variation in the catchment is shown in Figure 2-60.

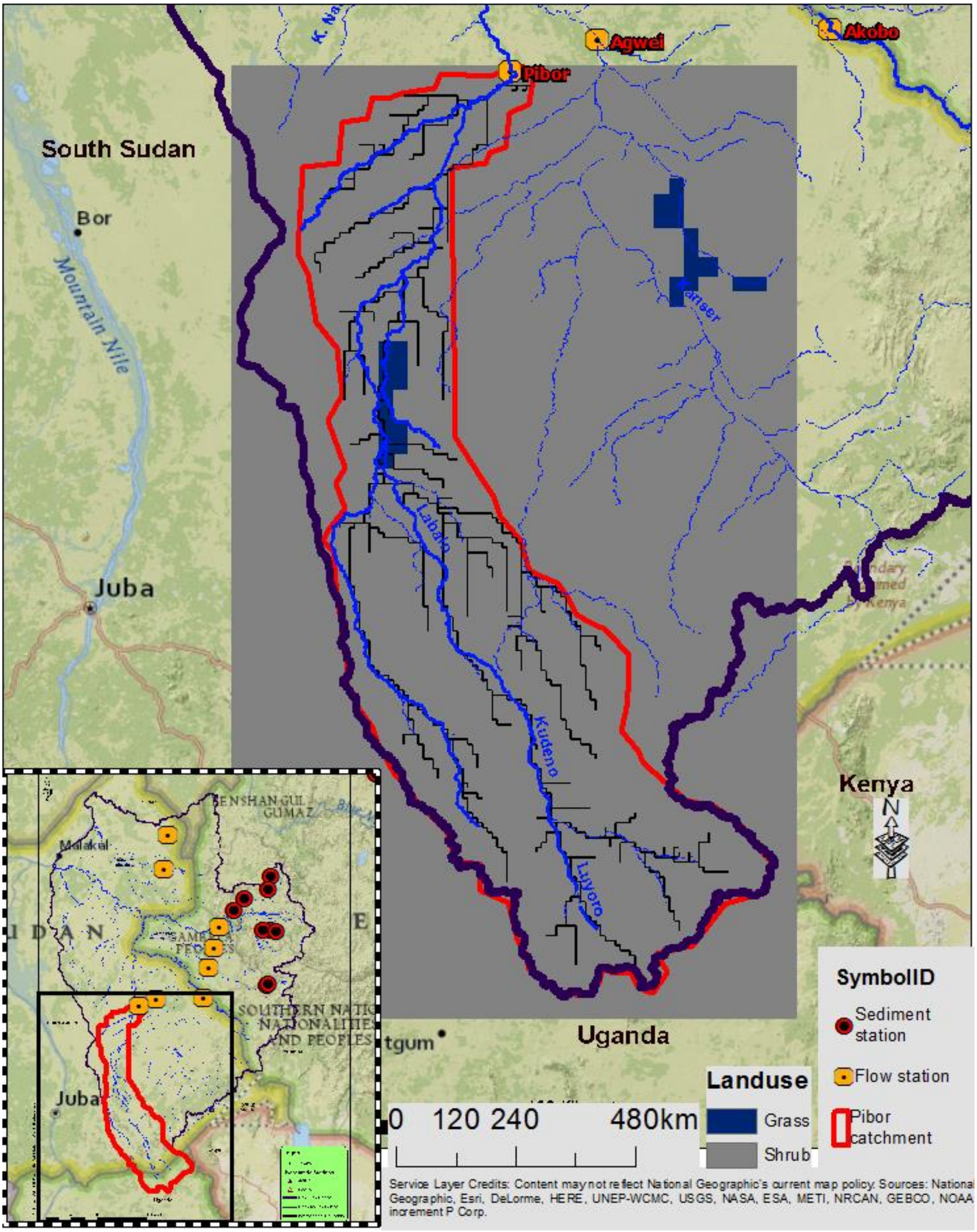



*Figure 2-60: Pibor River sub-catchment land use variation as used in SHETRAN model*

### 2.3.6.1 Pibor catchment flow calibration

The model was set up and calibrated for the period 1952 to 1990 and validated for the period 1989 to 1992. Parameters that varied from the model default values are shown in

Appendix 16. The main channel was calibrated to Manning n value of 0.04 and overland n values of 0.02 to 0.06 dependent on land use. Saturated conductivity was calibrated to 15 m/day for the upper 1 m horizon and 5 m/day in the lower 12 m lower horizon.

The Pibor station calibration graph is shown in Figure 2-61 while the validation graph is shown in Figure 2-62. The calibration seems reliable based on the  flows, but during the validation period the simulated flows are overestimated. Figure 2-63 shows the simulated 40 year flow record.

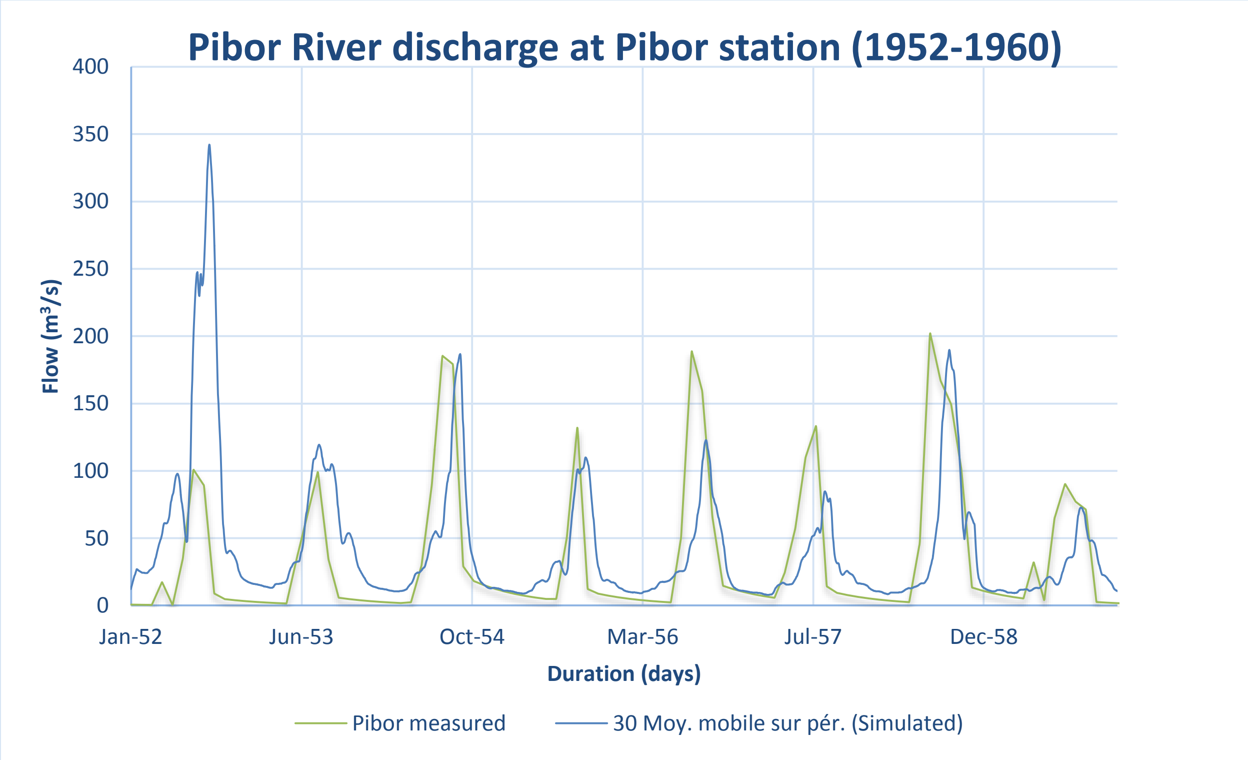



*Figure 2-61: Pibor River calibration at Pibor station (plotted as monthly flows)*

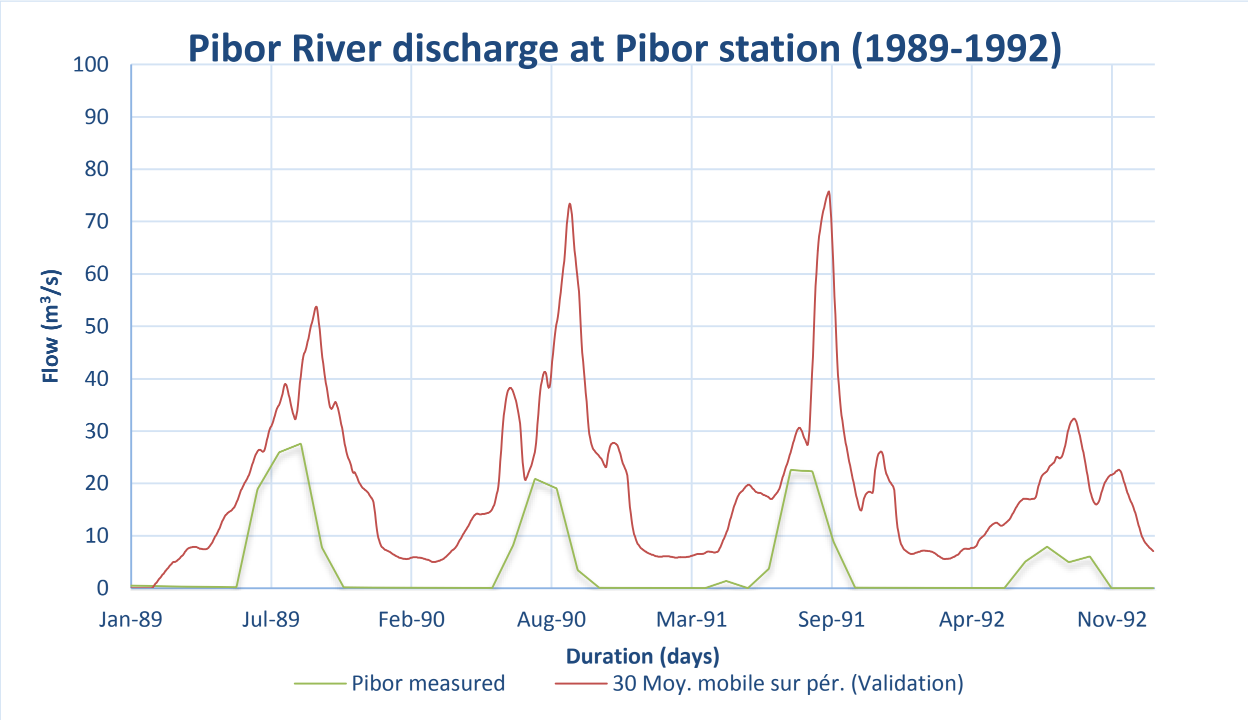



*Figure 2-62: Pibor River validation at Pibor station (plotted as monthly flows)*

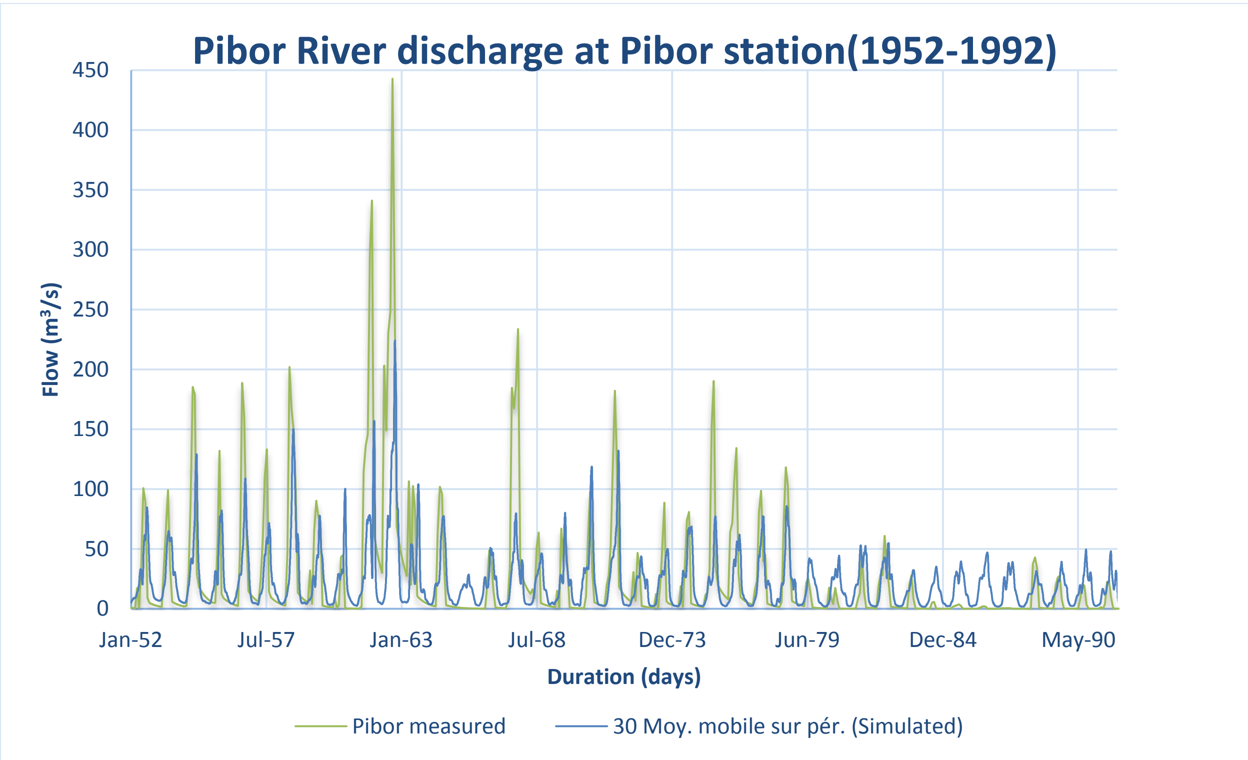



*Figure 2-63: Pibor River simulated flows at Pibor station (plotted as monthly flows)*

### 2.3.6.2 Sediment calibration

There was no calibration data available in this catchment thus the SHETRAN parameters from the Gilo catchment were used. The Pibor gauging station simulated sediment loads are shown in Figure 2-64 and the rating curve in Figure 2-65.

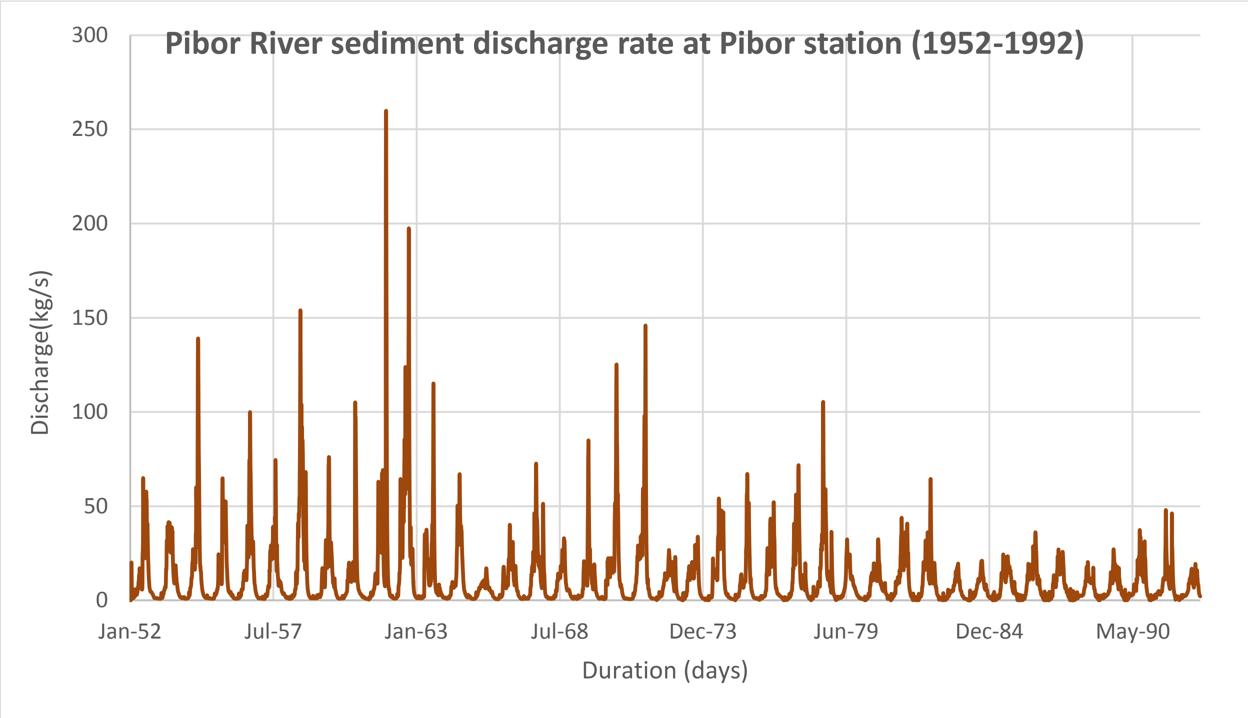



*Figure 2-64: Pibor River simulated sediment loads at the Pibor station*

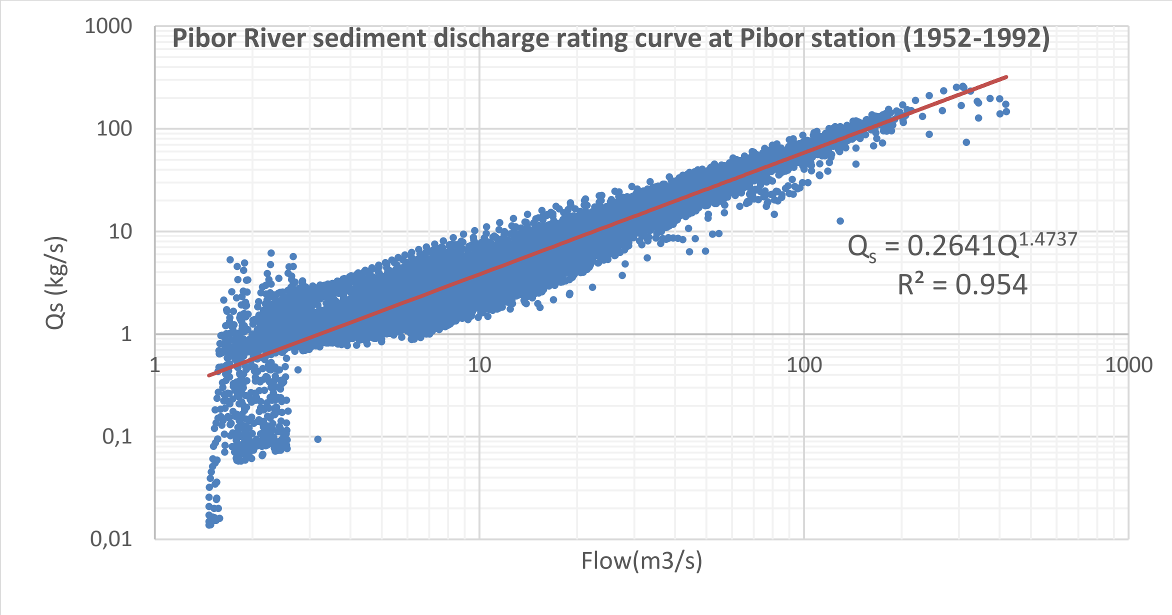



*Figure 2-65: Pibor River simulated sediment load rating curve at the Pibor station*

The Pibor station sediment yield was calculated taking April to March as the hydrological year. Table 2-10 shows the resulting sediment yield calculation.

*Table 2-10: Pibor River sediment yield calculation at Pibor gauging station (1952-1992)*

| | |
|---|---|
| **Catchment area (km$^2$)** | 28254 |
| **Average Qs (t/day)** | 1027 |
| **Sediment yield (t/km$^2$.a)** | 13 |

## 2.3.7 Daga and Yabus catchment

The Daga and Yabus catchments were delineated from a 30 arc DEM within 200x200 SHETRAN grid limitation and 1500 river links. 112 x107 grids of 1980 spatial resolution represented this watershed shown in Figure 2-66.

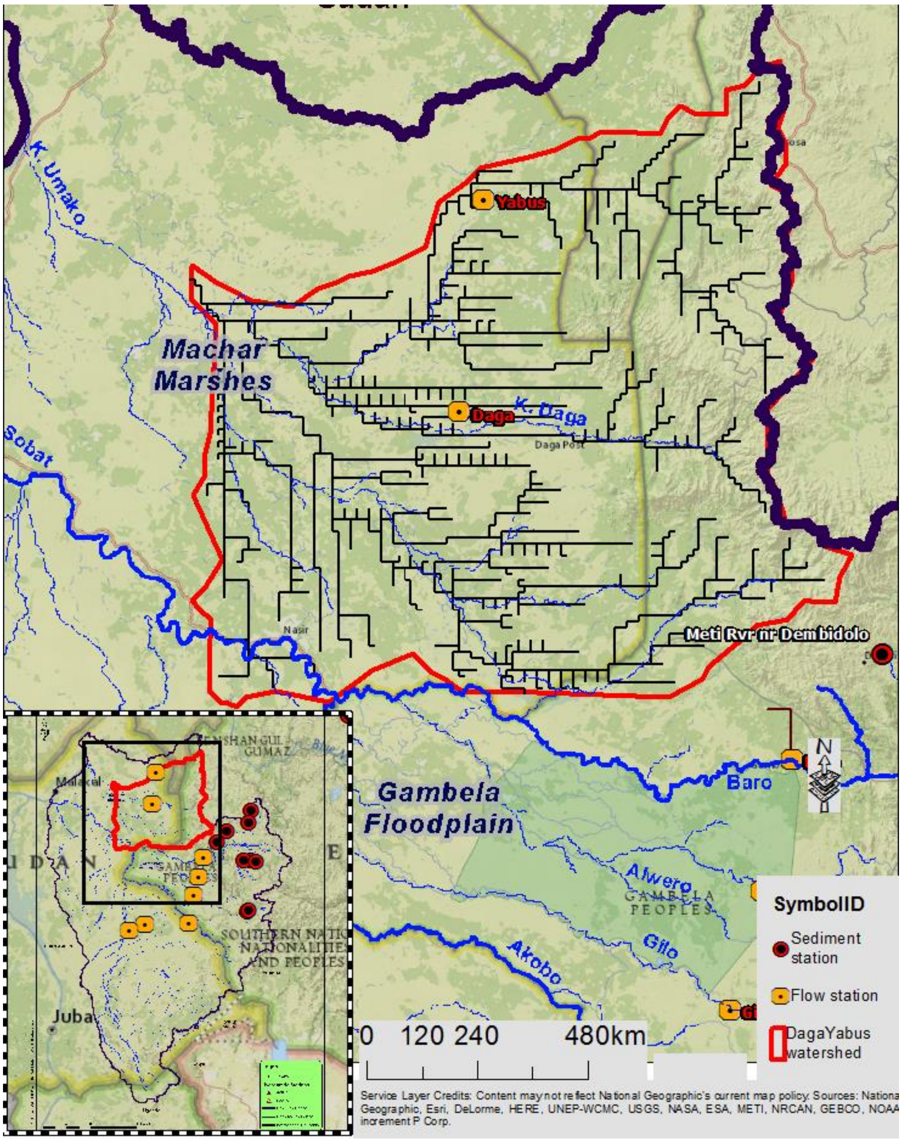



*Figure 2-66: Daga and Yabus sub-catchment and SHETRAN river links (black) as used in the model*

To conform to the SHETRAN land use library, four vegetation classes were identified and are shown in Figure 2-67.

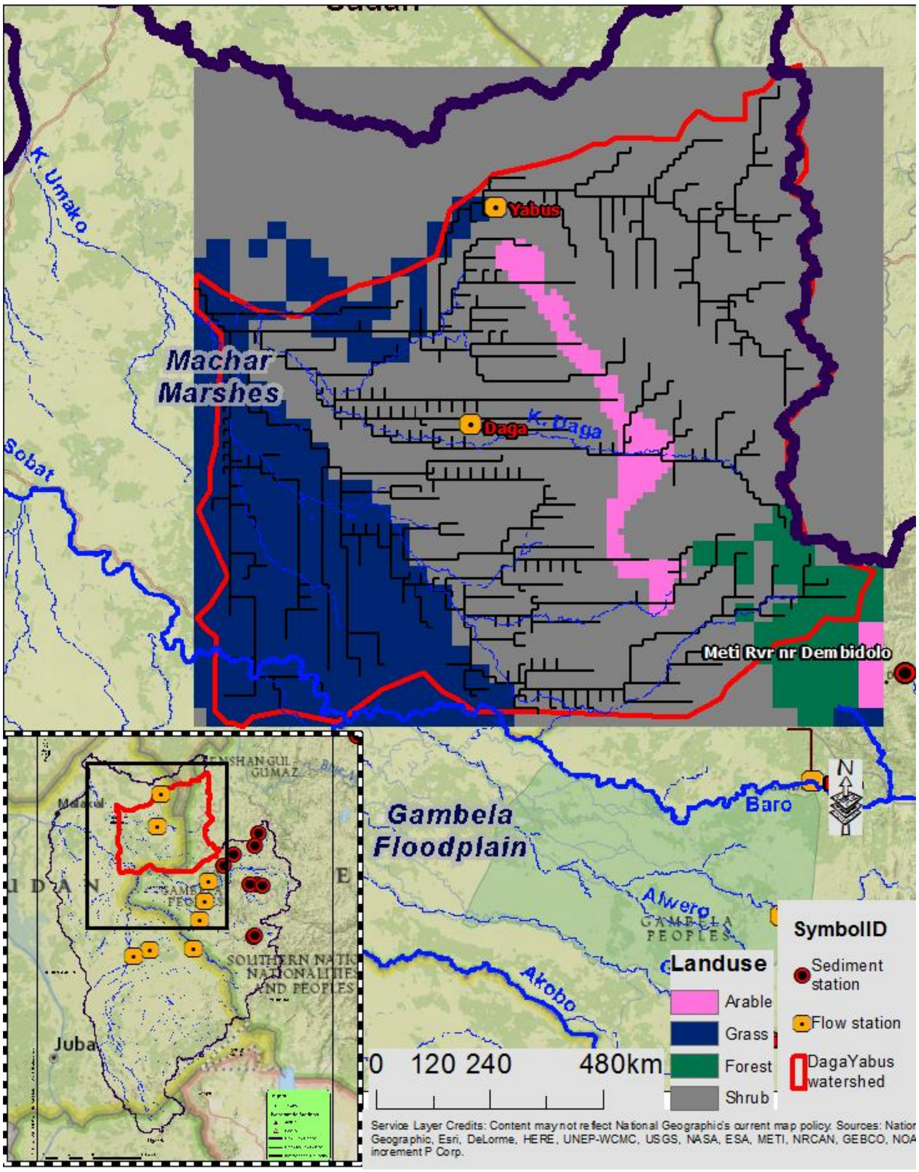



*Figure 2-67: Daga and Yabus sub-catchment land used variation as used in SHETRAN model*

### 2.3.7.1 Daga and Yabus River flow calibration

The model was set up and flow calibrated for the period 1952 to 1960, and validated for the period 1989 to 1992. Parameters that varied from the model default values are shown in Appendix 18. The main channel was calibrated to a Manning n value of 0.04 and overland range of 0.05 to 0.2 dependent on vegetation type.

The Daga River catchment calibration graph is shown in Figure 2-68, while the validation is shown in Figure 2-69. The simulation for the whole period 1952 to 1992 is shown in Figure 2-70.

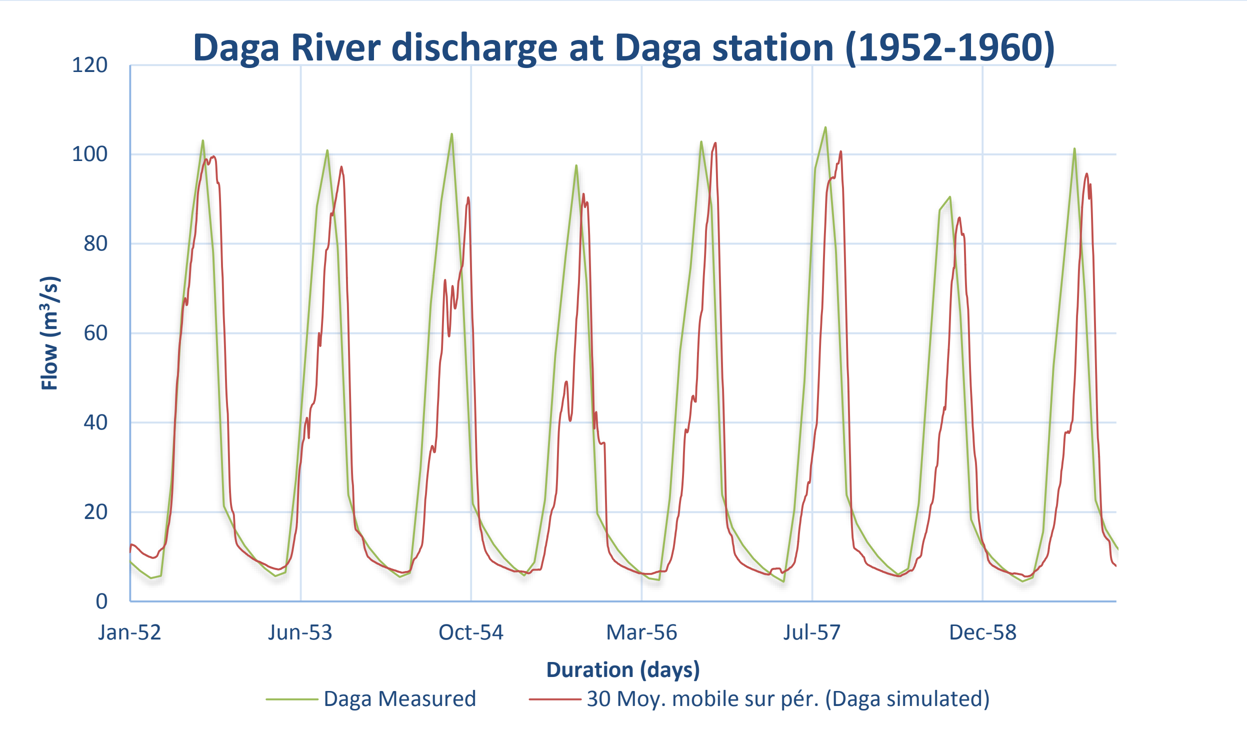



*Figure 2-68: Daga River calibration at Daga gauging station (plotted as monthly flows)*

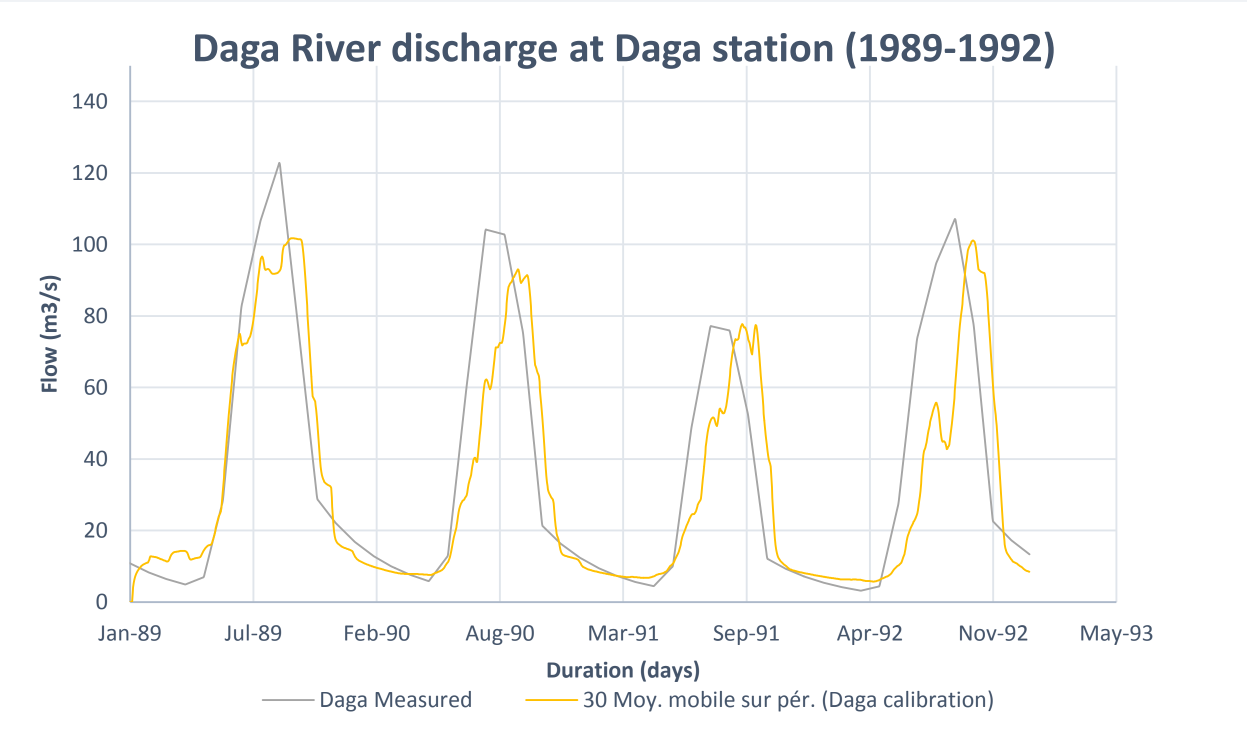



*Figure 2-69: Daga River validation at the Daga station (plotted as monthly flows)*

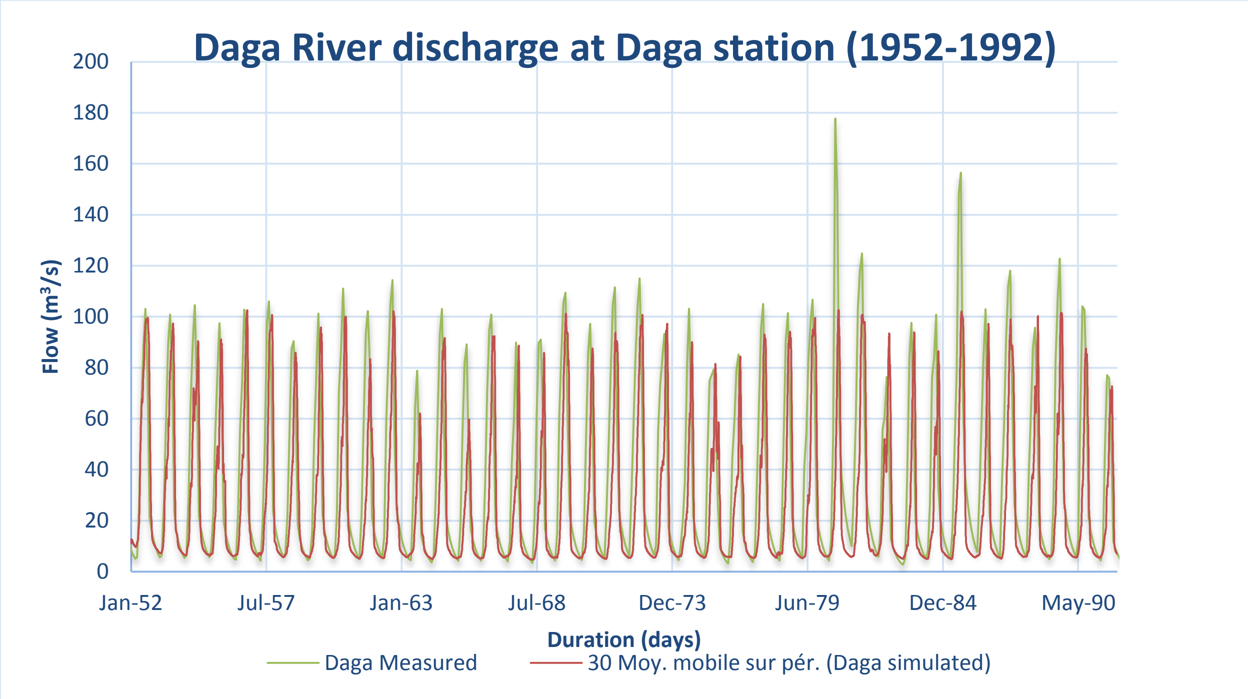



*Figure 2-70: Daga River simulated flows at the Daga station (plotted as monthly flows)*

The Yabus River catchment calibration graph is shown in Figure 2-71, while the validation is shown in Figure 2-72. The simulation for the whole period 1952 to 1992 is shown in Figure 2-73.

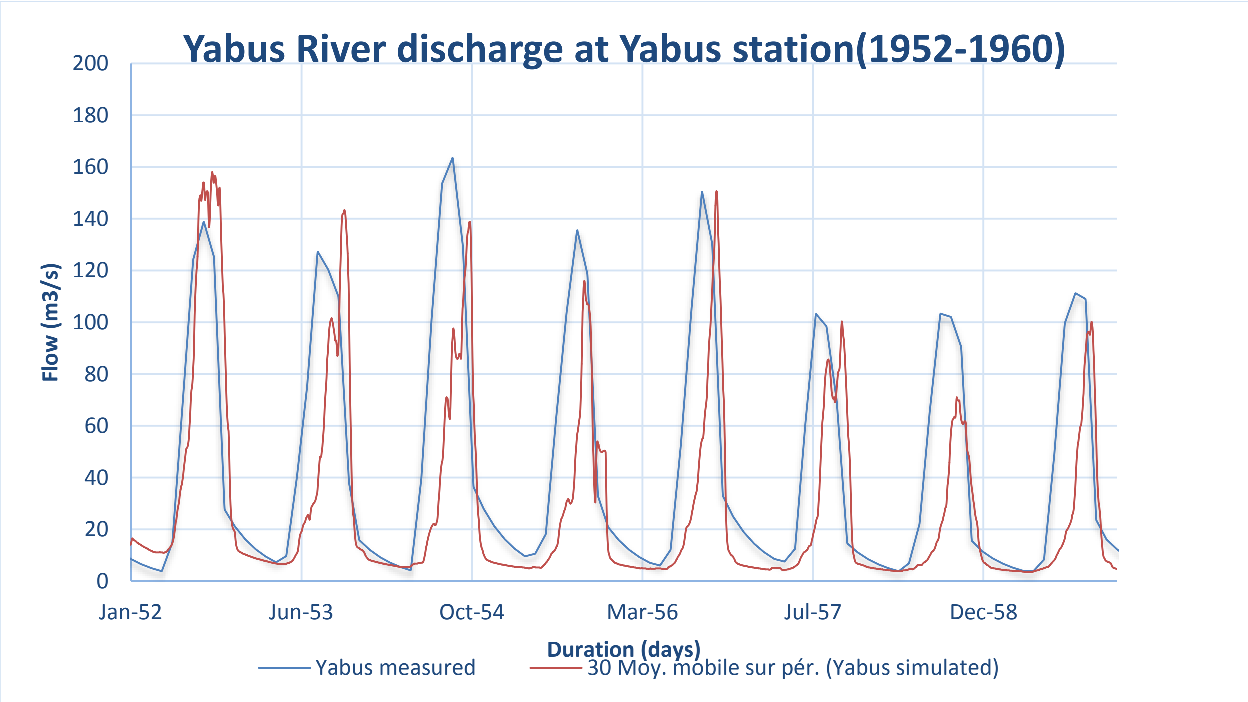



*Figure 2-71: Yabus River calibration at Yabus station (plotted as monthly flows)*

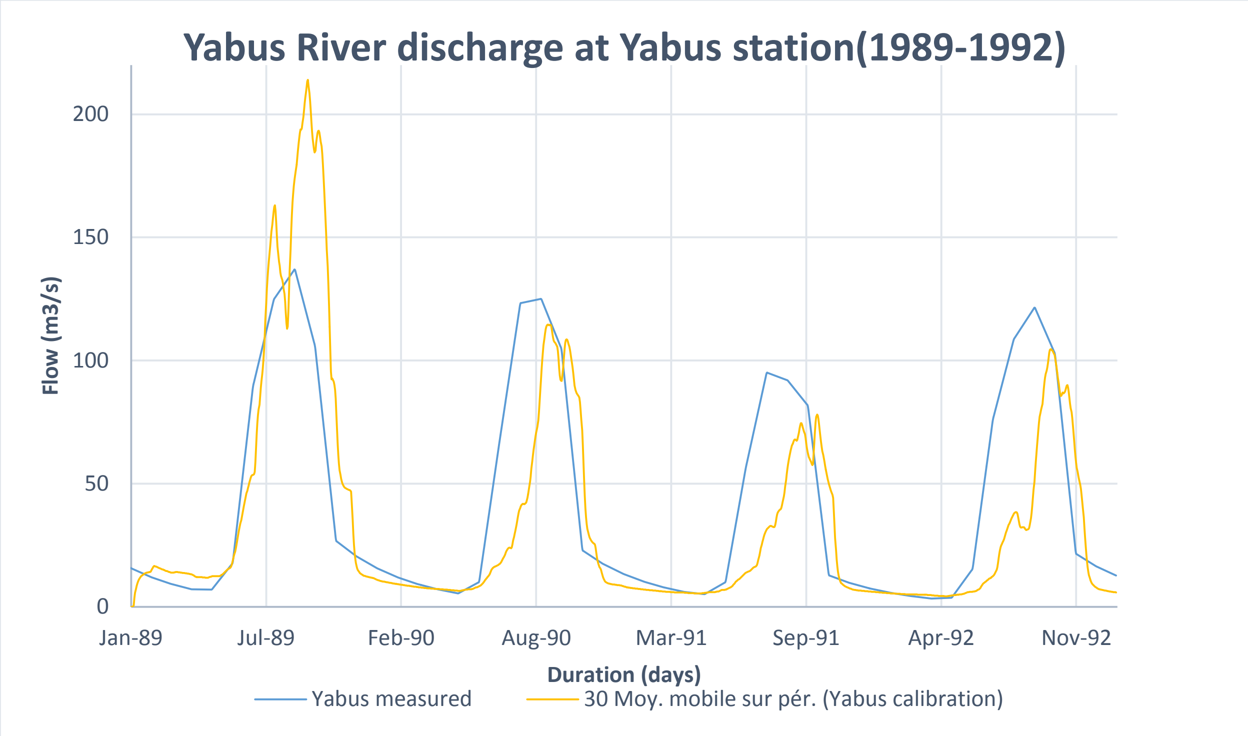



*Figure 2-72: Yabus River validation at Yabus station (plotted as monthly flows)*

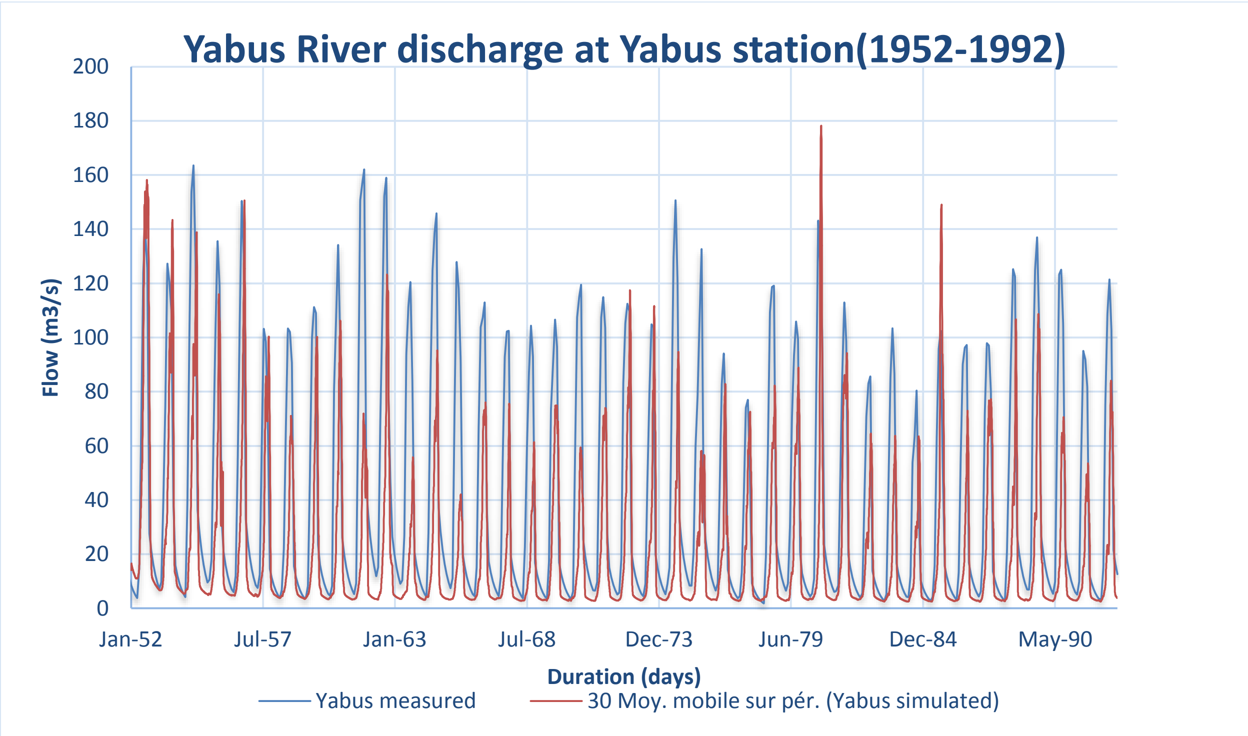



*Figure 2-73: Yabus River long-term simulated flows at Yabus station (plotted as monthly flows)*

### 2.3.7.2 Sediment calibration

No sediment calibration data was available for this catchment and therefore SHETRAN parameters from the Baro watershed were used. The Daga gauging station simulated sediment loads are shown in Figure 2-74 and the rating curve in Figure 2-75.

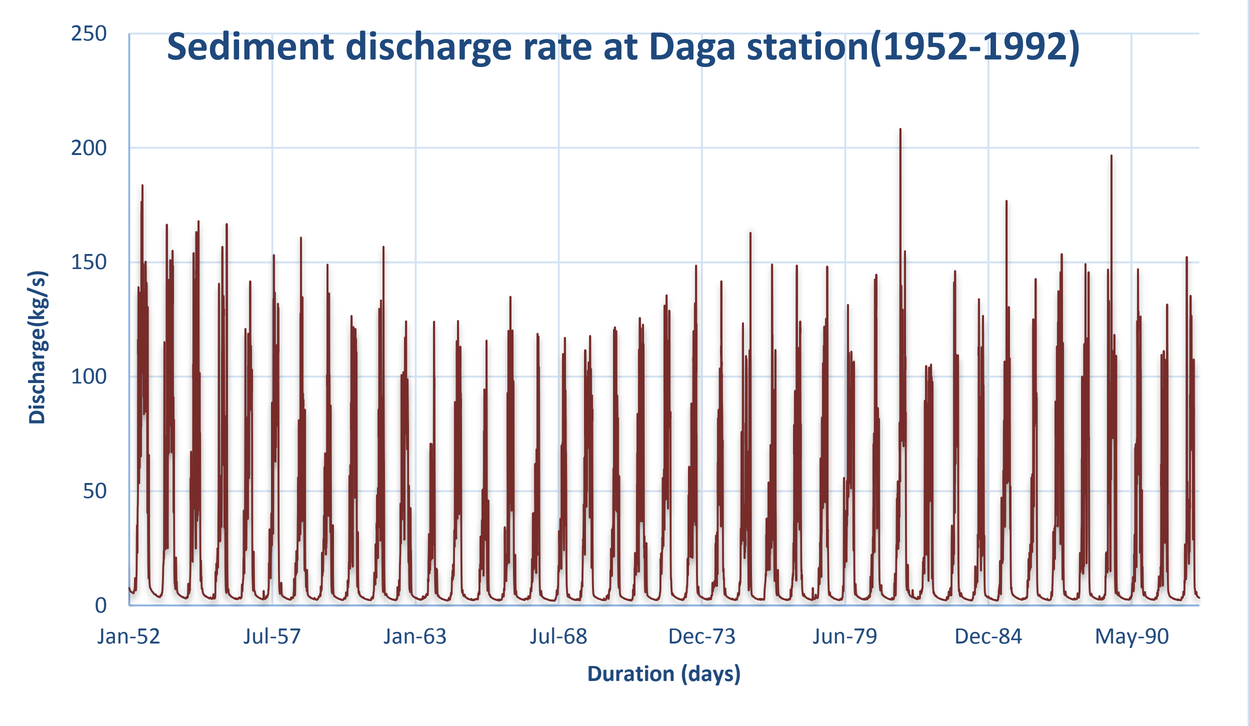



*Figure 2-74: Daga River simulated sediment loads at the Daga gauging station*

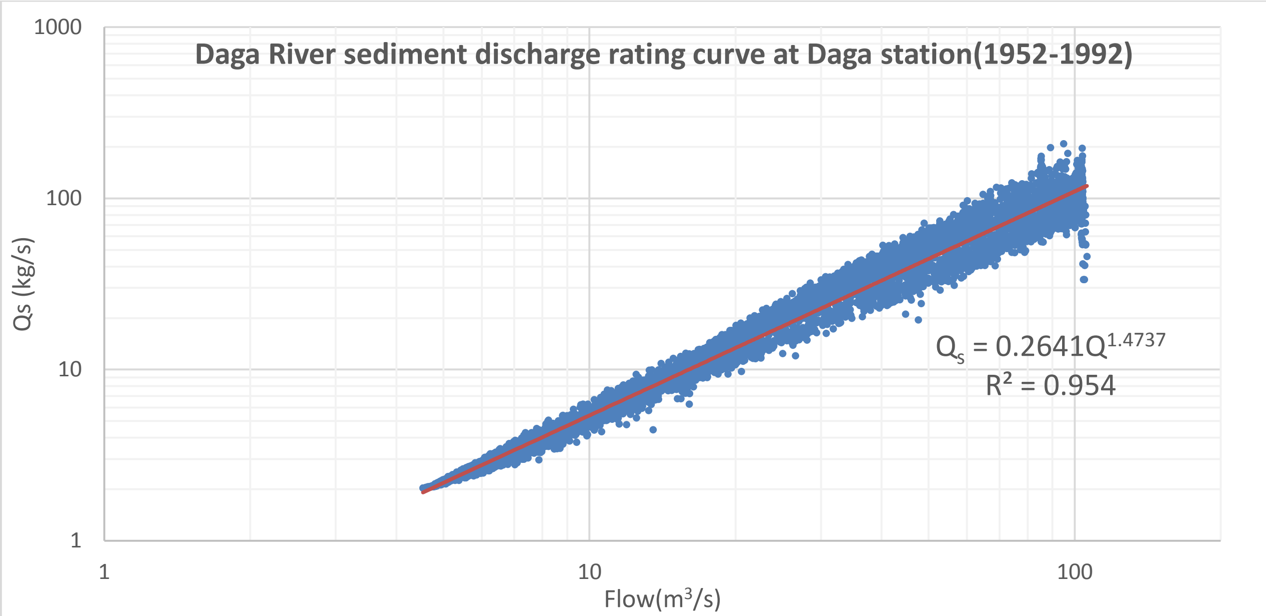



*Figure 2-75: Daga River simulated sediment rating curve at the Daga station*

The Yabus gauging station simulated sediment discharge rate is shown in Figure 2-76 and the rating curve in Figure 2-77.

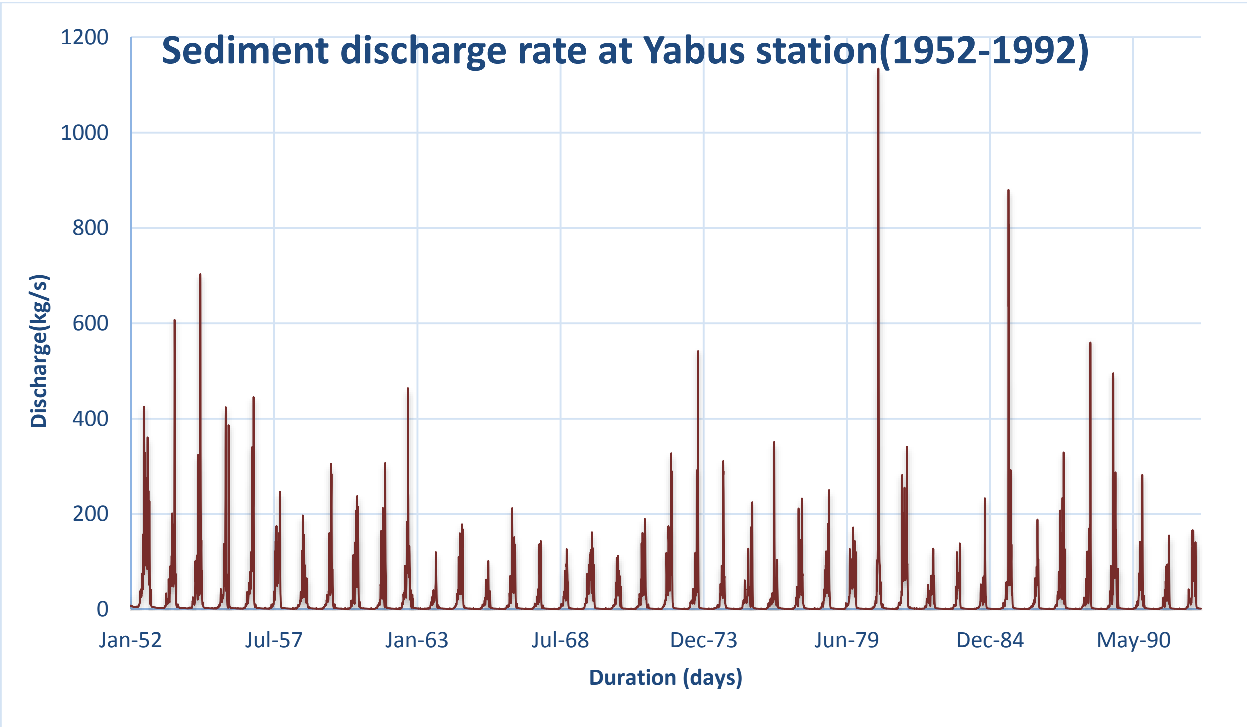



*Figure 2-76: Yabus River simulated sediment loads at the Yabus station*

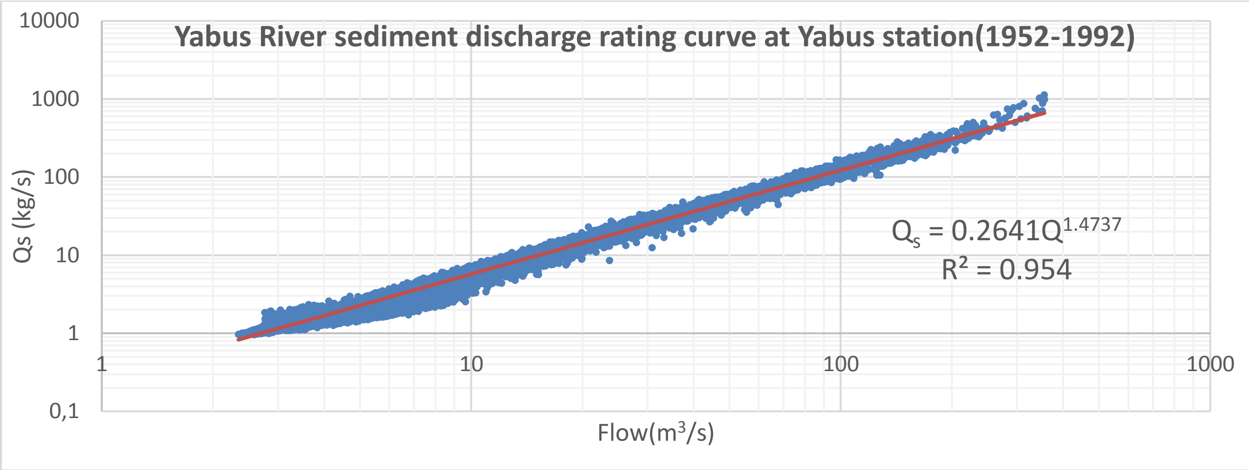



*Figure 2-77: Yabus River simulated discharge-sediment load rating curve at Yabus station*

The sediment yield was calculated taking April to March as the hydrological year. The Daga station simulated sediment yield calculation is shown in Table 2-11, while the Yabus station yield is shown in Table 2-12.

*Table 2-11: Daga catchment simulated sediment yield at Daga station (1952-1992)*

| | |
|---|---|
| **Catchment area ($km^2$)** | 3356 |
| **Average Qs (t/day)** | 2044 |
| **Sediment yield($t/km^2.a$)** | 222 |

*Table 2-12: Yabus catchment simulated sediment yield at Yabus station (1952-1992)*

| | |
|---|---|
| **Catchment area ($km^2$)** | 6156 |
| **Average Qs (t/day)** | 1888 |
| **Sediment yield ($t/km^2.a$)** | 112 |

### 2.3.8 Sobat catchment

The 30 arc Dem was used to delineate Sobat catchment within the 200 x200 SHETRAN grid limitation and 1500 river links. 86x158 grids of 1980 spatial resolution represented this catchment shown in Figure 2-78. The watershed extent formed the model boundary with the river outlet as the downstream boundary. The saturated conductivity was calibrated to 20 m/day to for the upper 1 m and 5 m/day for the lower 14 m horizon.

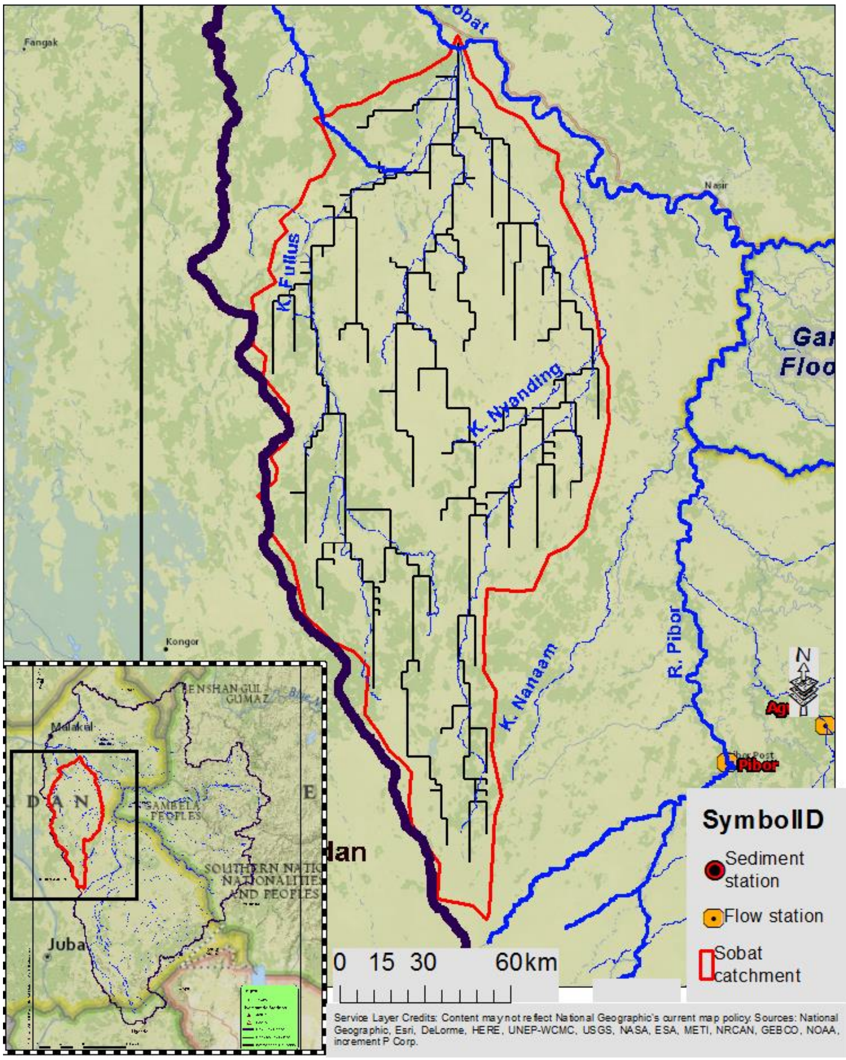



*Figure 2-78: Sobat River sub catchment and SHETRAN river links (black) as used in the SHETRAN model*

To conform to SHETRAN land use library, two main land uses were identified: shrub and grass. The land uses are shown in Figure 2-79.

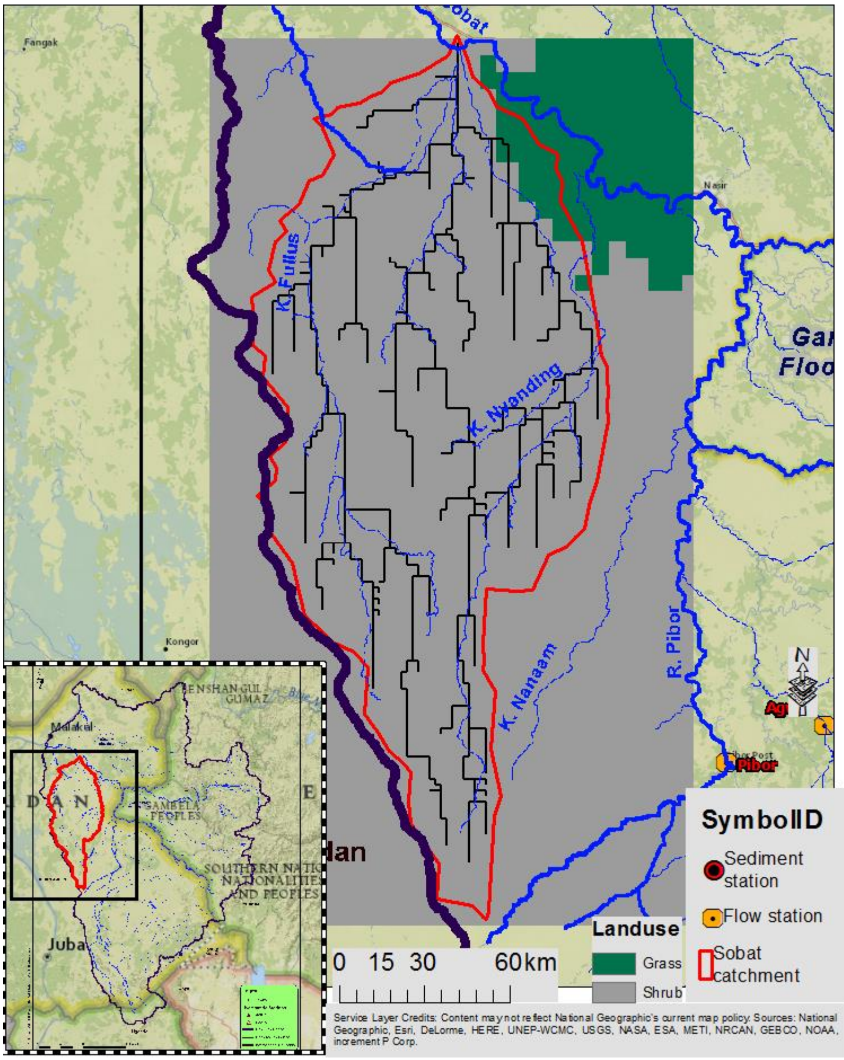



*Figure 2-79: Sobat sub-catchment land use variation as used in the SHETRAN model*

### 2.3.8.1 Sobat catchment sediment and flow calibration

No data was available for this catchment, thus SHETRAN values from the neighbouring Pibor catchment were used and simulated for the period 1952 to 1992.

Figure 2-80 shows the simulated flows with the corresponding sediment loads at the outlet of the catchment shown in Figure 2-81.The simulated discharge-sediment load rating curve at the outlet is shown in Figure 2-82 with the calculated sediment yield in Table 2-13.

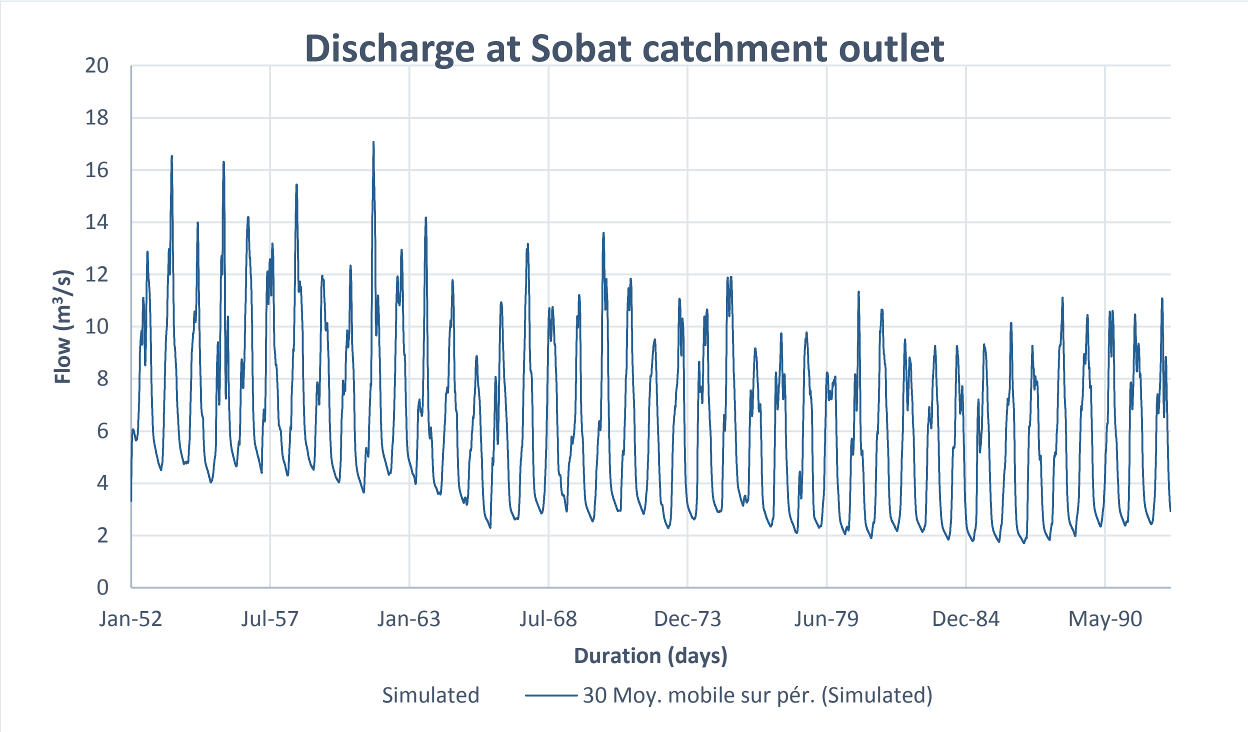



*Figure 2-80: Sobat catchment simulated flows at the outlet of the catchment (plotted as monthly flows)*

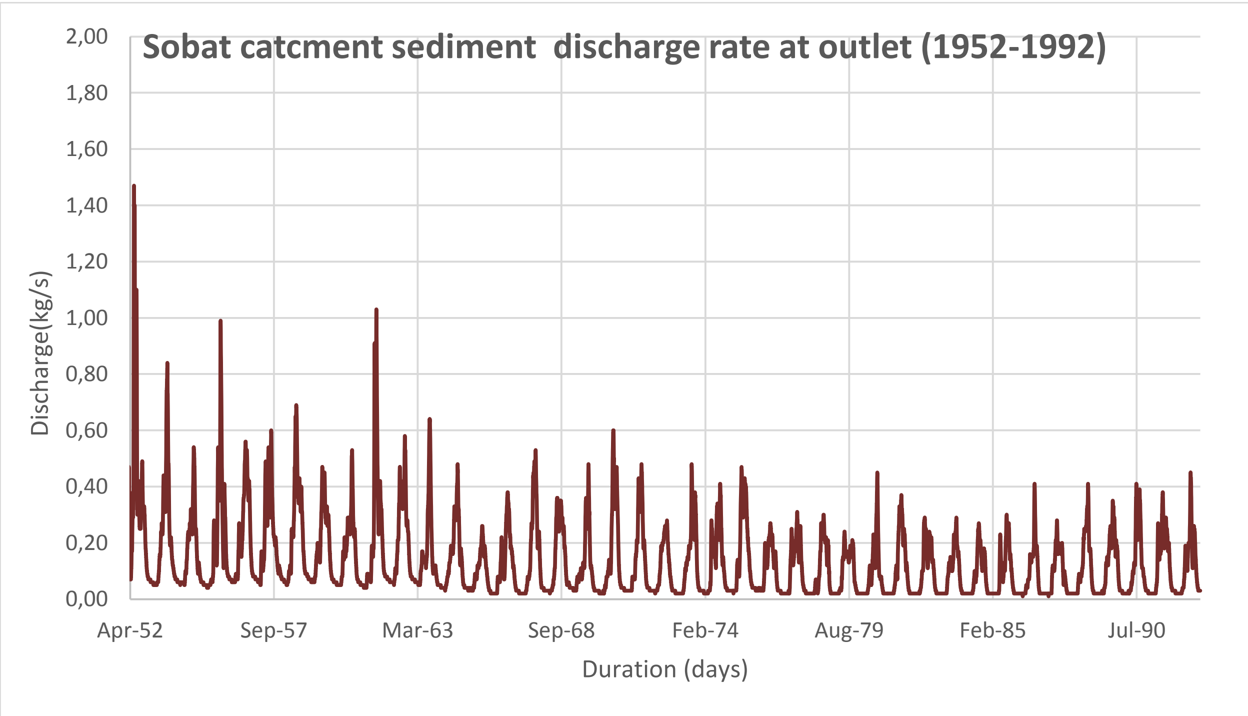



*Figure 2-81: Simulated Sobat catchment sediment loads at the outlet*

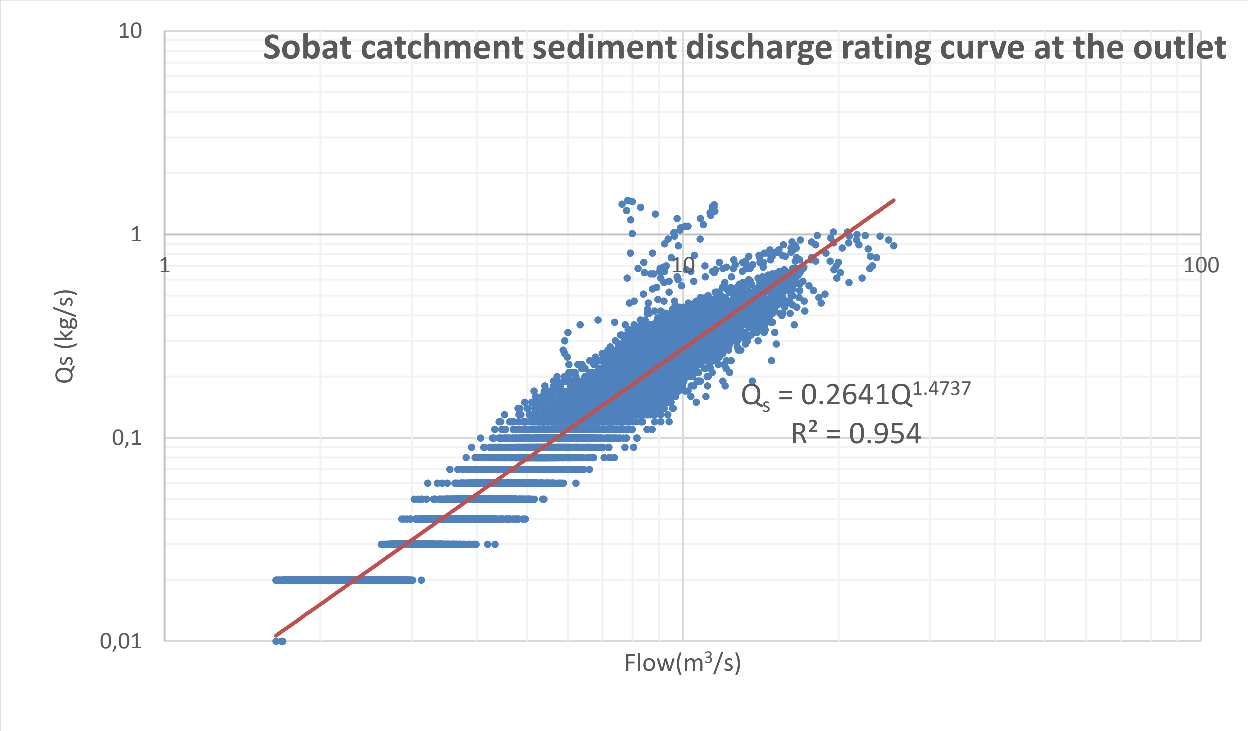



*Figure 2-82: Simulated Sobat catchment discharge-sediment load rating curve at the outlet*

*Table 2-13: Sobat sub-catchment sediment yield at the outlet (1952-1992)*

| | |
|---|---|
| **Catchment area ($km^2$)** | 22512.00 |
| **Average Qs (t/day)** | 24.68 |
| **Sediment yield ($t/km^2.a$)** | < 10 |

## 2.3.9 Marshlands

Due to the complex flow network and SHETRAN limitation, the marshlands were not simulated. The location of the unsimulated zone is shown in Figure 2-83.

Sediment yields in this location were obtained by taking a weighted average yield from neighbouring catchments and assuming no sediment deposition.

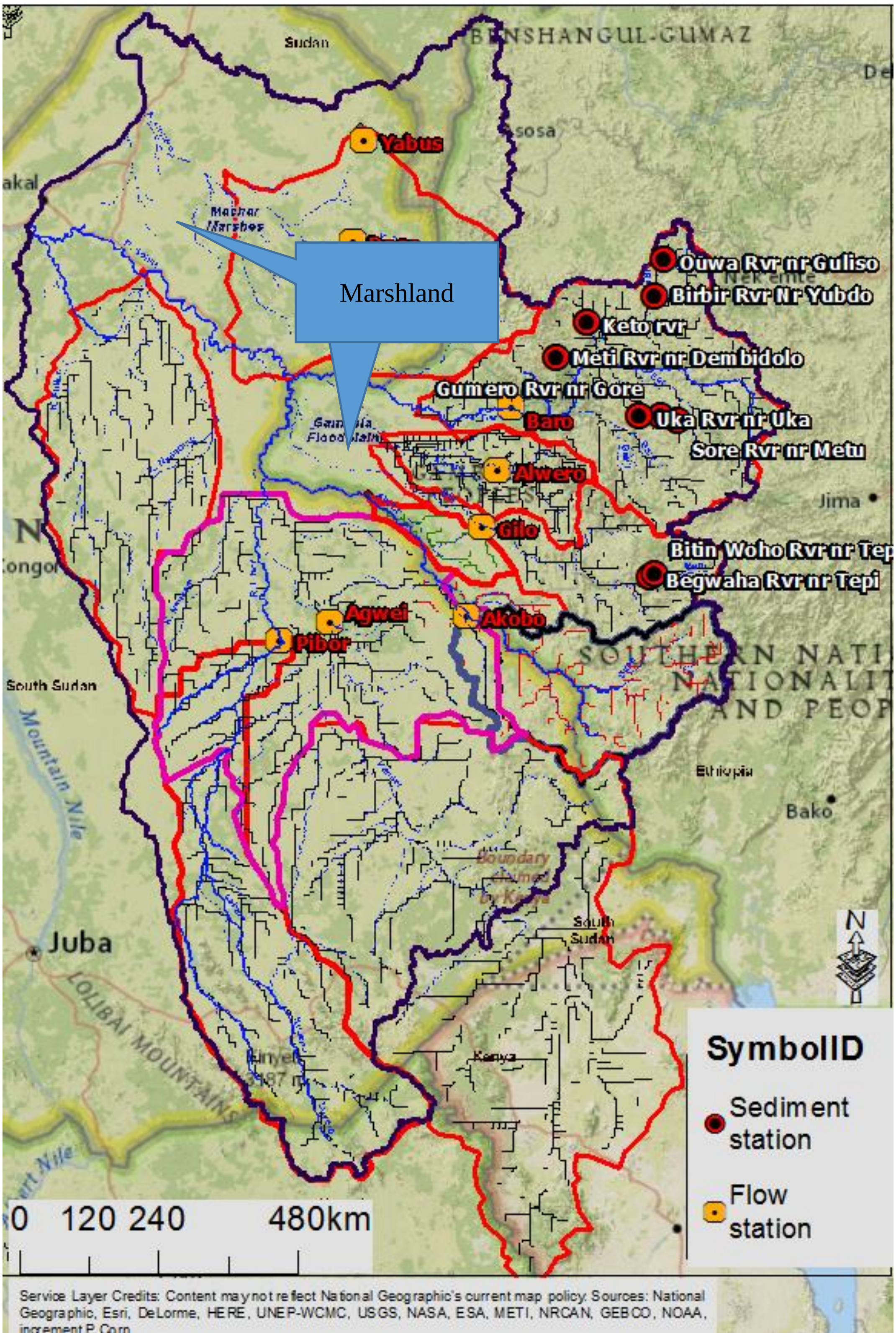



*Figure 2-83: Marshland locations where SHETRAN model simulations were not carried out*

# 3. SEDIMENT YIELD MAP

From the SHETRAN model long term simulations (40 years), smaller sub-catchments were delineated and data extracted on the river channels at the locations of interest for the whole simulated period (1952-1992). Appendix 20 shows the positions where sediment yields were calculated with the results tabled in Appendix 21. The resulting sediment yield map is shown in Figure 3-1.

Where the sediment yields were simulated to be less than 10 t/km$^2$.a, the yield was adjusted to 10 t/km$^2$.a on the map, considering the accuracy of the predictions. The sediment yield map values indicate the mean long term sediment yield of the total catchment draining to a specific location.

The highest sediment yields are in the east of the study area, with a maximum of 872 t/km$^2$.a. Sediment yields in catchments in the south and west of the study area are relatively low.

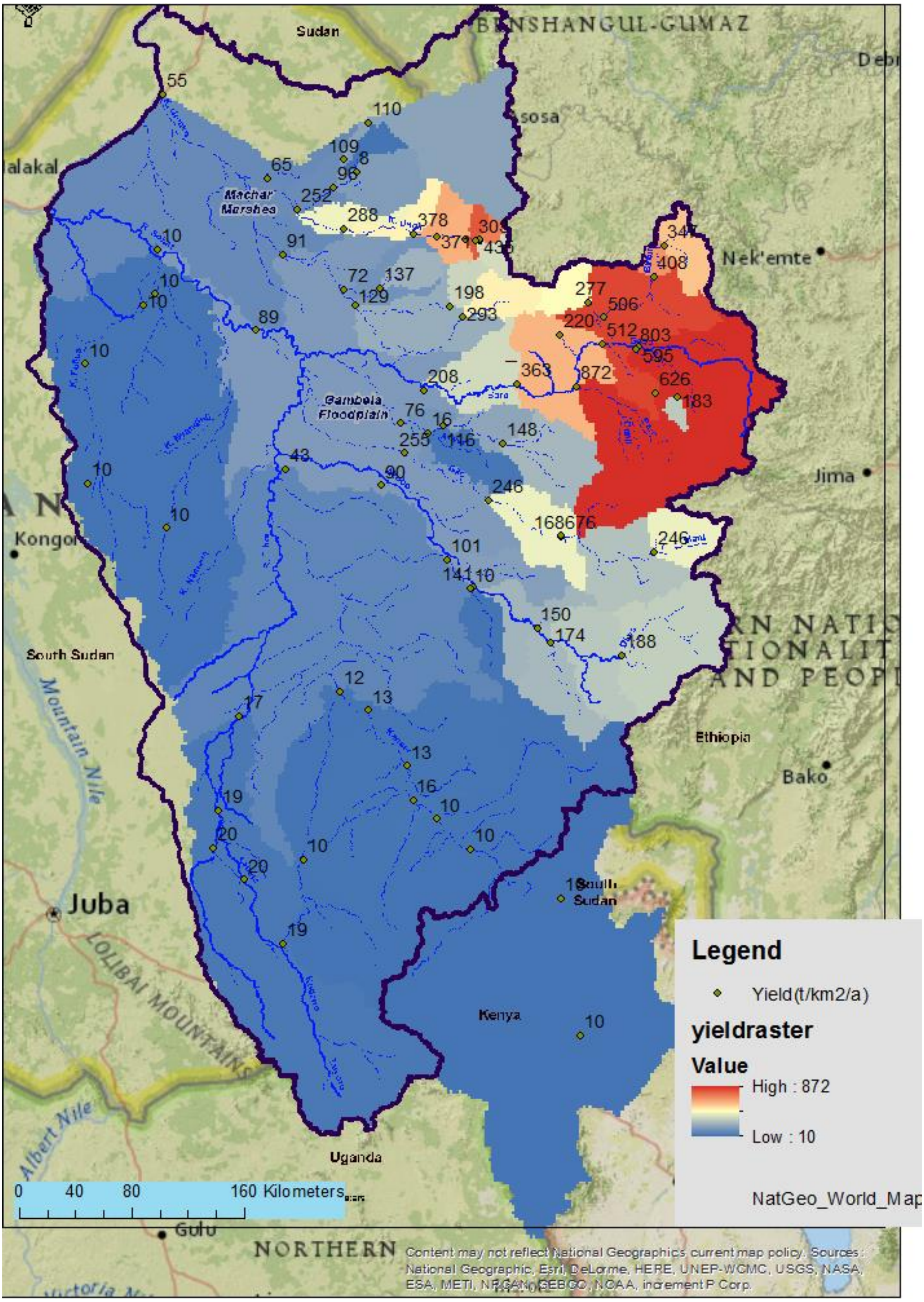

Legend
Yield (t/km2/a)
yieldraster
Value
High : 872
Low : 10
NatGeo_World_Map
0 40 80 160 Kilometers
Sudan
BENISHANGUL-GUMAZ
Machar Marshes
Gambela Floodplain
Nek'emte
Jima
Kongor
South Sudan
Mountain Nile
Juba
LOLIBAI MOUNTAINS
Albert Nile
Uganda
Gulu
NORTHERN
Kenya
Ethiopia
Bako
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

*Figure 3-1: Baro-Akobo-Sobat sediment yield map (values on map indicate sediment yields of the total catchment draining to that location)*

# 4. CONCLUSIONS

The key objective of this report was to develop a sediment yield map for the study area. A detailed methodology was followed by using the SHETRAN model. This physically based rainfall-runoff-sediment transport model was set up on a 30 arc Dem, and sub-catchment flows were calibrated and validated where flow records are available. Simulated daily sediment loads were also calibrated against sediment loads in the rivers where records are available. A 40 year daily flow record and sediment loads were then simulated to obtain the mean long term sediment loads and yields in the study area. Due to the complex flow network and SHETRAN limitation, the marshlands in the north-west of the study area were not simulated. Sediment yields in the marshlands were obtained by taking a weighted average yield from neighbouring catchments.

Appendix 20 shows the positions where sediment yields were calculated with the results tabled in Appendix 21. The resulting sediment yield map is shown in Figure 3-1.

The highest sediment yields are in the east of the study area, with a maximum of 872 $t/km^2.a$. Sediment yields in catchments in the south and west of the study area are relatively low: (< 30 $t/km^2.a$).

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# 6. APPENDICES

*Appendix 1: Baro-Akobo-Sobat flow gauging stations coordinates*

| Station name | Longitude | Latitude |
|---|---|---|
| Baro | 34.5812 | 8.25 |
| Agwei | 33.444 | 6.917 |
| Akobo | 34.2947 | 6.9542 |
| Gilo | 34.3934 | 7.5058 |
| Alwero | 34.4904 | 7.8595 |
| Pibor | 33.1308 | 6.7997 |
| Yabus | 33.662 | 9.923 |
| Daga | 33.5864 | 9.2889 |

*Appendix 2: Default canopy and leaf parameters (SHETRAN, 2013).*

| Vegetation | Canopy Drainage1 | | Canopy Storage | Vegetation cover indices | |
|---|---|---|---|---|---|
| | CK (mm s-1) | Cb (mm-1) | CSTCAP(mm) | PLAI | CLAI |
| Arable | 1.40E-05 | 5.1 | 1.5 | 1 | 6 |
| Grass | 1.40E-05 | 5.1 | 1.5 | 1 | 6 |
| Forest | 1.40E-05 | 5.1 | 5 | 1 | 6 |
| Shrub | 1.40E-05 | 5.1 | 1.5 | 1 | 3 |
| Urban | 1.40E-05 | 5.1 | 0.3 | 0.3 | 1 |

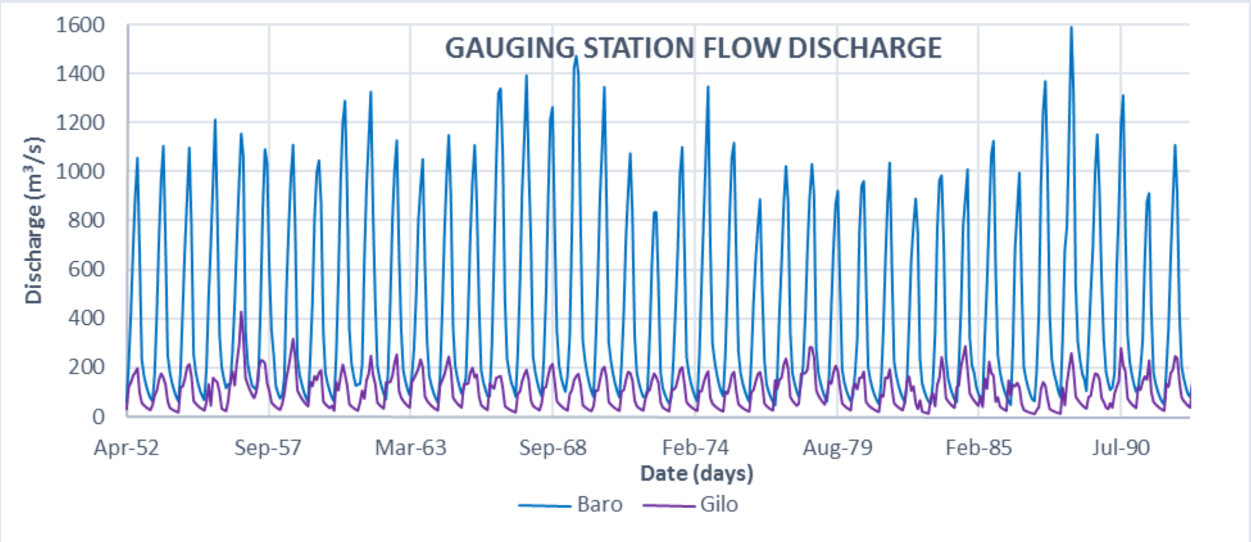
*Appendix 3: Default root density function (SHETRAN, 2013)*

| Vegetation | Total rooting depth | Depth of cell below Ground | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 | 1.0 | 1.2 | 1.4 | 1.6 | 1.8 | 2.0 |
| **Arable** | 0.8 | 0.31 | 0.228 | 0.17 | 0.1 | 0.072 | 0.06 | 0.04 | 0.02 | | | | | | | |
| **Grass** | 1.0 | 0.25 | 0.18 | 0.15 | 0.12 | 0.1 | 0.08 | 0.06 | 0.03 | 0.02 | 0.01 | | | | | |
| **Evergreen forest** | 2.0 | 0.13 | 0.12 | 0.11 | 0.1 | 0.09 | 0.08 | 0.07 | 0.06 | 0.05 | 0.03 | 0.06 | 0.04 | 0.03 | 0.02 | 0.01 |

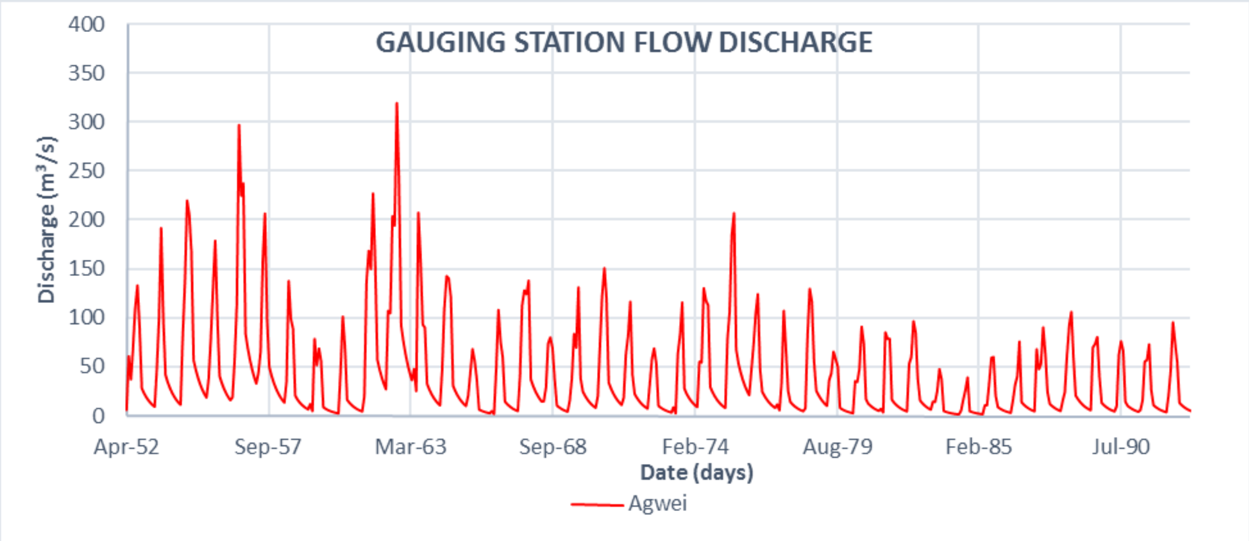
| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Shrub** | 1.0 | 0.25 | 0.18 | 0.15 | 0.12 | 0.1 | 0.08 | 0.06 | 0.03 | 0.02 | 0.01 | | | | | |
| **Urban** | 0.5 | 0.4 | 03 | 0.2 | 0.07 | 0.03 | | | | | | | | | | |

*Appendix 4: Default library of soil parameters (SHETRAN, 2013)*

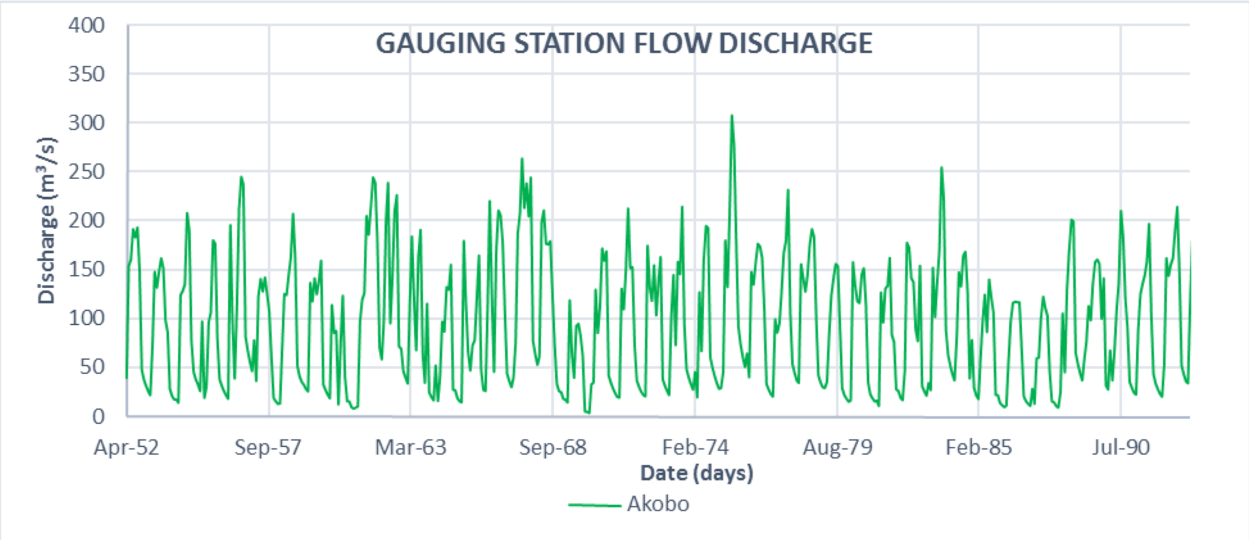
| Soil Type | Saturated Water Content | Residual Water Content3 | Saturated Conductivity (m/day)4 | vanGenuchte n- alpha (/cm)3 | vanGenuchte n-n3 |
|---|---|---|---|---|---|
| Silty Clay (10% Sand, 40% Clay) | 0.529 | 0.212 | 0.019 | 0.00654 | 1.531 |
| Clay Loam (35% Sand, 27% Clay) | 0.489 | 0.153 | 0.055 | 0.00923 | 1.657 |
| Sandy Silt Loam (35% Sand, 10% Clay) | 0.434 | 0.086 | 0.317 | 0.00838 | 1.587 |
| Sandy Clay (52% Sand, 40% Clay) | 0.499 | 0.233 | 0.029 | 0.01069 | 1.879 |
| Sandy Clay Loam (65% Sand, 24% Clay) | 0.461 | 0.167 | 0.103 | 0.01236 | 2.071 |
| Sandy Loam (65% Sand, 10% Clay) | 0.412 | 0.098 | 0.622 | 0.01441 | 1.736 |



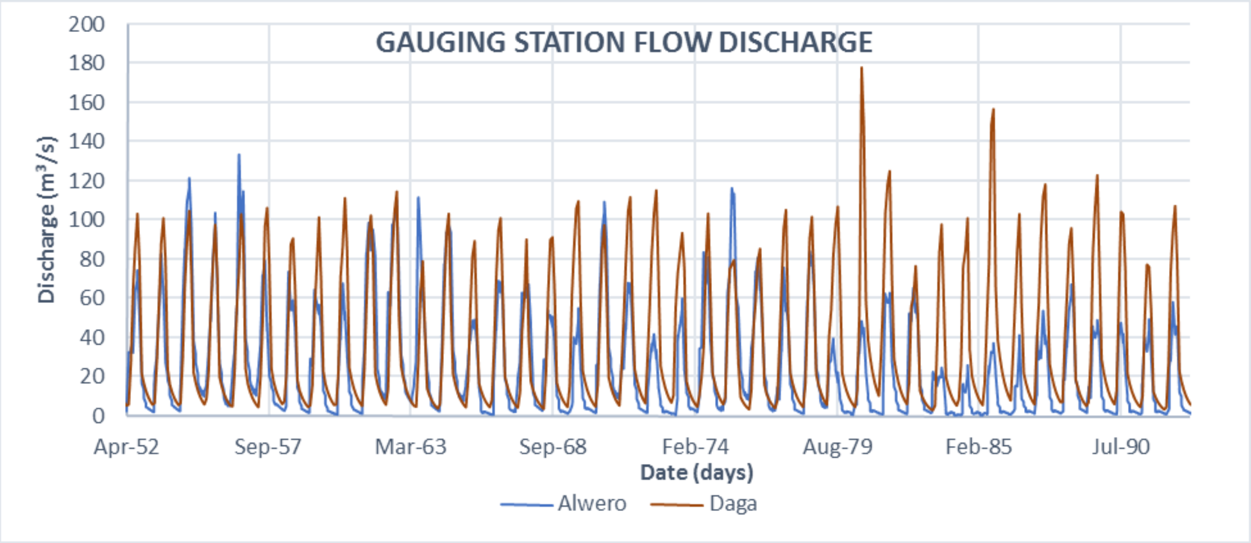

*Appendix 5: monthly flows at Baro and Gilo gauging stations*



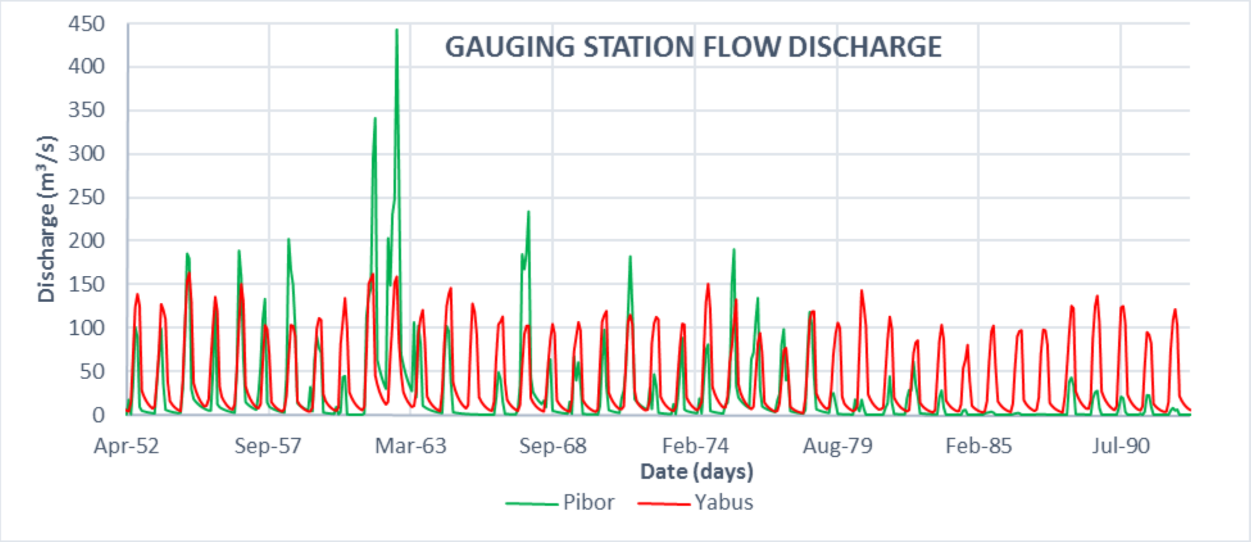

*Appendix 6: monthly flows at Agwei gauging station*




*Appendix 7: monthly flows at Akobo gauging station*



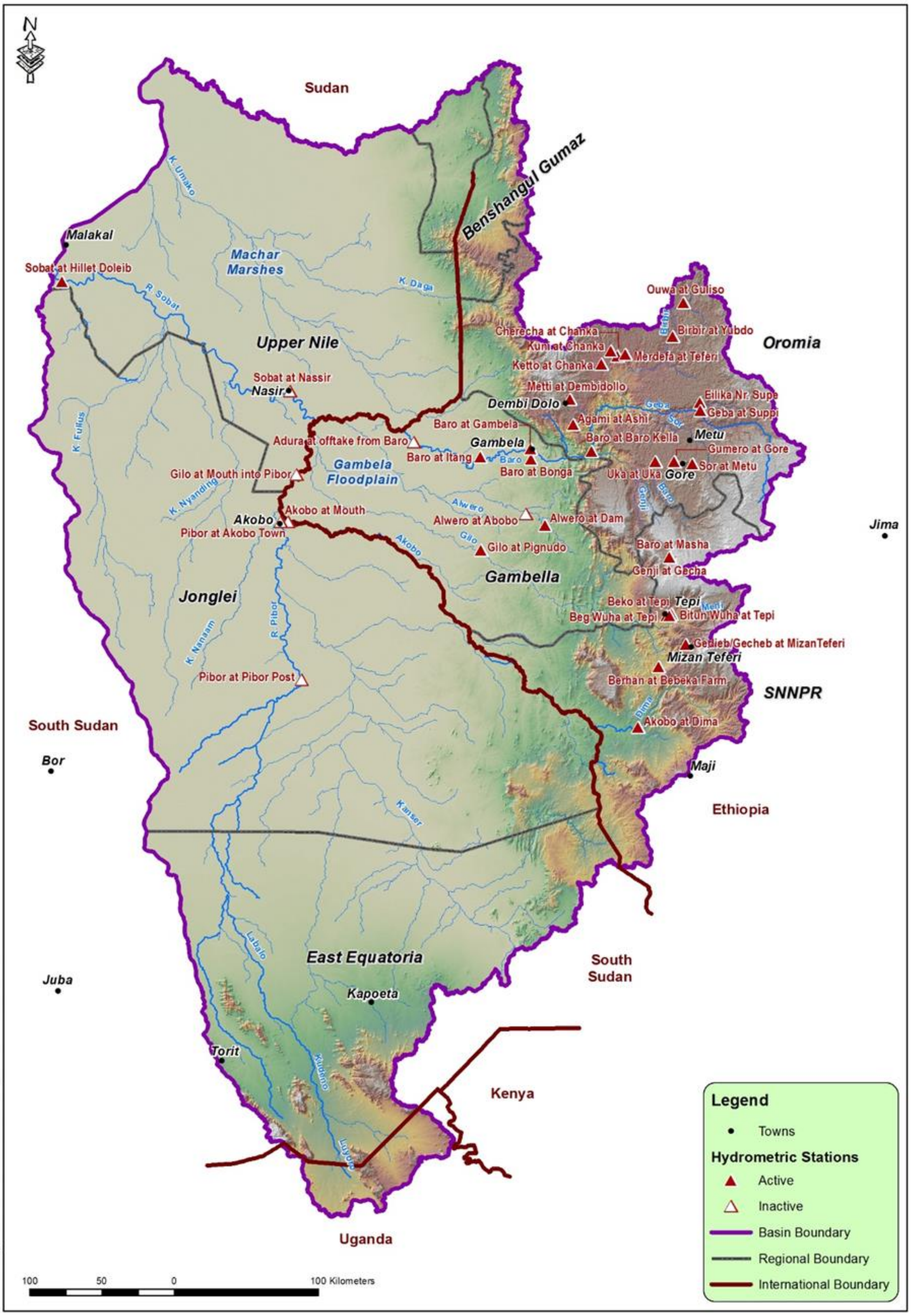

*Appendix 8: monthly flows at Alwero and Daga gauging stations*




*Appendix 9: monthly flows at Pibor and Yabus gauging stations*

*Appendix 10: Baro-Akobo-Sobat rainfall weather station details*

| Station | Source | Type | Period | Lat | Long |
|---|---|---|---|---|---|
| Abobo | EMP | Penman | 1956-1987* | 7.51 | 34.33 |
| Gambela | EMP | Penman | 1906-1993* | 8.15 | 34.35 |
| Pokwo | EMP | Penman | 1956-1989* | 8.1 | 34.28 |
| Metu | EMP | Penman | 1952-1992* | 8.2 | 35.35 |
| Mizan | EMP | Penman | 1953-1992* | 7 | 35.35 |
| Wush | EMP | Penman | 1953-1992* | 7.11 | 36.1 |
| Anger | EMP | Penman | 1954-1992* | 9.22 | 36.22 |
| Arjo | EMP | Penman | 1954-1992* | 8.45 | 36.3 |
| Bambessi | EMP | Penman | 1955-1992* | 9.45 | 34.44 |
| Gimbi | EMP | Penman | 1952-1992* | 9.1 | 35.47 |
| Kurmuk | EMP | Penman | 1961-1988* | 10.26 | 34.28 |
| Mendi | EMP | Penman | 1955-1992* | 9.47 | 35.05 |
| Nedjo | EMP | Penman | 1952-2003* | 9.3 | 35.29 |
| Dongoro | EMP | Penman | 1952-1992* | 9.16 | 35.41 |
| Wama | EMP | Penman | 1975-1987* | 8.46 | 36.45 |
| Bonga | EMP | Penman | 1953-1992* | 7.13 | 36.14 |
| Gambela | Shahin, 1985 | Open Water | 1950-1957 | 8.25 | 34.58 |
| Akobo | Shahin, 1985 | Open Water | 1950-1957 | 7.78 | 33.02 |
| Gore | Norplan, 2006 | Open Water | 1974-2003 | 8.15 | 35.53 |
| Baro-1 | Norplan, 2006 | Open Water | 1974-2004 | 8.07 | 35.33 |
| Baro-2 | Norplan, 2006 | Open Water | 1974-2005 | 8.15 | 35.33 |
| Genji | Norplan, 2006 | Open Water | 1974-2006 | 8.12 | 35.22 |
| Jimma | FAO Calculator | Penman-Monteith | | 7.67 | 36.83 |
| Juba | FAO Calculator | Penman-Monteith | | 4.8 | 31.6 |
| Malakal | FAO Calculator | Penman-Monteith | | 9.55 | 31.65 |
| Torit | FAO Calculator | Penman-Monteith | | 4.41667 | 32.55 |
| Pibor Post | FAO Calculator | Penman-Monteith | | 6.8 | 33.133333 |




*Appendix 11: Baro-Akobo-Sobat sediment gauging station locations*

*Appendix 12: Baro catchment SHETRAN vegetation parameters*

| | Canopy storage capacity (mm) | | Leaf area index | | Maximum rooting depth(m) | | AE/PE at field capacity | |
|---|---|---|---|---|---|---|---|---|
| **Parameter** | **Default** | **Used** | **Default** | **Used** | **Default** | **Used** | **Default** | **Used** |
| Arable | 1.5 | 1 | 4 | 1 | 0.8 | 0.8 | 0.6 | 0.7 |
| Evergreen forest | 5 | 3 | 6 | 1 | 2 | 1 | 1 | 1 |
| Shrub | 1.5 | 1.5 | 3 | 1 | 1 | 1 | 0.4 | 0.7 |

*Appendix 13: Alwero catchment SHETRAN vegetation parameters*

| | Canopy storage capacity (mm) | | Leaf area index | | Maximum rooting depth(m) | | AE/PE at field capacity | |
|---|---|---|---|---|---|---|---|---|
| **Parameter** | **Default** | **Used** | **Default** | **Used** | **Default** | **Used** | **Default** | **Used** |
| Arable | 1.5 | 1 | 4 | 1 | 0.8 | 0.8 | 0.6 | 0.7 |
| Evergreen forest | 5 | 3 | 6 | 1 | 2 | 1 | 1 | 1 |
| Shrub | 1.5 | 1.5 | 3 | 1 | 1 | 1 | 0.4 | 0.7 |
| Urban | | | | | | | | |

*Appendix 14: Gilo catchment SHETRAN vegetation parameters*

| | Canopy storage capacity (mm) | | Leaf area index | | Maximum rooting depth(m) | | AE/PE at field capacity | |
|---|---|---|---|---|---|---|---|---|
| **Parameter** | **Default** | **Used** | **Default** | **Used** | **Default** | **Used** | **Default** | **Used** |
| Arable | 1.5 | 1.5 | 4 | 4 | 0.8 | 0.8 | 0.6 | 1.2 |
| Evergreen forest | 5 | 5 | 6 | 6 | 2 | 2 | 1 | 1.5 |
| Shrub | 1.5 | 2 | 3 | 3 | 1 | 1 | 0.4 | 1.2 |
| Urban | 0.3 | 0.3 | 0.3 | 0.3 | 0.5 | 0.5 | 0.4 | 0.4 |

*Appendix 15: Akobo catchment SHETRAN vegetation parameters*

| | Canopy storage capacity (mm) | | Leaf area index | | Maximum rooting depth(m) | | AE/PE at field capacity | |
|---|---|---|---|---|---|---|---|---|
| **Parameter** | **Default** | **Used** | **Default** | **Used** | **Default** | **Used** | **Default** | **Used** |
| Arable | 1.5 | 1.5 | 4 | 4 | 0.8 | 0.8 | 0.6 | 1.4 |
| Evergreen forest | 5 | 5 | 6 | 6 | 2 | 2 | 1 | 1.7 |
| Shrub | 1.5 | 2 | 3 | 3 | 1 | 1 | 0.4 | 1.4 |
| Urban | 0.3 | 0.3 | 0.3 | 0.3 | 0.5 | 0.5 | 0.4 | 0.6 |

*Appendix 16: Pibor catchment SHETRAN vegetation parameters*

| | Canopy storage capacity (mm) | | Leaf area index | | Maximum rooting depth(m) | | AE/PE at field capacity | |
|---|---|---|---|---|---|---|---|---|
| **Parameter** | **Default** | **Used** | **Default** | **Used** | **Default** | **Used** | **Default** | **Used** |
| Shrub | 1.5 | 2 | 3 | 3 | 1 | 1 | 0.4 | 0.4 |
| Grass | 1.5 | 1.5 | 6 | 4 | 1 | 1 | 0.4 | 0.6 |

*Appendix 17: Agwei catchment SHETRAN vegetation parameters*

| | Canopy storage capacity (mm) | | Leaf area index | | Maximum rooting depth(m) | | AE/PE at field capacity | |
|---|---|---|---|---|---|---|---|---|
| **Parameter** | **Default** | **Used** | **Default** | **Used** | **Default** | **Used** | **Default** | **Used** |
| Shrub | 1.5 | 2 | 3 | 3 | 1 | 1 | 0.4 | 0.6 |
| Grass | 1.5 | 1.5 | 6 | 4 | 1 | 1 | 0.4 | 0.6 |

*Appendix 18: Yabus and Daga catchment SHETRAN vegetation parameters*

| | Canopy storage capacity (mm) | | Leaf area index | | Maximum rooting depth(m) | | AE/PE at field capacity | |
|---|---|---|---|---|---|---|---|---|
| **Parameter** | **Default** | **Used** | **Default** | **Used** | **Default** | **Used** | **Default** | **Used** |
| Arable | 1.5 | 1 | 4 | 1 | 0.8 | 0.8 | 0.6 | 0.7 |
| Evergreen forest | 5 | 3 | 6 | 1 | 2 | 1 | 1 | 1 |
| Shrub | 1.5 | 1.5 | 3 | 1 | 1 | 1 | 0.4 | 0.7 |
| Grass | 1.5 | 1.5 | 6 | 6 | 1 | 1 | 0.4 | 0.8 |

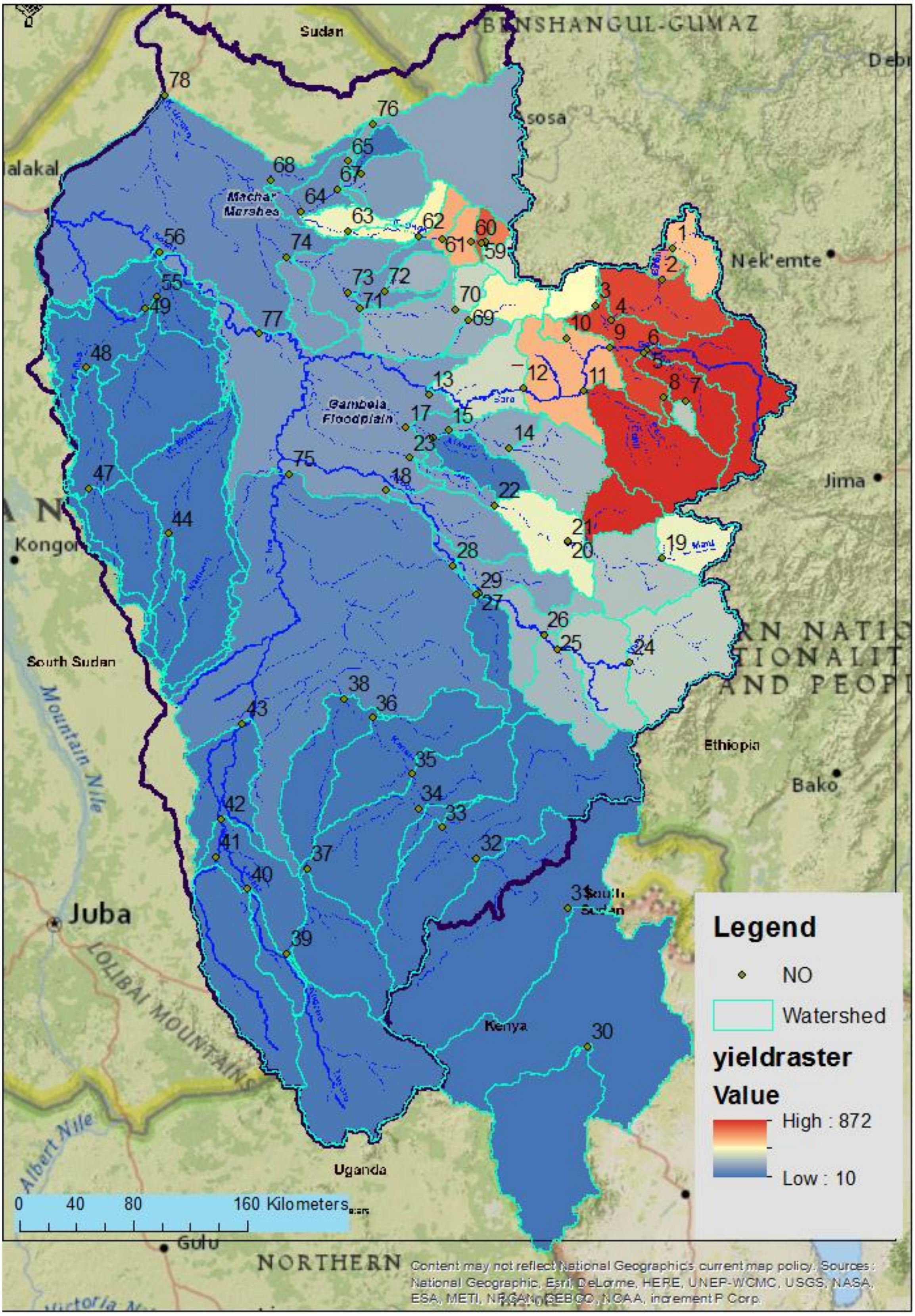
*Appendix 19: Sediment concentration and load data used from previous studies (SELKHOZPROMEXPORT, 1990)*

| Location | Date | Flow ($m^3/s$) | Concentration (mg/l) | Daily sediment load (t/day) |
|---|---|---|---|---|
| **Birbir** | 16-Oct-88 | 31.68 | 292.81 | 801 |
| | 01-Apr-90 | 7.05 | 61.25 | 37 |
| **Sore river near Metu** | 04-Sep-86 | 133.47 | 155.25 | 1790 |
| | 18-Mar-88 | 4.49 | 71.43 | 28 |
| | 05-Oct-88 | 173.6 | 59.38 | 891 |
| | 04-Mar-89 | 1.34 | 24.02 | 3 |
| | 24-Mar-89 | 2.14 | 17.84 | 3 |
| | 05-Jun-89 | 22.3 | 1232.53 | 2375 |
| | 26-Jun-89 | 48.03 | 109.6 | 455 |

| | | | | |
|---|---|---|---|---|
| | 06-Nov-89 | 16.58 | 101.9 | 146 |
| | 16-Nov-89 | 16.58 | 178.75 | 256 |
| | 27-Jun-90 | 96.18 | 281.25 | 2337 |
| | 03-Aug-90 | 132.11 | 96.25 | 1099 |
| | 04-Aug-90 | 114.51 | 102.19 | 1011 |
| | 10-Aug-90 | 141.7 | 105.94 | 1297 |
| | 17-Aug-90 | 124 | 108.12 | 1158 |
| | 25-Aug-90 | 139.67 | 188.75 | 2278 |
| | 18-Aug-90 | 139.67 | 79.37 | 958 |
| | 18-Aug-90 | 255.52 | 82.5 | 1608 |
| | 26-Aug-90 | 140.39 | 134.38 | 1630 |
| | 27-Aug-90 | 134.82 | 90.94 | 1059 |
| | 27-Aug-90 | 148.93 | 183.12 | 2356 |
| | 24-Dec-90 | 4.8 | 78.44 | 33 |
| **GUMERO RIVER NEAR GORE** | 17-Mar-88 | 0.12 | 105.45 | 1.1 |
| | 22-Sep-88 | 5.44 | 46.88 | 22 |
| | 23-Sep-88 | 14.81 | 43.76 | 56 |
| | 24-Sep-88 | 12.63 | 34.38 | 37.5 |
| | 25-Sep-88 | 18.94 | 51.05 | 83.5 |
| | 16-Oct-88 | 8.03 | 10.42 | 7.2 |
| | 03-Oct-88 | 8.6 | 33.34 | 2.9 |
| | 16-Mar-89 | 0.7 | 162.35 | 9.8 |
| | 23-Mar-89 | 0.38 | 51.08 | 1.7 |
| | 06-Jun-89 | 1.48 | 53.63 | 6.9 |
| | 26-Jun-89 | 5.31 | 78.68 | 36.1 |
| | 17-Jun-89 | 0.71 | 161.66 | 9.9 |
| | 20-Nov-89 | 0.86 | 100.64 | 7.5 |
| | 01-Jul-90 | 3.63 | 66.04 | 20.7 |
| **UKA RIVER NEAR UKA** | 22-Sep-88 | 5.09 | 65.63 | 28.9 |
| | 23-Sep-88 | 5.89 | 42.71 | 21.7 |
| | 24-Sep-88 | 6.12 | 53.13 | 28.1 |
| | 28-Sep-88 | 4.17 | 51.05 | 18.4 |
| | 30-Sep-88 | 5.41 | 12.51 | 5.8 |
| | 02-Oct-88 | 5.41 | 42.72 | 20 |
| | 03-Oct-88 | 5.5 | 12.5 | 5.9 |
| | 06-Jun-89 | 0.42 | 88.68 | 3.2 |
| | 25-Sep-89 | 2.63 | 32.29 | 7.3 |
| | 25-Sep-89 | 2.63 | 40.71 | 9.3 |
| | 25-Sep-89 | 2.63 | 29.99 | 6.8 |
| | 20-Sep-89 | 3.47 | 154.76 | 46.4 |
| | 20-Oct-89 | 3.47 | 119.76 | 35.9 |

| | | | | |
|---|---|---|---|---|
| | 20-Nov-89 | 3.47 | 124.99 | 37.5 |
| | 23-Dec-89 | 4.8 | 62.86 | 26.1 |
| | 23-Nov-89 | 4.8 | 61.19 | 25.4 |
| | 23-Nov-89 | 4.8 | 58.37 | 24.2 |
| | 30-Jun-90 | 2.13 | 98.44 | 18.1 |
| | 30-Jun-90 | 2.13 | 72.5 | 13.3 |
| | 30-Jun-90 | 2.13 | 92.19 | 17 |
| | 25-Sep-90 | 6.2 | 117.19 | 62.8 |
| | 25-Sep-90 | 6.2 | 124.69 | 66.8 |
| | 25-Sep-90 | 6.2 | 157.5 | 84.4 |
| **OUWA RIVER NEAR GULISO** | 20-Sep-84 | 14.71 | 556.37 | 707 |
| | 24-Sep-84 | 10.17 | 292.94 | 257 |
| | 14-Oct-84 | 5.99 | 130.39 | 67 |
| | 20-Sep-85 | 11.96 | 1206.56 | 1247 |
| | 19-May-88 | 2.77 | 579.42 | 139 |
| | 28-Jun-88 | 7.3 | 398.49 | 251 |
| | 16-Oct-88 | 13.7 | 329.17 | 390 |
| | 26-Jun-89 | 7.1 | 727.98 | 447 |
| | 14-Nov-89 | 7.55 | 304.38 | 199 |
| | 14-Nov-89 | 7.55 | 331.88 | 216 |
| | 14-Nov-89 | 7.55 | 307.81 | 201 |
| | 31-Mar-90 | 1.94 | 108.44 | 18 |
| | 31-Mar-90 | 1.94 | 108.13 | 18 |
| | 31-Mar-90 | 1.94 | 113.44 | 19 |
| | 24-Jun-90 | 2.81 | 421.05 | 102 |
| | 24-Jun-90 | 2.81 | 365.53 | 89 |
| | 24-Jun-90 | 2.81 | 344.74 | 84 |
| **METI RIVER NEAR DEMBIDOLO** | 20-Oct-83 | 5.24 | 204.73 | 92.7 |
| | 21-Oct-83 | 4.9 | 119.18 | 50.5 |
| | 02-Sep-84 | 4.02 | 224.2 | 77.9 |
| | 03-Sep-84 | 2.69 | 152.22 | 35.4 |
| | 04-Sep-84 | 2.61 | 98.24 | 8.5 |
| | 07-Sep-84 | 5.45 | 201.88 | 95.1 |
| | 02-Sep-85 | 4.02 | 170.53 | 59.2 |
| | 06-Aug-86 | 3.41 | 522.15 | 153.8 |
| | 19-May-88 | 1.66 | 426.24 | 61.1 |
| | 29-Jun-89 | 1.63 | 336.56 | 47.4 |
| **KETO RIVER NEAR CHANKA** | 16-Aug-82 | 36.69 | 587.04 | 1860 |
| | 17-Aug-82 | 46.36 | 522.44 | 2093 |
| | 18-Aug-82 | 48.1 | 271.4 | 1128 |
| | 19-Aug-82 | 72.6 | 467.29 | 2931 |

| | | | | |
|---|---|---|---|---|
| | 20-Aug-82 | 69.76 | 395.28 | 2382 |
| | 21-Aug-82 | 60.04 | 561.08 | 2911 |
| | 07-Jul-86 | 48.1 | 1534.66 | 6378 |
| | 17-Oct-87 | 77.07 | 460.42 | 3066 |
| | 25-Aug-89 | 54.4 | 823.75 | 3872 |
| | 29-Jun-89 | 11.11 | 538.92 | 517 |
| **KUNNI RIVER NEAR CHANKA** | 28-Jul-89 | 2.18 | 355.39 | 67 |
| | 18-Aug-89 | 6.53 | 822.19 | 464 |
| | 19-Aug-89 | 6.84 | 607.81 | 359 |
| | 20-Aug-89 | 7.26 | 801.25 | 503 |
| | 24-Aug-89 | 9.4 | 672.19 | 546 |
| | 25-Aug-89 | 8.63 | 983.13 | 733 |
| | 04-Nov-89 | 1.44 | 98.13 | 12 |
| | 26-Jun-90 | 1.56 | 297.81 | 40 |




*Appendix 20: Sediment yield calculation numbering*

Note that sediment yields at positions 77 and 78 were calculated from neighbouring catchments.

*Appendix 21: Sediment yields at various locations in the Baro-Akobo-Sobat study area (this study)*

| Catchment name | Sub-catchment No. | Coordinate | | Accumulated catchment up to point | |
|---|---|---|---|---|---|
| | | | | Area | Sediment Yield |
| | | X | Y | $km^2$ | $ton/km^2.a$ |
| **Baro** | 1 | 778742.71 | 1010772.69 | 1425 | 347 |
| | 2 | 771402.10 | 988618.92 | 1865 | 408 |
| | 3 | 725249.05 | 970251.87 | 1026 | 277 |
| | 4 | 735749.42 | 960017.41 | 4781 | 506 |
| | 5 | 761183.95 | 938748.75 | 4148 | 595 |
| | 6 | 758564.57 | 937589.88 | 2330 | 803 |
| | 7 | 788524.39 | 903205.55 | 269 | 183 |
| | 8 | 773157.36 | 906064.82 | 102 | 626 |
| | 9 | 734964.33 | 940867.27 | 14738 | 512 |
| | 10 | 704494.86 | 947455.41 | 266 | 220 |
| | 11 | 716824.46 | 910876.69 | 4744 | 872 |
| | 12 | 674160.50 | 912280.81 | 23542 | 363 |
| | 13 | 607928.77 | 907872.69 | 26122 | 208 |
| **Alwero** | 14 | 664628.77 | 870372.69 | 2858 | 148 |
| | 15 | 621728.77 | 882672.69 | 4048 | 116 |
| | 16 | 610962.09 | 877881.88 | 1682 | 16 |
| | 17 | 592028.77 | 884472.69 | 6410 | 76 |
| **Gilo** | 19 | 771734.19 | 793276.05 | 1720 | 246 |
| | 20 | 705602.73 | 803747.80 | 5015 | 168 |

| | | | | | |
|---|---|---|---|---|---|
| | 21 | 705682.11 | 804365.16 | 1676 | 676 |
| | 22 | 654132.80 | 829916.88 | 9375 | 246 |
| | 23 | 594812.52 | 863480.20 | 9993 | 255 |
| **Akobo** | 24 | 748898.08 | 719464.52 | 5115 | 188 |
| | 25 | 698150.90 | 728777.87 | 8085 | 174 |
| | 26 | 688639.11 | 739021.67 | 10538 | 150 |
| | 27 | 642706.03 | 767762.98 | 12534 | 141 |
| | 28 | 625117.81 | 787560.47 | 14399 | 101 |
| | 18 | 578168.34 | 840322.07 | 17203 | 90 |
| **Agwei** | 30 | 719528.77 | 449172.69 | 7472 | 10 |
| | 31 | 705428.77 | 546672.69 | 21742 | 10 |
| | 32 | 641528.77 | 581772.69 | 35927 | 10 |
| | 33 | 616928.77 | 603072.69 | 46751 | 10 |
| | 34 | 600428.77 | 616272.69 | 47328 | 16 |
| | 35 | 595928.77 | 640872.69 | 58447 | 13 |
| | 36 | 568328.77 | 680472.69 | 63587 | 13 |
| | 37 | 522728.77 | 573972.69 | 3874 | 10 |
| | 38 | 548528.77 | 693972.69 | 66920 | 12 |
| **Pibor** | 39 | 508028.77 | 514272.69 | 7410 | 19 |
| | 40 | 480728.77 | 559872.69 | 8550 | 20 |
| | 41 | 458228.77 | 582672.69 | 5513 | 20 |
| | 42 | 461828.77 | 609072.69 | 17095 | 19 |
| | 43 | 477128.77 | 675972.69 | 20324 | 17 |
| **Sobat** | 44 | 424868.77 | 810012.69 | 1717 | 10 |

| | | | | | |
|---|---|---|---|---|---|
| | 47 | 369428.77 | 841692.69 | 3854 | 10 |
| | 48 | 367448.77 | 926832.69 | 6649 | 10 |
| | 49 | 409028.77 | 968412.69 | 8401 | 10 |
| | 55 | 416948.77 | 976332.69 | 12855 | 10 |
| | 56 | 418928.77 | 1008012.69 | 22538 | 10 |
| **Daga** | 57 | 647528.77 | 1014672.69 | 494 | 213 |
| | 58 | 647528.77 | 1014972.69 | 221 | 435 |
| | 59 | 644528.77 | 1014672.69 | 729 | 303 |
| | 60 | 637928.77 | 1014972.69 | 1042 | 486 |
| | 61 | 617228.77 | 1017072.69 | 1787 | 371 |
| | 62 | 601028.77 | 1019172.69 | 2372 | 378 |
| | 63 | 551228.77 | 1022772.69 | 3326 | 288 |
| | 64 | 518228.77 | 1036872.69 | 4345 | 252 |
| | 65 | 551228.77 | 1071972.69 | 6347 | 109 |
| | 66 | 559928.77 | 1063272.69 | 600 | 10 |
| | 67 | 543728.77 | 1052172.69 | 9147 | 96 |
| | 68 | 496628.77 | 1058472.69 | 14838 | 65 |
| | 69 | 635828.77 | 959772.69 | 1302 | 293 |
| | 70 | 626528.77 | 967572.69 | 683 | 198 |
| | 71 | 559028.77 | 968472.69 | 5397 | 129 |
| | 72 | 577028.77 | 980772.69 | 944 | 137 |
| | 73 | 551228.77 | 979872.69 | 2076 | 72 |
| | 74 | 508028.77 | 1004472.69 | 11358 | 91 |
| | 75 | 510114.08 | 851586.14 | 118685 | 43 |

| | | | | | |
|---|---|---|---|---|---|
| Pibor and Agwei extension | 29 | 641270.66 | 766949.38 | 1702 | 10 |
| Yabus | 76 | 568856.75 | 1098106.38 | 6156 | 110 |
| Marshland | 77 | 488327.38 | 950713.48 | 206107 | 89 |
| Marshland exit to Nile | 78 | 422804.07 | 1118223.29 | 43310 | 55 |

# Annex 1-D: Groundwater report

# BARO-AKOBO-SOBAT MULTIPURPOSE WATER RESOURCES DEVELOPMENT STUDY - BASELINE STUDY

# Annex 3-D Groundwater report

# TABLES AND FIGURES

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# ACRONYMS AND ABREVIATIONS

| | |
|---|---|
| AfDB | African Development Bank |
| ACORD | Association for Cooperative Operations Research and Development |
| ACTED | Agency for Technical Cooperation and Development |
| BAS | Baro Akobo Sobat |
| CAMP | Comprehensive Agriculture Development Master Plan |
| CBA | Cost Benefit Analysis |
| CMA | Catchment Management Association |
| CRA | Cooperative Regional Assessment |
| DEM | Digital Elevation Model |
| EEPCO | Ethiopian Electric Power Corporation |
| EHA | Erosion Hazard Assessment |
| EIA | Environmental Impact Assessment |
| ENID | Eastern Nile Irrigation and Drainage |
| ENCOM | Eastern Nile Committee Of Ministers |
| ENPM | Eastern Nile Planning Model |
| ENPT | Eastern Nile Power Trade |
| ENSAP | Eastern Nile Subsidiary Action Plan |
| ENTRO | Eastern Nile Technical Regional Office (NBI) |
| EPA | Environmental Protection Authority |
| FAO | Food and Agriculture Organization |
| GDEM | Global Digital Elevation Model |
| GDP | Gross Domestic Product |
| GEF | Global Environment Facility |
| GIS | Geographic Information System |
| GTP | Growth and Transformation Plan |
| GWh/y | GigaWatt hour/year |
| HEP | Hydroelectric Power |
| IDEN | Integrated Development of Eastern Nile |
| ILWRM | Integrated Land and Water Resources Management |
| IPCC | Intergovernmental Panel on Climate Change |
| IUCN | International Union for Conservation of Nature and Natural Resources |
| IWMI | International Water Management Institute |
| IWRDMP | Integrated Water Resources Development and Management Plan |
| IWRM | Integrated Water Resource Management |
| JMP | Joint Multipurpose Project |
| MAFCRD | Ministry of Agriculture, Forestry, Cooperatives and Rural Development |
| MASL | Meters Above Sea Level |
| MCA | Multi Criteria Analysis |
| MDG | Millennium Development Goals |
| MEDIWR | Ministry of Electricity, Dams, Irrigation and Water Resources |
| MERET | Managing Environmental Resources to Enable Transitions |
| MLFI | Ministry of Livestock and Fisheries |
| MoA | Ministry of Agriculture |
| MoEN | Ministry of Environment |
| MoWIE | Ministry of Water, Irrigation and Energy |
| MSIOA | Multi Sector Investment Opportunity Analysis |
| MTR&B | Ministry of transport, roads and bridges |
| MW | Mega Watt |
| MWC&T | Ministry of Wildlife Conservation and Tourism |
| NB-DSS | Nile Basin Decision Support System |
| NBI | Nile Basin Initiative |
| NCORE | Nile Cooperation for result project |
| NDVI | Normalized Difference Vegetation Index |

| | |
|---|---|
| NELSAP | Nile Equatorial Lakes Subsidiary Action Program |
| NGO | Non-Governmental Organization |
| Nile-COM | Nile Council of Ministers |
| PIM | Project Implementation Manual |
| PLSPP | Policies, Legislation, Strategies, Plans, and Programs |
| PPP | Private Public Partnership |
| PMU | Project Management Unit |
| PRSP | Poverty Reduction Strategy Program |
| RATP | Regional Agricultural Trade and Productivity Project |
| RPSC | Regional Project Steering Committee |
| RSS | Republic of South Sudan |
| RUSLE | Revised Universal Soil Loss Equation |
| SAP | Subsidiary Action Program |
| SEA | Strategic Environmental Assessments |
| SIS | Soil Information System |
| SLMP | Sustainable Land Management Program |
| SNNPR | Southern Nations, Nationalities and Peoples' Region |
| SRFE | Satellite Rainfall Estimates |
| SRTM | Shuttle Radar Topographic Mission |
| SSEA | Strategic Social and Environmental Assessment |
| SVP | Shared Vision Program |
| SWAT | Soil and Water Analysis Tool |
| SWOT | Strength Weakness Opportunity Threat |
| SWSC | Soil-Water Storage Capacity |
| UNDP | United Nations Development Program |
| UNHCR | United Nations High Commissioner for Refugees |
| UNICEF | United Nations Children's Fund |
| USAID | United States Agency for International Development |
| WaSH | Water Sanitation and Hygiene |
| WB | World Bank |
| WBISPP | Woody Biomass Inventory and Strategic Planning Project |
| WCYA | Women, Children and Youth Affairs |
| WEES | Water for Eastern Equatoria |
| WFP | World Food Program |
| WM | Watershed Management |
| WRMA | Water Resources Management Authority |
| WRMD | Water Resources Management and Development |
| WSS | Water Supply and Sanitation |
| WUA | Water Users Association |

# 1. INTRODUCTION

The aim of this report is to present the groundwater development potential in a format that is accessible and useable for development planning purposes. In relation the Terms of Reference (with respect to groundwater), it states the following: “Based on secondary data and studies, the Consultant will map and characterize groundwater resources potential and utilization for development uses”.

The Inception and Scoping Phases included assessing the availability and quality of data and a start was made in compiling data for the Baseline Study. During the Baseline Study data was compiled in the final formats and this involved extrapolating from the incomplete data sets obtained in the Scoping Phase or developing new data sets from scratch. Because most original data sets are sparse and because the mapping scale is small (to cover the vast study area), some of the results presented cannot carry a high degree of confidence, although on a qualitative basis, the results are likely to reasonably reflect the groundwater conditions of the area.

The main deliverable, where a considerable portion the team’s time was spent, are the maps on the ‘Extractable rate of groundwater recharge’ (Chapter 3). Given the sparse available data sets, new data sets were generated in most cases, and a methodology to quantify the groundwater resource potential was developed. The results are satisfactory and compare favourably to similar regional studies on other areas in Africa. It is recomemnded that Option 2 of the ‘Extractable rate of groundwater recharge’ (Figure 3-3) be adopted as the current best estimate of the groundwater potential for the BAS sub-basin.

The hydrogeologists responsible for this report are:

- Mr Abebe Ketema, Consultant Hydrogeologist, Ethiopia.
- Mr Gedion Tsegaye Sahle, GTS Services Plc., Ethiopia.
- Dr Ricky Murray, Groundwater Africa. South Africa.

# 2. GROUPING AREAS WITH SIMILAR GROUNDWATER SUPPLY POTENTIAL

The process of grouping areas with similar groundwater supply potential and then quantifying the potential yields of these areas was as follows:

**Step 1.** Define the groundwater yield-related criteria

i. Regional permeability (termed BAS Lithologic Permeability). Assumption: Yield potential increases with higher regional permeability. Regional permeability may be primary permeability (like pore spaces in unconsolidated and consolidated formations), or it may be the regional permeability that is associated with average jointing and fracturing in hard-rocks.

ii. Secondary permeability (termed BAS Geologic Structures). Assumption: Yield potential increases with higher lineament, joint and fault densities.

iii. Topographic location (termed BAS Topography: Slope). Assumption: Yield potential increases in areas with gentle slopes and in valley bottoms.

iv. Groundwater recharge (termed BAS Regional Groundwater Recharge). Assumption: Yield potential increases with increasing recharge.

**Step 2.** Quantify the above criteria

i. BAS Lithologic Permeability: Group geological formations with similar regional permeabilities. The source information was compiled from numerous studies and text books (identified during the Scoping Study – see the following section).

ii. BAS Geologic Structures: Group areas with similar lineament densities. The lineament data set used was from this study (see the following section) and areas were selected based on geological formations and geographical areas.

iii. BAS Topography: Slope: The DEM used in this study (see the following section) was used to compile a slopes layer (in degrees) and areas with similar slopes were grouped together.

iv. BAS Regional Groundwater Recharge: Using recharge estimates from various sources identified in the Scoping Study a formula to estimate recharge was developed using a percentage of Mean Annual Precipitation (MAP). The MAP data used was generated in this project (see the hydrology section). The recharge values were checked with previous studies and correlated sufficiently well to use for the entire study area.

**Step 3.** Develop a weighting system

i. The four criteria above were each divided into groups: For Regional Permeability, 5 groups were created, and for the other 3 criteria, 3 groups were created. Each group has a score with the most favourable groundwater areas having high scores, and the least favourable having low scores. I.e. the groups reflect how favourable an area is for groundwater development.

ii. Each criteria was applied a weighting factor based on the value of each criteria to groundwater development. The weighting factors applied were: Regional permeability (25%); Secondary permeability (20%); Topographic location (30%); Recharge (25%).

**Step 4.** Group areas of similar weights

i. Applying the above approach to the study area produced areas ranging from low values representing poor groundwater development areas to high values representing good groundwater development areas.

ii. The areas were then grouped into 5 classes: High, Medium to High, Medium, Low to Medium, Low.

**Step 5.** Quantify the 5 class areas

i. This was done by assigning extractable percentages of groundwater recharge to the groundwater availability layer.

## 2.1 BAS LITHOLOGIC PERMEABILITY

The main geological spatial data produced are lithological units and geologic structures (structural linearments), mainly mapped or derived from remotely-sensed data and existing geological maps. The remote-sensing analysis was carried out in 2015 by TTI Production (a sub-contractor used on the project).

Some 31 mapping units (30 lithologic and 1 water) were identified at 1: 100,000 (100K) scale. The attribute table of the geology GIS shapefile includes relevant information like lithological descriptions, stratigraphy and mapping codes. The surficial lithological units were first grouped according to main permeability types. Each mapping unit within these groups was assigned relative permeability classes by referring to available maps and reports as well as incorporating personal experiences of the study team (see Table 2-1, Table 2-2, Table 2-3 and Figure 2-1, Figure 2-2). These classes take into consideration primary permeability and regional secondary permeability due to degrees of large-scale fracturing and weathering. A description of the lithological codes is give in Appendix 1.

*Table 2-1 Sediments, mainly intergranular permeability type*

| Stratigraphy | Litho-Unit Code | Permeability Class |
|---|---|---|
| Holocene to Recent | Q_undif | Medium |
| | Q_fan | Medium - High |
| | Qal | Medium |
| | Qc | High |
| Pleistocene to Holocene | Qal2 | Medium |
| Cenozoic, Plio-Pleistocene | CzUR | Medium |

*Table 2-2: Volcanic, mainly fracture permeability type*

| Stratigraphy | Litho-Unit Code | Permeability Class |
|---|---|---|
| Quaternary? | VL | Low |
| Cenozoic | CzVa | Low |
| | CzVb | Medium |
| Paleogene to Neogene | Pga | Medium |

*Table 2-3: Basement, mainly fracture/weathering permeability type*

| Stratigraphy | Litho-Unit Code | Permeability Class |
|---|---|---|
| Precambrian | PE_Gabbro | Low |
| | PEGr | Low |
| Upper Proterozoic | Gt1 | Low |
| | Gt2 | Low |
| | PE3a | Low |
| | PE3lb | Low |
| | UB | Low |
| Middle Proterozoic | PEs | Low |
| | PEsa | Low |
| | PEsm | Low - Medium |
| | PEsq | Low |
| | PEsy | Low |
| | PEum | Low |
| Lower to Middle Proterozoic | PE1 | Low-Medium |
| | PE1_hard | Low |
| Lower Proterozoic | PEp | Low-Medium |
| | PEpgns | Low |
| | PEps | Low |
| Archean? | PE1b | Low |
| Archean | PEx | Low |

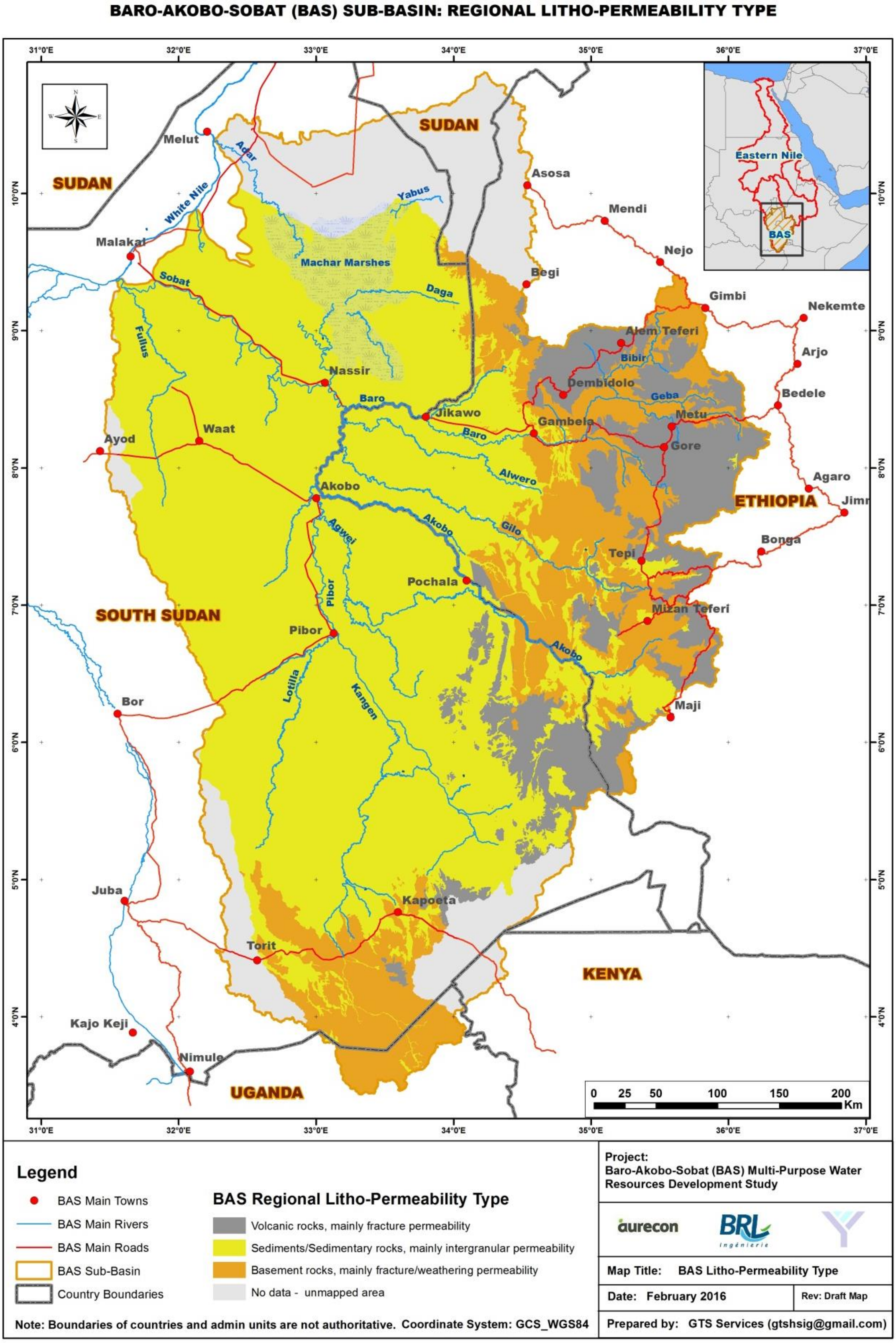


*Figure 2-1: BAS Regional Litho-Permeability Type*

BARO-AKOBO-SOBAT (BAS) SUB-BASIN: REGIONAL LITHO-PERMEABILITY CLASSES

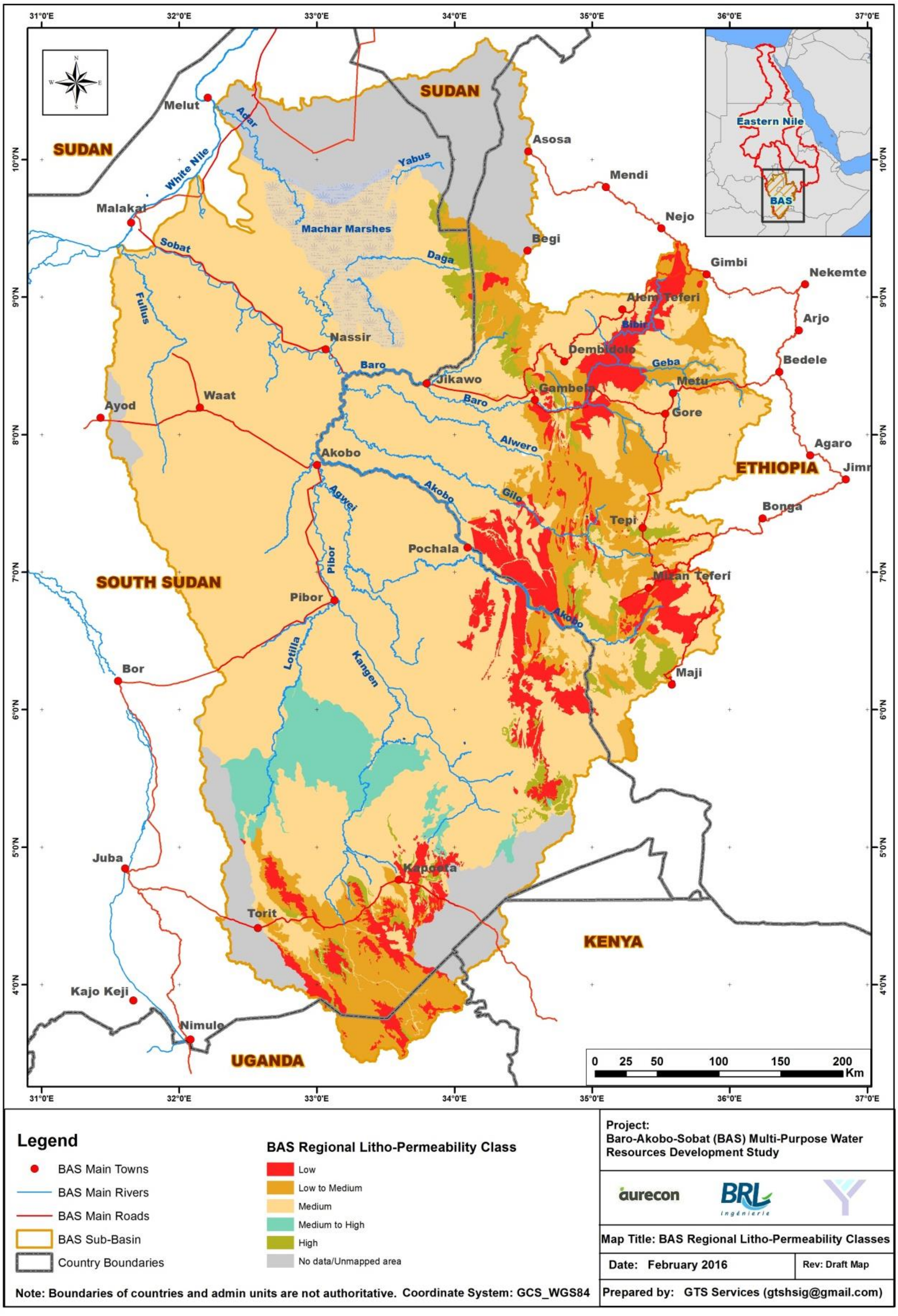


*Figure 2-2: BAS Regional Litho-Permeability Class*

## 2.2 BAS GEOLOGIC STRUCTURES

Some geological structures play an important role in enhancing the permeability of the host rocks by creating secondary porosity and permeability. While this statement holds in most places, it does not necessarily hold in all places, as fractures may have been cemented up, for example, during geothermal processes. Detailed analysis and field mapping would be necessary to identify only those structures that enhance permeability, but this was outside the scope of this exercise. Regional geological structures were mapped as part of this project at 1:100,000 scale using mainly remote sensing techniques. Areas of high fault/lineament densities were considered favourable for groundwater occurrence.

The main geo-structures identified and mapped, include faults (certain & inferred), photo-lineaments and tecto-lineaments. Their densities were assessed and grouped into different classes (Table 2-1) and mapped accordingly (Figure 2-3). The high land parts of Baro Akobo (Ethiopia) and parts of Eastern equatorial state of South Sudan are characterised by high structural densities owing to their underlying hard rock formations, while the flat low lands of the project area are characterised by poor structural densities as these area are covered by alluvial deposits of primary porosity and permeability.

*Table 2-4: Regional Geologic Structures Density*

| **Geo-structures Density (per Km$^2$)** | **Class** |
|---|---|
| < 0.025 | High |
| 0.02 – 0.05 | Medium |
| 0.05 – 0.1 | Low-Medium |
| 0.1 – 0.2 | Low |
| > 0.2 | Very Low |

BARO-AKOBO-SOBAT (BAS) SUB-BASIN: REGIONAL GEO-STRUCTURES DENSITY

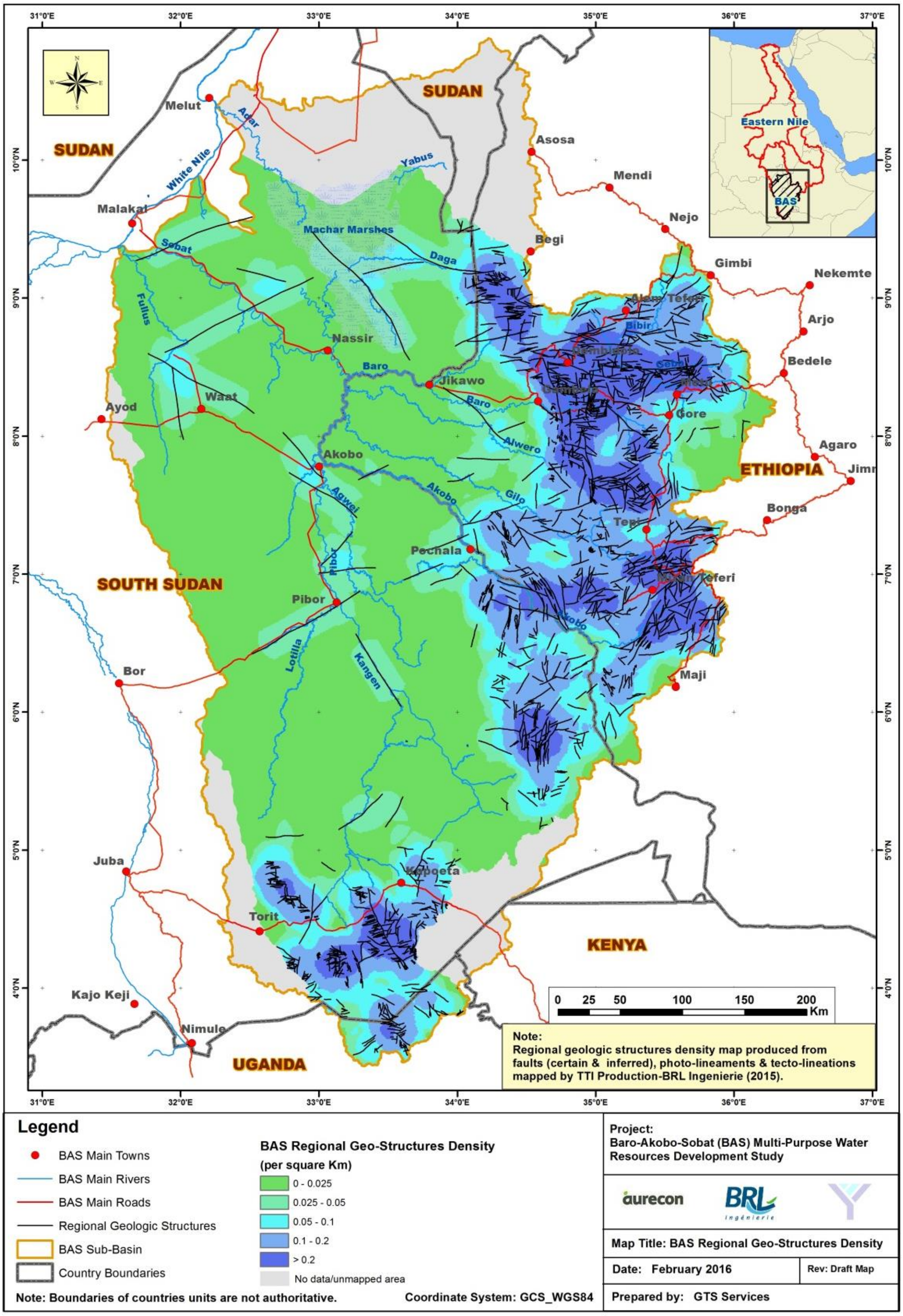


*Figure 2-3: BAS Geo-StructuresDensity*

## 2.3 BAS TOPOGRAPHY: SLOPE

Mountains and areas with steep slopes are generally not favourable for groundwater development. While they may form areas of high recharge and throughflow, it is generally the flatter areas that are targeted for groundwater supply. A slope map (the BAS Slope map) was produced from the SRTM Digital Elevation Model (DEM) at a 30m spatial resolution. The slopes were in degrees were then grouped into flat/plain area, gentle, moderate, and steep slope groups (Figure 2-4).

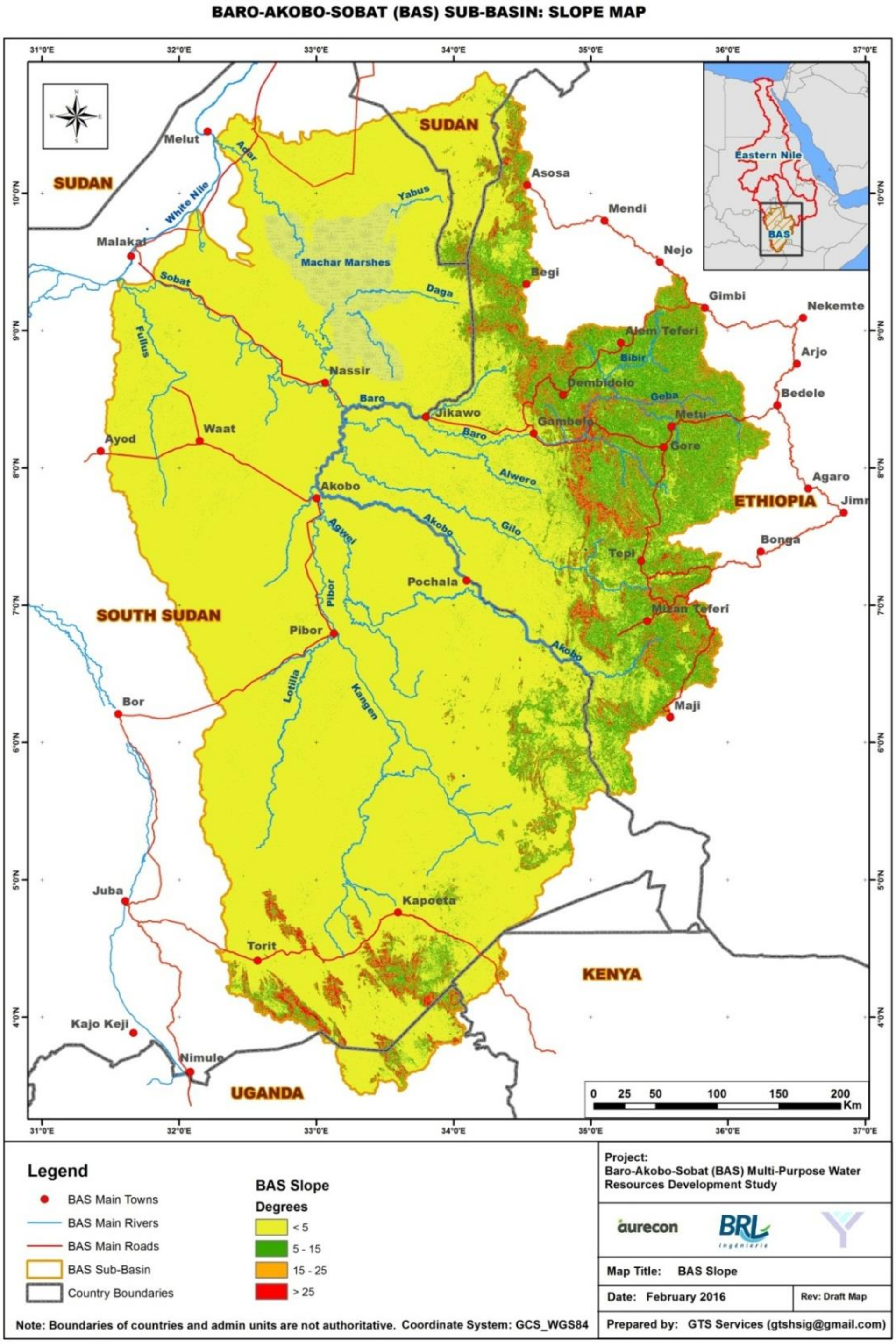


*Figure 2-4: BAS Slopes*

## 2.4 BAS Regional Groundwater Recharge

### 2.4.1 Introduction

Groundwater recharge rates are difficult to establish without good field data. In the absence of this, indirect means are needed to provide reasonable estimates. The approach adopted was to use the two main determining factors: Rainfall and infiltration capacity.

### 2.4.2 BAS Mean Annual Rainfall

Groundwater recharge generally occurs after a certain rainfall threshold has been surpassed within a specific time period. Without local time-series data on rainfall-infiltration relationships, a reasonable approach is to use mean annual rainfall as the baseline data.

The rainfall map (Figure 2-5) prepared during this project shows that the mean annual rainfall over the study region ranges from < 800mm for the areas of Upper Nile in the North of the project area and Eastern Equatoria state in the South of the study area, to over 1500mm over the Ethiopian highlands of the Baro Akobo basin in the East. The rest of the rainfall values are zoned in a decreasing pattern from East to West of the BAS study area.

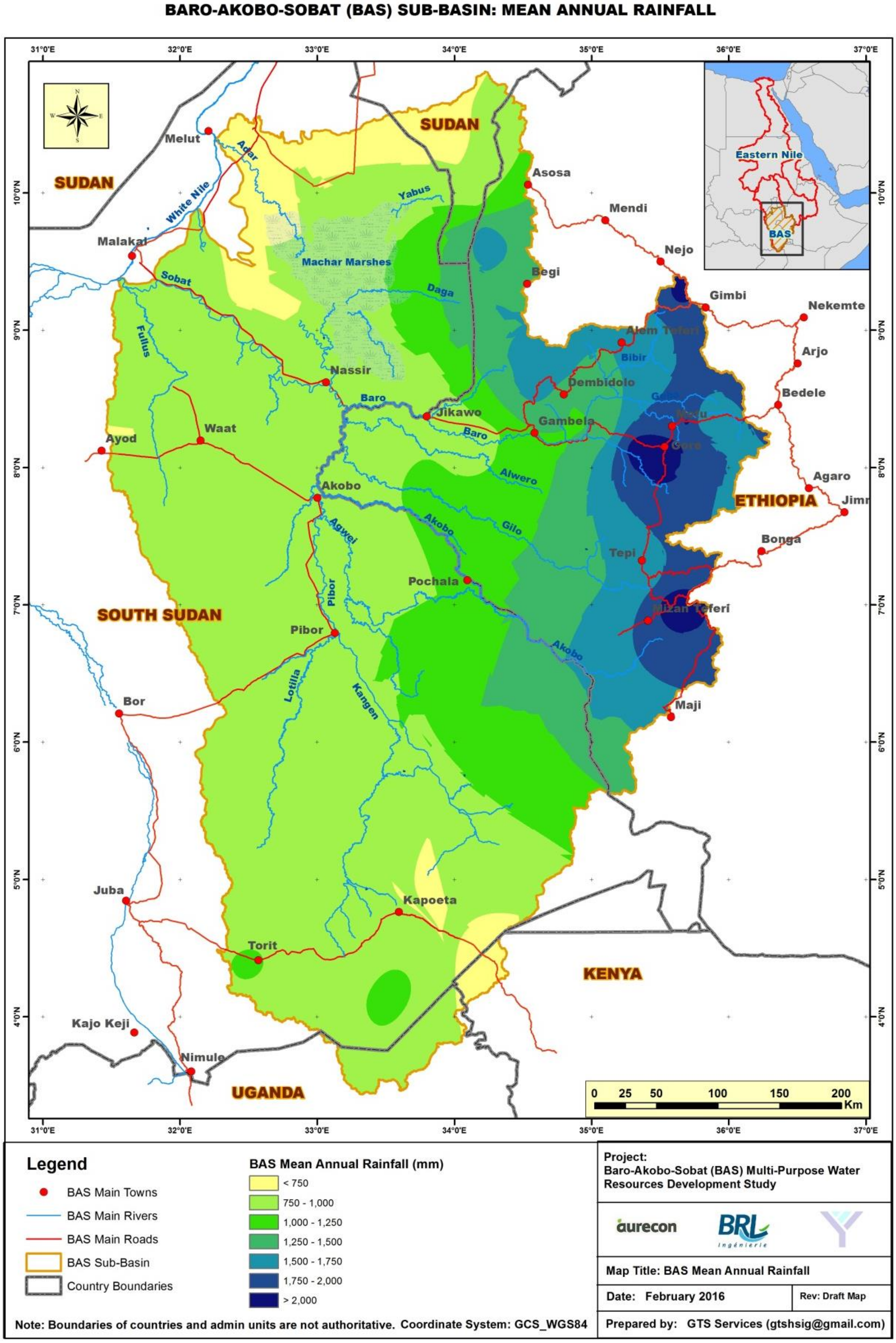


*Figure 2-5: BAS Mean Annual Rainfall*

### 2.4.3 BAS Regional Infiltration Coefficients

Direct infiltration into the weatherd zone overlying the hard rock and into exposed fissures and fractures varies depending on the permeability and infiltration capacity of the rock units over the study area. In areas where the permeability of the surface formation is low, the infiltration capacity is limited and much of the potential recharge is rejected and enters drainage channels and rivers as surface runoff. The relationship between recharge and rainfall varies significantly, even at a local scale, and can be established by taking the nature of precipitation into account, the nature and thickness of the topsoil and the weathered zone, the rock types and fracture systems, topographical factors, etc. In this study, a generalised approach was followed and the BAS regional litho-infiltration coefficient map was produced by giving infiltration coefficients to the various geologic lithologic units depending on their permeability class (Table 2-5and Figure 2-6).

The high infiltration rates correlate with geological units inferred to posses relatively high permeability. From the table, it is evident that that the sediments with intergranual permeability of the type (Qc ) are characterized by relatively high infiltration rates (0.175%), while other sediments covering large portion of the study area are given medium values (0.1%). Volcanic rocks are characterized by variable permeability properties and hence the infiltration coefficient of these volcanic units ranges from low (0.05%,CzVa) to medium (0.10%, CzVb, Pga). The infiltration coefficient assigned to the basement rocks is in general low (0.05 %).

In general, the capability of an aquifer system to integrate the effects of the precipitation over a number of years depends on the deep infiltration properties of the rocks and the drainage area. Infiltration rates vary widely, depending on geology, land use, the character and moisture content of the soil, and the intensity and duration of precipitation, from possibly as much as 0.175% over permeable grounds to about 0.05 % over basement environments of the study area.

*Table 2-5: BAS Regional Infiltration Coefficients*

| Litho-Unit Code | Permeability Class | Infiltration Coefficient |
|---|---|---|
| Q_undif | Medium | 0.1 |
| Q_fan | Medium - High | 0.15 |
| Qal | Medium | 0.1 |
| Qc | High | 0.175 |
| Qal2 | Medium | 0.1 |
| CzUR | Medium | 0.1 |
| VL | Low | 0.05 |
| CzVa | Low | 0.05 |
| CzVb | Medium | 0.1 |
| Pga | Medium | 0.1 |
| PE_Gabbro | Low | 0.05 |
| PEGr | Low | 0.05 |
| Gt1 | Low | 0.05 |
| Gt2 | Low | 0.05 |
| PE3a | Low | 0.05 |
| PE3lb | Low | 0.05 |
| UB | Low | 0.05 |
| PEs | Low | 0.05 |
| PEsa | Low | 0.05 |
| PEsm | Low - Medium | 0.08 |
| PEsq | Low | 0.05 |
| PEsy | Low | 0.05 |
| PEum | Low | 0.05 |
| PE1 | Low - Medium | 0.08 |
| PE1_hard | Low | 0.05 |
| PEp | Low - Medium | 0.08 |
| PEpgns | Low | 0.05 |
| PEps | Low | 0.05 |
| PE1b | Low | 0.05 |
| PEx | Low | 0.05 |

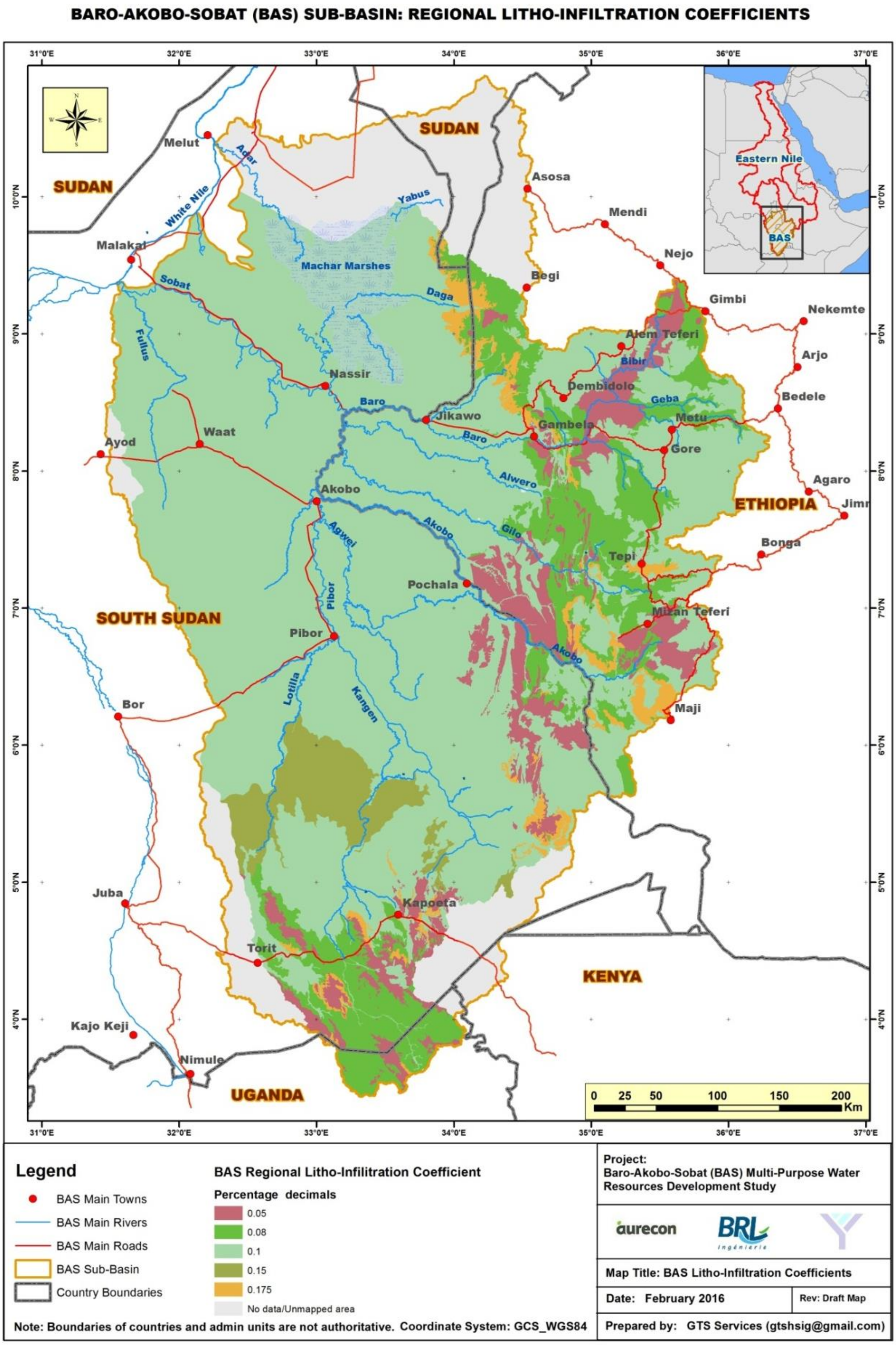


*Figure 2-6: BAS Regional Litho-infiltration Coefficient*

### 2.4.4 BAS Regional Groundwater Recharge

While acknowledging the complexity of groundwater recharge and the various local hydrogeologic processes that govern its effectiveness, rainfall data together with infiltration estimates were combined to present a regional map of groundwater recharge (Figure 2-7).

The annual recharge rates determined for the study area fall in the range of < 50mm/yr to about 300mm/yr. The relatively higher recharge rates correspond to the highland areas with permeable grounds especially the Ethiopian highland parts of the Baro Akobo basin. The vast plain areas covering the South Sudan as well as the low lands of Gambela plain gets relatively lower recharge rates (<100mm/yr) mainly due to the lower rate of precipitation over these areas. However, it should be noted that the aquifers, especially the deep aquifers underlying these areas, such as the regional aquifers within the Alwero Formation underlying the Gamela Plain which are inferred to extend towards South Sudan, could receive additional recharge from the lateral influx of water as a result of deeper percolation processes from the adjacent high lying areas in the east of the study region (the Ethiopian highlands). The details of this and its quantifications, however, would require a specialist study.

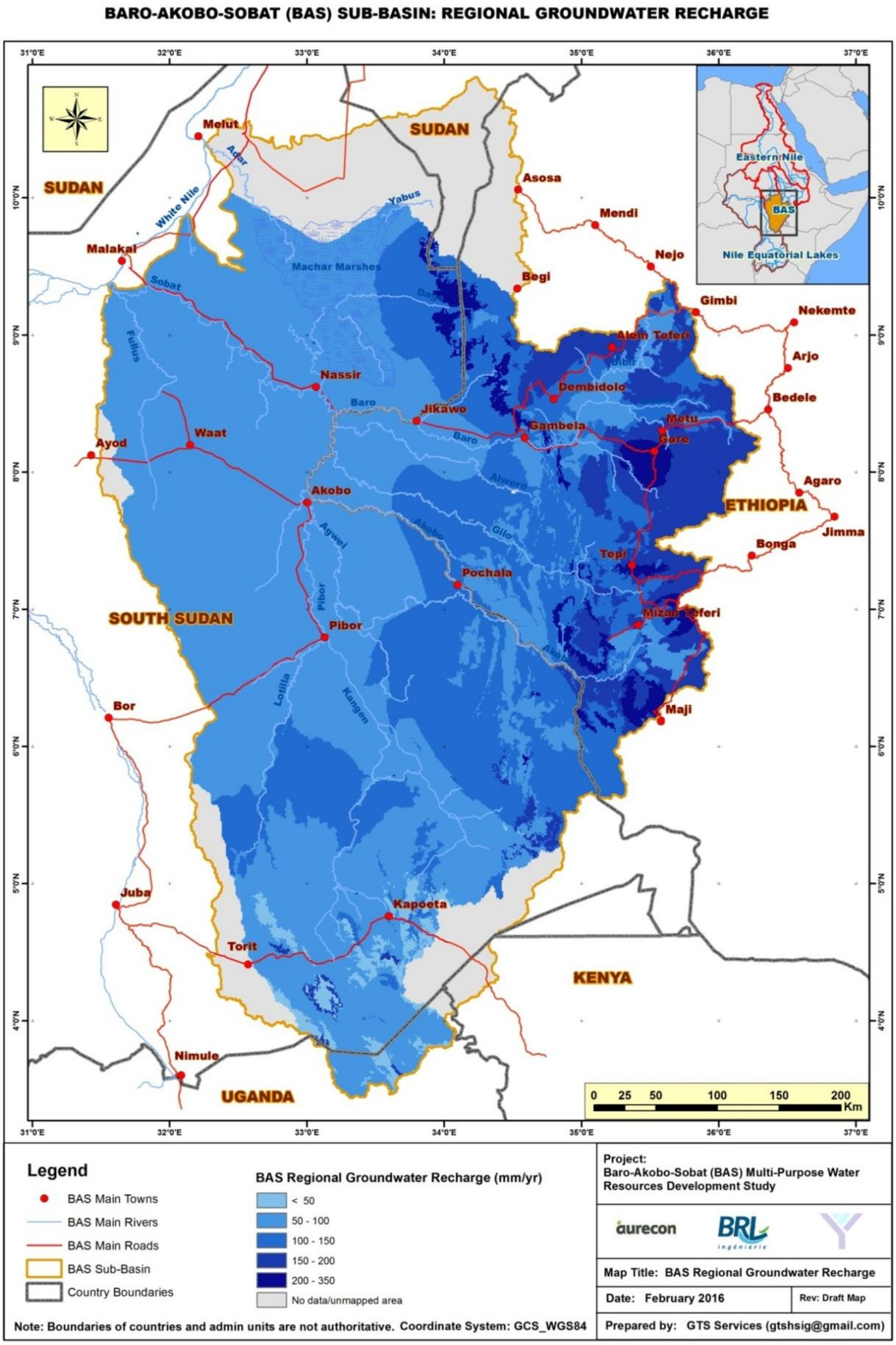


*Figure 2-7: BAS Regional Groundwater Recharge*

# 3. BAS GROUNDWATER POTENTIAL

## 3.1 INTRODUCTION

The process used to quantify the groundwater potential followed two steps:

i. Define groundwater availability by develop a weighting system that takes the four criteria above into account.

ii. Quantify the areas by assigning extractable percentages of groundwater recharge to the groundwater availability layer.

### 3.1.1 BAS Groundwater Availability

In order to obtain a regional groundwater availability map, an overlay analysis was performed using the above layers. ArcGIS 10.3 spatial analyst was used to assist in weighting and combining the multiple input layers and to produce the groundwater availability map (Figure 3-1). The main input layers used for the overlay analysis together with the layer and class weights are shown in Table 3-1 to Table 3-4.

*Table 3-1: BAS Regional Litho-Permeability*

| Permeability Class | Weight | Layer Weight |
|---|---|---|
| Low | 5 | 0.25 |
| Low to Medium | 10 | |
| Medium | 20 | |
| Medium to High | 30 | |
| High | 35 | |

*Table 3-2: BAS Regional Geo-Structures Density*

| Geo-Structures Density (square Km) | Class | Weight | Layer Weight |
|---|---|---|---|
| 0 - 0.025 | Very Low | 5 | 0.2 |
| 0.025 - 0.05 | Low | 10 | |
| 0.05- 0.1 | Low to Medium | 20 | |
| 0.1 - 0.2 | Medium | 30 | |
| > 0.2 | High | 35 | |

*Table 3-3: BAS Topography: Slope*

| Slope (degrees) | Type | Weight | Layer Weight |
|---|---|---|---|
| 0 - 5 | Flat / Plain Areas | 50 | 0.3 |
| 5 - 15 | Gentle Slopes | 30 | |
| 15 - 25 | Moderate Slopes | 15 | |
| > 25 | Steep Slopes | 5 | |

*Table 3-4: BAS Regional Groundwater Recharge*

| Recharge (mm/yr) | Class | Weight | Layer Weight |
|---|---|---|---|
| < 50 | Low | 5 | 0.25 |
| 50 - 100 | Low to Medium | 10 | |
| 100 - 150 | Medium | 20 | |
| 150 - 200 | Medium to High | 30 | |
| 200 - 335 | High | 35 | |

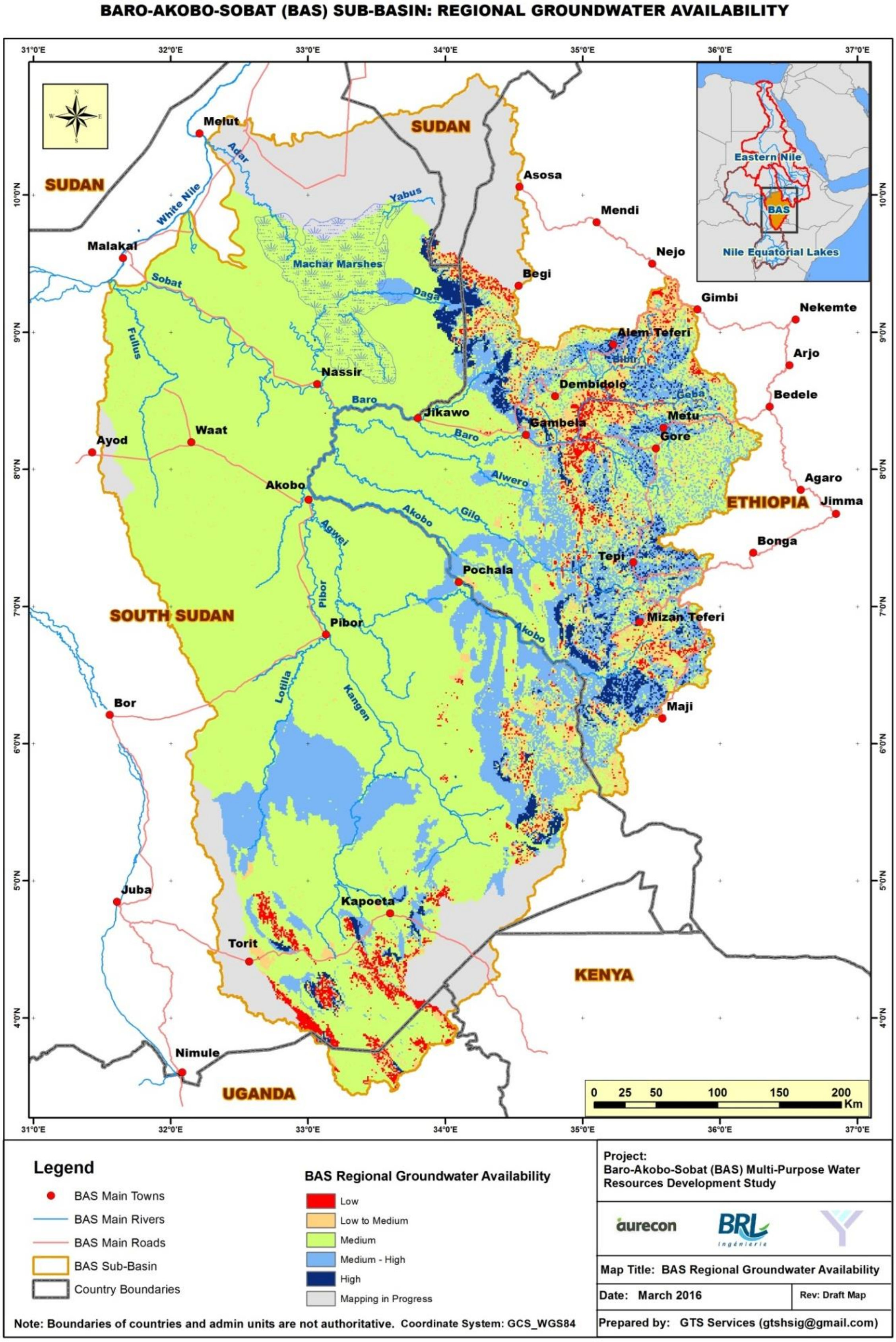


*Figure 3-1: BAS Regional Groundwater Availability*

## 3.2 BAS GROUNDWATER POTENTIAL

The final step in presenting the groundwater yield potential was to quantify the Groundwater Availability groups. This was done by assigning extractable percentages of groundwater recharge to the groundwater availability layer (Table 3-5). While the concept and quantification of extractable groundwater potential, safe yields, sustainable yields, etc, remain a contentious debate amoungst hydrogeologists, the approach taken (using % recharge) was considered a reasonable option given the available data. Previous studies have shown that in using this approach, the abstractable proportion of recharge has a wide range of values, from ~10 % to ~70 % (Miles and Chambet, 1995; Hahn et al., 1997), depending on variations in local geological conditions; and Ponce (2007) found average values to be ~40%.

*Table 3-5: BAS Extractable Percentage (%) of Regional Groundwater Recharge*

| Groundwater Availability | Extractable % of Recharge (Option 1) | Extractable % of Recharge (Option 2) | Extractable % of Recharge (Option 3) |
|---|---|---|---|
| Low | 5 | 5 | 7 |
| Low - Medium | 10 | 15 | 17 |
| Medium | 20 | 25 | 27 |
| Medium - High | 30 | 30 | 35 |
| High | 40 | 50 | 50 |

The values from these options were used to determine the extractable rate of recharge in mm/yr as well as prepare the groundwater potential maps in $10^3 m^3/km^2/yr$ (Table 3-6, Table 3-7, Table 3-8 and Figure 3-2, Figure 3-3, Figure 3-4).

It must be noted that the above approach take surface geology into account, and not aquifers that may exist at depth that are not evident at the surface. An example of this is in the lowers plains where the Alwero Formation exists in the sub-surface. This formation is considered to have high groundwater potential, but is not exposed at the surface, and receives lateral recharge from the highlands. It is discussed later in the report.

*Table 3-6: BAS Abstractable Volume of Groundwater, Option 1*

| GW Availability Zones | Extractable % of Recharge | Area (Km$^2$) | % of Total BAS Area | Yield (Mm$^3$/yr) | Yield (m$^3$/day/km$^2$) |
|---|---|---|---|---|---|
| Low | 5 | 6 077 | 2.3 | 24 | 11 |
| Low - Medium | 10 | 13 274 | 5.1 | 138 | 29 |
| Medium | 20 | 163 246 | 62.7 | 3 063 | 51 |
| Medium - High | 30 | 37 520 | 14.4 | 1 583 | 116 |
| High | 40 | 6 689 | 2.6 | 552 | 226 |
| Area to be processed | | 33 608 | 12.9 | | |
| Total | | 260 414 | 100.0 | 5360 | 56 |

*Table 3-7: BAS Extractable Volume of Groundwater, Option 2*

| GW Availability Zones | Extractable % of Recharge | Area (Km$^2$) | % of Total BAS Area | Yield (Mm$^3$/yr) | Yield (m$^3$/day/km$^2$) |
|---|---|---|---|---|---|
| Low | 5 | 6 077 | 2.3 | 24 | 11 |
| Low - Medium | 15 | 13 274 | 5.1 | 208 | 43 |
| Medium | 25 | 163 246 | 62.7 | 3 828 | 64 |
| Medium - High | 30 | 37 520 | 14.4 | 1 583 | 116 |
| High | 50 | 6 689 | 2.6 | 690 | 283 |
| Area to be processed | | 33 608 | 12.9 | | |
| Total | | 260 414 | 100.0 | 6333 | 67 |

*Table 3-8: BAS Extractable Volume of Groundwater, Option 3*

| GW Availability Zones | Extractable % of Recharge | Area (Km$^2$) | % of Total BAS Area | Yield (Mm$^3$/yr) | Yield (m$^3$/day/km$^2$) |
|---|---|---|---|---|---|
| Low | 7 | 6 077 | 2.3 | 34 | 15 |
| Low - Medium | 17 | 13 274 | 5.1 | 235 | 49 |
| Medium | 27 | 163 246 | 62.7 | 4 133 | 69 |
| Medium - High | 35 | 37 520 | 14.4 | 1 847 | 135 |
| High | 50 | 6 689 | 2.6 | 690 | 283 |
| Area to be processed | | 33 608 | 12.9 | | |
| Total | | 260 414 | 100.0 | 6940 | 73 |

All options appear reasonable when compared to similar regional studies that used different approaches, for example in the Awoja Catchment in Uganda (Murray, 2013) where yields between 21 – 129 m$^3$/day/km$^2$ were obtained, and in the Karoo, South Africa where yields ranging up to 182 m$^3$/day/km$^2$ were obtained (Murray, et al, 2012).

**Since the results are not hugely different, it is recomemnded at this stage, that Option 2 be adopted as the current best estimate of the groundwater potential of the BAS sub-basin.**

While the figures presented above are based on regional generalisations, a few specific points need to be made:

- A considerable part of the Ethiopian highland volcanics shown as medium to high in terms of groundwater availability are also regarded in previous studies as relatively high productive volcanic aquifers belonging to Mekonnen and Tepi basalts.
- The north-trending geologic structures associated with intrusive plugs and dykes may act as groundwater barriers but it is mentioned in the ARDCO-GEOSERV study (1995) that areas in contact with these features could be highly fractured and favorable for groundwater abstraction, indicating the validity of the geologic structures density map.
- Considerable parts of the BAS sub-basin have been mapped as alluvial/colluvial deposits (including lacustrine-alluvials, screes and talus) which have been generally regarded as unconsolidated sediments of intergranular porosity with relatively medium to high permeability. Underlying these deposits in the Gambela plain is the Alwero Formation which comprises sandstones, aleurolites and argilites (Selkhozpromexport, 1990). Reported is an artesian borehole in this formation showing the confined nature of the relatively deeper sandstone aquifer. In the transition zone between the Ethiopian highland and the Gambela plain, there are also the Paleogene Gilo formations (aleurolite, argillites, sandstones and limited conglomerates) and the relatively productive Miocene Gog basalts underlying the alluvio-colluvial deposits (Selkhozpromexport, 1990).
- Despite the fact that the basement rocks on the highlands are considered as having relatively low and low-medium primary permeability, fractured and weathered parts of some of these rocks in areas receiving considerable rainfall can give rise to better productivity. This has also been noted also in the ARDCO-GEOSERV (1995).
- The lateritic deposits which commonly form from weathering of underlying rocks are common sources of shallow groundwater as evidenced from the hand-dug wells data compiled by ARDCO-GEOSERV, 1995.

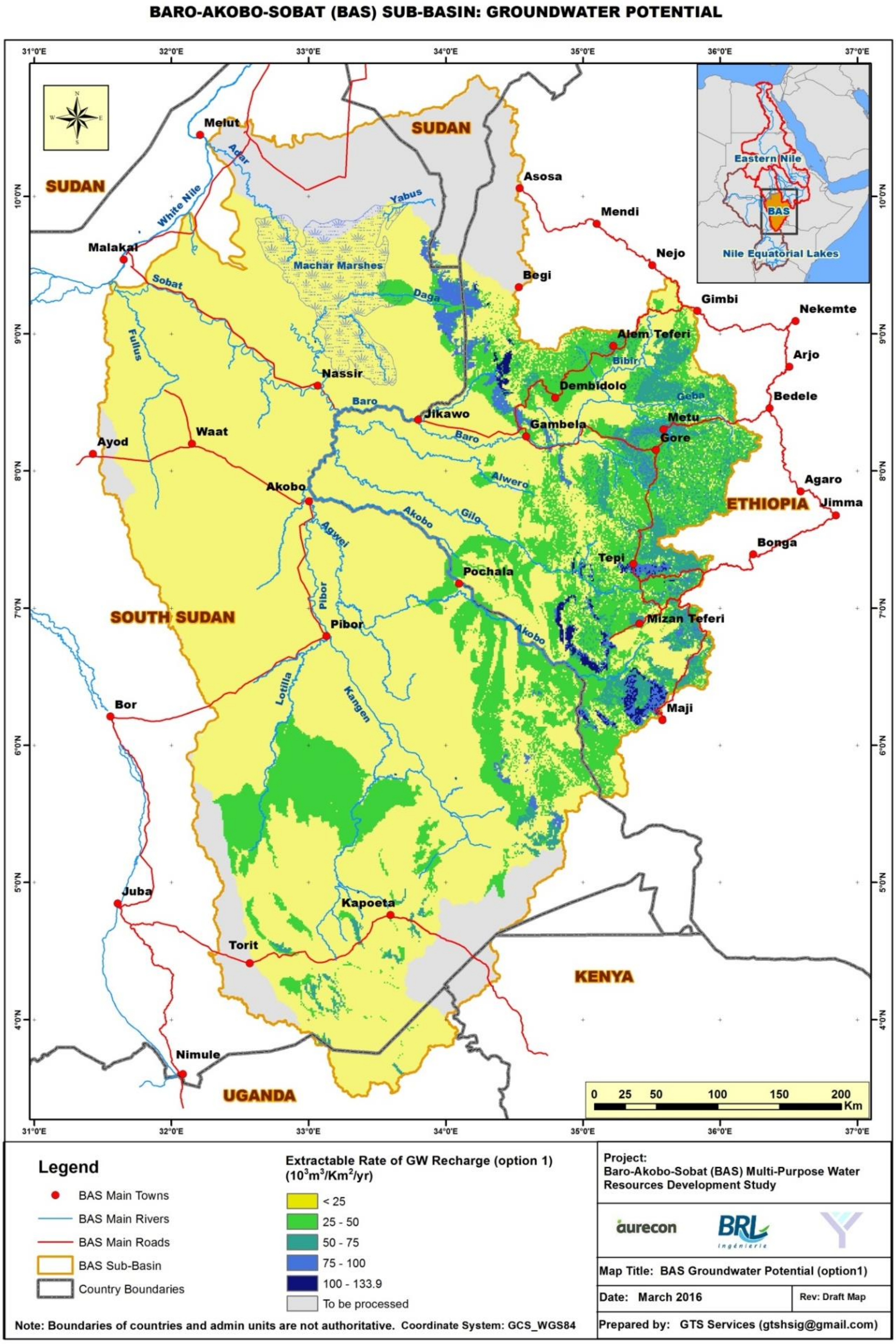


*Figure 3-2: Extractable rate of groundwater recharge – Option 1*

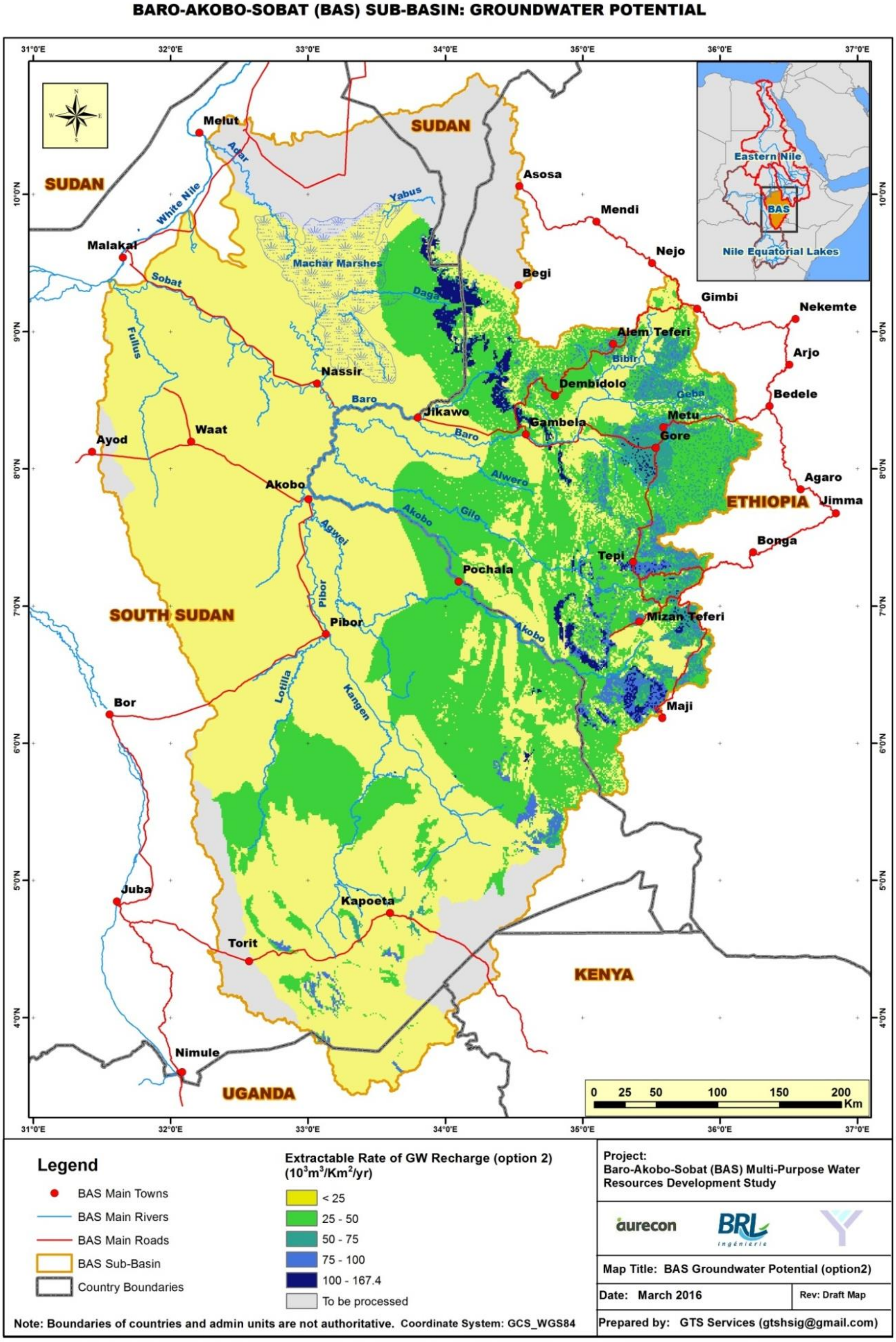


*Figure 3-3: Extractable rate of groundwater recharge – Option 2*

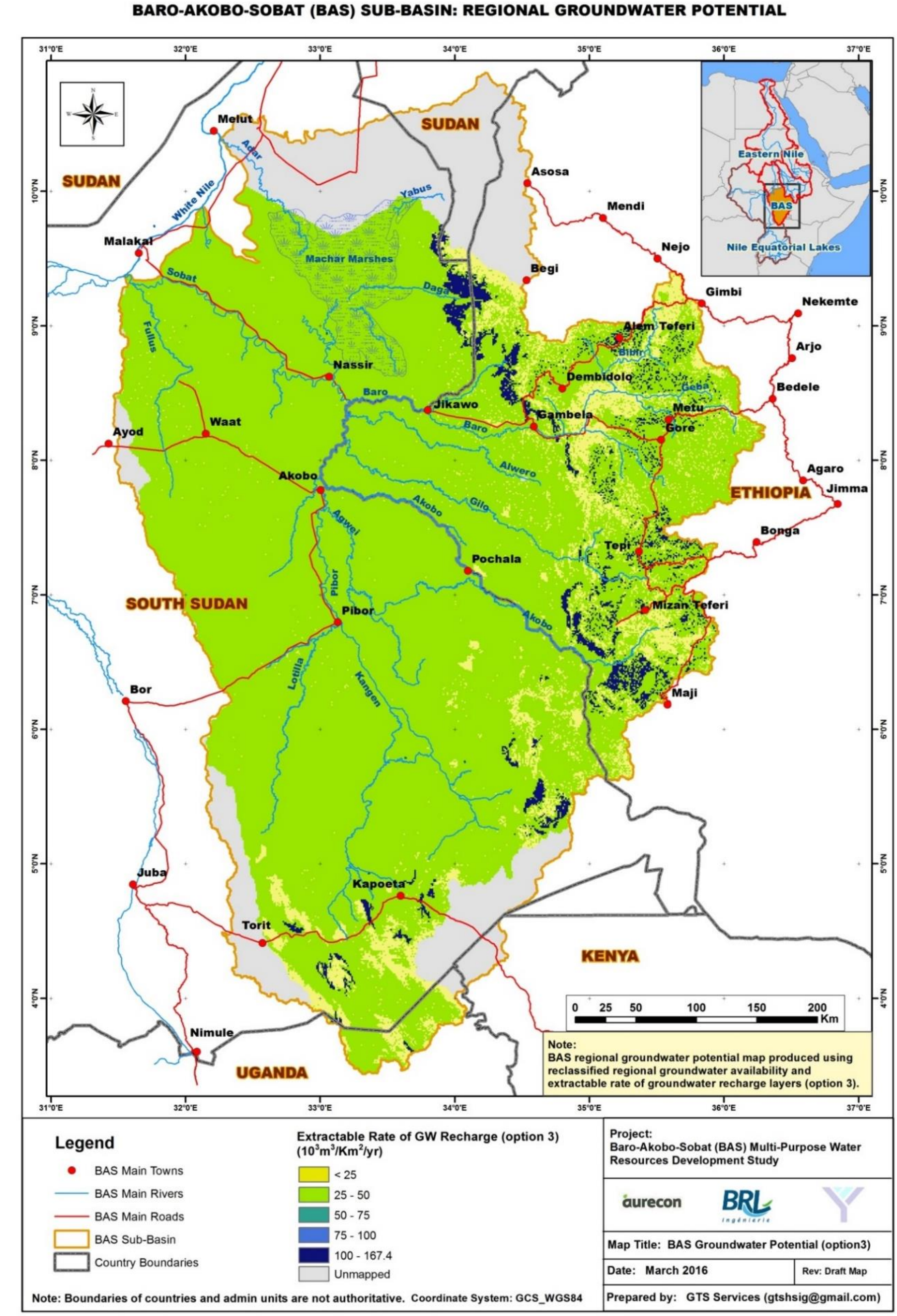


*Figure 3-4: Extractable rate of groundwater recharge – Option 3*

# 4. GROUNDWATER QUALITY

## 4.1 INTRODUCTION

Water quality variations over the project area are complex as a result different physical and geochemical processes that take place due primarily to the diversity in the geology. The spatial coverage of data is also limited and usually dependent on localised surveys of individual projects.

The available literature indicate that generally groundwater quality is good throughout the Blue Nile Basin part of the study area. The water is generally "fresh" (low salinity) and suitable for most uses. There are, however, localized exceptions such as high salinity due to mineralization arising from more reactive rock types, and from contamination due to urbanization. Contamination is greatest in areas with highly permeable unconsolidated sediments, and where water is drawn from hand-dug wells and unprotected springs (Demlie and Wohnlich, 2006) as quoted by Charlotte MacAlister (2010).

Works of Charlotte MacAlister (2010), showed that salinity of the Umm Ruwaba sedimentary formation in South Sudan (an aquifer which is considered to be the second-most important groundwater resource in the region after the Nubian Sandstones aquifer), is generally good, but may rise over 5000 mg/l along its margins (Ahmed *et al.,* 2000). The study also indicated the need for establishing groundwater quality monitoring systems. The same work also indicated that in the adjacent Ugandan part of the region, groundwater quality in most areas meets the guideline requirements for drinking water with the exception of iron and manganese in highly corrosive low pH groundwater, and nitrates in densely populated areas associated with poor sanitation. Generally, however, the groundwater is fresh.

The TDS (total dissolved solids) of the springs on BAS Ethiopian highlands were plotted with graduated symbols (Figure 4-1). Except for few highly mineralized samples, most of the springs have TDS less than 500 mg/l. Data is still being collected to present TDS for the whole BAS sub-basin I.e it will include the well-known saline and brackish waters in the Upper Nile part of South Sudan).

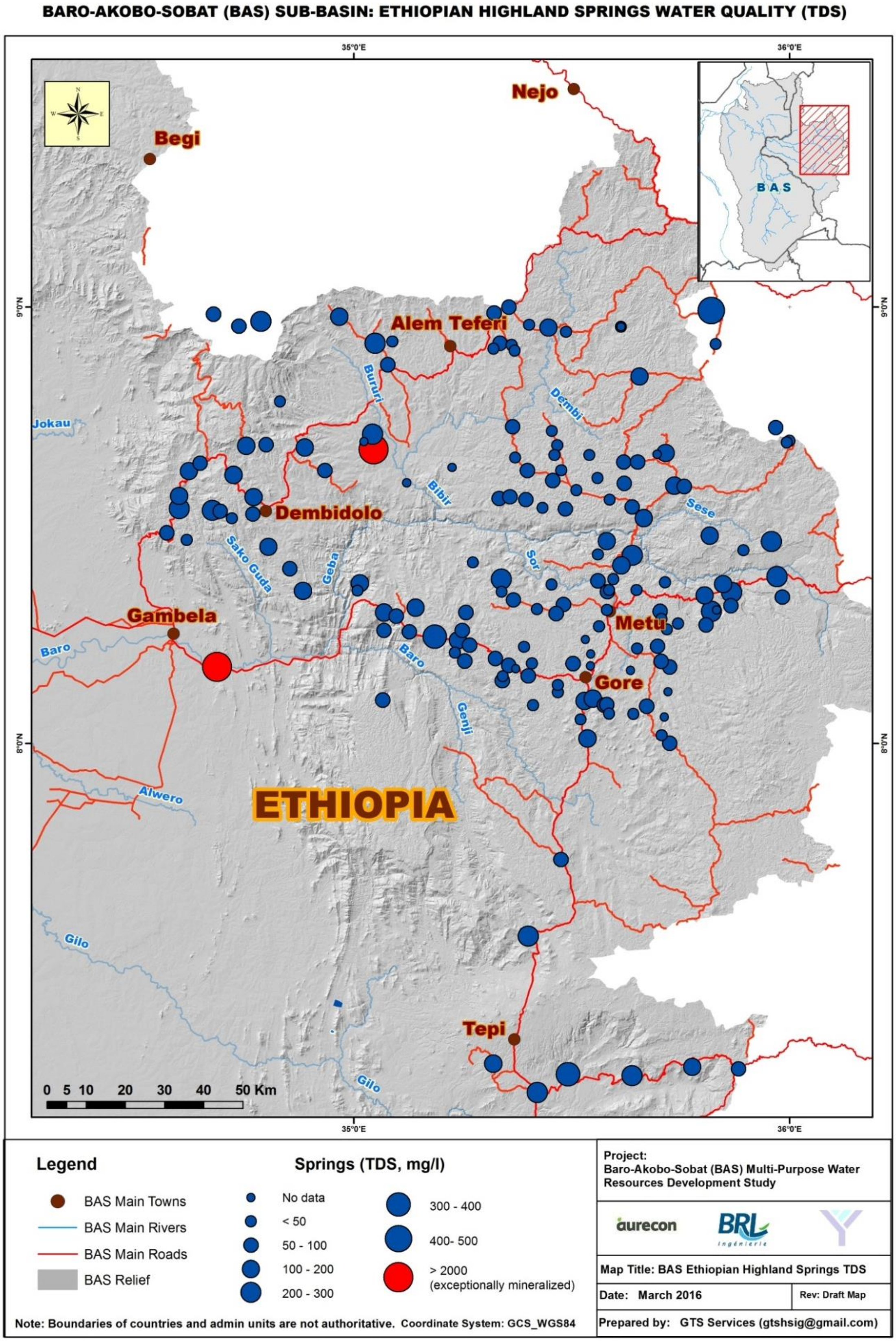


*Figure 4-1: Spring TDS values on the Ethiopian side of the study area.*

## 4.2 UPPER BARO AKOBO

During the study of ARDCO-GESERV (1995) for the upper part of the Baro Akobo Basin, about 237 groundwater samples were collected and analyzed from different sources (springs, hand dug wells and boreholes), most of which were from springs. The results from these samples indicate that the area has fresh groundwater and the dominant water type is calcium bicarbonate.

Except very few fault controlled springs which are reported to show high mineralization (TDS 2230mg/l), all samples indicate fresh groundwater with TDS less than 600mg/l. This is due to the favorable hydrogeological setting of the region in that it gets rapid flushing by the prevailing high rainfall and short distance from the recharge areas. In the Upper Baro Akobo Basin, four thermal springs have been located in the Bako and Godere River valleys bounding the Tepi Shield in the north and south.

## 4.3 GAMBELA PLAIN

The Russian Master Plan study (Selkhozpromexport, 1990 ; commonly referred to as the 'Russian Study') on water and land resources of Gambela Plain included fairly detailed studies on water quality. According to this study, the groundwater is slightly saline to fresh i.e its (TDS) is not higher than 1000 mg/l and in most cases it is 200 to 600 mg/l, and pH values varie from 6.5 to 8.4. The total hardness is mostly 1.5 to 4.0 meq and in a few cases reaches to 7.5 meq.

The study showed that in the Jikawo–Baro inter fluvial area, the groundwater is primarily of hydrocarbonate of sodium and sodium-magnesium type while in the Baro-Alwero and Alwero-Gilo inierfluvlal areas, it belongs to bicarbonate of calcium magnesium or sodium types. Towards the east, near the Abobo-Chiru the groundwater is reported to be characterized by hydrocarbonate –chloride and sodium magnesium type of mineralization, and at Gog, the water type is calcium-magnesium.

In terms its suitability for irrigation, the groundwater is classified as a low salinity hazard with SAR values from 0.1 to 6.13.

The study also indicated that there are strips of areas where the iron content is high - up to 89 mg/l, and its use for potable water supply is not possible without treatment. Areas indicated are: In the Jikawo-Baro interfluves, nearly right on the watershed along the Baro River there is an aquifer strip with an iron concentration of more than 10 mg/l, the maximum being 23.9 mg/l. A similar strip trending east of the Gambela Plain was distinguished in the Baro-Alwero interfluvial area. There the iron concentration was found to be 29.0 mg/l, and at Gog, which is in the Alwero-Gilo interfluves, it was 61 .5 mg/l. The maximum limit for potable water supply is considered to be 1mg/l. Similarly, the contents of manganese and copper are also higher than usual: up to 14.8 and 1.6 mg/1, respectively. Their permissible values for potable water supply are 0.5 mg/l and 1 mg/l respectively for manganese and copper.

The study showed that quality of artesian water from the Alwero Formation is fresh with TDS values of 300 mg/l, the pH i.s ~7.0, and the total hardness 3.8 meq. Because of the confined nature of the aquifer, contamination is virtiually impossible.

The other source of data/information regarding water quality is from the works of Seifu Kebede (2013) in his Groundwater in Ethiopia Book. In this work, the water quality conditions of the aquifers within the Gambela plain are characterized as follows:

***Recent alluvial deposits:*** The alluvial deposits although of limited aerial extent are considered an important water source for villages. They have generally good water quality, high permeability, are unconfined, have a shallow water table of <10 meters and recharge each wet season. Except for few cases of mineralized water samples, the water quality of the area is good for water supply and irrigation uses. Total dissolved solids in the Gambella Plain range from 72 to 955 mg/l making the groundwater suitable for irrigation use.

***Quaternary alluvio lacustrine sediments:*** Groundwater in the quaternary alluvio lacustrine sediments is slightly saline with TDS slightly less than 1000 mg/l. In most cases it varies between 200 and 600 mg/l.

***Alwero formations:*** The Alwero formation underlies the quaternary alluvio lacustrine sediments, buts dips to the west and would be found in the sub-surface in the adjacent South Sudan, is considered to be a high groundwater potential, confined aquifer with fresh groundwater (TDS of 300 gm/l). The groundwaters are dominated by the Ca cation, and $HCO_3$, $SO_4$ and Cl anions.

## 4.4 SOUTH SUDAN

The water quality characteristics of groundwaters of the South Sudan side of the project area have been abstracted from the information obtained from the hydrogeological map of the South Sudan and from the water supply study reports of Bor and Torit towns which are the capitals of the Jonglei and Eastern equatoria regions respectively. Two dominant aquifer systems are described:

***Umm Ruwaba Formation:*** The bulk of South Sudan groundwater resources are found within this formation which is characterized by unconsolidated sands, clays and gravels with low to high permeability. The Umm Ruwaba Formation is considered part of a regionally extensive confined aquifer, and is found to occur as semi-continuous, sub-continuous and continuous aquifers of local to sub regional extent. In South Sudan, it is the principal source of drinking water, but very little work has been undertaken to determine its distribution and extraction levels.

Around the Bor area, located on the Eastern bank of the Bahr el-Jebel river in the centre of South Sudan, within the southern end of the Sudd Basin, the Umm Ruwaba Formation is described as consisting of both vertically and horizontally variable permeability aquifers. The aquifers usually consist of confined sand and gravel layers (alluvial sediments). The thickness of the unconsolidated sediments is reported to be at least 1000 metres. The depth to water is around 10 meters and water salinity varies from 100 to over 5000 mg/l (fresh to brakish, rarely saline). Generally, groundwater quality is considered suitable for raw water supply. However there is variable hardness, iron and manganese that may pose a risk of scale formation and pipeline blockage in some areas such as Bor locality (SMEC, 2013).

The study indicated that although there are many boreholes in the Bor town area, some have been abandoned due to water quality problems. The groundwater is described as low salinity, variable pH and moderate hardness with elevated nitrate. Elevated nitrite and total coliforms are encountered especially in the shallow aquifer. All metals analyzed are reported to be below laboratory detection limits. It was recommended that if well water in Bor is considered as a source for town water supply, it should be chlorinated and mixed with at least an equal volume of treated surface water. The suggested measures to be taken are softening or mixing with river water to reduce the total hardness to less than 200 mg/L.

A water quality baseline assessment study was carried out by the Nile Basin Transboundary Environmental Action Plan in 2005. In this report, a monitoring station at Malakal was established to assess the concentration levels of different contaminants. Some of the elevated constituents considered were total dissolved solids (TDS), electrical conductivity (EC), chloride, nitrate, nitrite and ammonia. A comparison with WHO guidelines was also made. Since Bor is located on the Bahr el-Jebel which ultimately flows to Malakal, the data at Malakal station was considered indicative only. The EC results based on monthly data showed a variation with time which was related to the agricultural activity in the upstream catchment of Bahr-el-Jebel. The Bar el-Jebel river water is already used as a source of supply for Bor, but the intake location is not ideal as it is too close to the built-up area and vulnerable to pollution from commercial and residential activities (SMEC 2013).

***The basement complex:*** The Basement Complex rocks form an extensive hydrogeological unit in South Sudan covering one third of the country. Groundwater occurs in fractures and fault zones and may be recharged directly from rainfall. Water quality is generally considered good with low salinity.

This unit prevails in parts of the Eastern Equatoria region in the southern part of the project area and includes the Torit area. In general, it is characterized as a poor water bearing formation. However, fractures and weathered zones provide water of good quality and quantity. The existing sources of water for Torit are both surface water and groundwater. Torit town is situated on Basement Complex rocks beside the Keneti River. Currently Torit obtains some water from the Keneti River and also from groundwater for its urban water supply.

Not all wells are operating in Torit due to reported salinity problems and other factors. The groundwater is said to be of variable quality, being fresh to brackish, however there is no analytical information on water quality or bacteriological contamination (SMEC 2013). Since the groundwater quality around Torit urban area is not considered suitable for long term raw water supply due to high salinity, very hard water, elevated cations and high levels of contamination, the study recommended the softening or mixing of groundwater with surface water to reduce the total hardness to less than 200 mg/L

## 4.5 SALINE GROUNDWATER ZONES

Previous studies indicate that salinity levels exceeding allowable limits have been observed in Jonglei and Unity States of South Sudan making groundwater unsafe in some areas of these areas. While higher concentrations of fluoride, sulphate and nitrates have been observed in a few states, overgrazing and deforestation has also affected water resources quality by increasing the turbidity and siltation in water structures.

From the hydrogeological map prepared for South Sudan (SMEC, 2013) and DVA-GIS : African Development Bank, hydrogeological map of Sudan and South Sudan, it can be noticed that in the Northern part of the study area, within the Gonglei State, an area with brackish groundwater TDS 1500 – 5000 mg/l is mapped.

Areas of elevated salinity may coincide with oil exploration sites in Unity State. It is recommended that groundwater be monitored and that the impact of effluent from waste stabilization and oxidation ponds around Juba, west of the present project boundary, be assessed.

# 5. EXISTING GROUNDWATER USE

The Baro-Akobo-Sobat (BAS) sub-basin water points collected for the project include springs, hand dug wells, boreholes and limited water harvesting, hafir and spring catchment points. The water point records were evaluated as indicators of groundwater use from different source types.

Figure 5-1 and Figure 5-2 show the BAS water points collated/database used for the project thus far. The springs spatial database for the Ethiopian highland part has been properly organized but the hand dug wells and boreholes database for Ethiopia and South Sudan have been plotted just to produce the required map but requires some quality checking and cleaning. Additional borehole data will also be included.

The Ethiopian highland springs were plotted on the BAS groundwater availability map and coincide with the areas delineated as relatively high and medium-high, indicating partly the validity of the GW availability results.

Except where there are limitations of the resource base in terms of its availability or water quality, groundwater is the preferred source of water supply for rural as well as urban centres within the project area. In general, the current use of groundwater is at its lower rate and limited to the shallow aquifer systems largely for domestic water supply, while there is also a possibility for utilization from the potentials of deeper aquifer systems.

There are no known large scale development works in the basin using groundwater such as for irrigation purposes. Recent inventory records have not been obtained for existing groundwater use supported by abstraction rate and monitoring data. From the records during the ARDCO-GEOSERV (1995) inventory, 22 boreholes, 68 hand dug wells (HDW) and 42 springs were recorded, which are reported as sources of domestic water supply in the Baro Akobo highland part of the project area.

Depths of boreholes were in the range of 44 to 108 m with yield records in the range of 1.5 l/s to 8 l/s. However, studies have also indicated a potential yield of 20 l/s (Selkhozpromexport, 1990). The hand dug wells have depths of 4 to 24m.

Similarly, the boreholes data retrieved from South Sudan for the Jonglei, Eastern Equatoria and upper Nile states provide regional information on the status of groundwater development and drilling practices. Though the information contained is not complete, registrations of a total of 1642, 305 and 73 boreholes data records have been obtained for the Eastern Equatoria, Jonglei and Upper Nile states respectively out of which 1343 of them fall within the present study area. From the data with records and at a regional scale, it is evident that the wells drilled are shallow mostly in the range of 30 – 100m depth and their yields are low in the range of less that 0.01 to 5 l/s.

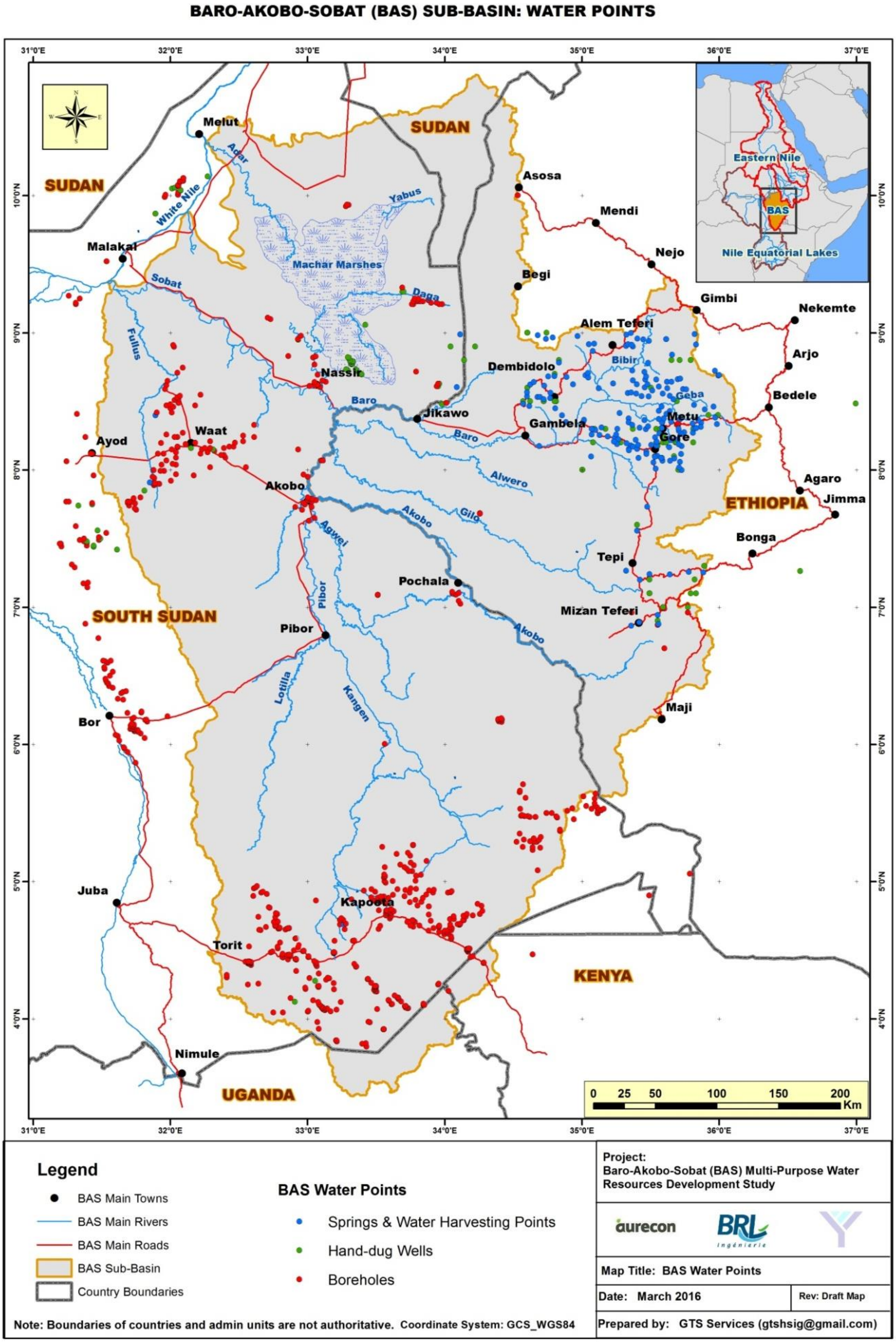


*Figure 5-1: Water points distribution*

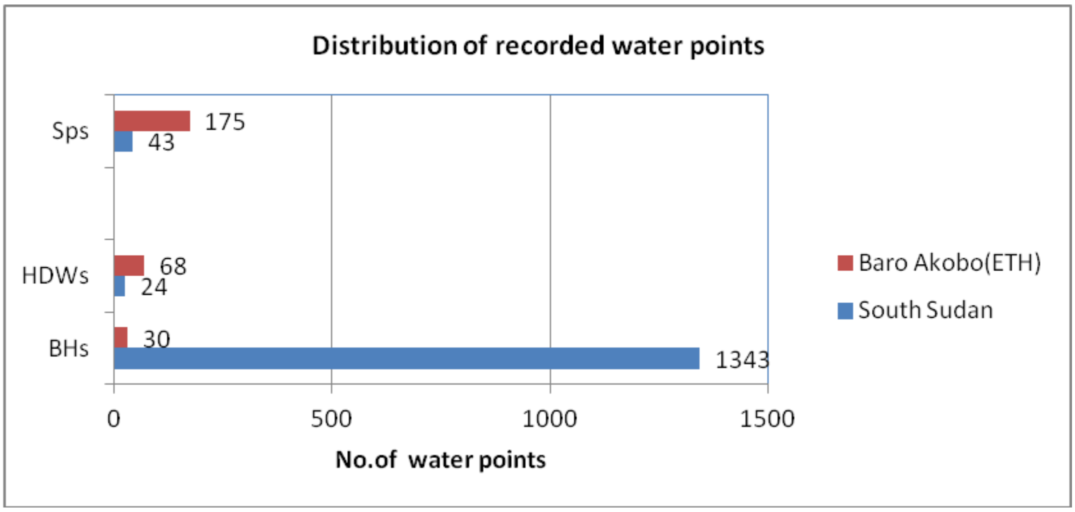


*Figure 5-2: Distribution of recorded water points within the study area*

Records show that relatively large number of boreholes have been drilled within the Southern Sudan part of the study area while concentrations of springs exist in the highland part of the Baro Akobo Basin of Ethiopia (although some of the springs have not been protected). The density of hand dug wells may indicate the potential of shallow groundwater which is expected in the recent alluvial deposits close to river channels.

Groundwater data is hugely dependent on having good drilling, test pumping and water use records. Typical information includes: depth and method of drilling, whether the targeted aquifers were penetrated, borehole construction and evaluation (testing), water quality analyses, water levels, water temperatures, etc. In general, there is limited data, and this constrains the proper evaluation and characterization of aquifer systems, estimations of groundwater potential and use. In many parts of Africa, and it is uncertain to what extent this applies to the study area, groundwater use is frequently restricted by the lack of robust conveyance infrastructure, or poor maintenance thereof, rather than the resource itself.

Figure 5-3 and Figure 5-4 indicate that 89 % of the boreholes drilled in the areas fall within the shallow groundwater systems zones. Only few boreholes appear to have been drilled into relatively deeper aquifers; the notable case being the boreholes drilled during the Russian Study (Selkhozpromexport, 1990) of Gambela Plain. Boreholes exceeding 100m gave potential yields of up to 20 l/s within the deeper aquifer system of the Alwero Formation. The maximum borehole depth recorded was 176m. This hole penetrated the Gilo formation on the Gambela Plain.

All in all the data shows that currently groundwater use is limited to waters found at shallow and medium depths. As demand increases, for example for irrigation use, the option of drilling into deeper aquifers that could provide large yields should be explored.

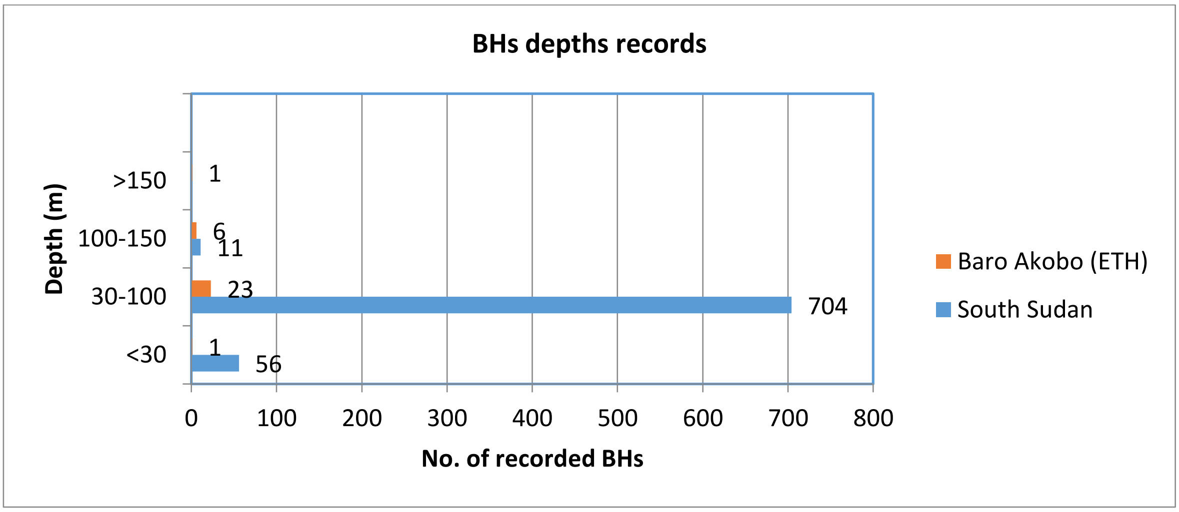


*Figure 5-3: Recorded ranges of Boreholes depths*

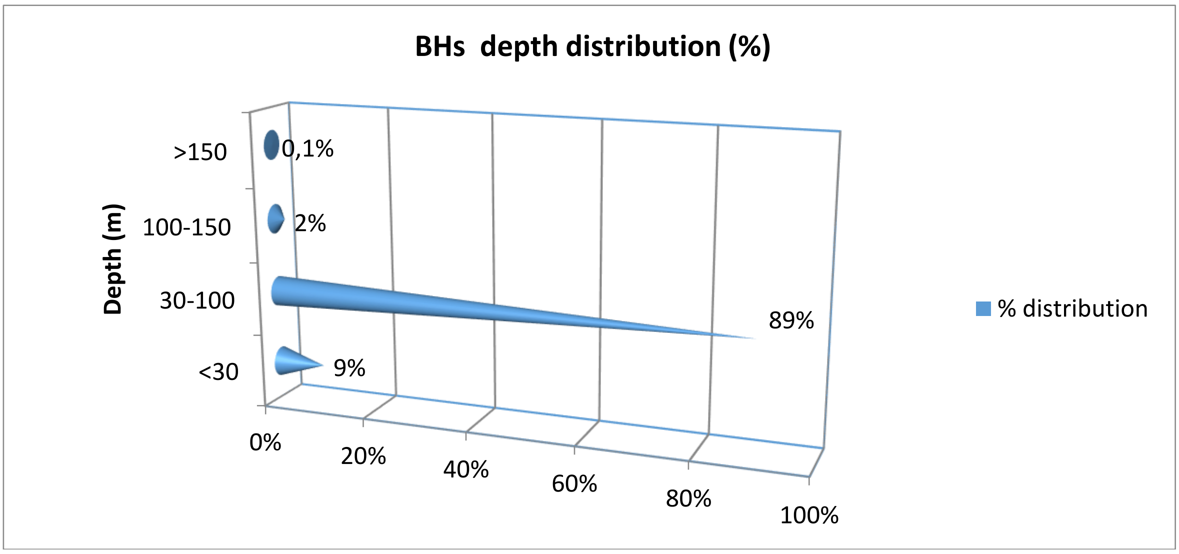


*Figure 5-4: Percentage distribution of boreholes depths*

Borehole yields are controlled by many factors among which geological factors, particularly permeability, and drilling methods are major determinants. Borehole yields in the study area are reportedly generally low. Only 4 % of the wells show yields falling in the range of 2 to 5 l/s and only 0.3 % fall within the 5 to 10 l/s range. The majority of the wells (67 %) are reported to have very low yield below 0.5 l/s (Figure 5-5).

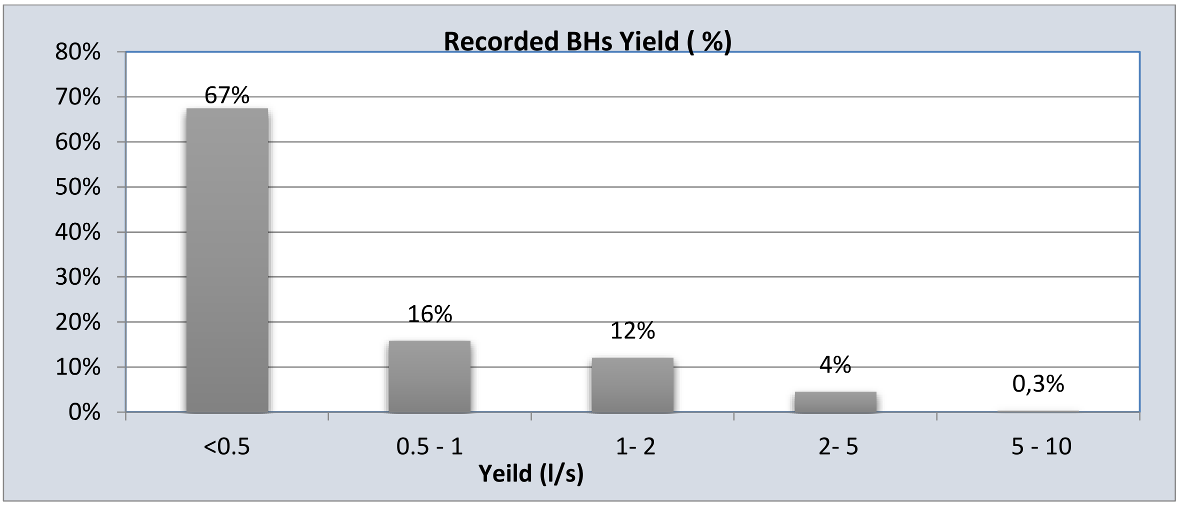


*Figure 5-5: Graph showing recorded boreholes yields*

For the Sobat part of the study area, it is evident that groundwater significantly supports water supplies for the towns of Bor and Torit, together with other centres. However, this practice is confronted with problems such as wells becoming dry, saline or polluted and this has resulted in abandoning many of them and shifting to surface water. Since relatively sophisticated treatment is required for surface water, this option is expensive and poses a number of management challenges. It must be noted that in many parts of Africa, boreholes and wells have been reported as “dry” when actually the pumps or conveyance infrastructure is faulty. It is not known whether the reportedly dry wells in the study area are indeed dry or whether this is the term commonly used when people cannot draw water from a well, irrespective of the reason.

Bor town, located on the banks of the Bahr el Jebel River (Nile), uses treated surface water. There are about 55 domestic water supply boreholes in the town, some of which are apparently abandoned due to being dry, saline or contaminated.  Drilling records suggests that prior to 2008 most boreholes were drilled to a depth of less than 40m. Since 2008 borehole depths increased to around 80m. This may suggest over-use of the resource, but there could be numerous other reasons why boreholes were drilled deeper (e.g. better equipment may have made it easier to drill). Yields are said to be ‘moderate’ to ‘good’ although no quantitative data is available. Water is generally intersected from 30 to 60 metres depth, but the best quality is found from around 80 to 90 m below ground. The geology is thought to be alluvial sands and gravels of the Umm Ruwaba Formation which are considered part of a regionally extensive confined aquifer. Records indicate a well drilled to a depth of 150m has a potential yield of 12 l/s.

Torit is located on the northern bank of the Keneti River, and like Bore, uses treated surface water. Studies indicate that 98 boreholes have been located in the town. Some 19 bores were abandoned or were disused due to being dry, saline or equipment (pump) failures, which needs further evaluations. Borehole yields are low, and most are relatively shallow (<40 m prior to 2007/8), tapping into groundwater at the weathered rock - fresh rock interface. Recent drilling completion reports indicate the average borehole is now 70 m deep and screened in fresh fractured rock.

In conclusion, and from the review of previous works and present evaluations, it can be concluded that there is very little utilization of groundwater resources within the project area compared to the available resource. Although data from recent surveys has not been obtained, as indicative information, the study of ARDCO-GEOSEV (1995) shows that groundwater abstraction rates from all ground water sources is only in the range of 3.4 $Mm^3$/year for the upper Baro Akobo part of the study area. This is comprised of springs (2.0 $Mm^3$/year), hand dug wells (0.675$Mm^3$/year) and drilled wells (0.66 $Mm^3$/year). In total, this yield is equivalent to an abstraction of groundwater from about 10 boreholes at a rate of about 10.5 l/s  from the entire mapped study area. The assessment was made based on the surveys conducted over 34 woredas.

# 6. BOREHOLE WATER SUPPLY POTENTIAL

## 6.1 NUMBER OF PEOPLE THAT CAN BE SUPPLIED WITH DIFFERENT PUMPS

The number of people that can be served at various abstraction rates and the number of boreholes required is shown in Figure 6-1 and Figure 6-2. Figure 6-1 shows that a borehole that is equipped with a hand pump can serve about 200 people if operated for 12 hours a day (this equates to each person having ~3 minutes to fill a 20 L container, or continuous abstraction at 0.1 L/s). The higher-yielding solar pumps can yield ~80 m$^3$/day (although this varies with pumping head and pump type), and this can supply ~4 000 people/day (e.g. average of 2 L/s x 12 hours/day). A diesel or electric powered pump supplying 5 L/s can supply ~10 000 people/day using a 12-hour pumping cycle.

Figure 6-2 shows, for example, that 5 boreholes equipped with hand pumps can supply ~1000 people, but if the borehole yields were sufficient to support solar, diesel or electric pumps, then up to ~30 000 people could be supplied with solar pumps and >50 000 people could be supplied with diesel or electric pumps.

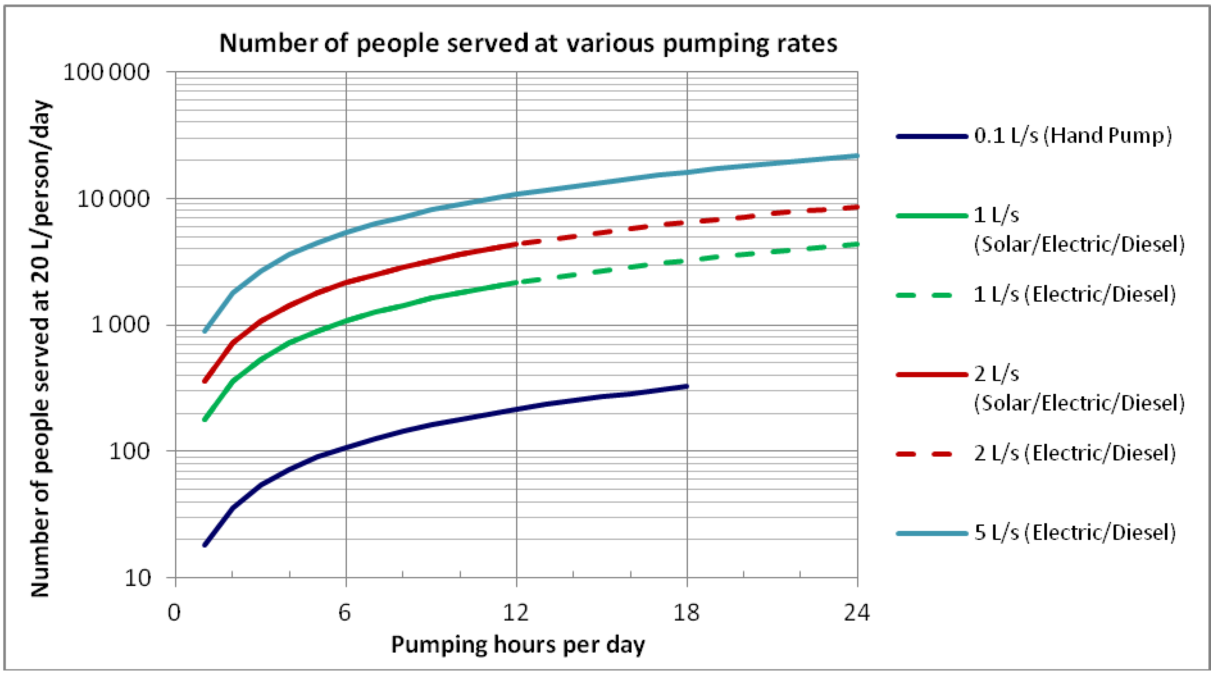


*Figure 6-1: The number of people that can be served by one borehole at various pumping rates*

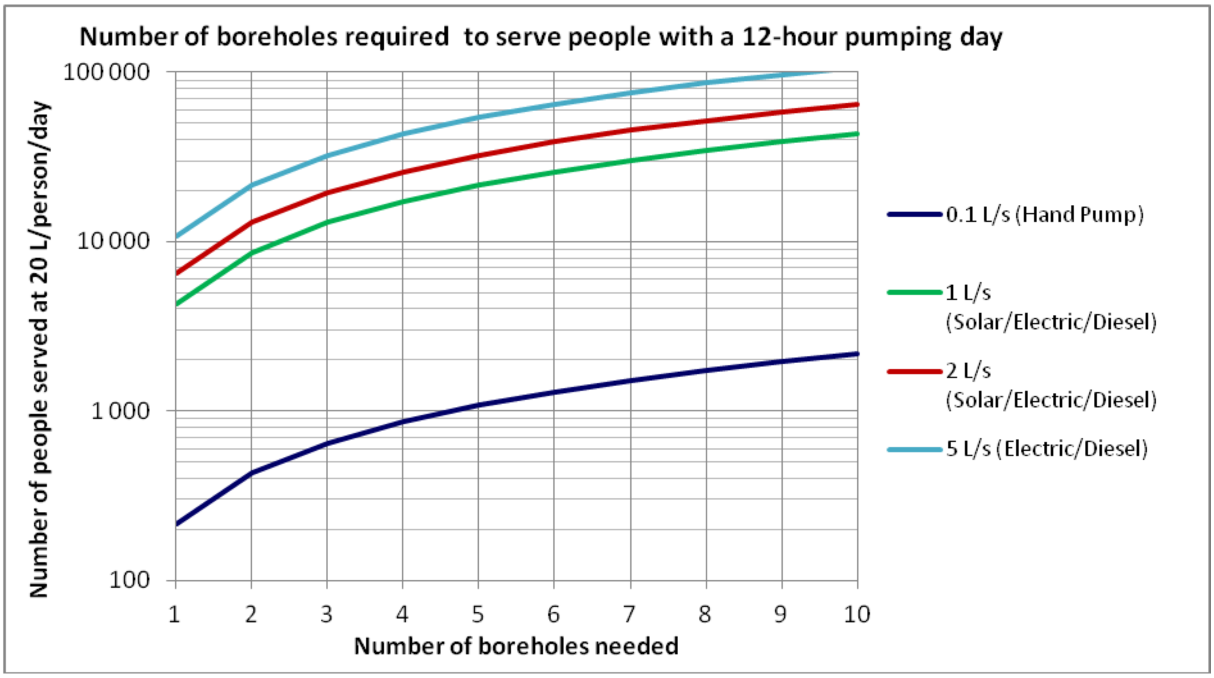


*Figure 6-2: The number of boreholes required to serve various population sizes*

## 6.2 GROUNDWATER DEVELOPMENT POTENTIAL

### 6.2.1 Summary

The statement from the TAMS-LGL (1997) report "*There is some groundwater development potential in effectively all areas of the Baro-Akobo Basin*" could equally apply to the entire study area (the BAS Basin), as all areas have enough groundwater resources to meet small-scale rural domestic and livestock requirements. However there are 4 main aquifer types that can potentially provide more water than merely the basic requirements for scattered rural settlements; these are:

i. Fractured Basement Complex rocks

ii. Porous and permeable unconsolidated sediments

iii. Fractured basalts, and in particular the Gog Formation basalts.

iv. Permeable sandstone of the Alwero Formation.

All four aquifer types appear to be underutilised (and the Alwero Fm sandstones are not used at all), and all can possibly be developed to meet domestic, livestock and irrigation requirements, although for irrigation purposes, prime areas in these aquifers would need to be located.

In essence, groundwater can meet the needs of all rural villages (including pastoralists), small towns and most medium-sized towns. In some areas it can also meet the requirements of main cities. The populations associated with these terms are those used by TAMS-ULG (1997), and are shown in Table 6-1 (just the upper population values are given). Table 6-1 also shows the pumping supply options that could be used to meet these demands.

*Table 6-1: Number of boreholes and pumps required to meet domestic water demands (at 20 L/p/day)*

| Settlement | Population | Hand Pump | Solar Pump | Diesel/Electric Pump |
|---|---|---|---|---|
| Villages | 1 000 | 5 | 2 | 1 |
| Small towns | 4 000 | - | 6 | 1 |
| Medium towns | 10 000 | - | - | 1 |
| Main cities | >10 000 | - | - | >1 |

### 6.2.2 The high-potential but poorly understood Alwero Formation

There is one major area of uncertainty in the study area and additional knowledge on this could open up development opportunities for people in both western Ethiopia and southern South Sudan. This is the Alwero Formation sand/sandstone aquifer. During the Russian Study (Selkhozpromexport, 1990) 6 boreholes were drilled into this confined aquifer in the Gambela Plains, and after testing them, the recommended combined production yield was 50 L/s (or ~8 L/s on average; see Table 6-2). These boreholes did not fully penetrate the aquifer, and it is expected that with properly designed production boreholes, the yields could be higher.

*Table 6-2: Summary of drilling results from the Russian Study (Selkhozpromexport, 1990)*

| Bh. No. | Depth (m) | Recommended Production Rate (L/s) |
|---|---|---|
| 200 | 62 | 10 |
| 100 | 79 | 5 |
| 104 | 130 | 20 |
| A84 | 35 | 3 |
| 4 | 63 | 5 |
| 38 | 26 | 7 |
| | Av. 66 m | Total 50 L/s |

Besides the high yields, the water quality was also found to be very good. Borehole 104 had a TDS of 313 mg/L (~50 mS/m) and a pH of 7.0, and low in all constituents including rare elements (TAMS-ULG, 1997). By all accounts, the water should be suitable for domestic and irrigation use. Being a confined aquifer, the water is unlikely to be contaminated with micro-organisms, and therefore for bulk domestic supplies would possibly require no treatment, although chlorination is recommended due to possible contamination in the conveyance infrastructure.

The aquifer has not been mapped and thus its geographic extent in the sub-surface is not known, but it is expected to stretch from the eastern parts of the Gambela Plains in Ethiopia to the west, into South Sudan; and it's northern and southern boundaries are likewise, not known. The aquifer is considered to be recharged in the east via seepage through basalts and the granites/gneisses of the Basement Complex. It is also thought to dip gently to the west (i.e. deepen) and that it may become increasingly artesian in that direction – i.e. the further west one drills into it, the greater the pressure in the aquifer (to an extent that it may flow freely at the surface).

The aquifer thickens westwards where it was found to reach a thickness of 200 - 300 m in the central part of the Gambela Plain. It consists of two bands with the thicker, upper band (~120 m thick) consisting of sands, sandstones and clays, and the lower, thinner band (~80 m thick) consisting of clays. The groundwater targets are the sands/sandstones in the upper band. Where these are fairly coarse grained and thick, high-yielding boreholes can be expected. They can be located with reasonable accuracy by conducting geophysical surveys.

The transmissivity values obtained from the Russian Study (Selkhozpromexport, 1990) varied from 7 – 190 $m^2$/day, and it was concluded that the "prevailing" transmissivity value was in the order of 100 – 120 $m^2$/day.

In order to establish the potential yield from this aquifer, a hypothetical wellfield was modelled using the aquifer parameters obtained during the Russian Study (Selkhozpromexport, 1990). The model used was designed by Murray, et al (2012) called the C-J Wellfield Model and is based on the Cooper-Jacob approximation of the Theis equation (which is suitable for the Alwero Fm confined aquifer). The model was developed to assist in well field designs – i.e. positioning the spacing of boreholes in a well field. It is a relatively simple model in comparison to groundwater flow models that require large time-series data sets to calibrate. This model uses aquifer parameter values to calculate the effect (drawdown) that boreholes have on each other; it does not take aquifer recharge, storage or discharge into account (a sophisticated finite difference or finite element numerical model is required for this). In using the C-J Wellfield Model, it is assumed that after each year of abstraction, the groundwater levels return to their starting levels due to natural recharge. So long as the abstraction rates are not too high, this assumption is reasonable, as it has been noted by various authors (eg TAMS-ULG, 1997) that potential groundwater recharge vastly exceeds natural discharge and abstraction.

The boreholes were placed in 4 rows, all 1 km apart. An arbitrary place for the wellfield was given merely to show the lay-out (Figure 6-3), but this could be anywhere in Ethiopia or Southern Sudan, where the Alwero Fm lies below the surface. The location of the area shown in Figure 6-3 is about 50 km west of Gambela, near Itang (which was an area recommended for groundwater development by TAMS-ULG, 1997).

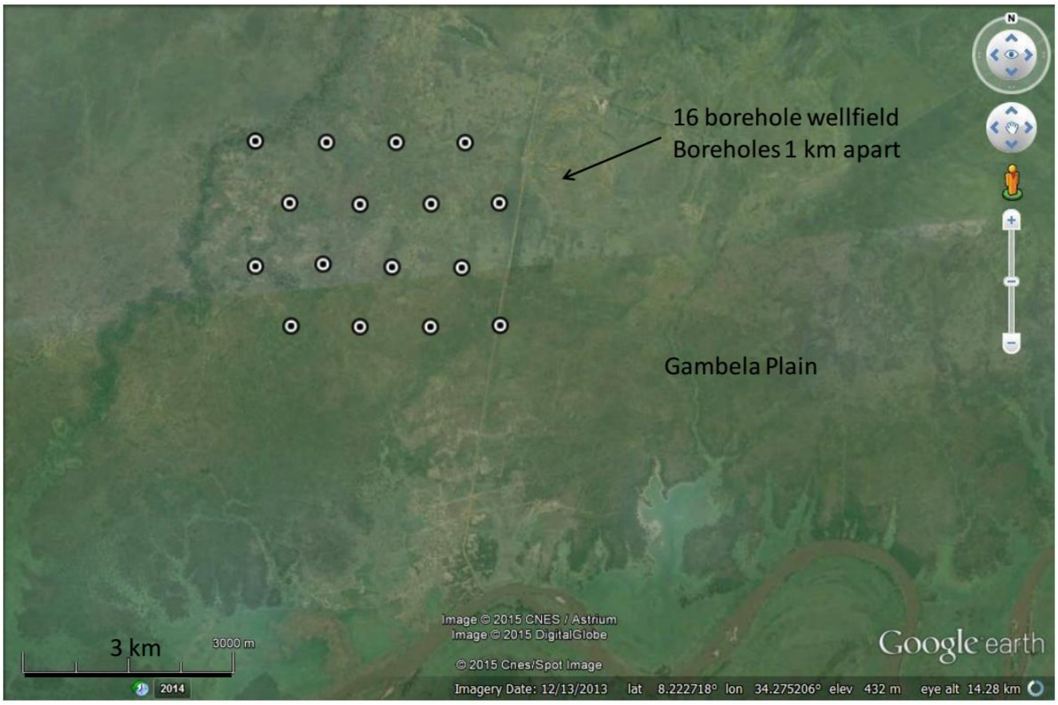


*Figure 6-3: Layout of boreholes in theoretical wellfield (this borehole configuration could be anywhere in Ethiopia or Southern Sudan where the Alwero Fm lies below the surface)*

The transmissivity value given to all boreholes was 100 $m^2$/day, and the storage coefficient (S-value) was 0.001, which represents a confined aquifer (the Russian Study, Selkhozpromexport, 1990, did not provide S-values). Four scenarios were run and after each the drawdown (water level decline) in all boreholes was noted after one year of non-stop pumping. In each scenario, all boreholes were pumped at the same rates for the year. The pumping rates were 2.5 L/s; 5 L/s; 7.5 L/s and 10 L/s, giving combined yields of 40 – 160 L/s. Figure 6-4 shows the results of a model run, and Figure 6-5 presents the results from all scenarios.

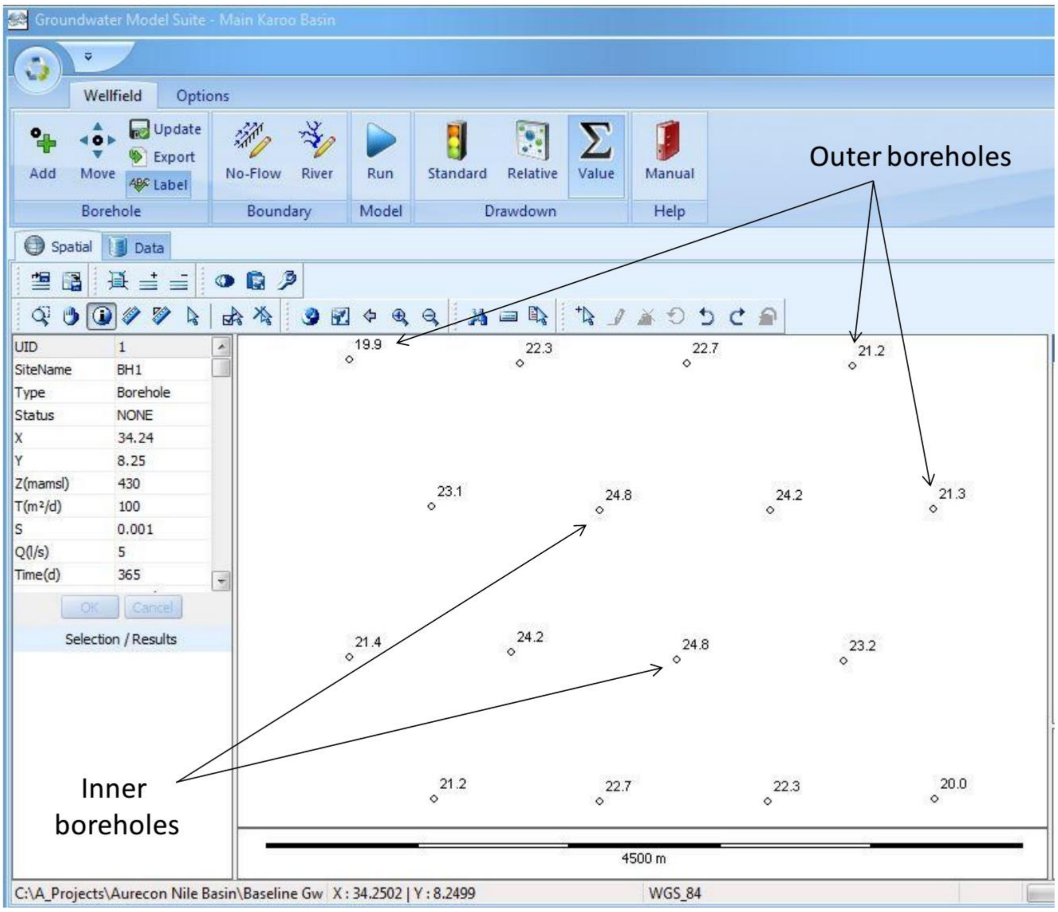


*Figure 6-4: The C-J Wellfield Model - an example of a model run showing drawdown after a year of pumping all 16 boreholes*

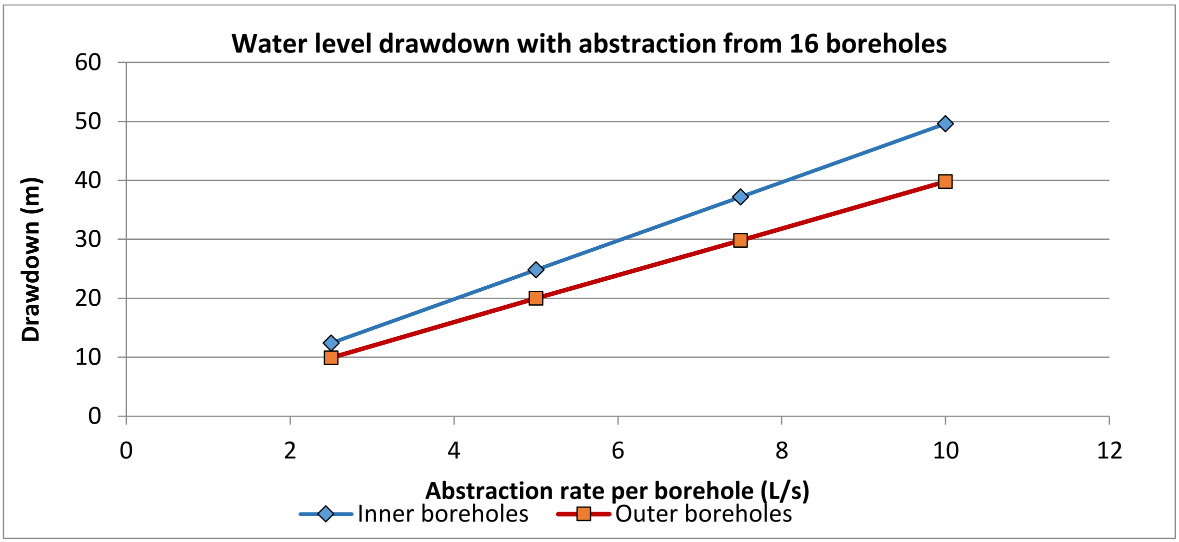


*Figure 6-5: Results from the C-J Wellfield Model showing the water level drawdown after 1 year of abstraction (the boreholes in the centre of the wellfield are called the inner boreholes and those at the edge of the wellfield called the outer boreholes)*

The results from the model show, for example, that if all 16 boreholes are pumped at 5 L/s (i.e 6 912 m$^3$/day in total), then after 1 year of pumping, the water levels in the centre of the wellfield will decline ~25 m, and at the outskirts of the wellfield, the will decline ~20 m. These are the drawdown levels in the pumping boreholes. If the boreholes were pumped at 10 L/s (13 824 m$^3$/day), the water levels would drop by ~50 m in the centre of the wellfield and by ~40 m at the outskirts.

From this wellfield layout, it is evident that the pumping rates should not be higher than about 5 L/s as it is not good management practice to draw water levels down too deeply. The scenario with abstraction at this rate was repeated using an S-value of 0.0005 to cater for a conservative storage coefficient, and it was found that the maximum drawdown in the inner boreholes was 29 m and the outer boreholes 24 m. I.e. 5 L/s appears to be about the maximum abstraction rate with a 1 km borehole spacing.

A last scenario was run, this time every alternative borehole was switched off, i.e. the spacing between pumping boreholes was ~1.7 – 2 km, and it was found that if the 8 remaining boreholes were pumped at 8 L/s continuously for a year, the drawdowns were similar to those obtained by pumping all boreholes at 5 L/s (the drawdown values obtained were 25 m and 21 m for the inner and outer boreholes respectively). In this scenario, 5530 m$^3$/day was abstracted for 8 boreholes as opposed to the 6 912 m$^3$/day from the 16 boreholes. The conclusion from this is that a more economically favourable borehole layout would be place them ~2 km apart and pump them at ~8 L/s. In reality, actual drilling results would dictate production yields, but this nevertheless suggests that with the aquifer parameters obtained from the Russian Study (Selkhozpromexport, 1990), a borehole spacing of ~2km should be planned.

The modelling exercise shows that if the Alwero Fm does have a regional transmissivity value of about 100 m$^2$/day, and if the storage coefficient is in the order of $10^{-4}$ – $10^{-3}$, and if natural recharge can replenish the aquifer during the rainfall season, then it is possible to abstract ~ 5 500 m$^3$/day from a 8-borehole wellfield, and ~7 000 m$^3$/day from a 16-borehole wellfield that occupies a ~4 km by ~4 km space on the ground.

# 7. GROUNDWATER MANAGEMENT

## 7.1 INTRODUCTION

Managing groundwater for water supply purposes should have three main functions. The *first* should be to ensure that the aquifer is used optimally. This means that it should not be over-pumped as that would negatively impact on its long-term sustainable yield or on the environment. It also means that if the aquifer is being under-utilised, this will become known. The *second* main reason is to ensure that the water quality in the aquifer is not negatively affected. This may be as a result of high abstraction from the aquifer, or from poor groundwater protection (from latrines, animal enclosures, etc). The *third* main reason is to optimise borehole pumping rates so that the pumping equipment operates efficiently. Pumping rates are frequently set too high, and this cause unnecessarily high pumping heads, a waste of energy, and at times, pump failure. An additional function, which is usually captured in the first two points, is to ensure that environmental integrity is maintained. This may mean abstracting groundwater at a rate lower that the aquifer's sustainable yield in order to maintain spring flows.

The management system needs to include the following main tasks: data collection; data capture; data analysis; and operational changes (Figure 7-1).

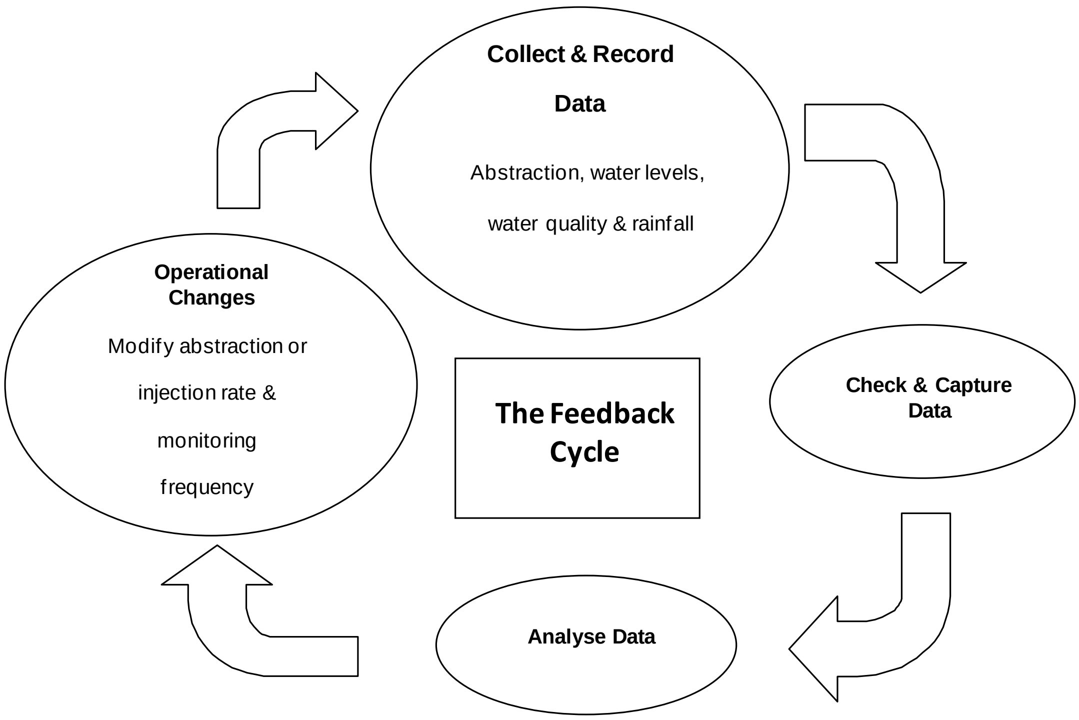


*Figure 7-1: Groundwater Management Tasks*

*Data collection* is simple and inexpensive, and should form part of all pump operators' operation and maintenance (O&M) tasks. Inexpensive data logging equipment is also recommended to ensure good quality data is obtained. Information needed includes borehole water levels and abstraction data on a monthly basis (although with data loggers this can be recorded on a daily basis or even more frequently), and water samples for water quality assessments on a seasonal or yearly basis. In certain areas more frequent water quality monitoring may be advisable. *Data analysis* needs to be done by a hydrogeologist who then must recommend *operational changes* if needs be. A management system can only be effective if all four components in the management cycle are attended to. Integrating groundwater management into O&M procedures is thus critical for overall resource and infrastructure management.

## 7.2 CURRENT MANAGEMENT STATUS

At this stage it is assumed that very little groundwater management (as described above), if any, takes place in the study area. All proposed projects will need to incorporate the necessary monitoring and management tasks mentioned above. In addition to this, and in order to obtain more information on the aquifers recommended for demonstration projects, additional monitoring boreholes should be installed. These boreholes will enable the hydrogeologist who analyses the data to establish if there is any regional effect of large-scale groundwater abstraction, and this will help in managing the wellfields and it will help in designing future wellfields and groundwater development projects.

The concept of groundwater management goes with the process of proper understanding of the resource base and balancing the demands with the available potential without causing adverse impacts. These include issues such as availability of comprehensive and complete studies (mapping of the resource at larger scales), groundwater database, water abstraction and monitoring records, proper operation and maintenance practices, etc. These are dependent on the availability of skilled manpower and institutional capacity as well the required budgets.

The contention that the current practice of groundwater management within the study area is in a poor state is borne out by the observation from previous studied that many of the boreholes are not properly functional. An example are the boreholes drilled in thick alluvial sediments around Bor town in South Sudan. Here the borehole yields are limited by screen lengths, small diameters and limited pump capacities. Similar limitations are also recorded in the Ethiopian side of the study area.

To improve the current groundwater management status, following measures should be undertaken:

- Capacitate the sector institutions for proper monitoring, management, development and utilization of groundwater resources.
- License and control groundwater development and use practices.
- Prepare detailed and exhaustive studies to map and determine the available resource in a reliable and more accurate way.
- Develop groundwater management plans at local and regional levels.
- Establish proper metering and monitoring systems for sustainable use of the resource including applications of modern technologies.
- Give appropriate emphasis on groundwater development technological issues and operation and maintenance requirements.
- Establish applicable environmental protection regulation in relation to groundwater resources protection.

# 8. POSSIBLE DEVELOPMENT PROJECTS

Groundwater can probably meet the demand for **domestic** water in most areas. The limiting factor from a groundwater perspective is the number of boreholes or wells that would be required to meet a specific demand and not the reliability of the resource itself. In low-permeability areas a number of boreholes may be required, but in the areas with high permeability, a few boreholes should meet the requirements for most domestic use. There are, however, specific areas where the water quality may be the limiting factor. In such areas, additional treatment, besides chlorination, would be required.

Urban centers should be supplied from deep boreholes or large diametre wells sunk into properly protected aquifers. Rural settings can be supplied from shallow wells, protected springs or hand dug wells depending on their respective demands. In most case, well yields of 0.2 to 1 l/s could meet the demand for rural villages if good construction and sanitary protections are provided.

In this project, priority areas of the Akobo and Jore woredas, and the Kapoeta area, were identified as possible sites for groundwater development projects that would target the needs of both human and livestock requirements. Projects in these areas should reduce conflict and improve health.

**Livestock** water supplies can be integrated with domestic supplies or developed independently depending on the local conditions and requirements. Like domestic supplies, it is quite likely that all areas can be supplied with groundwater.

At this stage it appears as if no groundwater-based **irrigation** projects exist in the study area. The ARDCO GEOSERV (1995) study mentioned that “the potential for high rate of groundwater production for irrigation is not considered feasible throughout most of the project area”. While this certainly holds for the low-permeability areas where hand dug wells are prevalent, it probably does not hold for the prime aquifers that are yet to be exploited such as the Alwero Formation aquifer described above.

The following areas were identified as prospective groundwater development areas with production capacities in the range of 1.5 l/s to 20 l/s (TAMS,1996):

- Itang vicinity (50 km west of Gambela)
- Vicinities of Jikaro-Baro
- Vicinities of Baro-Alwero
- Vicinities of Alwero-Gilo
- Vicinities of Gilo-Akobo

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**[1] The list of references is not exhaustive and is currently being completed.**

# 10. APPENDIX 1. LITHOLOGICAL DESCRIPTIONS

Tertiary-Quaternary Sediments

| Stratigraphy | Litho-Unit Code | Lithologic Description |
|---|---|---|
| Holocene to Recent | Q_undif | Undifferentiated alluviums and unconsolidated recent deposits |
| | Q_fan | Fan deltas type deposits with rapid lateral facies changes |
| | Qal | Recent alluvium in active river beds and wadi undifferentiated deposits |
| | Qc | Colluvium - unconsolidated screes and slope deposits - undifferentiated talus materials |
| Pleistocene to Holocene | Qal2 | Older alluviums deposits - raised or incised terraces and large levees - abandoned distributary channels |
| Cenozoic, Plio-Pleistocene | CzUR | Unconsolidated sands with some gravels, silts and clays |

Tertiary-Quaternary Volcanic Rocks

| Stratigraphy | Litho-Unit Code | Lithologic Description |
|---|---|---|
| Quaternary ? | VL | Small volcanoes or plugs and ring complex |
| Cenozoic | CzVa | Rhyolitic volcanic rocks |
| | CzVb | Basaltic volcanic rocks |
| Paleogene to Neogene | Pga | Trap basaltic series - Alkali olivine basalt and tuffs with some trachytes and rare rhyolites |

Precambrian Basement Rocks

| Stratigraphy | Litho-Unit Code | Lithologic Description |
|---|---|---|
| Precambrian | PE_Gabbro | Gabbroic rocks |
| | PEGr | Granitic rocks |
| Upper Proterozoic | Gt1 | Syntectonic granitoid rocks |
| | Gt2 | Post-tectonic intrusive granites |
| | PE3a | Amphibolite, chlorite, talc schists, greenstones and quartzites |
| | PE3lb | Chlorite schists, quartzites and intermediate metavolcanics |
| | UB | Ultrabasic rocks |
| Middle Proterozoic | PEs | Undifferentiated metasediments (amphibolite facies of metamorphism) |
| | PEsa | Amphibolites |
| | PEsm | Marbles - amphibolite facies of metamorphism |
| | PEsq | Quartzites rocks |
| | PEsy | Undifferentiated Syenitic rocks |
| | PEum | Ultramafic rocks - Peridotites, Dunites, Harzburgites and Lherzolites |
| Lower to Middle Proterozoic | PE1 | Basement lower complex - undifferentiated magmatic and metasediments |
| | PE1_hard | Basement lower complex - undifferentiated magmatic and metasediments (competent facies) |
| Lower Proterozoic | PEp | Undifferentiated metamorphic rocks |
| | PEpgns | Undifferentiated gneissic rocks |
| | PEps | Schistose supercrustal metasediments - amphibolite facies of metamorphism |
| Archean ? | PE1b | Basement complex - Burji Gneiss (fine foliated biotite gneisses and schists) |

| | | |
|---|---|---|
| Archean | PEx | Undifferentiated Granulite and Mylonitic facies rocks |

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# BARO-AKOBO-SOBAT MULTIPURPOSE WATER RESOURCES DEVELOPMENT PROJECT STUDY

## BASELINE, DEVELOPMENT POTENTIALS, KEY ISSUES AND OBJECTIVES REPORT

## *Annex 2: Biological environment*

*Final version – April 2017*

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# BARO-AKOBO-SOBAT MULTIPURPOSE WATER RESOURCES DEVELOPMENT STUDY

# Baseline, Development Potentials, Key issues and Objectives
# Appendix n°2 - Environment Report

# TABLES AND FIGURES

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# ACRONYMS AND ABREVIATIONS

| | |
|---|---|
| AfDB | African Development Bank |
| ACORD | Association for Cooperative Operations Research and Development |
| ACTED | Agency for Technical Cooperation and Development |
| BAS | Baro Akobo Sobat |
| CAMP | Comprehensive Agriculture Development Master Plan |
| CBA | Cost Benefit Analysis |
| CMA | Catchment Management Association |
| CRA | Cooperative Regional Assessment |
| DEM | Digital Elevation Model |
| EEPCO | Ethiopian Electric Power Corporation |
| EHA | Erosion Hazard Assessment |
| EIA | Environmental Impact Assessment |
| ENID | Eastern Nile Irrigation and Drainage |
| ENCOM | Eastern Nile Committee Of Ministers |
| ENPM | Eastern Nile Planning Model |
| ENPT | Eastern Nile Power Trade |
| ENSAP | Eastern Nile Subsidiary Action Plan |
| ENTRO | Eastern Nile Technical Regional Office (NBI) |
| EPA | Environmental Protection Authority |
| FAO | Food and Agriculture Organization |
| GDEM | Global Digital Elevation Model |
| GDP | Gross Domestic Product |
| GEF | Global Environment Facility |
| GIS | Geographic Information System |
| GTP | Growth and Transformation Plan |
| GWh/y | GigaWatt hour/year |
| HEP | Hydroelectric Power |
| IDEN | Integrated Development of Eastern Nile |
| ILWRM | Integrated Land and Water Resources Management |
| IPCC | Intergovernmental Panel on Climate Change |
| IUCN | International Union for Conservation of Nature and Natural Resources |
| IWMI | International Water Management Institute |
| IWRDMP | Integrated Water Resources Development and Management Plan |
| IWRM | Integrated Water Resource Management |
| JMP | Joint Multipurpose Project |
| MAFCRD | Ministry of Agriculture, Forestry, Cooperatives and Rural Development |
| MASL | Meters Above Sea Level |
| MCA | Multi Criteria Analysis |
| MDG | Millennium Development Goals |
| MEDIWR | Ministry of Electricity, Dams, Irrigation and Water Resources |
| MERET | Managing Environmental Resources to Enable Transitions |
| MLFI | Ministry of Livestock and Fisheries |
| MoA | Ministry of Agriculture |
| MoEN | Ministry of Environment |
| MoWIE | Ministry of Water, Irrigation and Energy |
| MSIOA | Multi Sector Investment Opportunity Analysis |
| MTR&B | Ministry of transport, roads and bridges |
| MW | Mega Watt |
| MWC&T | Ministry of Wildlife Conservation and Tourism |
| NB-DSS | Nile Basin Decision Support System |
| NBI | Nile Basin Initiative |
| NCORE | Nile Cooperation for result project |
| NDVI | Normalized Difference Vegetation Index |
| NELSAP | Nile Equatorial Lakes Subsidiary Action Program |
| NGO | Non-Governmental Organization |

| | |
|---|---|
| Nile-COM | Nile Council of Ministers |
| PIM | Project Implementation Manual |
| PLSPP | Policies, Legislation, Strategies, Plans, and Programs |
| PPP | Private Public Partnership |
| PMU | Project Management Unit |
| PRSP | Poverty Reduction Strategy Program |
| RATP | Regional Agricultural Trade and Productivity Project |
| RPSC | Regional Project Steering Committee |
| RSS | Republic of South Sudan |
| RUSLE | Revised Universal Soil Loss Equation |
| SAP | Subsidiary Action Program |
| SEA | Strategic Environmental Assessments |
| SIS | Soil Information System |
| SLMP | Sustainable Land Management Program |
| SNNPR | Southern Nations, Nationalities and Peoples' Region |
| SRFE | Satellite Rainfall Estimates |
| SRTM | Shuttle Radar Topographic Mission |
| SSEA | Strategic Social and Environmental Assessment |
| SVP | Shared Vision Program |
| SWAT | Soil and Water Analysis Tool |
| SWOT | Strength Weakness Opportunity Threat |
| SWSC | Soil-Water Storage Capacity |
| UNDP | United Nations Development Program |
| UNHCR | United Nations High Commissioner for Refugees |
| UNICEF | United Nations Children's Fund |
| USAID | United States Agency for International Development |
| WaSH | Water Sanitation and Hygiene |
| WB | World Bank |
| WBISPP | Woody Biomass Inventory and Strategic Planning Project |
| WCYA | Women, Children and Youth Affairs |
| WEES | Water for Eastern Equatoria |
| WFP | World Food Program |
| WM | Watershed Management |
| WRMA | Water Resources Management Authority |
| WRMD | Water Resources Management and Development |
| WSS | Water Supply and Sanitation |
| WUA | Water Users Association |

# 1. METHODOLOGY

## 1.1 PROCESS FOR STAKEHOLDER CONSULTATIONS

Numerous stakeholders consultations were conducted by the environmental team in South Sudan and Ethiopia. Consultations were conducted at Federal, Regional, Zonal and Woreda levels in Ethiopia and at Ministerial, state and counties levels in South Sudan.

The aim of the consultations were to get clear understanding of the basin's socio-environmental set up and to identify existing and potential challenges on natural and social environment of the basin and to obtain local knowledge and advices as how to conserve the fragile environment of the basin and how to integrate environmental issues in the proposed integrated BAS basin water resource development plan. Generic interview guide have been elaborated to facilitate stakeholder consultations. Hereafter is an example of guide used for consultations during the baseline phase:

*Figure 1-1: Key points of discussion for stakeholder consultations conducted during the baseline phase*

1. Missions, activities and capacities of the institution within the BAS, future projects within the BAS
2. Ecosystem in the BAS and their degree of interlinkages with water resources (identification of specific sensitive areas)
3. Habitats and species and status (good condition, threatened, severely threatened); status and conditions of protected areas of the BAS; opportunity and feasibility of the creation of additional protected area to conserve water-related ecosystems;
4. Ground/field knowledge validation of the maps produced in the study: Hydrographic network, Protected areas, land use, wetlands and floodplains;
5. Current tourism practices; potential for tourism/eco-tourism development within the BAS and main constraints for tourism development;
6. Threats to water-related ecosystems
7. Regulation and management within forest reserves; current forest conservation/rehabilitation projects;
8. Main ecosystem services (nature and quantification when possible);
9. Institutional arrangements in place

*Source: this study*

The target stakeholders were relevant Governmental and None Governmental Offices working on environmental protection, agriculture sector, forestry conservation, land use planning, water resource development, wildlife conservation, culture and tourism, etc.

Advises were obtained from various experts who are knowledgeable of the basin. Based on the suggestions given during the consultations, site visits to the specific environmental hotspots were conducted to get first-hand information.

The various consultations and field visits which were conducted specifically on the environmental aspects are listed in the following tables:

*Table 1-1: Summary of consultations with focus on environmental aspects*

| Stakeholder met | Country | Location | Date |
|---|---|---|---|
| Ministry of Water | Ethiopia | Addis Ababa | 27/04/2015 |
| Local representatives | Ethiopia | Nekemte | 28/04/2015 |
| Local representatives | Ethiopia | Metu | 29/04/2015 |
| Local representatives | Ethiopia | Gambella | 30/04/2015 |
| Ministry of Environment | South Sudan | Juba | 06/05/2015 |
| Ministry of water and irrigation | South Sudan | Juba | 06/05/2015 |
| MPs Jonglei State | South Sudan | Juba | 08/05/2015 |
| MPs Eastern Equatoria | South Sudan | Juba | 08/05/2015 |
| Local representatives | South Sudan | Torit | 09/05/2015 |
| Bench Maji Zonal Agriculture and Rural Development Office | Ethiopia | Mizan Teferi | 17/06/2015 |
| Menit Goldia Woreda Agriculture Development Office | Ethiopia | Bachuma | 18/06/2015 |
| Menit Shasha Agriculture Development Office | Ethiopia | Jamu | 18/06/2015 |
| Sheka Zone Agriculture and rural Development Office | Ethiopia | Masha | 19/06/2015 |
| West Wellega Zone Agriculture and Natural Resources Development Office | Ethiopia | Gimbi | 20/06/2015 |
| Ministry of Agriculture, SLM Project Coordination Office | Ethiopia | Addis Ababa | 22/06/2015 |
| SNNPR Sectoral Offices | Ethiopia | SNNPR | 18/06/2015<br>19/06/2015 |
| Gambella Sectoral Offices | Ethiopia | Gambella | 20/06/2015<br>21/06/2015 |
| Ministry of Environment | South Sudan | Juba | 20/01/2016 |
| Ministry of Wildlife, Conservation and Tourism | South Sudan | Juba | 20/01/2016 |
| USAID | South Sudan | Juba | 21/01/2016 |
| UNOCHA | South Sudan | Juba | 21/01/2016 |
| WCS | South Sudan | Juba | 21/01/2016 |
| Nile Basin Discourse | South Sudan | Juba | 22/01/2016 |
| USAID | South Sudan | Juba | 21/01/2016 |
| UNOCHA | South Sudan | Juba | 21/01/2016 |
| WCS | South Sudan | Juba | 21/01/2016 |
| Nile Basin Discourse | South Sudan | Juba | 22/01/2016 |
| NABU | Ethiopia | Bonga | 10/02/2016 |
| MELCA Ethiopia | Ethiopia | Masha | 11/02/2016 |
| Yeki woreda | Ethiopia | Yeki | 11/02/2016 |
| Majang Zone | Ethiopia | Meti | 12/02/2016 |
| Bench-Maji Zone | Ethiopia | Mizan Teferi | 11/02/2016 |
| South Government Sheka Zone Administration Office | Ethiopia | Masha | 11/02/2016 |
| Illu Ababora Zone | Ethiopia | Metu | 11/02/2016 |
| Ministry of Environment, Forest and Climate Change | Ethiopia | Addis Ababa | 17/02/2016 |
| EWNRA | Ethiopia | Addis Ababa | 18/02/2016 |
| EWCA | Ethiopia | Addis Ababa | |
| HoARECN | Ethiopia | Addis Ababa | |
| African Parks | Ethiopia | Addis Ababa | 17/02/2016 |

*Source: this study*

The identified environmental issues, challenges and suggestions forwarded during each consultation are described in section 2 of this report.

Stakeholders were also consulted regarding environmental aspects during the inception workshop (11th August 2015, Awasa, Ethiopia) and scoping workshop (24th & 25th November 2015, Khartoum, Sudan).

## 1.2 METHODOLOGY FOR DESK REVIEW / BIBLIOGRAPHY ANALYSIS

Information collected during stakeholder consultations has been enriched by a large desk review exercise. Various sources of documents and data were collected and analysed:

- ENTRO general and environmental studies on the BAS;
- ENTRO databases (especially GIS database);
- Older studies conducted on the BAS;
- Documents collected during the consultations with stakeholders;
- Various environmental papers and reports found on specific websites
- Information on on-going projects found on websites of institutions involved in biodiversity and watershed conservation in the basin.

The complete list of documents reviewed and analysed is presented in annex “references”.

The outcomes of the desk review are presented in section 3 of this report.

## 1.3 METHODOLOGY FOR SPECIFIC ANALYSIS ON WETLANDS DYNAMICS CONDUCTED IN THIS STUDY

As a result of the scoping phase, the need to better understand wetlands and inundation dynamics over time has been highlighted. As a response to this need, a specific analysis has been conducted in order to:

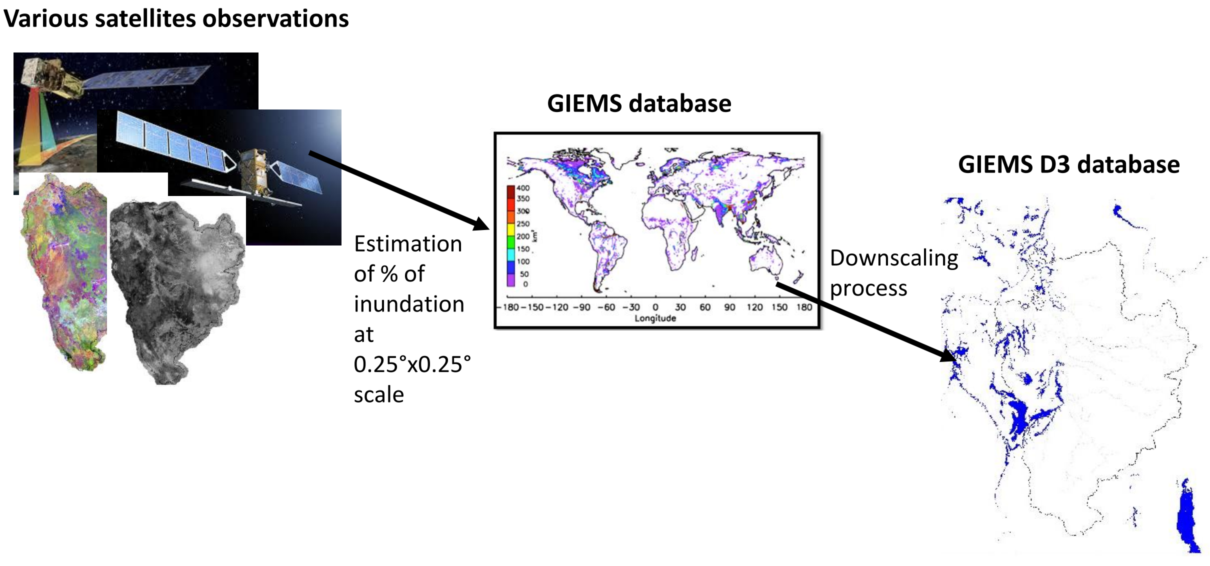
- Include inundation patterns in the modelling process;
- Have a better idea of wetlands intra and inter-annual variability to be able to assess potential impacts of water developments on these ecosystems and their services.

For this purpose, monthly inundation images of the BAS from 1993 to 2007 have been acquired and analysed. These monthly inundation images comes from a worldwide dynamic inundation database called GIEMS D3, which consists of a high-resolution global inundation map at a pixel size of 3 arc-seconds (approximately 90 meter at the equator).

This database is the result of a downscaling process of a less detailed dynamic inundation database called GIEMS. The Global Inundation Extent from Multi-Satellites (GIEMS) is a dataset providing the surface water extent and dynamics over the globe and over a long time record (1993-2007), based on a collection of satellite observations. The percentage of inundation is estimated over an equal-area grid (pixels of 0.25°x0.25° at the equator, i.e., roughly 28kmx28km), at a monthly time-scale.

The above explanations are synthetized in the figure below:

*Figure 1-2: Origin of GIEMS D3 product used in this study*




*Source: This study*

More information about GIEMS D15 can be found in the following papers:

- Moliane, L., Aires, F., Prigent, C., Fluet-Chouinard, E., Lehner B., 20 "Global, high spatial-resolution, dynamic and long-term inundation extent dataset, downscaled from GIEMS using topography information" Journal of Hydrometeorology, 14 (2), 594–607, doi:10.1175/JHM-D-12-093. 1, URL http://adsabs.harvard.edu/cgi-bin/nph-dataquery?bibcode=2013JHyMe..14..594A&link type=EJOURNAL.
- Aires, F., Papa, F., Prigent, C., 2013. "A long-term, high-resolution wetland dataset over the Amazon basin, downscaled from a multiwavelenght retrieval using SAR."

Several activities were performed to analyse conducted thanks to this data:

- Comparison of inundation patterns with historical rainfall, hydrological flow patterns in order to assess the origin of inundation (spilflow from the rivers, rainfall, underground water, combination of various factors, …), localize main spillway, and assess the minimum flow required for inundation to start;
- Visualization of intra and inter-annual by compiling monthly and yearly inundation maximal extent;
- Elaboration of a maximal inundation extent of the wetlands identified in the literature by compiling 1993-2007 maximal extent and 2014-2015 wetlands and floodplain mapping.

The results of the 1st activity are presented in the hydrological report. The results of the 2nd and 3rd activities are presented in section 4 of this environment annex.

# 2. RESULTS, INFORMATION AND ADVICES COLLECTED DURING/WITH STAKEHOLDER CONSULTATIONS

**Comprehensive minutes of consultations are presented in Annex 1**. This section only presents a summary of the key outcomes of these consultations.

## 2.1 KEY INFORMATION AND ENVIRONMENTAL AND SOCIO-ECONOMIC ISSUES IDENTIFIED PER BIOPHYSICAL AREAS DURING STAKEHOLDER CONSULTATIONS

### 2.1.1 Highlands

During the stakeholders consultations, the following information and issues have been identified in the BAS highlands:

- Deforestation of natural forest for the expansion of farm land,
- Expansion of investors beyond the allocated land area and encroaching into forest areas /e Expansion of tea and coffee plantation by the investors / land requirement for agricultural investment (tea and coffee investment), more than 40 investors are registered in the zone and about 18,000ha has been given for the investors;
- Population growth and influx of people from other parts of the country, primarily for the search of job as daily labour and later on some of them shift to farm by clearing forest areas;
- Increase in population and need for farm land;
- Use of charcoal as main energy source and income by the community,
- Weakening of traditional forest conservation practice. Young generation became reluctant to follow the old traditions such as keeping sacred places, worship areas, etc.;
- Resistance of people for new technologies;
- Tendency of farmers to use shifting cultivation or tendency of look for virgin land;
- Soil acidity and low production per ha,
- Lack of alternative livelihood system;
- Lack of suitable technologies;
- Lack of electricity for lighting and cooking, which pressurize on forest for fuel wood;
- Immigration of people from other parts of the country and illegally settle in the areas by clearing forest cover;
- Plantation of eucalyptus trees in wetland areas, which dries wetlands and water sources;
- Increased need for timber production;
- Absence of significant benefit from the protection of forest resources for the local communities;
- Soil erosion on farm lands and steep slopes,
- Lack of alternative energy to substitute fuel wood consumption,
- Conversion of wetlands into farm land
- Construction of roads through high forested areas directly remove trees and create access for timber production and illegal cutting of trees,
- Lack of proper coordination between investment and environmental protection offices,

- Lack of environmental monitoring and follow up after the allocation of land for investment,
- Significant gaps in the implementation and enforcement of environmental laws,
- Lack of standard buffer zone (e.g, Federal EPA says 1km buffer zone between water bodies and any development, regional office says 2km, International says 150m),
- Weak setup of institution (Land utilization and administration and Environmental protection organized as one department under the Agriculture bureau which weakened the role of environmental protection).

### 2.1.2 Escarpments

During the stakeholders consultations, the following information and issues have been identified in the BAS escarpments:

- Slope and sliding nature of the soil;
- Soil erosion;
- Encroachment into forest areas for coffee plantation and other crop production;
- Illegal settlement;
- Labor attracted by the agro- investment from other parts of the country tend to shift to farming by clearing virgin forest;
- Forest clearance for tea plantation by the Indian Investors. The land allocation policy for investment which allows Federal investment office to allocate land for investors where the required land is more than 5000ha is affecting the natural resource. For instance, the tea investment area is the tower of water for the downstream areas including Alwero dam. Some rivers which were permanent before the impact on forest become seasonal due to the clearance of forest cover:
- Lack of proper land use plan.

### 2.1.3 Foothills / Piedmonts

During the stakeholders consultations, the following information and issues have been identified in the BAS Foothills / Piedmonts:

- In Torit area:
  - Trees and vegetation cover is diminishing in fast rate without any endeavor to replant or afforestation.
  - People are clearing trees for expanding farm land and for the production of charcoal. Charcoal is the main source of the energy in the country since there is no other alternative form of energy to substitute charcoal. Currently, charcoal is the easily available source of income for the rural people. At present, there is no approved law or policy regarding the conservation of environment.
- In SNPP:
  - Unplanned and unlimited grazing in the forest which is affecting the forest and forest products (coffee, spices, etc),
  - Conflicts between communities who are sharing the forest resources in the boundary of two communities,
  - Cross-border conflicts due to competition for grazing land and fish farming between local communities and ethnic groups of Southern Sudan. The other cause of the border conflict is cattle raid and killing people.

### 2.1.4 Flood Plains and wetlands

During the stakeholders consultations, the following information and issues have been identified in the BAS Floodplains and wetlands:

#### CHALLENGES IDENTIFIED IN THE SOUTH SUDANESE PART OF THE BAS

- Major challenges concerning wildlife:
  - Killing of wildlife by communities as well as by the army for wild meat,
  - Wildlife are facing huge problem from poachers and illegal traders (for example illegal people from Somalia kill wildlife for skin and other marketable parts). Wilde animals are also killed during the seasonal migration
  - Absence of national parks management plan,
  - Lack of awareness about the wildlife conservation and its use.
  - The impact is more severe during the mass migration of White eared Kob, one of the endangered species. They migrate to Gambella national park during the dry season as they can get water there and come back to South Sudan/Boma Park when the Gambela area is wet and muddy. The reason of migration is to search water in the dry period at the upstream and escape mud during the wet season. Their migration is considered by the local people as a sign for onset of rainy season and dry season.
  - Construction of the Jonglei canal has hindered the free movement of animals and denies access to larger grazing area.
- Major challenges concerning drinking water and water for livestock availability:
  - The semi desert areas are less populated area but with large number of livestock. The main challenge of the area is shortage of water for people and livestock. To solve this problem providing water should be seen as one of the components of the integrated water resources management project.
  - The possible source of water for this area seems harvesting water during the flooding season in cofferdams. The potential of ground water has not been assessed in detail. However, as per the information from local experts, ground water cannot be easily obtained in depths of less than 200m.
- Major challenges concerning pastoralism:
  - People are pastoralists that move in search of water and grazing land. Shallow wells drilled before are dried during the dry period. The drilled wells are not deep enough to sustain water during the dry period.
  - The pastoralist lifestyle is creating conflict due to the limitation of resources. According to the representative from South Kapoeta, nearly all of the major inter and intra-communal conflicts are linked either to cattle raiding and the subsequent spiral of violent retribution, or conflict among pastoralists and farmers over migration routes and access to water and pasture.
- Other environmental challenges:
  - Massive growth of Water hyacinth

#### CHALLENGES IDENTIFIED IN THE ETHIOPIAN PART OF THE BAS

- Gambella does not have its own environmental policy and guidelines,
- Lack of coordinated protection of environmentally sensitive areas like forest, wetlands and national park,
- Lack of management plan for the Gambella National Park,

- Lack of coordination between investment and environmental protection offices. Investors prepare EIA after they possessed the land and license. In principle, EIA should be a prerequisite for the possession of license. But in case of the Gambella, EIA is prepared just to indicate mitigation measures which makes EIA powerless tool.
- Influx of refugees into the region imposed adverse impacts on forest resources,
- Conflict between different tribes mainly due to cattle raid,
- Conflict between local community and pastoralists coming from Sudan in search of grazing and watering,
- Absence of strong cooperatives to supply farm inputs like fertilizers, selected seeds, etc,
- Shifting cultivation which has impact on forest resources,
- Water pollution by solid and liquid waste,
- Absence of liquid waste treatment plant for Gambella town,
- Absence of trucks to collect and dispose solid waste at the designated disposal site. (the designated solid waste disposal site is located 7km away from the Gambela town).
- Inventory of forest areas have been conducted and interpretation and analysis of the data is ongoing. The land use land cover map of the country is going to be issued within few months and will be available for the public. Regarding Gambela area, the inventory of forest resources has not been done so far and they are planning to undertake the inventory before finalising the land use land cover map of the country.
- There is currently an attempt to prepare and legalize a land use and development plan for Gambella. This effort is led by the Horn of Africa Regional Environment Center of the Addis Abeba University. It is funded by European Union (EU) through IGAD and relevant ministries is both the Federal and Regional government are members of the steering committee that finally approves the Land use and development plan.

## 2.2 SYNTHESIS OF MAIN ENVIRONMENTAL CHALLENGES IDENTIFIED DURING STAKEHOLDER CONSULTATIONS

Stakeholders' consultation and field visit revealed that the basin has the following environmental challenges:

- Forest degradation and deforestation in Upper catchment and Siltation of Reservoirs in Downstream

Forest degradation due to unplanned land allocation, farm expansion through deforestation and removal of indigenous trees for making charcoal and timber become severe. In rural as well as in an urban area of the South Sudan, charcoal is the main source of energy for cooking. There is no other alternative form of energy in the country at the moment. Each farmer is making charcoal for marketing. It becomes easily accessible business to get quick money to satisfy the financial needs of the rural people. During the field visit in Eastern Equatoria, we able to see that both sides of the road stacked with charcoal and Lorries were busy in transporting it to big cities like Juba. If charcoal making business continues at the current rate for some 5 and 10 years, the existence of trees in the woodland will be questionable.

Deforestation and degradation of upstream catchment will increase the rate of downstream reservoir and river bed siltation. It will also reduce amount of rainfall and eventually affect water availability. The siltation is also hindering the smooth use of river transportation. Therefore, water shade management is paramount important to sustain the existing and potential downstream water uses.

In order to minimize adverse impacts on forest the following measures are recommended during the consultation:

- Provide alternative energy, it could be biogas, solar, hydropower, etc,
- Use energy saving stoves,

- Promote reaforstation/replantation,
- Include Clauses in Environmental policy that control or prohibit execs charcoal production/use.
- Promote alternative livelihood such as honey production, use of none timber forest products like spices, incense, etc.

▶ Lack of Proper Wetland Management

Though the inventory and delineation of wetlands have not done exhaustively, South Sudan is considered as the richest place of wetland. These wetlands are the lungs and kidneys of ecosystem. Therefore, any development plan and implementation has to consider the sustainable functioning and existence of these wetlands. Water allocation for wetlands should be given priority. Source of water for each wetland has to be understood before any intervention.

▶ Wildlife Conservation Issues

Wildlife conservation is one of the environmental issues to be dealt in the integrated water resource development. The habitat comprises of water, grazing area and migratory routes should be secured.

As per the African wildlife conservation assessment migratory animals mainly white eared Kob are facing mass killing during the migration process. Therefore, maintaining safe migratory route and creating awareness among the community and arm force needs to be carried out. Connection of Gambella and Boma wildlife parks should be maintained. Undisturbed migratory corridors have to be included in the park delineation and management.

According to the undersecretary, the integrated water resource master plan project has to incorporate wildlife watering component to reduce wildlife killing particularly during the dry season migration for the search of water and grazing.

▶ Lack of proper coordination between investment and environmental protection offices.

## 2.3 SOLUTIONS/ACTIVITIES RECOMMENDED BY THE CONSULTED STAKEHOLDERS AND EXPERTS TO REVERSE OR ARREST ENVIRONMENTAL DEGRADATION OF THE NATURAL RESOURCES

During the consultation the following solutions/activities were recommended by the consulted stakeholders and experts to reverse or arrest environmental degradation of the natural resources:

▶ Promote small scale irrigation and increase productivity per ha of farm land;

▶ Develop mini-hydropower schemes in areas away from the main grid to replace fire wood and charcoal need;

▶ Introduce alternative livelihood system like modern beehives, spice production and marketing, ecotourism, aquaculture, etc;

▶ Introduce energy saving stoves and better technologies, introduce Coffee bricks from coffee husk for energy/cooking at coffee producing areas (Kefa, Sheka) and Introduce solar lamps for lightning.

▶ Promote biological conservation works in the degraded areas including reaforestation;

▶ Protect wetland areas, water towers and bamboo forest areas at the highland areas of the basin where tributary rivers of BAS originated;

- Strict implementation of forest management plan;
- Promote integrated and coordinated conservation works to avoid wastage of resources by doing redundant efforts,
- Establish strong coordination between investment offices and environmental protection offices to not locate investment projects on biodiversity hot spots and protected areas;
- Conduct prior EIA before allocating land for investment and accept the recommendation of ESIA as a main tool for decision.
- Conduct environmental monitoring and follow up after the allocation of land for investment;
- Work on capacity building and technology transfer;
- Include Clauses in Environmental policy that control or prohibit execs charcoal production/use.
- Work to link the forest are with carbon credit;
- Introduce farm technologies that help to produce high production from small farm land;
- Promoting ecotourism development
- Avoid allocating land for investment in high forest areas,
- Collect and dispose solid waste at designated place,
- Build capacity of cooperatives involved in solid waste collection and disposal by providing training and trucks;
- Collect and threat liquid waste of Gambella town,
- Build capacity of cooperatives involved in supplying farm inputs like fertilizers, selected seeds, etc
- Avoid tribe to tribe and cross boarder conflicts that caused mainly due to competition for grazing land, cattle raiding and watering points;.
- Solve civil unrest in South Sudan.

## 2.4 MAIN MISSING INFORMATION / DOCUMENTS

Several important documents and data which were identified during the scoping phase and required to various stakeholders during the consultations could not be collected at this stage. These documents include:

- Draft Environmental policy of South Sudan (currently submitted to the parliament for review and endorsement);
- Socioeconomic surveys for Boma and Badingilo including all details , maps (including GIS files);
- Ecological surveys for Boma and Badingilo areas including all details, maps (including GIS files);
- Socioeconomic and ecological surveys conducted within protected areas or other natural resources conservation projects;
- Documentation and maps relating to the preparatory work carried out in the Imatong mountains;
- Land use maps (Shapefiles and associated data) for Boma, Badingilo and any other areas in the basin;
- Boma and Badingilo draft management plans;
- Reports on discussions on the Boma-Gambella landscape;
- General description of the ecosystems provided by WCS for previous EIAs;
- Gambella region draft land use management plan;

  Ethiopian forest inventory.

# 3. DESK REVIEW / BIBLIOGRAPHIC ANALYSIS

## 3.1 FLORA AND FAUNA, LAND USE, AND BIODIVERSITY FEATURES OF BIOPHYSICAL AREAS

### 3.1.1 Delineation of Biophysical areas

During the scoping phase, the following observation has been made: landuse patterns, ecoregion limits of the BAS, and as a consequence, environmental and social features, challenges and potentials identified in the sub-basin are strongly related to relief features of the BAS sub-basin.

In the following sections, the baseline information concerning environmental features of the BAS is organized by biophysical areas. Biophysical areas are delineated using the biotic and abiotic features of the environment. This should allow a better understanding of the BAS environment functionalities and their interlinkages with water resources and uses compared to a thematic approach. The four sections discussing the biophysical areas are the following (refer to Figure 3-1 for more information on the biophysical areas delineation):

1. Highlands

   Located between 1,800 and 3,000 masl, highlands are part of the **Ethiopian montane grasslands and woodlands** ecoregion, mainly covered by dense forest and subsistence agriculture. For a small area located in South Sudan, highlands are also part of the **East African Montane Forest ecoregion.**

2. Escarpments

   Characterized by very steep slopes, located between 1,100 and 1,800 masl - part of the **Ethiopian Montane woodland** ecoregion, mainly covered by forest, montane pastures and subsistence agriculture

3. Foothills / Piedmonts

   Situated between 700 and 1,100 masl, foothills and piedmonts are part of the **eastern block of East Sudanian Savanna** and **Northern Accacia Commiphora Bushland and Thickets** ecoregions which are mainly covered by shrubs, dry savannas and Woodlands.

4. Floodplains and wetlands

   Situated between 370 and 700 masl, floodplains and wetlands are part of the **Saharan flooded grassland** ecoregion

The biophysical areas are described following the ecoregions found in the sub-basin. According to the WWF, an ecoregion is a *"large unit of land or water containing a geographically distinct assemblage of species, natural communities, and environmental conditions"*. The ecoregions classification should not be confused with the livelihood zones classification which is used many times in the report. Ecoregions are a reference classification used to study biodiversity conservation issues as the classification is made using flora and fauna criteria. This classification is different from the classification with agro-ecological zones which is particularly of use for the social analysis and to study economic sectors later in the report. Locations of the ecoregions are given in Table 3-1.

Several delineations for ecoregions exist, they put emphasis on different criteria and serve different purposes. Ecoregions in this report were defined according to the delineation from the WWF (867 terrestrial ecoregions). This is particularly usefull to study the biological environment in the sub-basin. These ecoregions were defined using numerous references which can be found with a complete description of the ecoregions on the website of the WWF (*http://wwf.panda.org/about_our_earth/ecoregions/ecoregion_list/).*

*Table 3-1: Main features of the ecoregions in the BAS sub-basin*

| Ecoregion | Code | Biome/Global ecoregion | Location within the sub-basin | Status WWF |
|---|---|---|---|---|
| **Ethiopian montane grasslands and woodlands** | AT1007 | Montane grasslands and shrublands | Ethiopian highlands, above 1,800 masl | Critical Endangered |
| **East African Montane Forest ecoregion** | AT0108 | Tropical and Subtropical Moist Broadleaf Forests | Mt. Kinyeti in the Imatong Mountains | Critical Endangered |
| **Ethiopian Montane woodland** | AT0112 | Tropical and Subtropical Moist Broadleaf Forests | Ethiopian escarpments, between 1,100 and 1,800 masl | Critical Endangered |
| **East Sudanian Savanna** | AT0705 | Tropical and Subtropical Grasslands, Savannas and Shrublands | West of the Ethiopian part of the sub-basin and East of the South Sudanese part of the sub-basin (between 700 and 1,100 masl) | Critical Endangered |
| **Northern Accacia Commiphora Bushland and Thickets** | AT0711 | Tropical and Subtropical Grasslands, Savannas and Shrublands | Extreme South-West of the Ethiopian part of the sub-basin and South of the South Sudanese part of the sub-basin (between 700 and 1,100 masl) | Information not available |
| **Saharan flooded grassland** | AT0905 | Flooded Grasslands and Savannas | West of the sub-basin, mostly in South Sudan (below 700 masl) | Vulnerable |

*Figure 3-1: Simplified schematic of the BAS relief and related proposed biophysical areas*

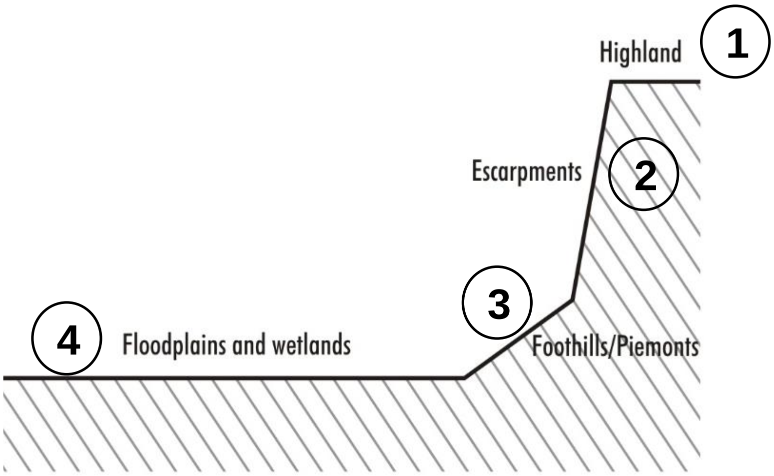



*Table 3-2: Distribution of the BAS biophysical area*

| Biophysical area of the BAS | Surface area (km2) | % of the BAS |
|---|---|---|
| Escarpments | 57439 | 22% |
| Highlands | 13956 | 5% |
| Piedmont / FootHills | 65563 | 25% |
| Flood plain and plain | 125668 | 48% |
| Total basin | 262626 | 100% |

*Figure 3-2: Relief of the BAS and biophysical areas*

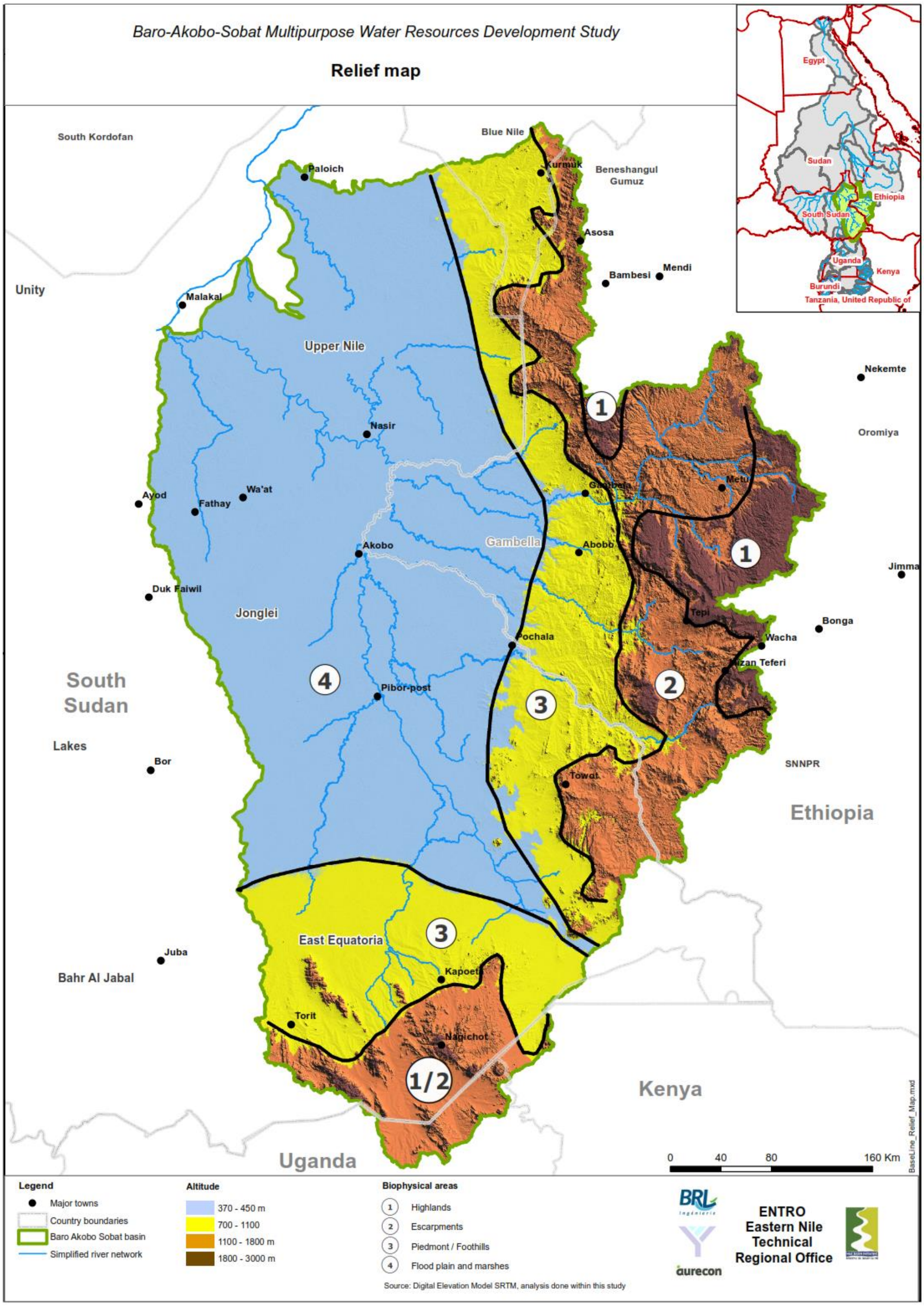


Figure 3-3: Eco-regions of the BAS and biophysical areas

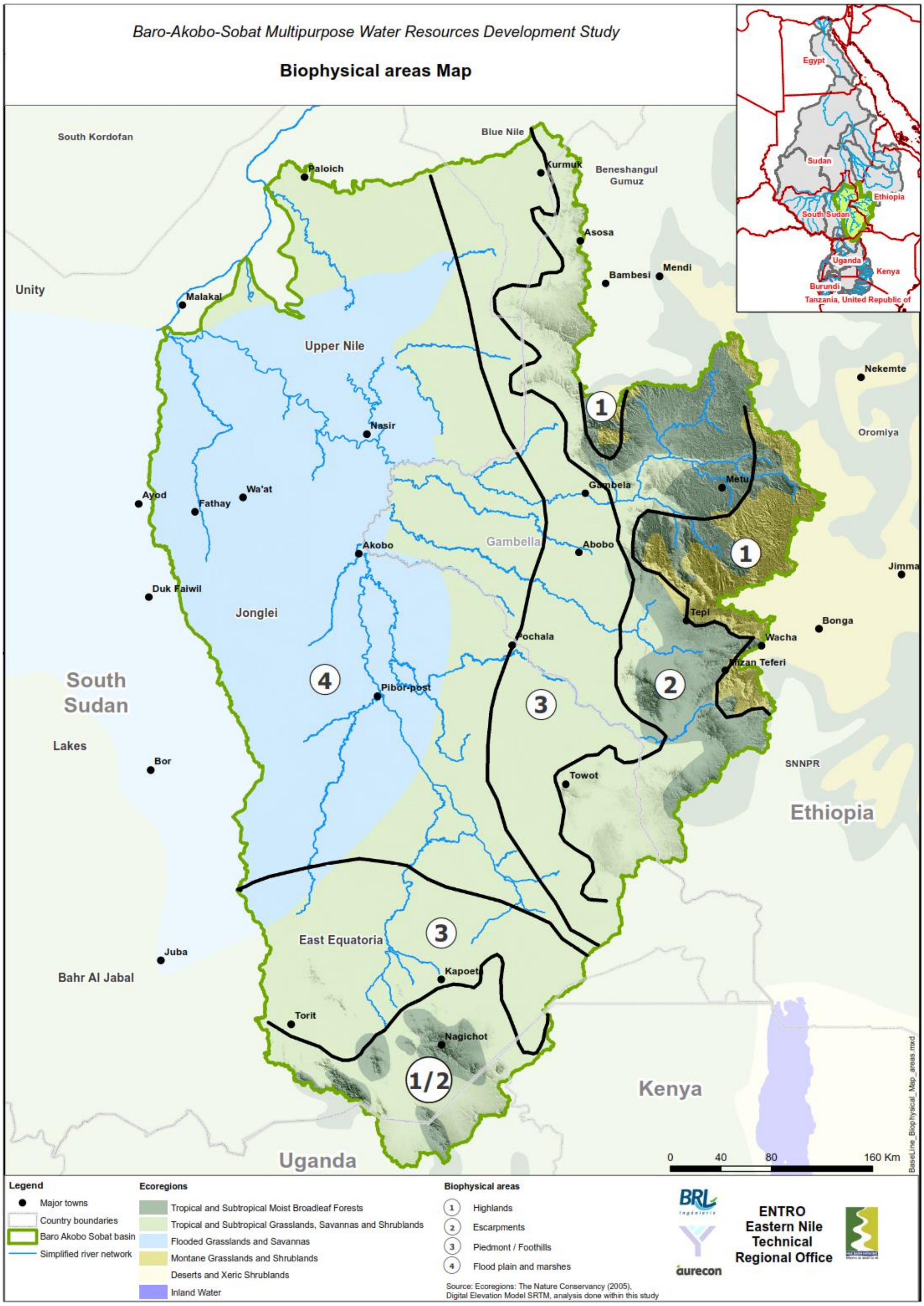
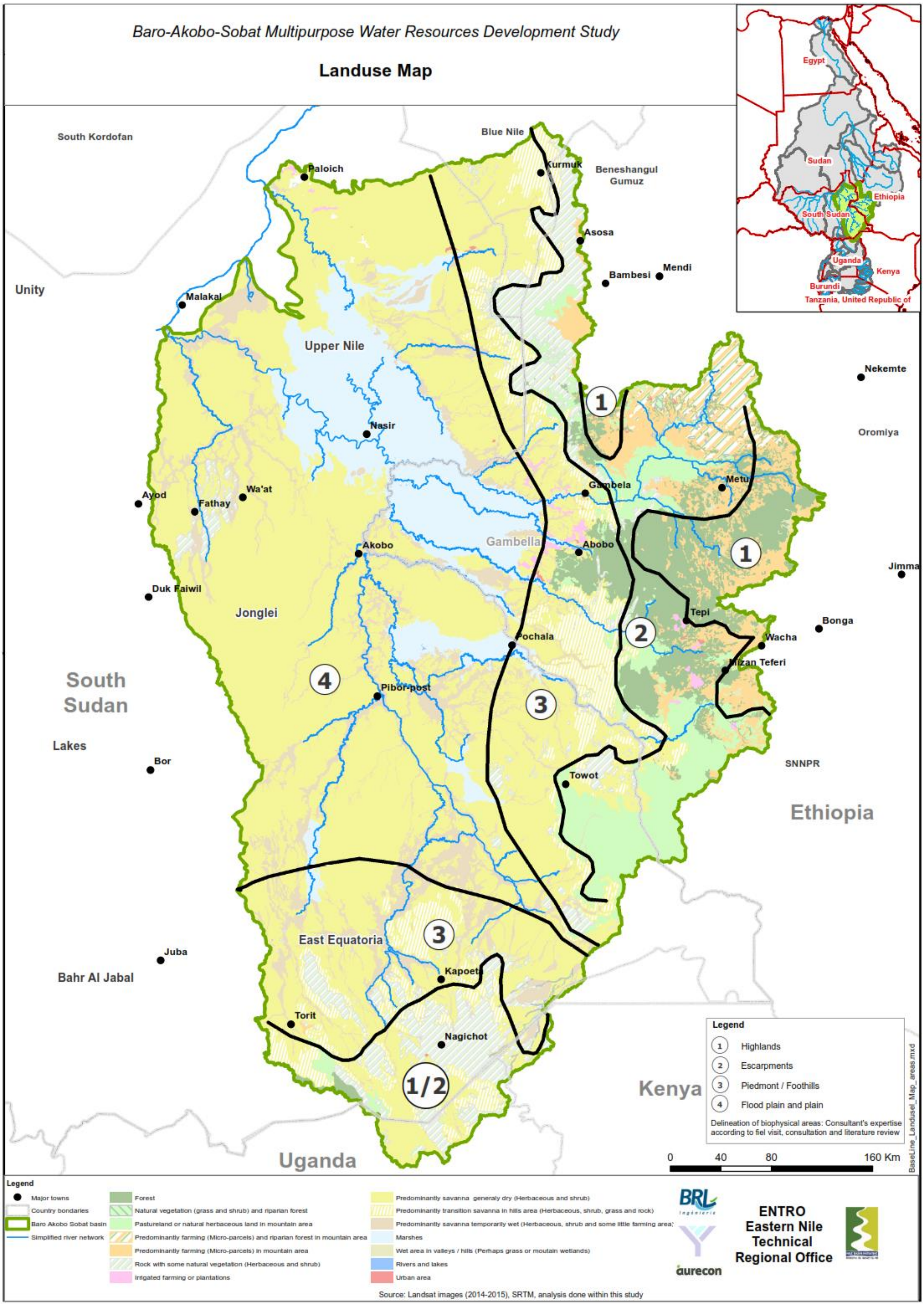


*Figure 3-4: Ecosystems of the BAS and biophysical areas*



## 3.1.2 Highlands

### *3.1.2.1 Highlands: general features*

Highlands are mainly situated in the eastern part and to a lesser extent in the southern part of the basin at an elevation varying from around 1,800 masl to 3,000 masl (Mont Kinyeti in the Imatong mountains reaches up to 3,187 masl). It is characterized by an undulating to rolling plateau, steeply incised by the major rivers with isolated high mountains such as Mount Tulu Welwel and Seccia (ENTRO, 2007a) .These mountains areas are characterised by very high rainfall (from 2000 to 2500 mm per year) and moderate evapotranspiration compared to floodplains. The rainy season lasts from May to October.

These highlands are the source areas for significant rivers such as the Baro, Alwero, Gilo, Akobo and Kinyeti and the population density is very high (refer to section 4.4).

As stated above, highlands of the BAS sub-basin are part of:

- The **Ethiopian montane grasslands and woodlands** ecoregion (Ethiopian highlands above 1,800 masl)
- The **East African Montane Forests** ecoregion (South Sudanese highlands, Imatong mountains)

### *3.1.2.2 Highlands; Ecosystems and vegetation*

The original vegetation of the BAS highlands was probably a mixture of closed forest (Friis, 1992 in Burgess et al., 2004). Currently, the highland areas are still largely covered with forest, even if forests have been severely encroached by agriculture. Elsewhere in the ecoregion (outside the BAS), these forests have almost disappeared. These remnant forest areas in the highlands are playing a crucial role in regulating river flows. In highly populated areas steep slopes and mountain tops are being farmed. The figure below shows the vegetation distribution in the BAS highlands:

*Table 3-3: Distribution of main vegetation types in the BAS highlands*

| Vegetation type | Surface area (km2) | % of the Higlands biophysical area |
|---|---|---|
| Forest | 7975 | 57% |
| Predominantly farming (Micro-parcels) in mountain area | 4904 | 35% |
| Predominantly farming (Micro-parcels) and riparian forest in mountain area | 407 | 3% |
| Pastureland or natural herbaceous land in mountain area | 363 | 3% |
| Wet area in valleys / hills (Perhaps grass or moutain wetlands) | 227 | 2% |
| Urban area | 34 | 0,2% |
| Rock with some natural vegetation (Herbaceous and shrub) | 19 | 0,1% |

*Source: this study*

The main highlands ecosystems are described in the following sections.

#### HIGHLANDS FOREST ECOSYSTEMS

Ethiopian highlands

In the Ethiopian highlands, forest ecosystems include the following characteristic species: *Albizzia gummifera, Syzygium guinnennense, Allophyllus abyssinicus, Schefflera abyssinica, Draceaena afromontana, Celtis africana, Chionanthus mildbraedii, Erythrococca trichogyne, Olea welwitschii, Vepris dainelli, Grewia ferruginea, Cyathea manniana, Croton macrostachyus, Phonix reclinata, Sapium ellepticum, Pouteria adolfifriedericii, Draceaena steudneri, Schefflera volkensii, Milletia ferruginea,* *Macaranga capensis, Psychotria orophila and Ficus spp*. Undergrowth in the high forest areas of Ethiopian highlands of the basin also consists of coffee Arabica, *Aframomum corrorima* and *Piper capense*, which are economically important products of the forest.

South Sudanese highlands

In the South Sudanese highlands, the climax vegetation found between 1,500 and 2,600 masl in the Imatong Mountain is closed evergreen forest with *Podocarpus milanjianus*, *Olea hochstetteri and Syzygium spp*. dominant over a shrubby understorey. Regret of *Acacia xiphocarpa* occupies large areas of old cultivation sites (ENTRO, 2007a). Between 2,600 and 3,000 masl *Podocarpus milanjianus* again forms the climax vegetation, but is less mixed with other species, apart from a little *Olea hochstetteri*. This zone includes large areas of mountain meadow dominated by the sedge *Bulbostyles atrosanguineus*. The *bamboo Arundinaria* alpina is also found. Much of the ground is wet or swampy because of the combination of high rainfall and low potential evapo-transpiration. Above 3,000 masl, ferns, *Erica arborea* and *Myrica salicifolia* are dominant. Many species of herbs occur (ENTRO, 2007a).

*Figure 3-5: Typical vegetation found in the BAS highlands*

Riverine forest along Baro river at the road from Masha-Gore

Corrorima (*Aframomum corrorima)*

Timiz (*Piper capense*)

Coffee Arabica

*Source: this study*

### HIGHLANDS WETLANDS ECOSYSTEMS

Even if highlands wetlands could not be mapped within the scope of this study, many small wetlands are reported in the literature. EPA (2003b) in ENTRO (2014) estimated the total area of wetlands to be about 1.5% of the total land area of the highland plateau. In the Kafa zone for example, wetlands represent the Afro-tropical Highlands wetland type of Ethiopia. They constitute swamps, marshes, forested wetland areas, peat swamps, and riverine wetlands and cover around 50, 000 ha (EWNRA, 2008).

The wetland flora of the highland plateau hosts commonly *Cyperus latifiolius, Leersia hexandra*, and *Panicum hymeniochilum*. In pristine wetlands *Guizotia scarba*, *Phyllanthus boehmii* and *Snowdenia petitiana* are more commonly found and cultivated wetlands at the end of the rainy season and *Anagallis serpens, Cyperus brevifolius, Fuirena stricta* and *Hygrophila auriclata* are more common in degraded wetlands and cultivated wetlands during the dry season (ENSAP-ENTRO, 2012 in ENTRO, 2014).

*Figure 3-6: Highland wetlands of the BAS*

*Source:* (EWNRA, 2008)

### 3.1.2.3 Highlands: distinctive biodiversity features and wildlife

Highlands are biologically rich and severely threatened. Their distinctive biodiversity features can be listed as follows:

- They are endowed with a high level of endemism, including:
  - a high number of endemic plants,
  - covering an important part of the South and Central Ethiopian Highlands endemic bird areas;
  - at least ten amphibians endemic or near endemic (Burgess et al., 2004)
- They host the last important remnant forest of the Ethiopian Upper Montane Forests, Woodlands, Bushlands and Grasslands ecoregion and the last important forest area in Ethiopia.
  - The cloud forests of the basin have international importance for their ecology, biodiversity and economy (due to significant contribution on the world market of coffee) (NABU, 2011).
  - Three forest areas have therefore been designated as Biosphere reserves in the basin (Yayu, Kafa, and Sheka).
  - Wildlife species in the Ethiopian Highlands include *Colobus and Vervet Monkeys, Tree Squirrel, Lion, Leopard, Antelopes, Buffalo, Elephant, Porcupine, Aardvark, Wart Hog and Forest Pig* (waterhog) (ENTRO, 2014).

### 3.1.2.4 Main threats to the BAS highlands ecosystems

#### GLOBAL THREATS TO THE BAS HIGHLANDS

The Ethiopian Montane grasslands and woodlands ecoregion as a whole is severely threatened (classified critical/endangered by the WWF). In the highlands, the high population density and the related widespread practice of subsistence farming, the huge demand for land for farming and for natural products are the predominant reasons for the widespread loss of vegetation (Burgess et al., 2004). In some areas, the population density reaches up to 1,000 inhabitants per km$^2$ (NABU, 2011)

The East African Montane Forest ecoregion is also classified as critical. This ecoregion does not form a continuous area but is constituted of several patches of forests in South Sudan, Kenya, Tanzania and Uganda which makes this ecoregion endangered. In South Sudan, three major patches are found in the Imatong mountains. Even if the population density is not currently high in the Imatong mountains, these forests do not cover a large area and are threatened by deforestation.

### Specific threats to highlands forest ecosystems

As stated above, high population density rates in the Ethiopian part of the sub-basin makes this area more subject to deforestation than the South Sudanese highland forests.

The highland areas of the basin were formerly covered with high forest. But these days, with population increase and expansion of farming into the forest cover, natural forest has significantly depleted. Only small portion has got remnant intact forests in the Ethiopian part of the sub-basin. Annual average deforestation rate is expected to be around 1.2 - 1.6 % (Sutcliffe, 2009 in ENTRO, 2014).

According to NABU (2007), the recent estimated rate of loss of highland forests reaches 80,000 - 200,000 ha/year in the Kafa region. If this rate remains constant in the future, the area covered with natural forest will have completely disappeared within 10 years (NABU, 2007).

NABU (2011) lists the following main drivers of deforestation and forest degradation in Kafa as follows:

- “Agriculture expansion: The conversion of forest land to agriculture is at first a way to increase the productivity. This can be mainly observed at forest borders, were farmers systematically clear the understorey (mostly initiated by forest grazing) and thereafter slash and burn the area. The harvested wood is used as an additional income (fire wood, or charcoal) or for the own consumption.
- Resettlement: If labor cannot support livelihood sufficiently, it results in a widespread illegal/uncontrolled use and conversion of forest land. It was observed, that dynamic forest perforation patches with unstable shape and size were settled by people without permission.
- Concessions (coffee): Large scale coffee investment (coffee investment area) is supported by the government. Due to the site requirements of Coffee plants, the upper storey of forest is thinned while the understorey is systematically removed. This practice decreases the biodiversity of the forest tremendously. Furthermore, the capability to store carbon is minimized. Local communities are banned for all purposes of forest use.
- Property rights: The unsecure defined allocation of property rights and the land tenure system in Ethiopia can be addressed as one of the main drivers for forest loss.
- Unsustainable use of forest resource: Legal and illegal forest use is increasing since customary user rights have been replaced by state sanctioned rights. Missing technical assistance in sustainable forestry and missing resource use (of plantations) from governmental side lead to illegal and unmanaged use of wood resource.”

### Specific threats related to highland wetlands ecosystems

Wetlands ecosystems have been studied in the Ethiopian part of the sub-basin. There is no information regarding wetlands in the South Sudanese highlands. Several studies undertaken by EWRP (Emergency Wetlands Reserve Program), Wetland Action (WA) and EWNRA (Ethio Wetlands and Natural Resources Association) in Western Oromiya Region, mainly in Jimma, Western and Eastern Wollega and Illubabor zones, revealed that wetlands have been drained for growing food crops for more than a century (Hailu A, 2006).

Highland wetlands also support other important uses for local communities. For example, wetlands uses and beneficiaries in Illubator are shown in the figure here after.

*Figure 3-7:Wetlands uses and beneficiaries of highlands wetlands in Illubator*

| Uses | Estimate of Households Benefiting |
|---|---|
| Social/ceremonial use of reeds | 100% (including urban dwellers) |
| Thatching reeds | 85% (for house construction) |
| Thatching reeds for granary roofing | >50% |
| Temporary crop guarding huts of reeds | 30% |
| Domestic water from springs | 50% |
| Craft materials | 5% |
| Medicinal plants | 100% |
| Dry season grazing | >30% |
| Water for stock | >30% |
| Cultivation | 10% |

*Source:* (Afework, 2001)

These various uses, when not properly managed, can contribute to wetlands degradation.

*Figure 3-8: Brick making in highland wetlands*

*Source:* (EWNRA, 2008).

## 3.1.3 Escarpments

### *3.1.3.1 Escarpments: general features*

Escarpments are generally situated between 1,100 and 1,800 masl. These areas are characterised by very steep slopes (much more important than in the highlands and foothills). The Escarpment area in the basin is a transition zone between highland and lowland areas. Some parts are also flatter like the Boma Plateau, situated between 1,100 and 1,300 masl. The Ethiopian Montane woodlands surround the highlands ecosystems described in the previous section. In South Sudan, escarpments are part of the East African Montane Forest ecoregion.

Rainfall can reach 2,300 mm per annum, from May to October. Ancient Precambrian basement rocks form the substrate of the forests and woodlands and bushlands in deep river valley (Burgess et al., 2004).

*Figure 3-9: Typical landscapes of BAS escarpments (left : Ethiopia; right: South Sudan)*

*Source: This study*

#### *3.1.3.2 Escarpments: ecosystems and vegetation*

The area supports East African evergreen and semi-evergreen forests, woodlands, and shrublands. Moister sites in southwest forest patches are dominated by tall trees, chiefly *Aningeria* and other Sapotaceae, species of Moraceae, and species of *Olea* (Burgess et al., 2004).

*Figure 3-10: Woody grass land at the escarpment of Gambella Region (left) and Savanna forest of the Boma Plateau (right)*

*Source: this study (left) and* (USAID, 2007b)

Transitional forests occur between 500 and 1,500 masl in Illubator and Kefa and have rainfall close to 2,000 mm per annum. These transitional forests change to Afromontane forests at approximately 1,500 masl altitude in the southwest, where the rainfall is between 700 and 1,500 mm (Friis, 1992 in Burgess et al., 2004). *Coffea Arabica* is the dominant natural understory shrub and wild coffee is harvested.

*Figure 3-11: Imatong lowland forest*

*Source: Safaris, 2016*

In the Akobo catchment around Bench-Maji and Sheka zones, edible roots like Taro and Enset are common and support livelihood of people. These edible roots are drought-resistant and help to soil conservation.

*Figure 3-12: Taro at Kafa (left) and Enset at Sheka (right)*

*Source: this study*

*Figure 3-13: Distribution of the main vegetation types in the BAS Escarpments*

| Vegetation type | Surface area (km2) | % of the Escarpments biophysical area |
|---|---|---|
| Pastureland or natural herbaceous land in mountain area | 14237,6 | 24,8% |
| Rock with some natural vegetation (Herbaceous and shrub) | 12603,4 | 21,9% |
| Forest | 7704,3 | 13,4% |
| Predominantly savanna generally dry (Herbaceous and shrub) | 6457,2 | 11,2% |
| Predominantly farming (Micro-parcels) in mountain area | 5845,0 | 10,2% |
| Predominantly transition savanna in hills area (Herbaceous, shrub, grass and rock) | 5371,0 | 9,4% |
| Predominantly farming (Micro-parcels) and riparian forest in mountain area | 3786,7 | 6,6% |
| Predominantly savanna temporarily wet (Herbaceous, shrub and some little farming area) | 422,4 | 0,7% |
| Natural vegetation (grass and shrub) and riparian forest | 404,7 | 0,7% |
| Irrigated farming or plantations | 228,8 | 0,4% |
| Wet area in valleys / hills (Perhaps grass or mountain wetlands) | 149,3 | 0,3% |
| Urban area | 109,5 | 0,2% |
| Water surfaces | 2,1 | 0,0% |
| Total | 57439 | 100% |

*Source: this study*

### 3.1.3.3 Escarpments: distinctive biodiversity features and wildlife

The Ethiopian Montane woodland ecoregion, like the Ethiopian montane grasslands and woodlands ecoregion from the BAS highlands, is part of the Afromontane archipelago-like regional center of endemism It supports a variety of forest types with associated bushland and woodland habitats and consequently have high species richness and endemic species (Friis, 1992 in Burgess et al., 2004). For example, the Mejang area is characterized by:

- A rich biodiversity: about 550 species of plants, 130 birds, 33 mammals and 20 species of Amphibians and Reptiles.
- Many rare and endemic species that are found in the area; e.g. 27 endemic plants, 3 endemic amphibians,
- Endemic plants, three of them are endangered: Aframomum zambesiacum subsp. Puberulum, Rinorea friisii, and Scadoxus nutans (MELCA, 2014).

*Coffea Arabica* comes naturally in the escarpments, contrary to higher areas, where it has been transplanted (ENTRO, 2014).

Yalden (1996) in Burgess et al. (2004) draws attention to the poverty of forest mammal fauna in the southwestern Ethiopian part of this ecoregion.

### 3.1.3.4 Main threats to the BAS escarpments ecosystems

For the time being, there is no significant pressure and human encroachment in the very steep parts of this area. They are covered with woody grass land and are used for grazing and wildlife habitat. This is why the escarpments host the largest areas of natural forests found in the Ethiopian montane woodland ecoregion. However, with the development of access roads and the increasing demand for fuel wood and charcoal, people could start exploitation of fuel wood and charcoal that would deplete woodland and cause degradation.

In accessible parts of the escarpments, all natural habitats are highly threatened because they have been reduced to small patches and are severely fragmented. Little habitat remains in its natural state, except in rocky ravines and other inaccessible areas. Agriculture is the main threat, coupled with exploitation of trees for fuelwood and timber. In many areas poor agricultural methods and overgrazing have resulted in intense soil erosion.

According to MELCA (2014), specific causes of deforestation in the Mejang area are identified as follows:

- Expansion of coffee plantation,
- Settlements and Agricultural expansion,
- Logging,
- Fire,
- Local wood consumption.

These causes are also valid for escarpments in other areas of the sub-basin in Ethiopia and South Sudan (especially for agricultural expansion, logging, fire and local wood consumption).

#### PROTECTION MEASURES IN THE ETHIOPIAN PART OF THE SUB-BASIN

As already mentioned, recent biosphere reserves on both highlands and escarpments have been created in the Ethiopian part of the sub-basin:

- Government of Ethiopia has adopted biosphere reserve approach for the first time in 2010 by creating the Yayu Coffee Forest in Oromia and the Kafa in SNNP regional states;
- The neighboring Sheka Forest has also become the third biosphere reserve in 2012 initiated and supported by MELCA Ethiopia (MELCA, 2014).

National Forest Priority Areas theoretically cover the entire forests areas of the BAS ethiopian highlands, escarpments and Foothills but do not provide effective protection and are not known at local level (NABU, 2011).

#### PROTECTION MEASURES IN THE SOUTH SUDANESE PART OF THE SUB-BASIN

In South Sudan, the Imatong mountains form a large forest reserve but effective protection of the area has been impended by the security situation in the country.

## 3.1.4 Foothills / Piedmonts

### *3.1.4.1 Foothills: general features*

Foothills or Piedmonts are situated between 700 and 1,100 masl. They form a transition area between escarpments, characterized by very steep slopes and flood plains which are extremely flat. The rainy season lasts from April to September. The foothill areas are part of the eastern block of **East Sudanian Savanna ecoregion** in Ethiopia and southern part of the sub-basin and **Northern Accacia Commiphora Bushland an Thicket ecoregion** in the southern part of South Sudan. Both ecoregions belong to the Tropical and Subtropical Grasslands, Savannas, shrublands and Woodlands Biome. They are mainly covered by shrubs, dry savannas and Woodlands.

*Figure 3-14: Typical landscapes of BAS Foothills / Piedmonts (left : Ethiopia; right: South Sudan)*

Source: This study

### 3.1.4.2 Foothills: ecosystems and vegetation

In the foothills area, the vegetation is undifferentiated woodland with trees that are mainly deciduous in the dry season, with and understory of grasses, shrubs, and herbs. Typical trees found in these areas are: Combretum and Terminalia species, *anogeissus leiocarpus, Boswellia papyrifera, Lanea schimperi, and Stereospermum kunthianum*. The solid-stemmed *bamboo Oxytenanthera abyssinica* is prominent in the western river valleys of Ethiopia. Dominant grasses include tall species of *Hyparrhenia, Cymbopogon, Echinochloa, Sorghum, and Pennisetum* (Tilahun et al., 1996 in Burgess et al., 2004).

*Figure 3-15: Lowland bamboo (left) and lowland woody grasslands (right) along Guba-Torit road*

Source: This study

*Table 3-4: Distribution of main vegetation types in the BAS Foothills*

| Vegetation type | Surface area (km2) | % of the Foothills biophysical area |
|---|---|---|
| Predominantly savanna  generally dry (Herbaceous and shrub) | 34 029 | 52% |
| Predominantly transition savanna in hills area (Herbaceous, shrub, grass and rock) | 13 699 | 21% |
| Predominantly savanna temporarily wet (Herbaceous, shrub and some little farming area) | 8 381 | 13% |
| Rock with some natural vegetation (Herbaceous and shrub) | 4 179 | 6% |
| Forest | 2 128 | 3% |
| Pastureland or natural herbaceous land in mountain area | 1 439 | 2% |
| Marshes | 1 028 | 2% |
| Irrigated farming or plantations | 382 | 1% |

| | | |
|---|---|---|
| Natural vegetation (grass and shrub) and riparian forest | 141 | 0,2% |
| Urban area | 81 | 0,1% |
| Predominantly farming (Micro-parcels) in mountain area | 51 | 0,1% |
| Water surfaces | 24 | 0,0% |
| Total | 65 563 | 100% |

*Source: this study*

### *3.1.4.3 Foothills: distinctive biodiversity features and wildlife*

The East Sudanian Savanna and Northern Accacia Commiphora Bushland and Thickets ecoregions have low rates of faunal endemism, with only one strictly endemic mammal, two strictly endemic reptiles and five bird species for the Easte Sudanian Savana ecoregion. However, this is an important area for endemic plants.

Threatened mammal species include elephants (*Loxodonta Africana*), wild dog (*Lycaon pictus*), cheetah (*Acinonyc jubatus*), and lion (*Panthera leo*). The roan antelope's (*Hippotradus equinus*) can also be found.

### *3.1.4.4 Main threats to the BAS Foothills ecosystems*

According to Burgess et al. (2004), the original wooded savanna habitat has been significantly reduced. The main treats to foothill ecosystems are:

- seasonal shifting of cultivation,
- overgrazing by livestock,
- cutting of trees and bushes for wood,
- burning of woody materials for charcoal,
- and uncontrolled wild fires.

The main threats to the species come from overgrazing, poaching and overhunting for meat.

## 3.1.5 Climate change consists of an additional threat while it exacerbates the above quoted impacts of human activities. Ability of the ecosystem to recover from overuse can indeed be reduced when there is little rainfall. Flood Plains and wetlands

### *3.1.5.1 Flood Plains and wetlands: general features*

This biophysical area covers more than the half of the BAS.

The Floodplains and wetlands biophysical area is situated between 370 and 700 masl. It consists of very flat clay plains that stretch from northwards South Sudanese foothills and westwards from Ethiopia foothills to the Sobat river. These plains have very gentle slopes between 0,01 and 0,012% (ENTRO, 2007a).

The rainfall reaches between 600 and 800 mm/year, falling between April and September during the hot season when temperatures average 30-33°C, dropping to an average of 18°C in the cooler season (Burgess et al., 2004). Mean annual evaporation is from 1600 to 1900 mm/year (ENTRO, 2007a).

Vertisols have developed in the waterlogged conditions over these nutrient poor sediments, although fluvisols and patches of luvisols can be found along the river courses.

This biophysical area is included in the two following ecoregions:

- The East Sudanian Savanna ecoregion, which belongs to the Tropical and Subtropical Grasslands, Savannas, Shrublands, and Woodlands biome (also largely present in the foothills / piedmonts biophysical area),
- The Saharan Flooded Grasslands ecoregion, which consists of Flooded Grasslands and Savannas.

*Figure 3-16: Typical landscapes of BAS floodplains and wetlands (left: Ethiopia; right: South Sudan)*

*Source: This study*

### 3.1.5.2 Flood Plains and Wetlands: ecosystems and vegetation

The floodplain ecosystem supports a variety of plant species ranging from those adapted to wet environments, under water during several months in a year, to those adapted to drier environments, occasionally flooding or only by rainfall. Moving from the center of the swamps, the ecological zones grade from the open water and submerged vegetation of a river-lake, to floating fringe wetlands, to seasonally flooded grasslands, to rain-fed wetlands, and finally to floodplains woodlands (Hickley, 1987 in Burgess N. & al, 2004). *Cyperus papyrus* is dominant at riversides and in the wettest swamps. *Phragmites* and *Typha* swamps are extensive behind the papyrus stands, and there is an abundance of submerged macrophytes in the open waterbodies.

Seasonal floodplains, up to 25 km wide, are found on both sides of the main swamps. Wild rice (*Oryza longistaminata*) and *Echinochola pyramidalis* grasslands dominate the seasonally inundated floodplains. Wild rice support a flooded period from 5 to 9 months, whereas *Echinochola pyramidalis* is inundated during less than 3 to 4 months in a year. The seasonally river-flooded grassland forms the '*Toich*', which yields dry season grazing areas important to the Nuer and Dinka agro-pastoralists. Yield is affected by the duration, timing and intensity of the flood (ENTRO, 2007a), varying from 1 ton/ha when non inundated to 7 ton/ha when inundated.

Beyond the floodplain, *Echinochloa haploclada, Sporobolus pyramidalis and Hyparrhenia rufa* grasslands cover the rain-fed wetlands. Mixed woodlands of *Accacia seyal, Ziziphus mauritiana, Combretum fragans,* and *Balanites aegyptica* border the floodplain ecosystem (Denny, 1991 in Burgess & al., 2004). Riparian forests species include: *Celtis kraussiana, Ficus sycomorus, Mimusops kummel, Tamarindus indica, Maytenus senegalensis, Kigelia aethiopum, Syzygium guineense and Acacia spp* (ENTRO, 2007a).

*Table 3-5: Distribution of the main vegetation types in the BAS wetlands*

| Vegetation type | Surface area (km2) | % of the Foothills biophysical area |
|---|---|---|
| Marshes | 25799 | 21% |
| Predominantly savanna temporarily wet (Herbaceous, shrub and some little farming area) | 16813 | 13% |
| Predominantly savanna generally dry (Herbaceous and shrub) | 81206 | 65% |
| Pastureland or natural herbaceous land in mountain area | 34 | 0,0% |
| Rock with some natural vegetation (Herbaceous and shrub) | 1133 | 0,9% |

| | | |
|---|---|---|
| Predominantly transition savanna in hills area (Herbaceous, shrub, grass and rock) | 166 | 0,1% |
| Water surfaces | 60 | 0,0% |
| Irrigated farming or plantations | 229 | 0,2% |
| Urban area | 54 | 0,0% |
| Petroleum domain | 125 | 0,1% |
| Total | 125668 | 100% |

Source: this study

### 3.1.5.3 Flood Plains and Wetlands: distinctive biodiversity features and wildlife

The BAS hosts **one of the most important mammal migration of the world** (USAID, 2010b). The **main migratory species is the White-eared Kob** (Kobus kob leucotis). White-eared Kobs are endemic to the BAS since migration routes are nearly confined within the sub-basin limits. White-eared Kobs are listed as “least concerned” but faces increasing threats leading to population decline. The inclusion of the White-eared Kobs in the CMS (Convention on Migratory Species) Appendix 2 has been proposed in 2014 (CMS, 2014). White-eared Kob population estimations vary from one source to another. For example, the WCS-HoA (2010) suggests that the total number of White-eared Kobs is as high as 753 000; USAID (2010) estimates the total population at 1.2 million. According to some experts (Frost, 2014), this migration is the 2nd most important of Africa, after the Serengeti one. According to others, the White-eared Kob migration rivals that of the Common Wildebeest *(Connochaetes taurinus)* in the Serengeti ecosystem (Kingdon et al. 2013) or could be even more significant (HoA-REC, 2011).

Migration routes **are strongly correlated with hydrological patterns** (HoA-REC, 2011). Fryxell et al. (1988) have studied the relationship between seasonal migration of White-eared Kob and resources (food, water availability) and show that “seasonal migration by white-eared kob is linked to shifting distributions of critical resources”.

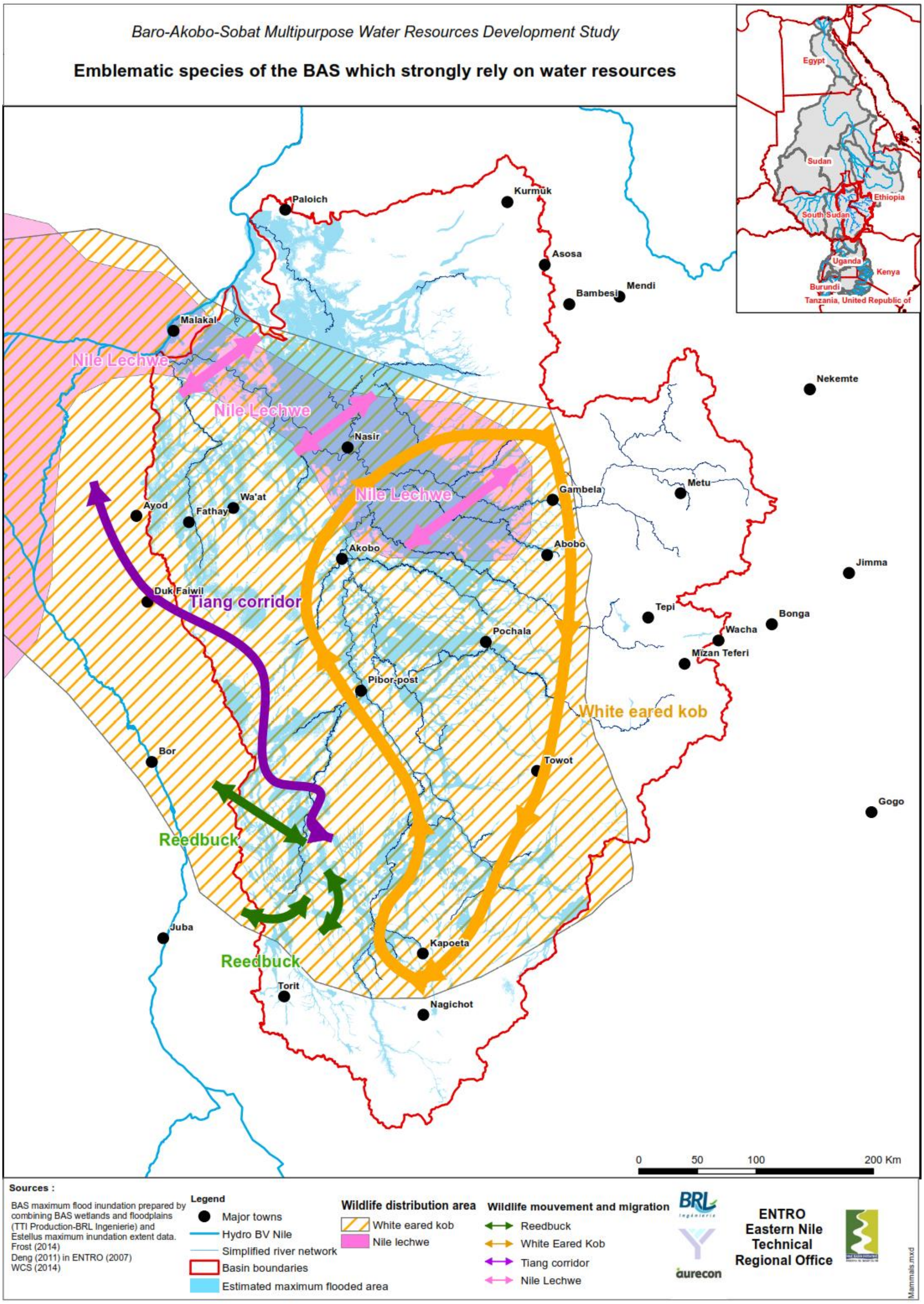
Apart from the White-eared Kob, the migration consists of Tiang, Mongalla gazelle and East African eland all followed by Lion, Jackal and Hyena. At the southern end of the migration they are joined by Zebra, Bright’s Gazelle, Giraffe and Beeisa Oryx. There are also roan Antelope and Buffalo near the Ethiopian foothills (Frost, 2014).

*Figure 3-17 : White-eared Kob in floodplain grassland (left) and Nile lechwe (right)*

*Source:* (Frost, W., 2014) (National geographic, 2015)

The BAS hosts the **Nile lechwe endangered species** which is present only in the Sudd swamps, *Machar marshes* and in Gambella region (Frost, 2014; IUCN SSC Antelope Specialist Group , 2008; Kingdon et al., 2013). Nile lechwe's primary habitat is swamps and marshes which are subject to seasonal inundation (Kingdon et al., 2013). **Local patterns of flooding have the most significant influence on the species** (Kingdon et al., 2013). Indeed, the Nile lechwe depends on the open area between floodwaters and drier ground, moving up and down the flood tide lines following the seasons (Frost, 2014). Nile Lechwe population seems to be reduced to a very low density (Kingdon et al., 2013; Frost, 2014).

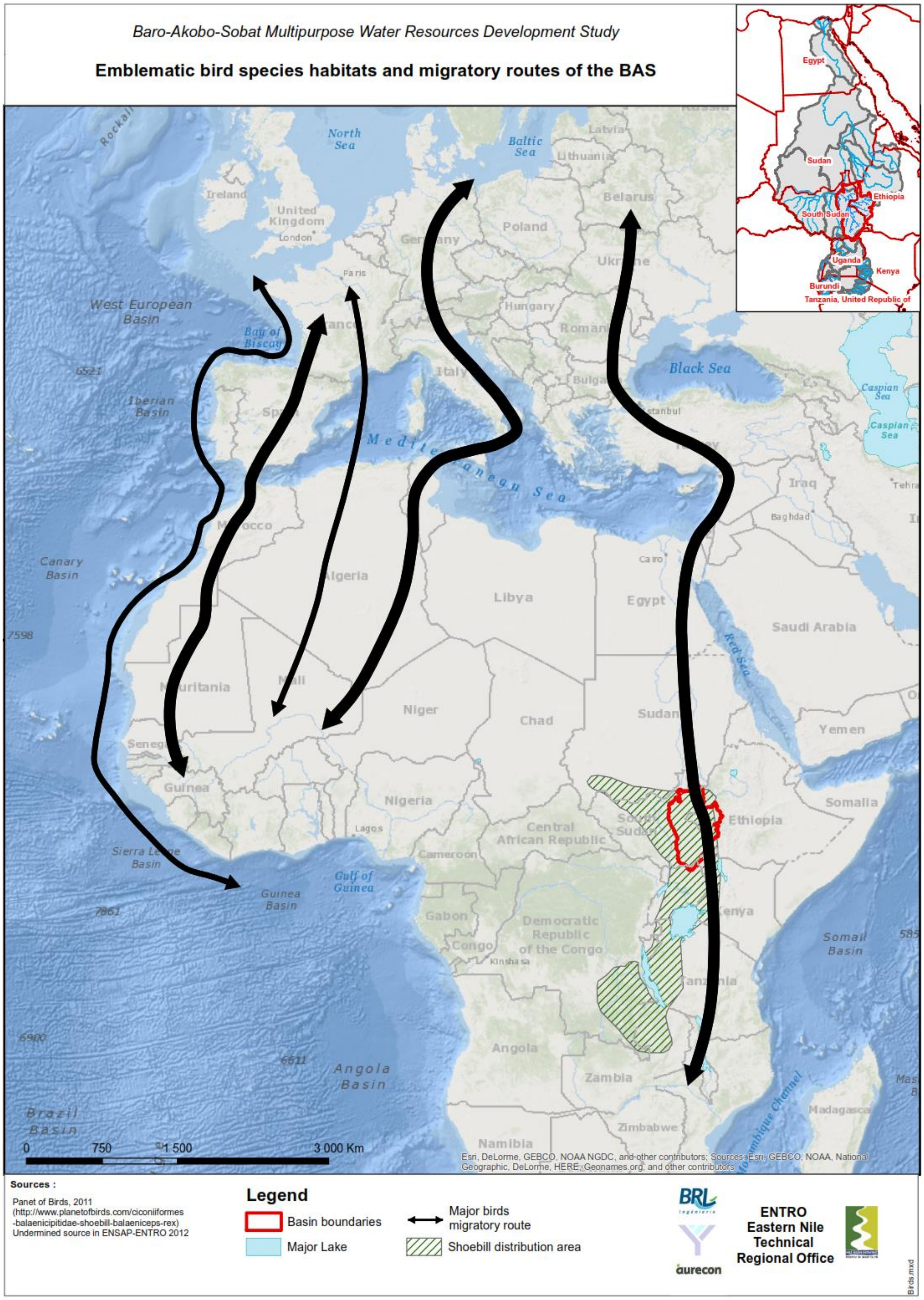
*Figure 3-18: Emblematic mammal species habitats and migratory routes of the BAS*



The BAS is situated on the major birds migratory routes between Africa and Europe and hosts an important population and diversity of birds (ENSAP-ENTRO, 2012) with more than 2.5 million using the floodplains of the Sudd annually, mainly migratory species moving between Europe and Africa (Robertson, 2001 in Burgess & al, 2004).

These wetlands also support the largest population of shoebill (*Balaeniceps rex*) in the world, estimated to be around 6,400 individuals (Robertson, 2001 in Burgess & al, 2004). The area is also a stronghold for the great white pelican (*Pelecanus onocrotalus*), ferruginous duck (*Aythya nyroca*) (Robertson, 2001 in Burgess & al, 2004), and black-cowed crane (*Balearica pavonina*) (Newton, 1996 in Burgess & al, 2004).

*Figure 3-19: Emblematic bird species habitats and migratory routes of the BAS*



Werner's garter snake (*Elapsoidea laticincta*) is a near-endemic snake, but other amphibians and reptiles are unremarkable (Burgess & al, 2004).

The basin waters and wetlands host a **high diversity of fish** (from around 90 to more than 100 species depending on sources) (ENTRO, 2007a). The main species found in the basin are *Lates niloticus* (Nile perch), and *Polypterus bichir* (Nile bichir), *Bagrus spp*., *Heterotis niloticus*, Clarias gariepinus, *Distichodus sp.,Gymnarchus niloticus, Barbus spp., Synodontis spp., ydrocynus sp., Citharinus sp.and Tilapia nilotica* (ENTRO, 2007a)

The BAS water bodies also support **various Malacofauna species**, including 13 gastropod species, (from which only one, *Gabbiella schweinfurthi* may be endemic) and 11 bivalve species (from which only the *iridinid Chambardia marnoi* is likely distinctive and confined to this part of the Nil). Near the mouth of the Sobat, large zones were invaded by the big bivalve, *Etheria elliptica*. The colonies of these mollusks provided a habitat for a rich fauna of Ephemeroptera and Trichoptera. The genera Amphipsyche, Cheumatopsyche, Aethaloptera and Ecnomis predominated (ENSAP-ENTRO, 2012).

The **benthos of the Sobat River is similar to that of the White Nile**. The clayey bottom of the bed was sparsely populated by Chironomidae (*Polypedilum sp., Clinotanypus sp., Stictochironomus sp., Cryptochironomus sp.*) and Trichoptera. The total biomass of the benthos in the middle of the river was about 0.2 g m-2 (ENSAP-ENTRO, 2012).

### *3.1.5.4 Main threats to the BAS Floodplains and wetlands ecosystems*

#### SPECIFIC THREATS CONCERNING WILDLIFE

The main threats to the mammal migrating species come from overgrazing, poaching and overhunting for meat.

Frost (2014) and Kingdon et al. (2013) estimate that the survival of the Nile lechwe Ethiopian population seems highly precarious and the South Sudanese one threatened. The main reported threats are the increased human pressure in the form of hunting / poaching; habitat degradation by domestic livestock, especially when large numbers of cattle penetrate the area during the dry season; impacts of oil exploration on water quality and current inadequate conservation measures.

Some population estimates of emblematic migratory species of the BAS are summarized in the tables below:

*Table 3-6: Population estimates of emblematic species of the BAS in the area*

| Date | Area investigated | Observation/ estimation | Species | Source |
|---|---|---|---|---|
| 2007 | South Sudan | 4,291 | Nile lechwe | Frost (2014) quoting the aerial survey carried out by WCS |
| 1983 | South Sudan and Ethiopia | 30,000 – 40,000 | Nile lechwe | Aerial survey of Mefit-Babtie (1983) in Kingdon (2013) |
| 1988 | Machar | 900 | Nile lechwe | Hillman & Fryxell (1988) in Kingdon (2013) |
| 2007 | Boma National park<br>Lotilla plains<br>Jonglei area | 700,000<br>46,000<br>12,000 | White-eared Kob | Fay et al (2007) in Kingdom et al (2013) |
| 1980-1983 | Boma National park | 800,000 | White-eared Kob | Fryxell & Sinclair (1988) |
| Early 1980s | Boma ecosystem | Nearly 1 million | White-eared Kob | Fryxell (1985), Hillman & Fryxell (1988) in Kingdom et al (2013) |

| Date | Area investigated | Observation/ estimation | Species | Source |
|---|---|---|---|---|
| 2009-2010 | Gambella National Park<br>Upper Akobo | 203,181<br>51,962 | White-eared Kob | TFCI (2010) |
| 2010 | Sudan's Boma-Jonglei Landscape | 1.2 million | white-eared kob, tiang, Mongalla gazelle, and reedbuck | USAID (2010) |
| 2001 | Not specified | 753,000 | White-eared Kob | WCS (2001) |

*Source: this study – compilation from various sources*

*Table 3-7: Recent wildlife population estimates from EWCA 2015 aerial survey in Gambella National Park*

| Specie | Scientific name | Individuals observed (n) | Population Estimate (Ŷ) |
|---|---|---|---|
| White eared kob | *Kobus kob leucotis* | 29,458 | 399,299 |
| Giraffe | *Giraffa cameleopardalis* | 33 | 447 |
| Buffalo | *Syncerus caffer* | 887 | 12,023 |
| Roan Antelope | *Hippotragus equinus* | 40 | 542 |
| Tiang | *Damaliscus lunatus* | 39 | 529 |
| Hartebeest | *Acelaphusbushel apuslelwel* | 16 | 217 |
| Waterbuck | *Kobus ellipsiprymnus* | 5 | 68 |
| Nile lechwe | *Kobus megaceros* | 28 | 192 |
| Shoebill stork | *Baleaniceps rex* | 26 | 34 |

*Source:* (EWCA, 2015) *b*

In South Sudan, the Jonglei canal is also detrimental to wildlife in the BAS sub-basin (according to stakeholders' consultations). It indeed blocks the annual movement of the tiang southwest to their wet season grazing area, and many thousands are shot as they try to find crossing points (Burgess & al., 2004).

In Ethiopia, the recent and planned development of huge mechanized farms in Gambella could become an important threat to wildlife migration and habitat. According to Pearce (2011), canal and roads have been constructed, land has been cleared, 55,000 ha have already been planted, including 35,000 ha of rice, 10,000 ha of maize, and 10,000 hectares of sorghum and 20,000 hectares of oil palm and sugar cane should be added soon within the original boundaries of Gambella national park. These original boundaries have been revised in order to make way for new agricultural concessions.

*Figure 3-20: Earth clearing before plantation of irrigated rice in Gambella (left) and farming in the original boundaries of Gambella national park (right)*

*Source : left : (Pearce, 2011) and right :* (Gebresenbet F., et al., 2013)

## OIL EXPLOITATION

Oil extraction and exploration is limited to the South Sudanese part of the basin, in Upper Nile State where there are 3 oil fields in activity: Paloch, Gumry and Adar Yale. Water quality issues have been reported to several NGOs by the local communities (Bonn International Center for Conversion, 2013; Cordaid, 2014). These communities usually rely on surface water for drinkable water and to provide water for the livestock. They have reported to the NGOs that they cannot use surface water anymore because of the pollution and noticed abnormal loss of livestock that they ascribe to oil contamination.

It should be noted that oil pollution can have adverse effects on surface water but also on groundwater and on the soils (polluted by oil residues).

## POOR SANITATION AND WASTE MANAGEMENT

Increased population density in the upper catchment areas and in the main towns of the basin, combined with poor sanitation and waste management can lead to local water quality problems.

*Figure 3-21: Washing and sewage discharge in the Kinyeti river (left) and untreated water for the Torit market (right)*

*Source:* (MWRI, 2012)

## SILTATION OF THE RIVERS

During a field mission to *Machar marshes* conducted in November and December 2012, siltation has been identified as an important issue.

Sand dunes and deposits in the Machar mouth have been observed and reported by local inhabitants on the Machar mouth, along the Khor Machar, on the Zure River / Adura river, and on the Baro river and its major spills and bifurcations. These deposits occurred in less than 10 years period and could have already important socio-economics, and environmental impacts. Erosion of the upper parts of the catchment seems to be the cause of the observed downstream siltation (ENTRO, 2012b).

### INVASIVE SPECIES IN WATERBODIES

Water hyacinth was observed during the site visit in Baro River below the Baro bridge at Gambella town. It is also mentioned during the discussion with South Sudan Transport office as a barrier for boat movement in Sobat River.

Water hyacinth (*Eichhornia crassipes*) is considered one of the world's worst weeds invading lakes, reservoirs, ponds, canals, and rivers due to its numerous adverse effects:

- Creates impenetrable barriers and obstructing various uses of water,
- Leads to complete blockage of navigation and fish migratory routes,
- Hinders irrigation by impeding water flow, by clogging irrigation pumps, and by interfering with weirs. Increased water loss through evapo-transpiration,
- Provides a breeding ground for disease vectors such as mosquitoes and the vector snails of schistosomiasis,
- Leads to depleting oxygen to aquatic communities, resulting in lack of phytoplankton which alters the composition of invertebrate communities, ultimately affecting fisheries,
- Destroys native plants and wildlife habitat (Rezene, 2014).

*Figure 3-22: Floating Water hyacinth observed in Baro River below the Baro bridge at Gambella town (letft) luxurious growth of water hyacinth at Koka Reservoir in Ethiopia (right)*

*Source: This study (left),* (Rezene, 2014) *(right)*

## 3.2 PROTECTED AREAS AND BIODIVERSITY CONSERVATION / WATERSHED PROTECTION INITIATIVES

### 3.2.1 Protected areas

Around 30% of the basin surface area is covered by protected areas. The BAS totalizes over 30 protected areas which area briefly presented in the table below. Despite this large number and important coverage, important issues have been identified:

- Important (for biodiversity and livelihoods) and threatened ecosystems are not covered by any type of specific protection. This is for example the case of the Machar marshes (see figure below);
- Effective protection is quasi insignificant in the basin. However, recent planning initiatives (land use management plan under preparation in Gambella region and protected area management plan are under review for Badingilo and Boma national parks) and conservation projects in biosphere reserves can be noticed.
- Little general updated information is available, especially concerning National Forest Priority Areas, Forest reserves, and Game reserves;
- Little detailed information is available, including for the National parks.

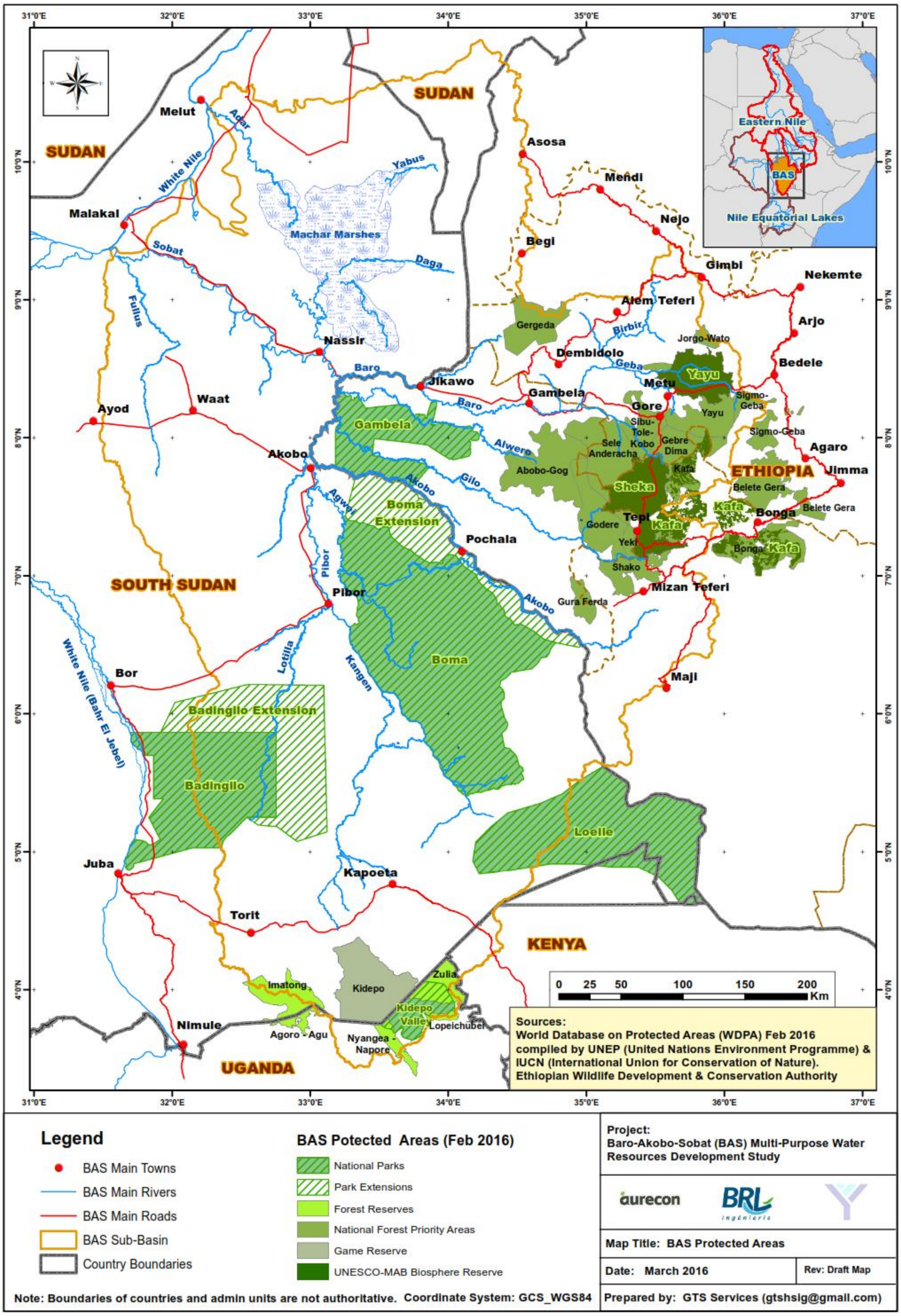
*Table 3-8 : Main characteristics of protected areas in the BAS*

| Type of protected area | Name | Country | Biophysical area | Total surface area (km$^2$) | Date of creation | Current status |
|---|---|---|---|---|---|---|
| National Park | Gambella | Ethiopia | Floodplains and wetlands | 4,554 | 1973 | Gazetted and demarcated in 2014. Cooperation between EWCA and African Parks for the management |

| Type of protected area | Name | Country | Biophysical area | Total surface area (km$^2$) | Date of creation | Current status |
|---|---|---|---|---|---|---|
| | Boma | South Sudan | Floodplains and wetlands Foothills and Piedmonts | 19,747 (24,634 with the proposed extension) | 1977 | Cooperation between MWCT and WCS for the management. Management plan under review. Currently closed for security reasons. |
| | Badingilo | South Sudan | Floodplains and wetlands | 8,934 (16,658 with the proposed extension) | 1986 | Cooperation between MWCT and WCS for the management. Management plan under review |
| | Loelle | South Sudan | Floodplains and wetlands Foothills and Piedmonts | 10,774 | | |
| | Kidepo valley | Uganda | Highlands, Escarpments | 1,430 | 1962 | |
| Forest reserve | Imatong | South Sudan | Highlands, Escarpments | 1,159 | 1952 | No management plan |
| | Agoro-Agu | Uganda | | 263 | 1948 | No management plan reported |
| | Nyangea-Napore | Uganda | | 423 | 1950 | |
| | Lomej | Uganda | | 8 | 1963 | |
| | Lopeichubei | Uganda | | 167 | 1963 | |
| | Zulia | Uganda | | 925 | 1950 | |
| National Forest Priority Area | Gura Ferda | Ethiopia | Highlands, Escarpments | 448 | | Bonga NFPA is the only demarcated NFPA in Kafa region; awareness level concerning NFPA is insignificant (NABU, 2011) |
| | Yeki | Ethiopia | Escarpments | 874 | | |
| | Shako | Ethiopia | Escarpments | 1009 | | |
| | Sibu-Tole-Kobo | Ethiopia | Highlands, Escarpments | 1006 | | |
| | Jorgo-Wato | Ethiopia | Highlands, Escarpments | 197 | | |
| | Sigmo-Geba | Ethiopia | highlands | 741 | | |
| | Yayu | Ethiopia | Highlands | 2301 | | |
| | Gergeda | Ethiopia | Highlands, Escarpments | 1405 | | |
| | Abobo-Gog | Ethiopia | Escarpments, Foothills | 2512 | | |
| | Gebre Dima | Ethiopia | Highlands, Escarpments | 2075 | | |
| | Godere | Ethiopia | Escarpments | 1699 | | |
| | Sele Anderacha | Ethiopia | Highlands, Escarpments | 2791 | | |

| Type of protected area | Name | Country | Biophysical area | Total surface area ($km^2$) | Date of creation | Current status |
|---|---|---|---|---|---|---|
| Game reserve | Kidepo | South Sudan | Highlands, Escarpments | 2,856 | 1975 | No management plan |
| Biosphere reserves | Kafa | Ethiopia | Highlands | 2,474 | 2010 | Cooperation between Kafa zone administration and NABUfor the management Management plan approved |
| | Yayu | Ethiopia | Highlands, Escarpments | 1,662 | 2010 | Management: various administrative levels, Oromiya Forestry and Wildlife Enterprise, Oromiya Bureau of Agriculture and Rural Development and Ministry of Science and Technology. Management plan approved |
| | Sheka | Ethiopia | Highlands, Escarpments | 2,396 | 2012 | Cooperation between Sheka administration zone and MELCA for the management Management plan (2015-2019) approved |

*Figure 3-23: Protected area of the BAS*




Source : this study

### 3.2.2 Existing conservation projects

The following on-going conservation projects have been identified :

- Improving South Sudan’s Livelihoods and Ecosystems Through Water Management in the Imatong mountains

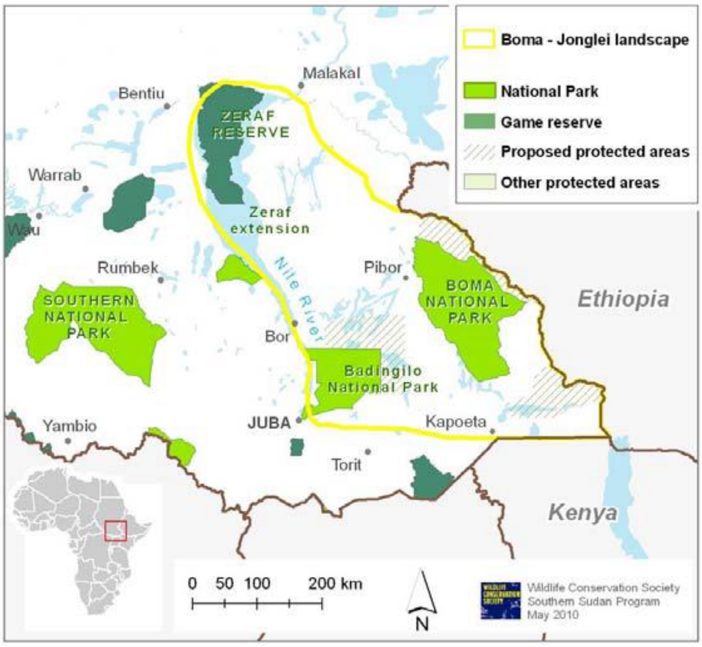
The African Wildlife Foundation has received a five year project grant from the Royal Netherlands Republic to secure the Imatong Mountains Water Tower in Equatoria State (African Wildlife fundation, 2014a). The projects aims at ensuring that the water tower of the Imatong Mountains, and particularly the catchment area of the Upper Kinyeti River are protected and sustainably managed, to ensure long-term water access to communities and ecosystems down river (African Wildlife Foundation, 2015). So far, a comprehensive socio-economic survey of the area has been conducted and published in 2014 (AWF, 2014b). Interventions in the middle part of the watershed should relate more to management of water use as well as agriculture (crop & livestock) use. By ensuring that water continues to permanently flow in the Kinyeti River, this project should contribute to securing livelihoods and food security around Torit for agricultural development and food security as well as safeguarding drinking water extraction for Torit town which will otherwise be in jeopardy. Furthermore, it should contribute to containing water related conflicts between farmers and pastoralists in the lower watershed and around Kinyeti's mouth (African Wildlife Foundation, 2015).

- Boma-Jonglei landscape project

This project was initiated in 2009 through a financial support from EU in order to promote trans-boundary, sub-regional interventions to respond to emerging issues and the environmental challenges through a financial support from EU (SSNCO, 2014). The program focuses on “strengthening institutional capacity, participatory land-use planning and resource management, establishing protected area management, improving community livelihoods, promoting ecotourism, and developing other incentives for sustainable land use to conserve this remarkable ecosystem and its magnificent wildlife migrations for the benefit of the people of Sudan and the world” (USAID, 2010a).

So far, integrated land-use and conservation plan for the Boma-Jonglei Landscape was developed through a fund from USAID/Sudan in 2010 and the Boma-Gambela Landscape has been identified as a pilot project (SSNCO, 2014).

*Figure 3-24 : Location of the Boma-Jonglei landscape*




Source: USAID (2010_a); Demetry (?)

- Protected Area Network Management and Building Capacity in Post-conflict South Sudan

This UNDP program planned for the period 2012-2016 aims at "laying the foundations for effective protected areas management by firstly, reassessing the present protected area estate to ensure the identification of key migratory routes and wildlife corridors within the protected area network and secondly, building the capacity of the Ministry of Interior and Wildlife Conservation to effectively manage and sustainably develop South Sudan's key protected areas" (UNDP, 2015).

It include specific activities in the BAS, such as socio-economic surveys, consultations with local representatives, demarcation and awareness raising on parks boundaries in Boma and Badingilo national parks (UNDP, 2015)

- IGAD Biodiversity Management Programme (BMP)

The Biodiversity Management Program (BMP) is a four-year (2015-2018) program implemented by IGAD ) and funded by the European Commission (EC) (ICRAF, 2015).

The Boma-Gambela landscape is one of the 3 demonstration sites of the program. It should help to enhance the biodiversity management of the Boma-Gambella landscape whilst improving the livelihoods of the people of Gambella (IGAD, 2015). The activites performed include:

- Improvement of Gambella park administration and infrastructure,
- Development of an integrated Land use and development plan for the Gambela region,
- Wildlife movements monitoring,
- Value chain development (honey and shea butter).

- NABU Conservation and sustainable use of the last wild coffee forests of Ethiopia project in the Kafa forest Biosphere Reserve

The project is planned to run for 3 years (2014-2017), is part of the International Climate Initiative (IKI) and is supported by the German Federal Ministry of Environment, Nature Conservation, Building and Nuclear Safety. It aims to continue and expand former NABU programmes such as reforestation, participatory forest management and energy saving stoves, while introducing new components such as biodiversity protection and community based management strengthening. From 2009 to 2014, almost 1,600 ha of degraded forest and agricultural land have been reforested and 10,000 ha of natural forest was integrated into Participatory Forest Management (NABU, 2015).

- Kafa wetlands strategy

In 2008, a wetlands strategy for the Kafa has been established in order to reduce wetlands degradation, “fill the gap created in wetland management in Kafa zone and also to promote similar efforts all over the country by learning from this” (EWNRA, 2008). The main objectives of the strategy are listed as follows :

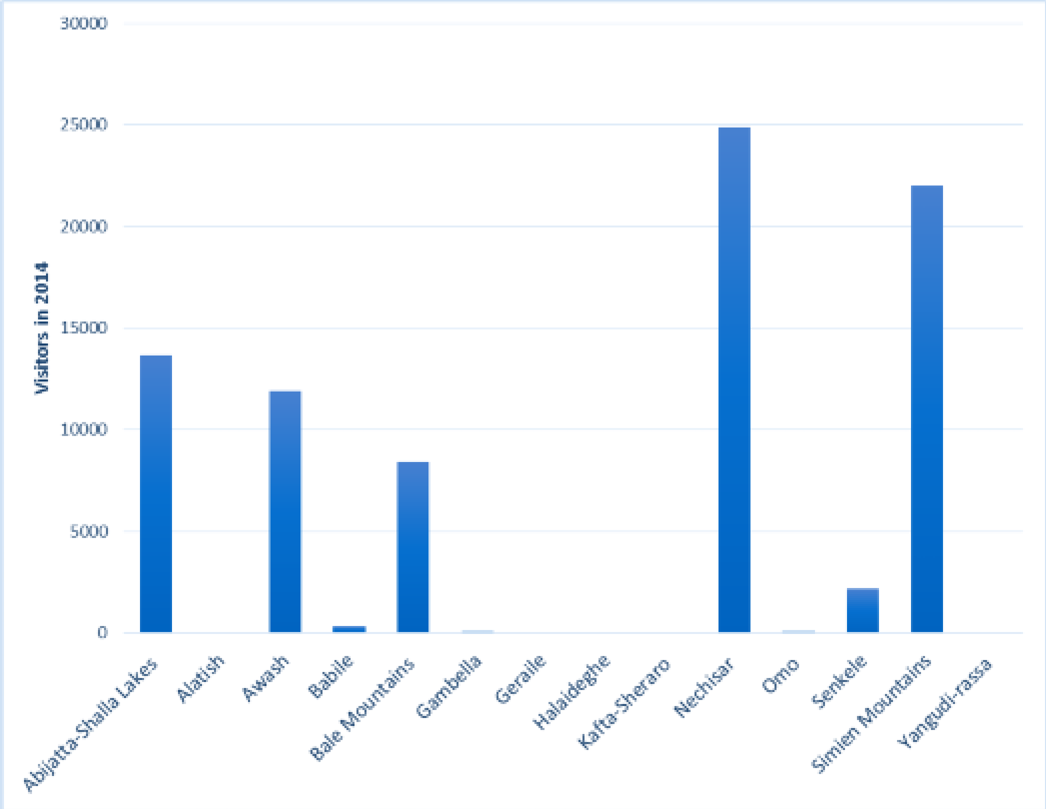
- “To integrate wetland management in to watershed or river basin management
- build data base on the wetlands of Kafa Zone and disseminate information on wetlands
- To secure support and promote relevant development and management studies/research for better wetland management” (EWNRA, 2008)

## 3.3 ECOTOURISM

Currently, tourism and ecotourism are largely underdeveloped in the BAS despite the huge potential offered by its rich natural resources, especially by water resources.

Since 2001, International visitor arrivals in Ethiopia have shown a strong upward trend (WTTC, 2014). Ethiopia has become a quite important tourism destination in Africa, not far from Kenya when one compares tourism and travel’s direct and total contribution to GDP. However, the Ethiopian part of the basin do not benefit yet from tourism growth (see figure below), mainly because of a lack effort to develop infrastructures that facilitate tourism and lack of coordinated management.

*Figure 3-25: Visitors numbers and growth for all EWCA protected areas*




Source: (EWCA, 2015)

Because of the huge potential for ecotourism in all biophysical areas of the basin, existing initiatives are going in several area. The main initiatives identified are:

- Gambela region, including Gambella national park, through IGAD BMP project. Beyond wildlife observation in the national park, the main attractions currently promoted by the Gambella region related to water resources and include brigdes on the Gilo and Baro rivers, lakes and waterfalls.
- Development of management and business plan for ecotourism and edition of a visitors' guide in Kafa Biosphere Reserve, Bonga, Ethiopia. Current activities include bird watching, walk through coffee forest, waterfalls, visits of tea plantations, etc. Infrastructure such as hiking trails with picnic huts, wildlife observation towers and camping site have been set up as part of 2009-2014 NABU 1$^{st}$ forest and climate protection in Kafa.
- Social empowerment through group and nature interaction in Sheka zone, organized by MELCA offering the following activities: camping in the forest, trekking, night watch, …
- Preparation of brochures by each regional state to be used by tourists and to advertise the available tourism potentials and attractions of their respective regions. These brochures contain valuable information about protected areas, list of wildlife species found in the protected areas and wildlife parks, landscapes, lakes, traditions, etc.
- In South Sudan, tourism has emerged recently but is currently insignificant for security reasons. No readily available brochures were found. Tourism development suffers from security issues but also from bad accessibility and poor accommodation services. Wildlife discovering in the National Parks and trekking in the Imatong Mountains (Mount Kinyeti, South Sudan highest peak) consist of the high potential attractions of the South Sudanese part of the BAS.

# 4. SATELLITE IMAGERY ANALYSIS INPUTS TO WETLANDS KNOWLEDGE IMPROVEMENT

### 4.1.1 Key results

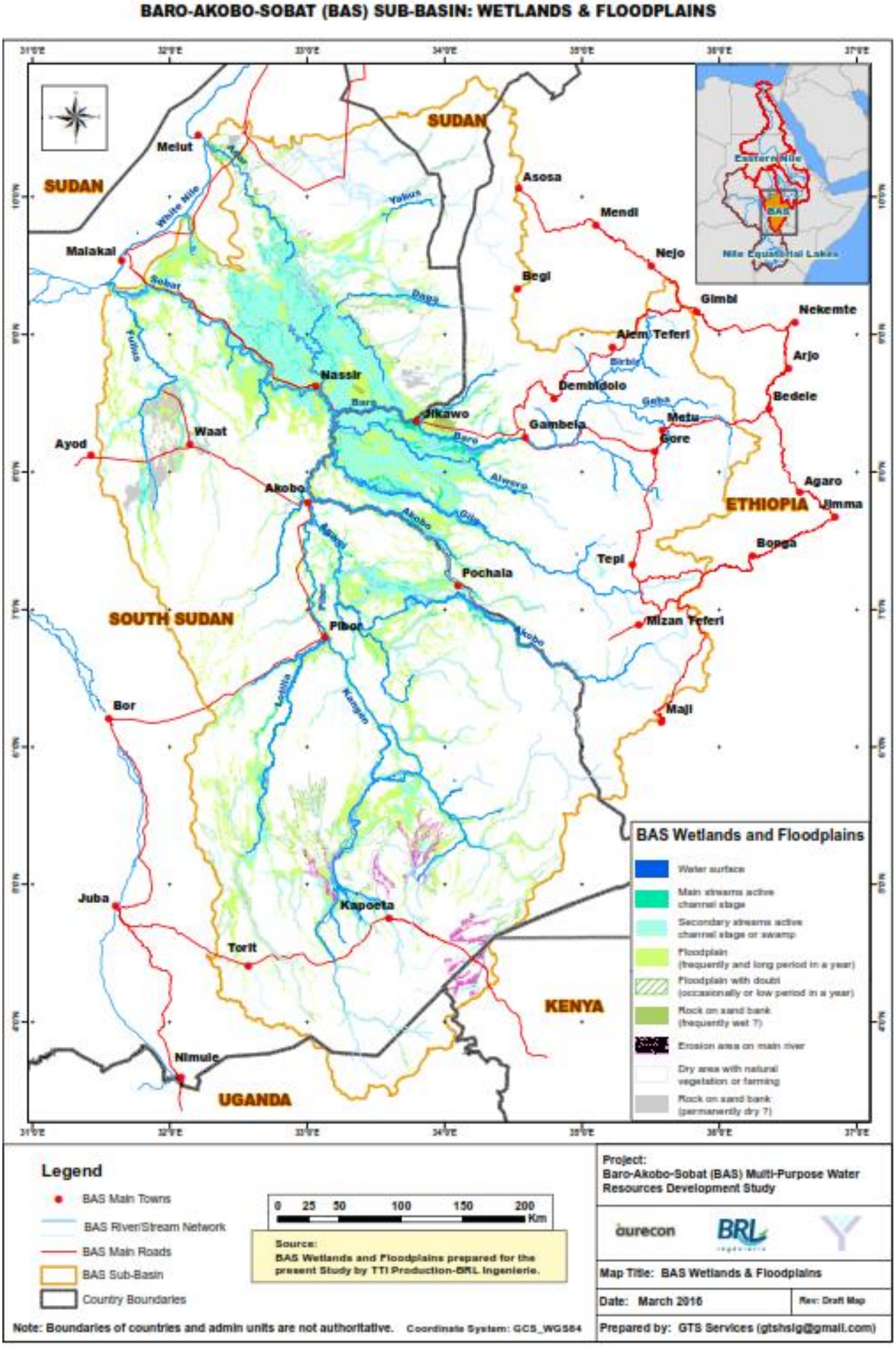
In order to better understand hydrological patterns of the BAS' wetlands, two types of data - both derived from satellite images analysis - have been used in this study:

- A static map of wetlands and floodplains based on 2014-2015 satellite images,
- 180 monthly inundation maps over the 1993-2007 period extracted from GIEMS D3 worldwide inundation database.

#### *4.1.1.1 Static map of wetlands and floodplains based on 2014-2015 satellite images*

This map have been elaborated specifically for this study, at the scale of the BAS. It is based on Landsat and radar satellite images from years 2014 and 2015.

*Figure 4-1: Static map of wetlands and floodplains based on 2014-2015 satellite images*




Source: This study

*Figure 4-2: Distribution of the BAS wetlands' category*

| Type of wetlands | Surface area (km2) | % of total wetlands |
|---|---|---|
| Main streams active channel stage | 7233 | 12% |
| Secondary streams active channel stage or swamp | 23069 | 38% |
| Flood plain (frequently and long period in a year) | 24688 | 40% |
| Flood plain with doubt (occasionally or low period in a year) | 4694 | 8% |
| Erosion area on main river | 1505 | 2% |
| Water surface | 38 | 0.1% |
| Total | 61227 | 100% |

*Source: This study, from Static map of wetlands and floodplains based on 2014-2015 satellite images*

It provides a **static visualization** of the wetlands of the basin. It shows various wetlands categories, such as :

- Main streams active channel stage,
- Secondary streams active channel stage and swamp,
- Frequent floodplain (frequently wet during long period in a year),
- Less frequent floodplain (occasionally wet or during a shorter period in a year).

It provides a comprehensive visualization (except of highlands wetlands). However, it provides only a partial visualization of the intra-annual variation of wetland size and distribution and does not allow any inter annual comparison.

#### *4.1.1.2 180 monthly inundation maps over the 1993-2007 period extracted from GIEMS D3 worldwide inundation database*

Extraction of GIEMS D3 worldwide inundation database on the BAS consists of 180 inundation maps of the basin: one for each month of the year on the 1993-2007 period.

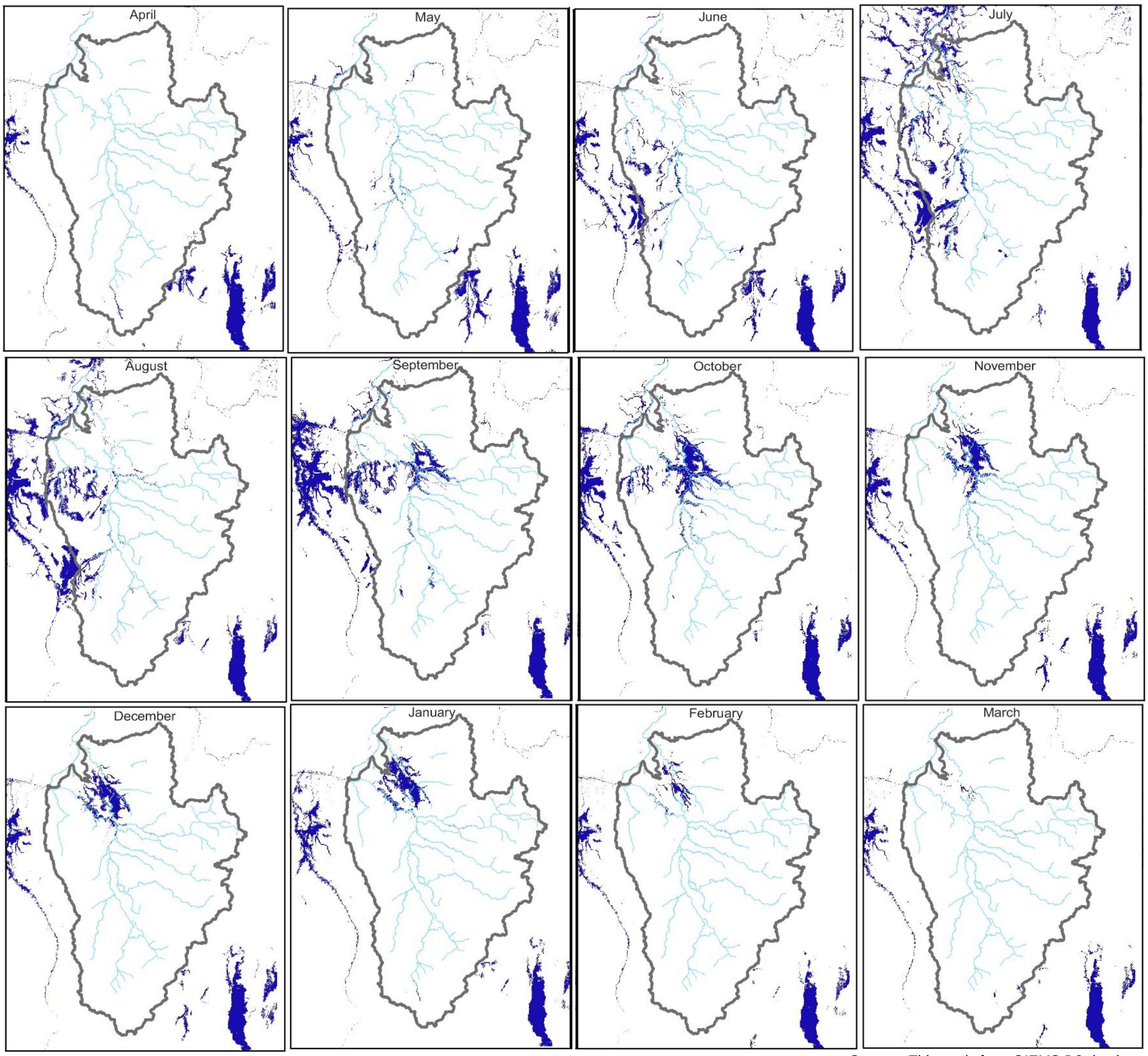
Comparison between the two sources of information combined with wetlands characteristics described in the literature analysis indeed suggests that GIEMS D3 database only shows:

- large inundated areas (scale is to coarse to catch up pools, small wetlands or small and average rivers of the BAS. For instance, it captures only major rivers such as the white Nile, Blue Nile and Baro at some points)
- open waterbodies and do not capture waterlogged lands and water under vegetation.

It does neither show distinction between wetlands' types.

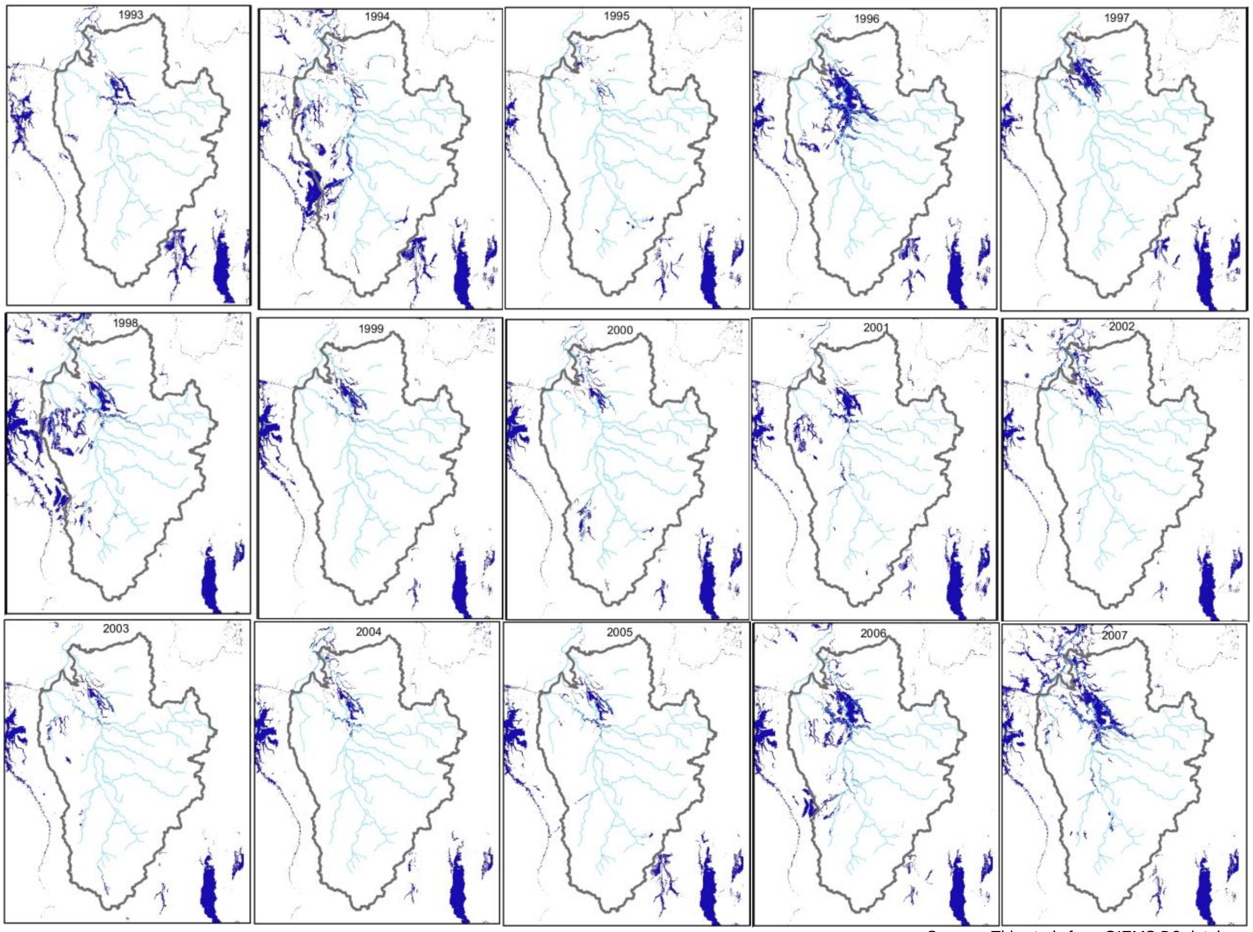
The figures below show the intra and inter annual variation of inundation patterns of the BAS derived from GIEMS D3 inundation database.

*Figure 4-3: Maximum inundation per month over the 1993 – 2007 period*




Source : This study from GIEMS D3 database

*Figure 4-4: Maximum inundation per year over the 1993 – 2007 period*

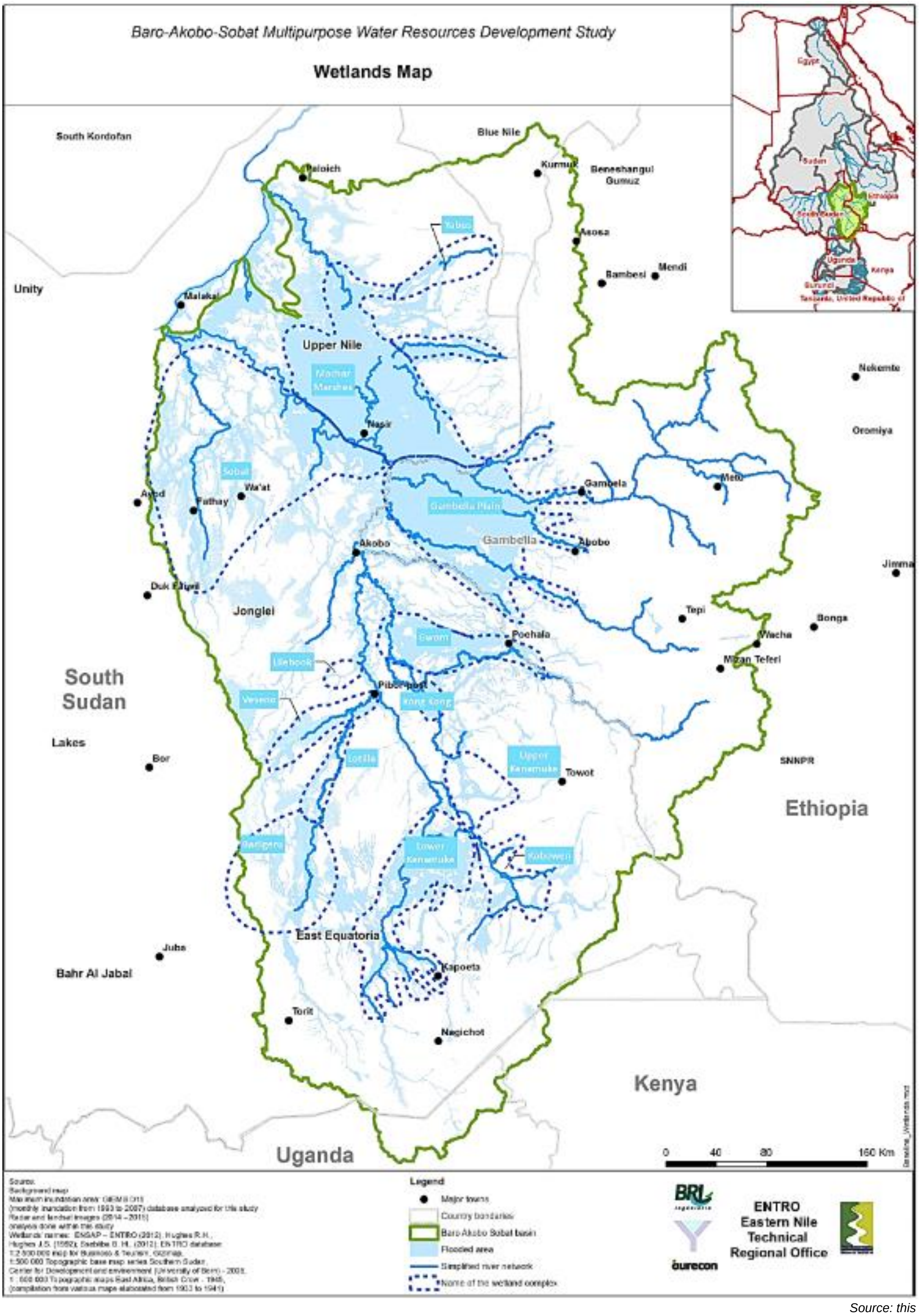



*Source : This study from GIEMS D3 database*

## 4.1.2 Potential maximal inundation area and potential maximum extent of wetlands of the basin

The figure below consists of a compilation of GIEMS D3 1993-2007 180 monthly images and the 2014-2015 wetlands static map. It should represent the inundation potential maximum extent and should be used for general guidance purposes only. Main wetlands names have been reported on the map according to literature review. This gives an indicative idea of the maximal extent of the various wetlands complexes of the BAS.

*Figure 4-5: Potential maximal inundation area and potential maximum extent of wetlands of the basin*




Source: this study

### 4.1.3 Key conclusions regarding wetlands

The analysis of the two above described sources of information lead to the following conclusions:

- The 2014-2015 static BAS wetlands map provide a comprehensive but static vizualisation of the BAS wetlands, whereas the 180 monthly inundation maps over the 1993-2007 period extracted from GIEMS D3 worldwide inundation database provide a dynamic but very partial vizualisation of the BAS inundation extent.
- An important part of the BAS plains is subject to inundation (representing up to around 60 % of the plains and 30 % of the total area of the BAS);
- Intra and inter annual variation are significant both in terms of surface area and location;
- In the southwestern part of the basin (Pibor, Nanam and Sobat sub-catchments), the major part of the wetlands consists of seasonal floodplains which rapidly dries up or drains into the river network, providing high quality grasslands up to the dry season. Only some isolated permanent marshes apparently offer standing water up to the dry season, such as the Badigeru and Upper Kenamuke wetlands.
- In the northeastern part of the basin (Agwei, Lower Akobo, Gilo, Baro, Alwero, Machar and Yabus), significant inundated / waterlogged areas remain up to the mid dry seasonafter the wet season, offering a dense network of both high quality grasslands and numerous water sources.
- Overflows from the western Ethiopian rivers, especially from the Baro, seem to significantly contribute to the inundation extent and duration of the Gwom, Gambella plains and Machar marshes wetlands;
- During wet years, the BAS inundated area can be equivalent to the Sudd in terms of surface area during the month of October and November and even superior to the Sudd at the beginning of the wet season (June). However, BAS wetlands are characterized by more significant seasonal variations.

# 5. SYNTHESIS OF MAIN FINDINGS

Synthesis of the previous sections per biophysical area, with sub-chapters per thematic (biodiversity, ecotourism, livelihoods, catchment), or the contrary: to be agreed together.

## 5.1 BASELINE SITUATION

### 5.1.1 Main ecosystem services provided by the BAS ecosystems

#### *5.1.1.1 The BAS natural resources are the main source of livelihood of the major part of the BAS population*

In each biophysical areas of the basin, communities strongly rely on natural resources for food resources, construction material, fuel, coffee and timber production.

##### *5.1.1.1.1 Domestic water use and food resources*

Wetlands are vital for domestic water use when several rivers have dried up.

An important part of highland wetlands have been drained and are used for cultivation. In some parts of the lowlands of the basin, recession agriculture occur. In western Ethiopia, the production from wetlands has been estimated to contribute up to 50 – 60% of the household's food security where wetland areas are large enough. The importance of wetland production for farmers lies in the fact that the wetlands can be harvested at the end of the dry season, when other food supplies are becoming exhausted (Hailu A, 2006).

Floodplains and wetlands are key resources for livestock in the dry season since they provide high quality grass and water for cattle grazing and watering (Denny, 1991) in (Burgess N. & al, 2004). In areas where there are no wetlands or where rivers are ephemeral, farmers move their cattle in search of water every day (Afework, 2001). The **main valuable plants for grazing are flooded grasslands** such as :

- Oryza which provides high quality grazing for much of the year even into the dry season and yield only 1 ton/ha when not flooded to 7 ton/ha when deeply flooded for a long period;
- Echinochloa pyramidalis which also grows even during the dry season and is thus a year-round pasture (ENTRO, 2007a),

whereas main rain-fed grasslands provide less quality grass and don't last during the dry season.

According to (Hailu A, 2006), it "would be no exaggeration to claim that the survival of the country's livestock is directly linked to the abundance of wetlands".

Waterbodies and other wetlands provide important fish resources. For example, only for the Gambella region, the current fish production of the region has been estimated at about 380 tons/year and the fish production potential of the region should range from 15,417-17,308 tons/year according to (MoA, 2010). According to (Hailu A, 2006), fish is the main source of protein for the 'Agnuak', who live along the banks of the Baro and Gillo Rivers. Fishing is undertaken by men whereas women are heavily involved with fish processing and preservation.

In the southern part of the basin, wildlife also provide sources of proteins and commercial bush meat a source of income.

Afromontane natural forests also provide a variety of food products such as honey, spices, palm, wildfruits (Asseffa, 2007). In the Akobo catchment around bench-maji and Sheka zones, edible roots like Taro and Enset are common and support livelihood of people. These edible roots are drought resistance and also help to soil conservation. Consultations also revealed that Sheka people make the livelihood majorly from the wild honey they produced in the forest. They have customary forest management associated with beekeeping which is called Kobbo in local language. It is forest management in which members of the community own part of the forest to use it only for hanging beehives and collecting of spices, which doesn't deter the sustainable existence of the species.

Some floodplain grasslands plants like Oryza can also be used as a crop at this end of the dry season when other sources of food become rare.

The sale of wildcoffee, growing under afromontane highland and lowland Ethiopian forests is also an important source of subsistence for the local communities (NABU, 2015).

Medicinal plants are also found especially in highland wetlands (Afework, 2001).

##### *5.1.1.1.2 Construction materials*

Sedges (carex) found in the BAS wetlands are widely used for tchating. For example, in Western Oromiya sedges prime importance is for thatching local houses (*tukuls*), among a variety of uses for the local communities, especially where other suitable materials are not available or are too expensive. In Illubabor Zone it is estimated that an estimated 85% of the local households use sedges or *cheffe* for roofing their houses or *Tukuls* (Hailu A, 2006) (Afework, 2001).

Bamboo forest are also used for construction in western and southern part of the basin.

Brick making is also reported in Oromiya wetlands (EWNRA, 2008) and in South Sudan.

##### *5.1.1.1.3 Energy*

Charcoal is considered as the main source of fuel used in the BAS urban centers and play an important role in forest and bushland degradation.

##### *5.1.1.1.4 Timber*

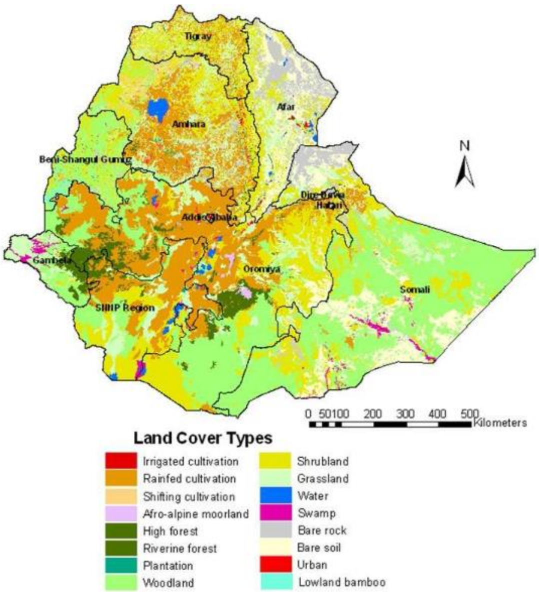
Afromontane highlands and lowlands forests offer large old high quality wood from *Daniellia oliveri* and *Khaya senegalensis* trees for instance.

(Asseffa, 2007) has estimated that households from Sheka forests generate about 44% of their income from forest and forest products.

#### ***5.1.1.2 Head catchments remnant forests and wetlands provide climate, flow and siltation regulation***

Head catchments wetlands and forests are known to play an important role flood regulation and control, micro-climate regulation and erosion control. The extent of these services vary depending on local climatic, topographic and vegetation characteristics. The biophysical characteristics of the basin, the percentage of forest cover on the head catchments and the regional importance of the forest area (over 20% of Ethiopia's forest cover are located in the basin (FAO, 2010) in (Conservation, 2012)) make these services particularly important in the basin.

*Figure 5-1: Dominant land cover types in Ethiopia, showing the importance of the BAS forests*



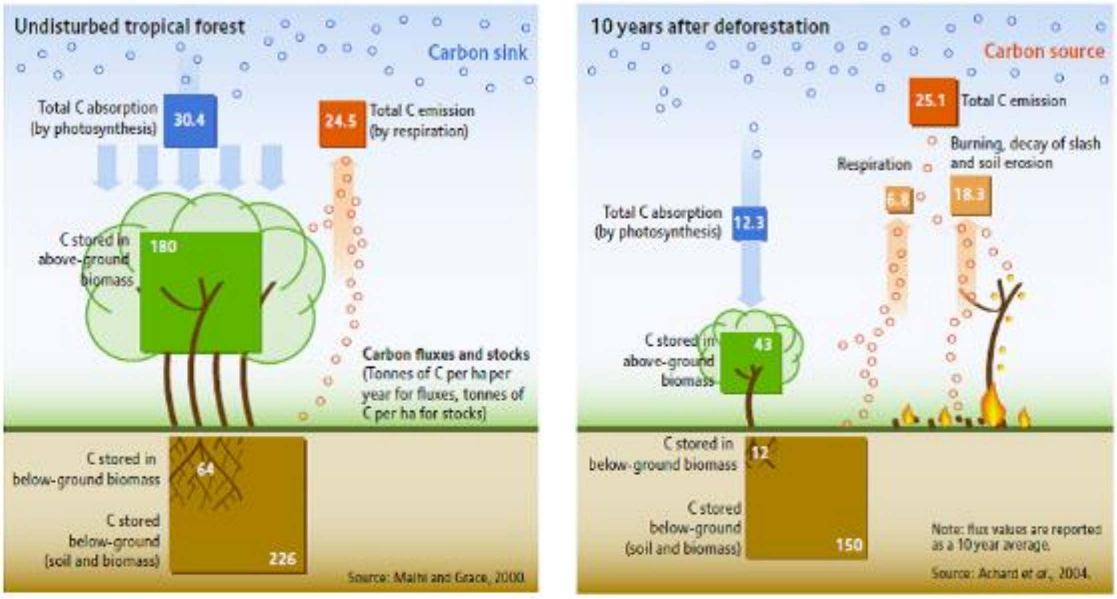

*Source: (WBISPP, 2014) in (Conservation, 2012)*

(Hailu A, 2006) reports that before deforestation and wetland drainage intensified in Highland Illubabor there was no history of flooding in the neighbouring Gambella Township. However, with increased deforestation and extensive drainage of wetlands flooding has become a major threat to Gambella Township leading to dikes construction.

Local experts in Majang zone revealed that some streams which were permanent some years back are now become seasonal as a result of deforestation and land use change and therefore stress the importance to protect the remnant forest cover of the upper catchment and promote reforestation works on degraded areas.

At the scale of the basin, highlands and escarpments forests also play a critical role in carbon sequestration. The following figure illustrates impacts of deforestation on carbon sequestration and emission:

*Figure 5-2: Deforestation's impacts on carbon sequestration and emission*




*Source: (UNEP, 2009) in (EWCA, 2015)*

### *5.1.1.3 The BAS ecosystems offer habitats for a rich biodiversity of flora and fauna*

The BAS ecosystems support habitats hosting a rich flora and fauna, characterised by a high rate of endemism in the mountain and large endangered and threatened herds of mammals in the plains (cf section 3.1of this annex).

### *5.1.1.4 Flood patterns influences wildlife habitats and play a critical role in their migration*

According to (Kingdon, K. & Hoffman, M. (eds), 2013), the local patterns of flooding have the most influence on the Nile lechwe more than the differences between dry and wet seasons.

The flood extent directly influence the availability of resources (grass and water) on which antelopes rely, consisting in an important driver in the migration (Fryxell, J. M. , 1991) (Fryxell, J. M. & Sinclair, A. R. E., 1988).

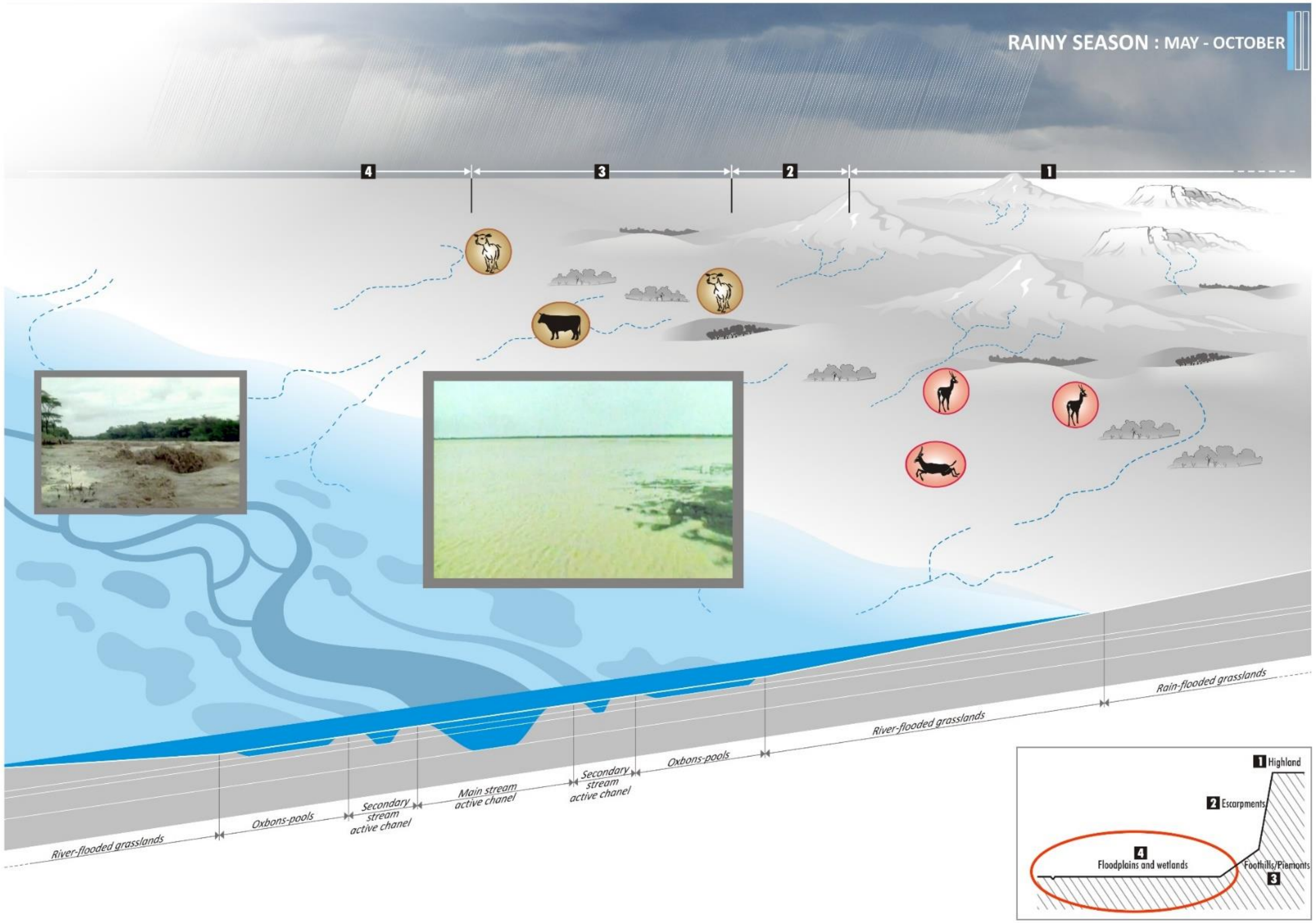
Birds habitats are also directly linked to flood recession areas (Zwarts L., 2012).

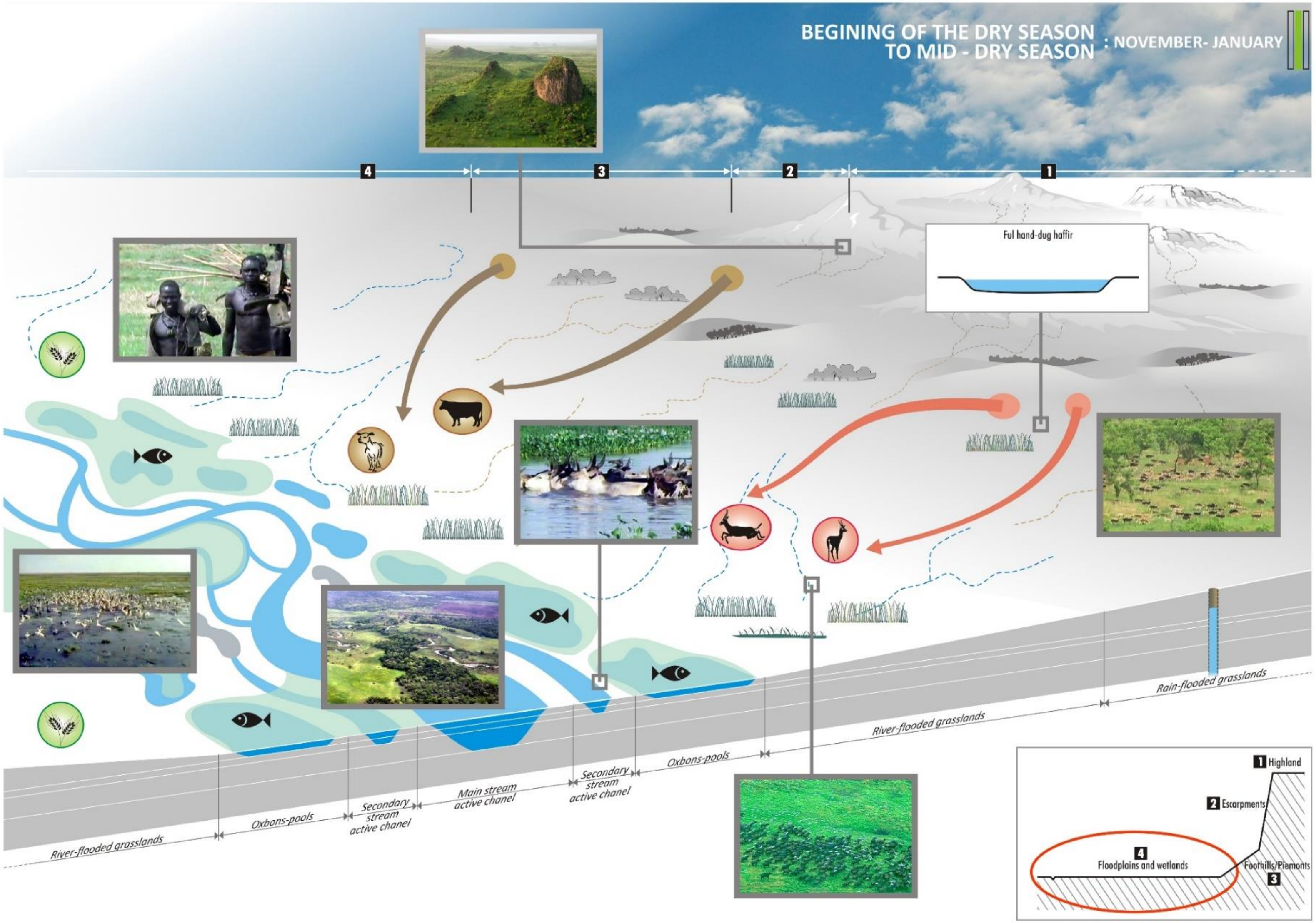
Apart from wildlife, the entire socio-economic organization and livelihood of the plains depend on floodplains and wetlands seasonal variations. The following schematics illustrate how both wildlife and human activities adapt to changing environment and natural resources availability. It shows uses of wetlands and floodplains at 3 periods of the year :

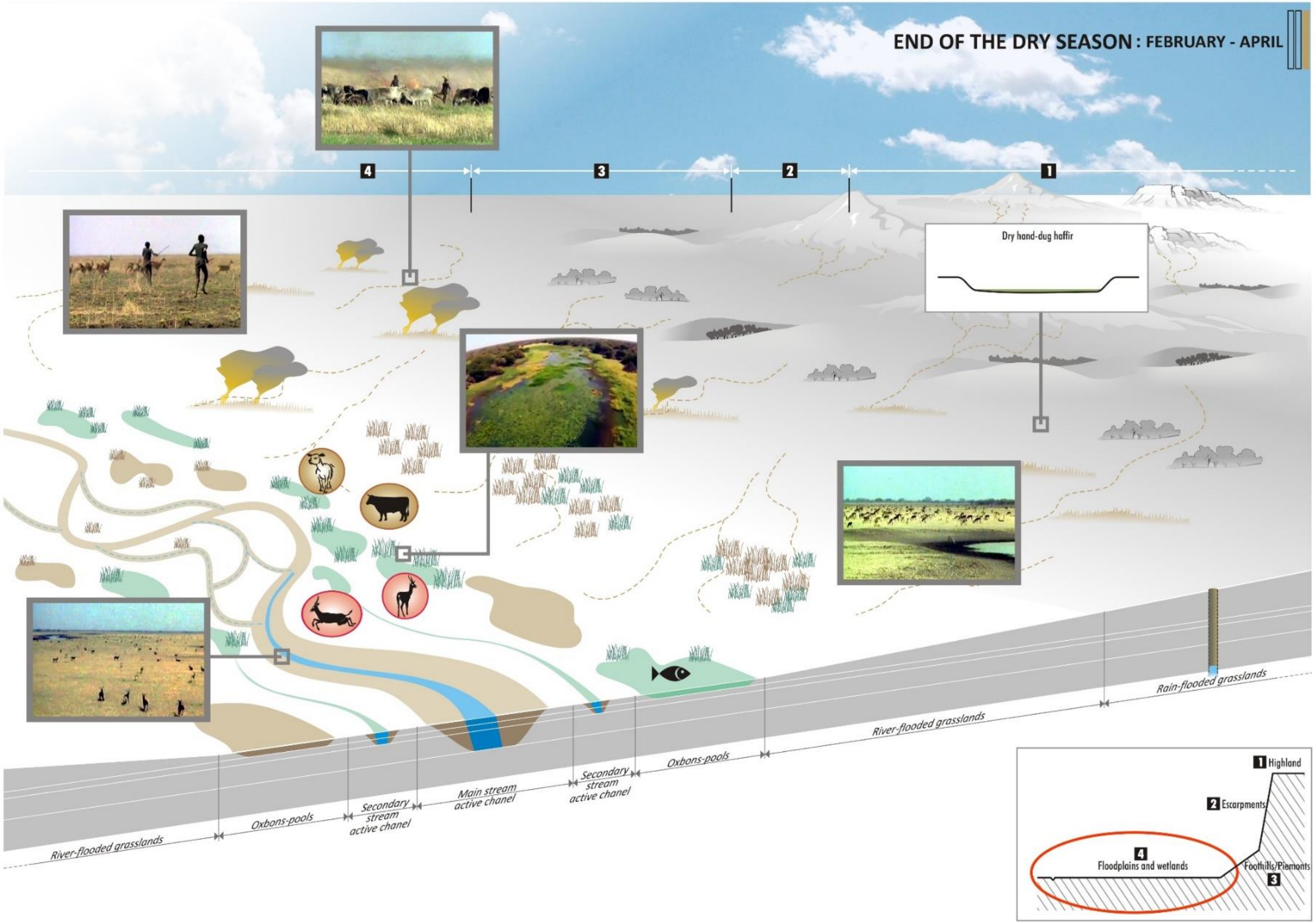
- The heart of the rainy season: June-October
- The beginning of the dry season up to the mid-dry season: November - January
- The end of the dry season : February to May

These schematics have been specifically elaborated for this study according information collected through consultations and literature review.

*Figure 5-3: BAS Floodplains seasonal uses*




BEGINING OF THE DRY SEASON
TO MID - DRY SEASON
: NOVEMBER- JANUARY
4
3
2
1
Ful hand-dug haffir
Rain-flooded grasslands
River-flooded grasslands
Oxbons-pools
Secondary stream active chanel
Main stream active chanel
Secondary stream active chanel
Oxbons-pools
River-flooded grasslands
1 Highland
2 Escarpments
4 Floodplains and wetlands
Foothills/Piemonts
3


END OF THE DRY SEASON : FEBRUARY - APRIL
4
3
2
1
Dry hand-dug haffir
River-flooded grasslands
Oxbons-pools
Secondary stream active chanel
Main stream active chanel
Secondary stream active chanel
Oxbons-pools
River-flooded grasslands
Rain-flooded grasslands
1 Highland
2 Escarpments
4 Floodplains and wetlands
Foothills/Piemonts
3

The above schematics show a simplified representation of human, cattle and wildlife movements according to the flooding gradient. The **Erreur ! Source du renvoi introuvable.** presented in section 2.1.4 of this annex shows wildlife movement at the basin scale.

#### *5.1.1.5 Rich biodiversity and pristine landscapes offer a huge opportunity for tourism development*

The variety of ecosystems of the BAS, its quite pristine character in an important part of the basin, the importance of the mammal and bird migration offer a huge potential for natural-resources based tourism.

Wildlife experts consider that the mammal migration of the BAS is equal to the Massai Mara – Serengeti one. The total annual numbers of visitors to this transboundary protected areas vary from 300,000 to 400,000. This is more than the current most visited national park of Ethiopia (Nechisar national park) and offer interesting perspectives for complementary sources of income for communities and for the two countries.

### 5.1.2 Synthesis of environmental specificities of the BAS

The BAS is one of the hot biodiversity spots in Africa:

- The presence of vast wetlands, flood plains, lakes, perennial rivers, high forest areas, wood and grass lands make the area rich in biodiversity.
- It hosts largest remaining forests of Ethiopia, including the few remaining intact primary Afromontane, Evergreen Forest Ecosystem, which supports a unique floral and arboreal primate species and natural or wild coffee genetic resource as well as rich bird species diversity.
- It supports one of the largest migration of mammals (total estimated at 1.2 million individuals) and bird in Africa – at least equivalent to the Massai Mara – Serengeti migration, which habitats and migratory routes mostly relies on water resources seasonal variations and flood extent and duration.
- It is endowed with quite preserved beautiful landscape.

Its population strongly rely on natural resources for domestic water, food resources, construction material, medicinal plants and sources of income.

Natural resources of the BAS provide other high value ecosystems services such as:

- Rainfall and moisture regulation by natural and open forests,
- Flow regulation and erosion control,
- Carbon sequestration,
- High potential for ecotourism.

Therefore the function of the BAS ecosystems is “reckoned as vital as it serves mainly to the maintenance of the biodiversity, of its watershed values, the environmental services it renders and of its economic values both at local, basin and global levels” (Berhan, 2008).

The existing threats on the BAS ecoystems, including deforestation and forest degradation as well highland and lowland wetland encroachment and degradation reduce the capacity of these ecosystems to provide the same level of services.

The current level of protection is very low but ongoing initiatives are promising.

## 5.2 DEVELOPMENT POTENTIALS

### 5.2.1 Multi-thematic potential development per biophysical areas of the BAS

#### *5.2.1.1 Highlands*

Highlands of the BAS basin has the following opportunities/ potentials:

- Alternative lively hood development potential that linked with the survival of forest such as modern honey production, none timber forest products, development of spices and connect to international markets.
- Potential to develop mini hydropower to reduce pressure on forest
- Potential to link forest with carbon credit.
- Potential to developing agro forestry
- High potential for Biodiversity Conservation (there is possibility of delineating and registration of Majeng forest as UNESCO Forest Biosphere)

#### *5.2.1.2 Escarpments*

Escarpments of the BAS basin has the following opportunities/ potentials:

- Biodiversity conservation,
- Landscape tourism,
- Catchment management.

#### *5.2.1.3 Foothills / Piedmonts*

Foothills of the BAS basin has the following opportunities/ potentials:

- Biodiversity conservation,
- Rain fed agriculture,
- Agro forestry,
- Grazing management,
- Hydropower development.

#### *5.2.1.4 Flood Plains and wetlands*

Flood plains of the BAS basin has the following opportunities/ potentials:

- Recession agriculture development potential,
- Dry season grazing for livestock and wildlife,
- Biodiversity conservation (mostly in wildlife protection areas and national parks),
- Aquaculture development potential,
- River fishery development potential,
- Irrigation potential.

## 5.2.2 Biodiversity, habitats and landscape conservation

### *5.2.2.1 Existing development projects in the basin*

Existing development projects are described in section 3.2.2 of this annex.

### *5.2.2.2 Identification of new project areas in the basin*

#### *5.2.2.2.1 Wetlands monitoring*

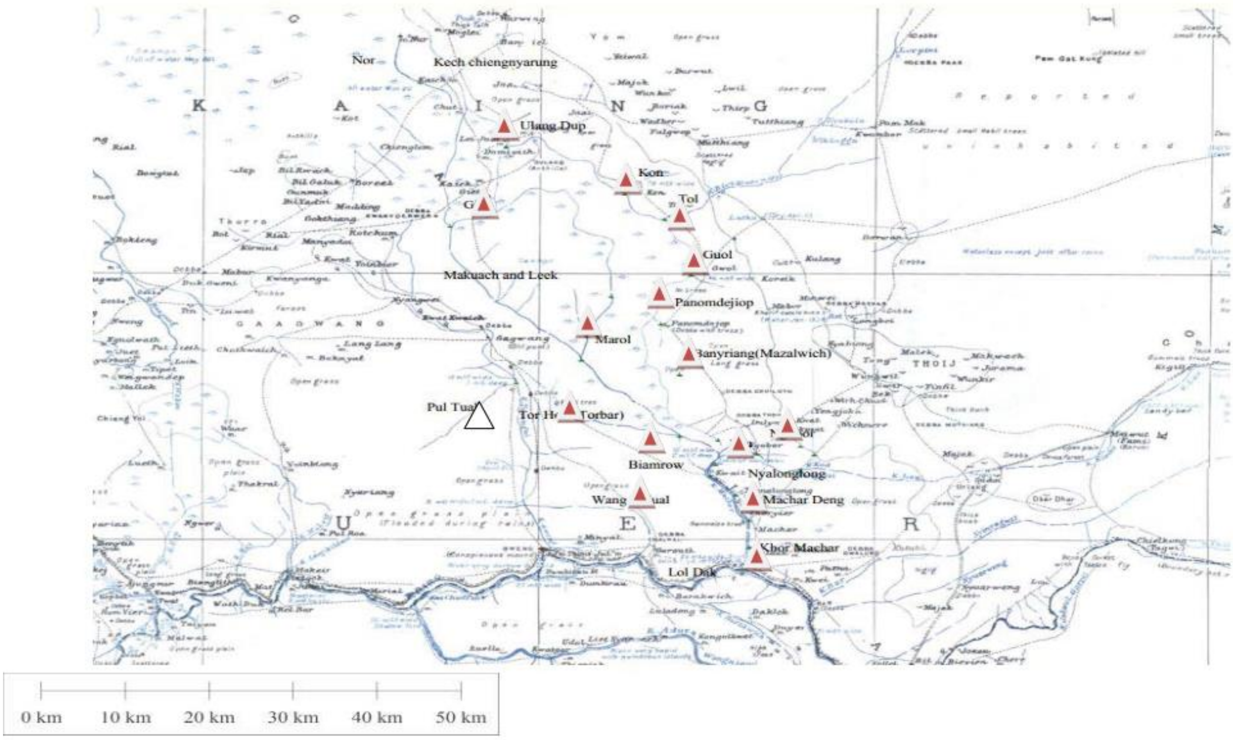
Literature review and stakeholders consultations have shown that wetlands knowledge is very low, especially on hydrological aspects.

This represents a key knowledge gap at the basin scale and is a key priority that should outstrip future water developments.

This idea is to create and monitor new water level and flow measurement sites in main wetlands in addition to the proposed measurement network.

During a field mission commissioned by ENTRO in 2012 water level and flow measurement sites in Machar Marshes have been proposed (see figure below):

*Figure 5-4: Proposed water level and flow measurement sites in Machar Marshes*




*Source: (ENTRO, 2012b)*

Socio-economic and updated fauna and flora survey should also be conducted in parallel as per proposed by (ENSAP-ENTRO, 2012).

### 5.2.2.2.2 Designation of the BAS main important wetlands as Ramsar sites

Designation of the BAS main important wetlands as Ramsar sites such as Badingilo, Gwom, Gambela plains and Marchar marshes. These wetlands have the potential to be recognized of international importance. Ramsar designation and related management plan implementation can be considered as an interesting tool to both protect wetlands ecosystems and improved livelihoods.

The following table illustrate the benefits of ramsar designation on wetlands condition.

*Table 5-1: Benefits of designation of Ramsar sites in Asia*

| | % of Asian Contracting Parties reporting | |
|---|---|---|
| | **Condition improving** | **Condition deteriorating** |
| **Ramsar Site** | **41 %** | **12 %** |
| **Other wetlands** | **12 %** | **47 %** |

*Source: (Ramsar Convention Secretariat, 2013)*

According to their spatial distribution, two potential Ramsar sites have been identified:

- Badingilo floodplains and marshes
- Marchar marshes, Gambela plains and Boma wetlands (Gwom)

The designation involves the following main activities:

- Engagement of the local community through awareness raising on the importance of the site to ensure their support and involvement in site designation, management and monitoring;
- Establishment of a broad-based ‘site management committee’
- Elaboration and implementation of a management plan
- Periodic assessments of the management effectiveness focused on the effectiveness of conservation and on the benefits to the local community (Ramsar Convention Secretariat, 2013).

These activities should take into account existing management plans and landuse plans and rely on exiting management authorities in Boma, Badingilo and Gambela National Parks. Activites will have to be developed from scratch in the Machar marshes. Difficulties of acees during the wet season and security issues are potential obstacles to the development of such initiatives.

### 5.2.2.2.3 Reforestation and rehabilitation of degraded forest areas

The main current initiatives (mainly through biosphere reserves) concerning the forest ecosystems in the basin mainly deal with natural forest conservation and occur where the forest coverage is still dense. Already highly degraded land also need attention in order to offset the effect of deforestation such as erosion, soil loss, siltation in the river and climatic and hydrological impacts. Target areas could be highlands and escarpments cultivated ecosystems of

- The north-east head catchment of the Baro sub basin;
- The head catchment of the Akobo sub basin
- Torit area.

*Figure 5-5: Highlands cultivated ecosystem in the Ethiopian part of the BAS*

Source: This study

Activities could include afforestation, tree nurseries, catchment management, agroforestry, plantation of fruit trees, management of grazing in the forests, but also development of alternative energy sources like small hydropower, use of fuel conserving stoves, solar energy; creation of awareness among the local people, development of mechanisms to use dry grass for household energy purposes…

Tools such as Participatory Forest Management (PFM), revitalisation of National Forest Priority Areas, development of forest management plans and land use plans in sensitive areas (currently lacking in the Imatong Mountains for instance) could be involved.

The ongoing Ethiopian forest inventory could bring interesting information to specifically document the targeted area as soon as it will be published.

##### *5.2.2.2.4 Development of solid and liquid waste management*

According the stakeholders consultations, urban pollution by solid and liquid waste is becoming a concern in some parts of the basin. So far, little has been done in this field, which open a significant potential for improvement. Development of solid and liquid waste management should be associated with water quality monitoring.

#### *5.2.2.3 Enabling environment*

The ongoing trend which consists of formalising the existing protected areas network (boundaries demarcation, official designation) and designating management authorities (NGO in cooperation with environmental authorities) is a progress which bring a start of a fertile ground for the above identified potential developments. Moreover, the following strategic documents are under review:

- South Sudan draft environmental policy of the country is submitted to the parliament for review and endorsement,
- Boma management plan,
- Badingilo management plan,
- Gambela region land use plan.

Their endorsement should contribute to strengthen the legislative and strategical environmental framework in the basin.

In parallel, the ratification of the Ramsar convention by Ethiopia could benefit to the identified development projects.

#### 5.2.2.4 Conclusion: conservation opportunities in the basin

Despite an important number and coverage of the BAS by protected area, the effective protection is very low. Important programs and projects are currently going on and should significantly improve the conservation situation if they succeed in achieving their goals.

Complementary initiatives are necessary, especially in areas which are not covered by existing initiatives such as the Machar marshes and the already high degraded land north-east of the Baro catchment, on the head catchment of the Akobo and around Torit.

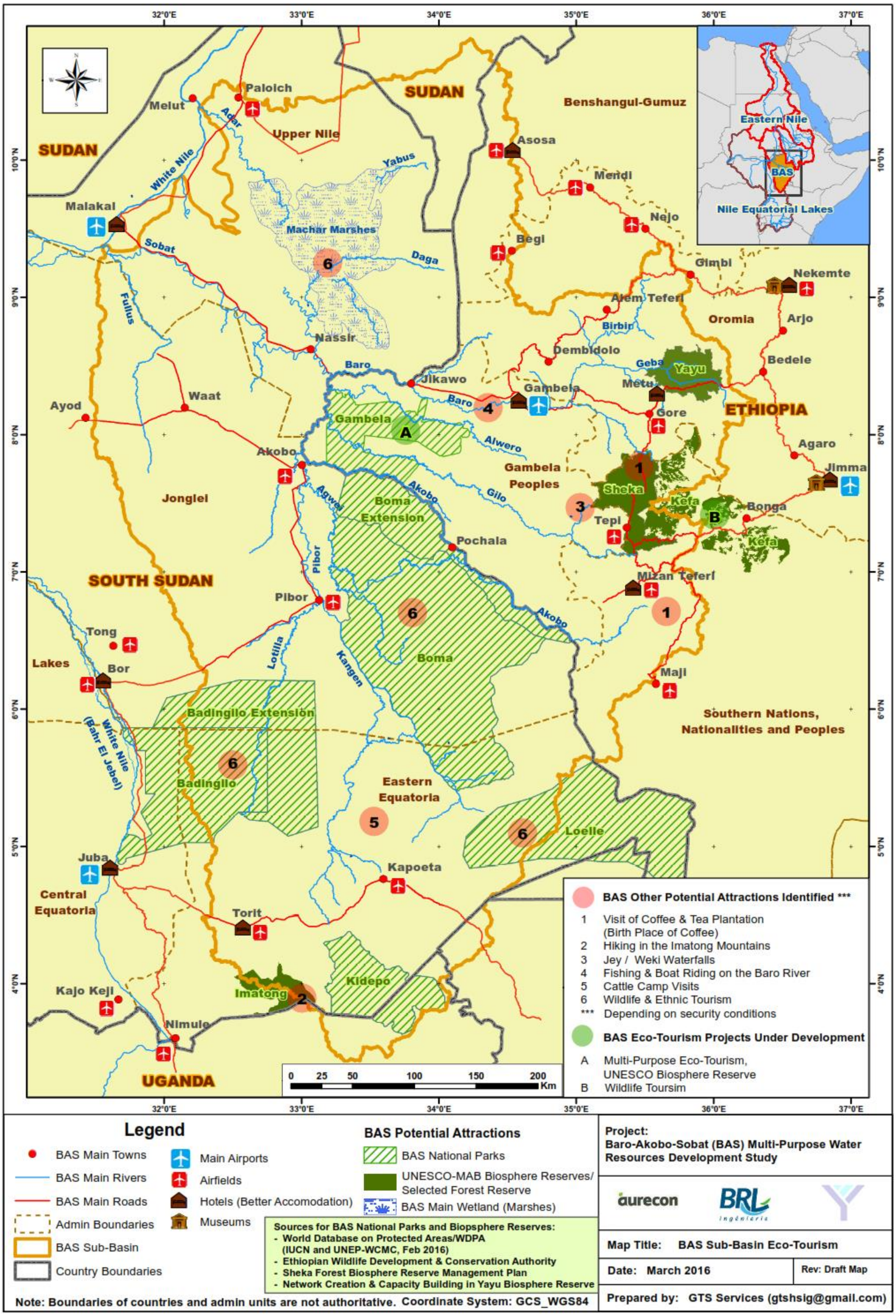
### 5.2.3 Ecotourism development potential

As already stated, the potential for ecotourism development in the basin is huge, considering the current level of development and the natural assets of the basin. The variety of ecosystems of the basin, its quite pristine character and the importance of mammals and birds migration offer a huge potential for natural-resources based tourism.

Wildlife experts consider that the mammal migration of the BAS is equal to the Massai Mara – Serengeti one. The mamal migration occurs in the lowlands areas (biophysical area 4) both in South Sudan (in and around Badingilo and Boma National Parks) and in Ethiopia (mainly in and around Gambella National Park) The total annual numbers of visitors to this transboundary protected areas vary from 300,000 to 400,000. This is more than the currently most visited national park of Ethiopia (Nechisar national park) and offers interesting perspectives for complementary sources of income for the communities.

The main potential ecotourism development identified in Ethiopia and in South Sudan through consultations and literature review are presented in the map below.

*Figure 5-6: Main existing and potential tourism development in the BAS*



### 5.2.4 Enabling environment

The two following facts illustrate the willingness of the two countries to further develop tourism and ecotourism:

- The Government of Ethiopia is currently “implementing a number of strategic measures to further develop the country’s tourism sector, including investment in infrastructure and capacity building on destination management and product development, through the recently established Tourism Transformation Council” (UNWTO, 2014).
- The Government of South Sudan, through (but not limited to)“ The Eastern Equatoria State Local Government and Wildlife Conservation Minister Charles Lokonoi Ambrose vows to improve the sector with prime objective to boost economy especially in protected areas of wildlife conservation and tourism as key target to realize sightseeing attractions of wildlife both flora and fauna in the state” (Nakimangole, 2013).

The major impediment for ecotourism development is the localized instability and the related security issues, especially in South Sudan.

### 5.2.5 Conclusion: opportunity to develop ecotourism in the basin

The BAS basin offers huge natural and cultural assets. Conservation and valorization of these assets could lead to the sustainable development of eco-tourism. This willingness to develop ecotourism has been largely mentioned during the consultations and few local and regional initiatives have been identified.

It should be noted that, on the short term, for security reasons, the opportunities to develop ecotourism are higher in the BAS highlands and escarpments. On the mid and long terms, there are huge opportunities to develop ecotourism in a large part of the basin.

## 5.3 KEY ISSUES AND OBJECTIVES

### 5.3.1 Key issues / challenges

The BAS key socio-environmental constraints identified thanks to stakeholders' consultations and literature review are described below:

#### *5.3.1.1 Stress on Wetlands*

In the marshes of BAS (*Machar marshes* and others), water stagnates and is exposed to a high evaporation rate. However, the evaporated water is not lost from the system as it is partly recycled in the form of rain and contributes to an increase of the air moisture index, which results in a reduction of evaporation in the dry season (Mohamed et al., 2005). Plans to reduce the inflow of rivers water into these wetlands by abstracting or regulating water at pick rivers flow would reduce the size and function of these wetlands and is expected to have a negative impact on the climate , ecosystem and social fabrics of the basin. Unless adequate care is taken, a dramatic impact is to be expected on wildlife, livestock and fish resources. The dry season food supply for wildlife and livestock will decrease due to reduced flooding, and wet season spawning areas for many fish species will also decrease.

Within the plateau area of the upper sub-basin there are many small permanent and semi-permanent wetlands, mostly occupied by *Cyperus latifolius*. These are mostly found in the upper reaches of the Sor, and Gabba rivers. These account for approximately 2% of the land area but they are becoming increasingly important as land pressures in the cleared area outside the forest increases. Management of wetlands for sustainable cultivation, when drainage is involved, is not easy and there has been extensive and, in some areas, complete, loss of wetlands in the southwest highlands of Ethiopia. The impacts of the loss of wetlands or their transformation for farming are considerable and are also distributed in different ways across the communities. Women and the poor are especially seriously affected when wetland cultivation leads to the loss of safe spring water for domestic use and the loss of plant materials for craft and domestic use. Similar losses are linked to wetland degradation, but in addition the typically richer cultivators lose out.

The main driving forces for wetland drainage cultivation are seasonal food shortages caused by grain storage problems and expansion of coffee plantation on previously cereals growing farm lands. More recently, there has been a growing demand from urban areas for cereals and vegetables which are grown in wetlands. Urban growth has been associated with the growth of the coffee-based economy and there has been some response by farmers close to urban centres to grow crops in response to these market opportunities. Resettlement in Ethiopia after the 1984 famine also led to the increased use of wetlands in some areas of Illubabor where the integrated resettlement approach was used. Local communities asked to host resettlers allocated them land which was not in use or not of prime quality, and in some cases, this included wetlands. Settlers were also encouraged to cultivate wetlands for an early maize harvest as they did not have root crops which help local farmers fill the hungry season food gap.

In the mid / late1980s, the NGO MFM developed a programme, in Illubabor, which sought to reduce the pressure for forest clearance by developing rural livelihoods in the areas outside the forest. One element in this was wetland drainage for vegetable cultivation. Although this element of the programme was closed by the late 1990s, it showed communities some of the possibilities, as well as some of the problems, that could be encountered in wetlands and provided a stimulus to further wetland drainage. Since the early 1990s there has been Wetland Task Forces in the south-west highlands of Ethiopia including parts of the upper Baro-Akobo sub-basin. In years when food shortages are severe in other parts of the country, the Task Forces set communities targets for additional wetland drainage and cultivation and regularly visit communities to ensure these are achieved. In some cases they are also requiring farmers to extend the drainage period and undertake double cropping in the wetlands.

### 5.3.1.2 Loss of Biodiversity

Biodiversity Conservation in Ethiopia has been given attention since long ago. The first National Park was established in the fifteenth century. King Zera' Ya'ekob (1434–1468) designated Menagesha-Suba Forest Area as one of the "crown forests" of the country. He ordered the area to be planted with seedlings of indigenous junipers from Wef-Washa Forest, located between Ankober and Debre Sina, and established Menagesha-Suba Park as the country's first protected area (PA).

The first recognized legislation on wildlife conservation in Ethiopia was passed in October 1908 by Emperor Menelik II (1888–1912), who decreed that elephant hunting should be regulated. Further legislation was passed in 1944 to regulate hunting of wildlife by ensuring that certain species were not overhunted. This early legislation demonstrates awareness of the limits of wildlife resources and the dangers people posed to them ( Governance for Effective and Efficient Conservation in Ethiopia, by Fikirte Gebresenbet, et al).

Currently, there are many designated protected areas of land including National Parks, Wildlife Reserves, Priority Forests, Biosphere Reserves and Community Conservation Areas in Ethiopia. These do not only act as biodiversity 'banks', but also provide important spiritual places and centres for traditional ecological knowledge. These protected areas can also have a direct economic benefit; bringing in revenues from tourism and carbon trading.

However, the challenge is that Ethiopia's protected areas are increasingly degraded. Land is being converted for subsistence and commercial agriculture, timber use, fuel wood and construction, protected grasslands used for livestock grazing. The loss of forests and other protected land is underpinned by a growing population, unsustainable natural resource management, poor enforcement of existing legislation, uncertain land tenure and very low public awareness of the impact of climate change and the importance of biodiversity and ecosystems.

### 5.3.1.3 Loss of Natural forest

The dominant environmental change in the Baro-Akobo sub-basin is the loss of forest cover which is most marked in the southern and eastern part of the upper sub-basin where the main areas of forest remain. The FAO Forest Resources Assessment (FAO, 2010) estimates the annual loss for forests and other wooded land in South Sudan at 277,630 hectares.

Analysis by the WBISPP (Woody Biomass Inventory and Strategic Planning Project) in the high forest areas of Ethiopia (Dima, Godere, Gog, Akobo and Gambella woredas) has estimated the rates of deforestation caused by expanding population was 2.23% per annum. Annual destruction of the woody biomass from the high forest areas for agricultural expansion in the Ethiopian side of the BAS basin was estimated at about 4,287 ha per annum in 1995. This will increase exponentially and it is estimated that Gambella Regional State could lose 32% of its high forest resources between 1990 and 2020. Some 68 per cent of the loss will occur in Godere and Dima woredas. These woredas are also exhibiting the fastest rate of decrease of forest.

The rate of deforestation is determined by the national and foreign demand for tree products. It is likely that deforestation (without significant improvement of protection) will increase at least proportionally with the number of national consumers, but probably much faster with the increasing number of consumers as a result of immigration, natural population growth and the extension of the market (e.g. to Kenya, Uganda and Sudan) due to the reduction of transport barriers. The factors playing an important role in deforestation are :

- Clearing for cultivation: The most important factor responsible for total forest clearing in BAS basin is cultivation. The average small scale farming household in the basin uses 0.4 to 1 hectares of land for the cultivation of subsistence crops. Currently, the total area under cultivation in low laying areas of the basin is still low. However, it may be expected that the cultivated area will increase proportionally with the increasing population and, in the longer term when agricultural mechanization becomes more common, even more. In Gambella area, mechanized farm is already booming. When the security situation improves, in South Sudan, mechanized agriculture is expected to expand at a fast rate. A survey of land-based investments (Deng, 2011) indicates that, from 2007 to 2010, foreign companies, governments and individuals have sought or acquired at least 2.64 million hectares (26,400 km$^2$) of land for agricultural projects, biofuel and forestry sectors in South Sudan. Private investment projects in agriculture may help the basin's economy forward, but if social and environmental aspects are not taken into account, social and environmental costs may be very high. This is particularly the case with mechanized agriculture, which does not contribute much to employment.

*Figure 5-7: Clearing of wood land for the expansion of farm in Torit State, south Sudan*

*Source: This study*

- Clearing for roads and settlements: To create space for roads, settlements and other social and economic infrastructure, forested areas are often to be cleared. The area cleared is usually larger than the area occupied by the structures themselves. Moreover, the impact of human presence and land use associated with roads and settlements usually reaches much further than the original area cleared. Continuous use of forest products by people and passing livestock results in an impact gradient in a wide zone along and around such areas, which may stretch over a distance of up to 5 km or more away from roads and settlements (Deodatus, 1998 in UNDP, 2011). Currently, roads are being constructed at various areas where there were no road previously. These roads will open up vast areas in the basin that were previously isolated. Road construction will have a positive influence on the economy of these areas, but at the same time pressure on their resources and natural environment will increase considerably.

- Charcoal burning: The main fuel used in urban centres of the BAS basin is charcoal. In South Sudan, many returnees burn wood to make charcoal to generate income, because no license is needed and simple tools are required. Moreover, the forest belongs 'to nobody.' The production of charcoal requires large quantities of wood and likely contributes significantly to deforestation. The situation of charcoal production is similar in all the parts of the basin and considered to be one of the main causes of deforestation and land degradation. Large quantities of charcoal are also exported. Based on some monthly figures on charcoal exportation from the Renk County in Upper Nile State to Sudan, it is estimated that now annually in the order of 60,000 bags of charcoal are exported from Renk County, representing 2,700 hectares of deforested land (Upper Nile State Ministry of Finance in (UNDP, 2011). This estimate is based on an extrapolation of the annual fluctuations in charcoal production due to seasonality. Since more charcoal may have been exported unregistered or illegally, the real figure is expected to be much higher. The development of hydropower could play a significant role to cope with deforestation.

*Figure 5-8: Charcoal making at Sheka zone of Ethiopia (left) and Charcoal ready for sell at Torit area in South Sudan (right)*

*Source: this study*

*Table 5-2: Number of bags of charcoal taxed for exportation to northern Sudan in Upper Nile during the first months of 2011*

| Months | Bags of Charcoal taxed for exported |
|---|---|
| January | 3,118 |
| February | Unknown |
| March | 7,596 |
| April | 3605 |
| May | 432 |

*Source: Upper Nile State Ministry of Finance in* (UNDP, 2011)

- Brick making in South Sudan: In the past, houses were made of sun-dried bricks. Nowadays more and more baked bricks are used. Brick bakers interviewed in the basin produced 120,000 bricks in one cycle, which are sold for 0.25 South Sudanese Pounds per piece (UNEP, 2007 in UNDP, 2011). One brick-baking cycle uses 8 cubic metres of firewood. Building the kiln takes 7-14 days, baking 7 days and taking the bricks out another 7-8 days. In Upper Nile brick makers produced between 80,000 and 160,000 bricks per kiln using one truck load of wood for large kilns and a half a truck load for small kilns. One brick-baking cycle was half a month, which means that the presence of one kiln accounts for the utilization of an average of 18 truckloads of firewood per year.
- Construction and fire wood: The demand for construction and fire wood has increased due to the construction of new settlements and population growth. For timber, higher quality wood of larger older trees (Daniellia oliveri, Khaya senegalensis) is exploited. If taken in large quantities, important elements of the vegetation are removed, which impacts vegetation structure and may increase erosion (UNEP, 2007 in UNDP, 2011)

*Figure 5-9: Wood collected for sell at Sheka zone near Tepi (left) and Fuel Wood collected along the Tepi-Meti road (right)*

*Source: this study*

- Livestock grazing/browsing: Livestock in the basin, particularly cattle, sheep and goats, consume grass and trees. Grazing is sustainable as long as the re-growth capacity of the vegetation matches the level of use. If the off-take by livestock is too high or if other factors of degradation (e.g. fire, clearing for different purposes, low rainfall, drop of water table) interact with grazing, the vegetation will degrade, which means that open tree savannas may fragment and on the long run they turn into grasslands or deserts (Miehe, 2010 in UNDP, 2011). The impact of livestock grazing is less visible and more difficult to quantify than that of clearing for agriculture and cutting for charcoal, fuel wood or construction. The most important contribution of livestock to deforestation is the removal of seedlings, which eliminates the capacity of the forest to regenerate.

- Fires: Bush fire is one of the factors for the degradation of forest. It may originate from a number of causes:

  - Farmers use fire to remove vegetation for cultivation; sometimes they lose control and wildfires result;
  - Pastoralists use fire to remove dry grass cover and to stimulate re-growth of perennial grasses (green flush);
  - Hunters use fire to chase animals hidden in the vegetation;
  - On some occasions natural fires occur due to thunderstorms, but this is actually rare since thunderstorms mainly occur in the wet season and they are accompanied by rain.

Fires destroy seeds, tree seedlings, rhizomes of perennial grasses and organic contents of the soil. Areas frequently devastated by fires lose tree re-growth and perennial grasses. Annual grasses, which have less nutritious value for livestock, gain an advantage from fire, since their seeds may survive in the subsoil or recolonize burned areas by dispersion through wind or herbivores.

- Population Growth and Resettlement: Population growth is in the order of 2.8% in the rural areas of the upper sub-basin. This growth is mostly due to natural increase, but there has been a long history, when permitted, of spontaneous migration of people in search of land or economic opportunities associated with the coffee economy, as well as planned resettlement from famine affected areas.

- Forest Land Allocation for State Farms and Investors: The process of forest land allocation for the estate farming in Ethiopia accelerated during the Derg government (1974-1991) as the road infrastructure in this area was improved. This period saw the establishment of the 8,000 ha coffee estate at Bebeka, to the west of Mizan Teferi and established another state farm for coffee near Tepi covering around 5,000 ha. In the lower basin the state farm at Abobo was also established partly in woodland. Since the change of government in 1991, and the introduction of the free market, forest land has been allocated to investors on long leases for estate agriculture. This has mostly been done in SNNPRS where a rather favourable attitude to investors exists, compared to that in Oromiya where more stringent EIA procedures have been applied. The new estates are mostly in Sheka Zone, near Masha, along the road from Tepi to Gore, but also west of Mizan Teferi. Recent land allocation for investors become more common in Gambella region. In all cases, the estates have been established in areas of high forest and, experience shows that when options exist for using secondary / thinned forest within the allocated area, investors prefer the high forest.

*Figure 5-10: Wushwush tea plantation at Kafa*

*Source: This study*

#### *5.3.1.4 Soil Erosion*

Soil erosion is a serious problem, which occurs particularly on sloping areas with coarse soil texture and poor vegetation cover. Factors accelerating erosion are deforestation for cultivation, over-grazing, wildfire and other activities responsible for the clearing of the land's natural ground cover. The major consequences of erosion are loss of soil quality which impacts natural vegetation and productivity in agriculture, and the siltation of rivers, lakes, dams and irrigation canals. Water erosion is more prominent in the highlands of the BAS basin due to higher human pressure, more sloping land and/ or generally coarser soil types compared to the landscapes dominated by the floodplains in the low laying areas of the basin.

#### *5.3.1.5 Scattered settlement*

The settlement pattern of the communities are mainly rural and are scattered along the river banks increasing susceptibility to flooding and reducing accessibility limiting access to basic social services and retarding development initiatives.

#### *5.3.1.6 Poor Agriculture Extension and Poor Credit Facilities*

Agricultural extension programs were not designed to address the complex socio cultural farming systems and agro – climatic conditions of the basin. Lack of or no rural credit facilities, agricultural input supply and market facilities, inadequate linkage between research – extension farmers and cooperatives, prevalence of livestock diseases and crop pests, inadequate market infrastructure and marketing information system, higher humidity and traditional farming techniques (hand tillage) are among the constraints limiting agricultural productivity in the basin. This leads to important loss of soil and to deforestation as a response to rapidly decreasing yields and increasing demand.

#### 5.3.1.7 lEncroachment into protected areas

In general, land-use change in the BAS basin is causing the extensive destruction of natural resources. For instance, Gambella National Park in Ethiopia is the country's largest national park formerly covering an area of 5061 km$^2$, with a unique ecosystem and wildlife composition. Many recognize great potential for wildlife conservation in this park, but this potential has not yet been tapped as it is expected. The state and federal governments carve up the land for "small" and big investments. Recently, the government established huge tracts of commercial farms within the former park area. Two large Indian and Saudi commercial plantations, Karuturi (300,000 ha) and Saudi Star (100,000 ha), have started producing rice encroaching to the national park area. As a result of these activities, EWCA and the Park Administration organized a workshop in December 2010 with the objective of re-demarcating the borders of the park. As a result the park area has been re-demarcated and reduced from former 5061 km$^2$ to 4575 km$^2$.

#### 5.3.1.8 Poverty, Poor physical and Social Infrastructures, Security issues

Poor physical and social infrastructure including communication (Poor access to health and education services inadequate technical/modern skills); Poor animal husbandry and animal health services; Poor market outlet, absence of roads and information, etc. are among the constraints of the basin development.

Also, unpredictable conflict between tribes and ethnic groups within the region and cross border conflict consist of additional obstacle for development and growth efforts exerted by the people. Over the last four years, pressure on natural resources such as land, food and shelter materials has increased due to the influx of refugee (and now IDP) populations in the area. Consequently, tensions between refugees and host communities have risen, frequently developing into violent conflict ( which in turn hinders the delivery of aid to both refugees and hosts, and affects the integration of refugees in the area). A specific study has shown that most important components of tension and dispute between refugees and neighbouring host community villages was in regards to natural resources and land, livestock and wood. Access to water was not found to be a prominent issue (REACH, 2016).

The combination of the above quoted factors, along with the persistence of poverty lead to high degree of dependency over the BAS natural resources and leads therefore to important pressures on them, especially in historic populated areas (highlands and escarpments) but also recently around refugees settlements (lowlands).

#### 5.3.1.9 Unsustainable Hunting of Wildlife

The civil war and continuing insecurity has seen a proliferation of firearms among the communities in the South Sudanese part of the basin. The proliferation of arms allows hunters to kill more wildlife with less effort. In the context of insecure tenure, wildlife has become an open access resource and well-armed hunters are rapidly depleting wildlife population. For long, food insecurity and local income had been the drivers toward wildlife hunting to supplement for inadequate animal protein especially during the wet season. It has also meant that conflicts over access to land and water have become appallingly violent in South Sudan, especially among the cattle keeping communities which in some occasion may also involve peasant. Lack of livelihood options for internally displaced people (IDP) and returning refugees in South Sudan has resulted in an overdependence on natural resources as a source of income, causing a rapid spread of unsustainable trade in bush meat across the basin. .

Livestock grazing pressure, access to water and the transmission of wildlife-livestock diseases (e.g., bovine tuberculosis, rabies, rinderpest, cooties) are important factors affecting local wildlife, livestock and human communities as well as natural resource management (USAID, 2010c).

### 5.3.2 Proposed development objectives

With regard to BAS key environmental issues, development potential and existing initiatives, the following development objectives can be proposed:

- Encourage forest conservation based on livelihood development activities such as:
  - Modern honey production in the highland areas by linking with forest and biodiversity conservation,
  - Spices and coffee production inside the forest and connect the products to international markets,
  - Linking forest conservation with carbon credit.
- Provide alternative energy sources in order to reduce deforestation and bushland degradation by:
  - developing mini hydropower projects at high land areas where the community are away from the main electricity line to reduce pressure on the forest of the highland areas
  - introduce energy saving stoves and lighting technologies to reduce need of charcoal and fire wood.
- Rehabilitate degraded highland areas by developing afforestation, agro forestry and catchment management.
- Strengthen the protected area network and promote transboundary natural resources and wildlife conservation by:
  - Designating the Badingilo and Machar marshes – Gambella plains – Gwom wetltands as Ramsar sites,
  - Delineating and promoting registration of Majeng forest as UNESCO Forest Biosphere
  - Delineating wildlife protection park along the Akobo river and interconnect Gambella and Boma national parks with wildlife movement corridor,
  - Promoting transboundary wildlife conservation through the establishment of a joint wildlife management plan between South Sudan and Ethiopian borders
  - Promoting ecotourism focusing on Gambella and Boma national parks and Sheka and Yayu forest biosphere reserves.
- Establish and implement a wetland monitoring network;
- Develop solid and liquid waste management;

### 5.3.3 Capacities building

During stakeholders' consultations, the following capacity building needs have been identified:

- Provide training to build capacity mainly in the GIS, satellite imagery and GPS use to inventory and delineate forest areas,
- Strengthen the capacity of Ministry of Environmental protection (particularly in South Sudan) with skilled manpower capable of preparing environmental guidelines and standards, Prepare land use plan and manage natural resource.
- Strengthen the biodiversity conservation institute in both Ethiopia and South Sudan,
- Establish Joint Wildlife conservation society/forum at the Ethio-South Sudan border;
- Establish Aquaculture department at each country and build capacity to promote aquaculture development.
- Establish BAS basin biodiversity conservation office and build its capacity.

# ANNEXES

# ANNEX 1: MINUTES OF MEETINGS

# 1. CONSULTATION IN SOUTH SUDAN

## 1.1 CONSULTATION WITH MINISTRY OF ELECTRICITY, DAMS, IRRIGATION & WATER RESOURCES

On May 6/2015 series of consultations were conducted in Juba with Government officials and experts. The first meeting was conducted at the Ministry of Electricity, Dams, Irrigation & Water Resources. After the introduction of the project and the objective of the team visit by the team leader, stakeholders to be part of the consultation were identified by the directorate of the Ministry of Electricity, Dams, Irrigation & Water Resources. The identified stakeholders in addition to Ministry of Water, Irrigation and Hydropower include Ministry of agriculture, Forestry, cooperatives and rural development, directorate of Electric and Dam, Ministry of Environment, Ministry of Transport, Roads &Bridges, Directorate of River Transport, Ministry of Wildlife Conservation and Tourism and Meteorology.

Some NGOs involved in development activities such as NERAS of Denmark, Netherland, GTZ, JICA were also identified as key stakeholders.

During the discussion with the officials and experts of the Ministry of Electricity, Dams, Irrigation & Water Resources some ongoing projects within the basin were identified. The major ones include: Comprehensive agriculture development master plan (including irrigation master plan) supported by JICA, African Wildlife conservation project at Eastern Equatoria funded by the Netherlands government/NGO, Gambela-Nasir/Melaka interconnection through navigation study supported by Sweden, Kenite hydropower Dam project at Torit area.

Question was raised by the director of Ministry of Electricity, Dams, Irrigation & Water Resources whether the study covers White Nile basin or not. The study tem member represented from ENTRO replied “for the time being the study not include White Nile basin but in the future the study may extended to White Nile based on the availability of finance. There was also argument on the naming of project because the naming didn’t include Pibor River which is one of the tributary of Sobat River. Old geological map was referred to see the starting point of Pibor river and copy of the map was collected as part of the important data collection.

Challenges of the basin were also identified during the discussion. The major challenges raised by the participants of the Ministry of Electricity, Dams, Irrigation & Water Resources include:

- Instability of the country due to tribal unrest,
- Lack of adequate infrastructures (road, water supply, electric power)
- Flood and drought,
- Unplanned urbanization and land allocation,
- Limited number or skilled manpower to develop and manage the resources,
- Mass killing of wildlife (local community and army) for wild meat,
- Deforestation mainly for charcoal production,

*Figure 1-1: Discussion with the officials and staff in the Ministry of Electricity, Dams, Irrigation & Water Resources in Juba*

*Source: This study*

## 1.2 CONSULTATION WITH THE DIRECTORATE OF HYDRO ELECTRIC AND DAM

According to the directorate of Hydroelectric and Dam, there are 4 hydropower sites proposed in the basin including White Nile. Two power interconnection studies are ongoing, one from Uganda and the other from Ethiopia through Gambella.

Hydropower dam site proposed in Eastern Equatoria is on Kenite River. Refer SMEC study for the details. There are no big potential areas in the sub basin part of South Sudan but there are several stations in Upper part in Ethiopia. Inter connecting from the ongoing Ethiopian Renascence Dam is not considered so far. However, the team members suggested considering it since there is transmission line from Sudan to northern part of South Sudan which can be benefited.

*Figure 1-2: Discussion with the Directorate and experts of Hydro Electric and Dam*

*Source: This study*

## 1.3 CONSULTATION WITH MINISTRY OF AGRICULTURE, FORESTRY, COOPERATIVES AND RURAL DEVELOPMENT

The director of the ministry explained the general ecology of the country. He mentioned wetlands, rain fed agriculture, fishery, irrigation and forest as major ecosystems. Rain fed agriculture is practiced in the southern part of the country where the rainfall is adequate. In southern part of the country including part of the Eastern Equatoria rain starts in April and extended to October or November which promotes rain fed agriculture.

There is green belt zone along White Nile where crops grow twice in a year. But in the eastern and western flat plain water harvesting will require to supplement crop production by irrigation. Also in semi-arid areas where there are pastoralists it needs water harvesting to sustain their livelihood. The main problems of pastoralists were identified during the discussions which include:

- Lack of water infrastructures for the livestock and people consumption,
- Poor productivity of livestock (no improved breed),
- Low level of awareness among pastoralist (cattle are more for prestigious purpose rather than economic resource),
- Livestock products are imported from other countries (Uganda) while the cattle population is huge in the country,
- Conflict among tribes on water and grazing areas.

Regarding to ongoing projects it was mentioned that there is a comprehensive agriculture development master plan study which is expected to be finalized at the end of June. The study has also a component on irrigation (irrigation master plan which is the subset of the Comprehensive master plan study).

*Figure 1-3: Discussion with the ministry of Agriculture, Forestry, Cooperatives and Rural Development officials and experts in Juba*

*Source: This study*

## 1.4 CONSULTATION WITH THE MINISTRY OF ENVIRONMENT

During the discussion existing and potential challenges on the environment were asked by the consultant team. The following challenges were identified by the participants of the meeting:

- Lack of proper management for the national parks,
- Killing of wildlife for wild meat,
- Lack of wetland management and wise use of it,
- Lack of approved environmental policy of the country (the environmental policy is under review by the parliament),
- Unplanned urbanization and unplanned land allocation without considering sensitive environments like wetlands,
- River pollution by urban waste,
- Siltation of rivers by sediment due to removal of vegetation at the upper catchment,
- Shrinkage of rivers due to climate change,

- Reckless removal of trees for agriculture expansion and for commercial purposes mainly for charcoal production,
- Absence of land use plan in sensitive areas like Imatong mountains,
- Lack of wetland inventory and delineation (Wetland inventory study was initiated by RAMSAR but interrupted due to war),
- Local people are poor not because of potential resources but due to lack of knowhow to use the resources and community unrest due to war.

Potential resources in Eastern Equatoria include fertile land, forest resources (bamboos, Gum acacia) honey production, springs and rivers from mountain areas, etc.

Participants also mentioned that any development in the watershed must consider:

- Basin wise not administration based,
- All users must be addressed,
- Not develop projects by fevering some communities in the expense of others (equitable share of resources).

*Figure 1-4: Discussion with the ministry of Environment in Juba*

*Source: This study*

## 1.5 CONSULTATION WITH NGOS REPRESENTATIVES AND EAST EQUATORIA INFRASTRUCTURE DIRECTOR AND EXPERTS

Participants were from the government offices and NGOs (See the list of attendants).

According to the discussion with Eastern Equatoria state environmental director and our visit along the road to Torit, trees and vegetation cover is diminishing in fast rate without any endeavour to replant or afforestation. People are clearing trees for expanding farm land and for the production of charcoal. Charcoal is the main source of the energy in the country since there is no other alternative form of energy to substitute charcoal. Currently, charcoal is the easily available source of income for the rural people. At present, there is no approved law or policy regarding the conservation of environment. Draft Environmental policy of the country is submitted to the parliament for review and endorsement.

As a mitigation measures participants of the discussion raised provision of alternative energy sources like hydropower, use of fuel conserving stoves, creation of awareness among the local people, promote reforestation, promote fruit tree plantation, promote farmers to use bee keeping and honey production, identify easily affected tree species and ban its removal by law, develop mechanisms to use dry grass for household energy purposes, etc.

As per the participants of discussion, culturally local people abstain from cutting some trees, trees which are considered sacred and cutting them believed by the community to cause some spiritual problems. But this days due to the war and tribal unrest, these trees conserved by one tribe were cut by another tribe and culture of conserving the environment by traditional ways have been eroded.

Wildlife conservation expert from Africa Wildlife conservation indicated challenges on the wildlife resources. The major challenges are:

- Killing of wildlife by communities as well as by the army for wild meat,
- Absence of national parks management plan,
- Lack of awareness about the wildlife conservation and its use.

The impact is more severe during the mass migration of White eared Kob, one of the endangered species. They migrate to Gambella national park during the dry season as they can get water there and come back to South Sudan/Boma Park when the Gambela area is wet and muddy. The reason of migration is to search water in the dry period at the upstream and escape mud during the wet season. Their migration is considered by the local people as a sign for onset of rainy season and dry season.

As it was expressed in the discussion, there are historical sites in East Equatoria like the mass grave of the war victims and cultural site where reburial of bones after the flesh separated from the bones take place. Community crocodile farm practiced in some areas can also be utilized as a tourist attraction. In the East Equatorial state scenic beauty of the mountains can be the natural attraction for local and international tourists.

*Figure 1-5: Discussion with the East Equatoria Directorate of Infrastructure and with NGO representatives in Torit*

Source: This study

In addition to discussion with government officials and NGOs representatives site visit to the proposed hydropower site on Kenite River was conducted. The proposed hydropower site is located at about 20 km south of Torit town. The nearest village to the hydropower site is known as Hilok-2. The area is accessible by car though it could be difficult in rainy days.

The proposed dam site is located in the center of valley surrounded by two hills. The river flow was considerably high at the time of visit and its flood plain is wide enough to hold much water. Both sides of the river are covered by tall elephant grasses. Following the grass, riverine trees are observed which marks the boundary of high flood level. The major tree species observed include: Ficus spp, Acacia polyachantha, Combertum collinum, Terminalia collinum and variety of Acacia Spp. Ecologically the larger area of the Kenite river catchment is characterized by Savanna woody grassland, where the tree species dominated by Combertum Terminalia and Acacia comphora type.

The Kenite River eventually ends up in the wetland at the downstream. Currently there is no clear indication that Kenite river is connected with Baro Akobo-Sobat basin or not.

According to the representatives from Kapoeta area, water harvesting potential at semi desert areas of East Equator needs to be assessed. The semi desert areas are less populated area but with large number of livestock. The main challenge of the area is shortage of water for people and livestock. To solve this problem providing water should be seen as one of the components of the integrated water resources management project. The possible source of water for this area seems harvesting water during the flooding season in cofferdams. The potential of ground water has not been assessed in detail. However, as per the information from local experts, ground water cannot be easily obtained in depths of less than 200m.

The consulted officials suggested that if water is to be provided for people and cattle, the distribution and location should be selected carefully to avoid water use conflicts. Series of cofferdams or boreholes need to be developed at agreed locations based on the community consultation. After the construction, each water point should be managed by water use committee established by the community or use the existing traditional ways of resource sharing in the community. The location of water harvesting schemes should also consider overgrazing and land degradation impacts. The schemes should be planned in such a way that they will not invite tribal conflicts and community turbulence.

*Figure 1-6: Kenite River at the proposed dam site (left) and nearest village to the proposed dam site known as Hilok-2 (right)*

*Source: This study*

## 1.6 CONSULTATION WITH GOVERNORS FROM NORTH WEST KAPOETA AND SOUTH KAPOETA

As per the discussion, there are dry areas where surface water is not available. People are pastoralists that move in search of water and grazing land. Shallow wells drilled before are dried during the dry period. The drilled wells are not deep enough to sustain water during the dry period.

The pastoralist lifestyle is creating conflict due to the limitation of resources. According to the representative from South Kapoeta, nearly all of the major inter and intra-communal conflicts are linked either to cattle raiding and the subsequent spiral of violent retribution, or conflict among pastoralists and farmers over migration routes and access to water and pasture.

As per the discussion, supplying adequate water points at several places following the major grazing territories will solve the conflict and unrest of communities.

Slow by slow promoting sedentary settlement and shifting from pastoralist life style to mixed farming system expected to improve the livelihood of the people. Irrigation development using underground water could also help to improve the livelihood of people. Some individuals are exercising irrigation at the bank of Singata River by digging well on the dry river bed and pumping it for small scale irrigation. But the problem is the water level draw down in the dry season and become difficult to pump. The representative/Official from South Kapoeta suggested that this integrated water resource development project is expected to solve such problems. The area has a seasonal river called Singata. It has large flow when the rain falls, but immediately the runoff disappeared in sand and become unavailable for use. The flow disappears in wetlands and sands before joining any known river system.

Water shortage is also common in rural towns. In some villages JICA has developed boreholes and installed pumps which operate using solar energy and they are working well. But in some villages boreholes dug were not functioning due to the maintenance problem. As per the officials, local communities are poor to cover the maintenance cost.

According to representatives from Kapoeta area to solve energy problem, investing in wind energy could be an option since there is high wind in the area.

According to the participants, other constraint for the resource management and development is shortage of infrastructures. Particularly road access to rural areas is a crucial problem. Road density at the moment is very low. During the rainy season most of the rural roads are impassable.

Also number of internally displaced people as a result of the civil conflict is increasing that leading to an unplanned land accusation and unplanned expansion of cities putting pressure on water and energy infrastructure within build up areas. Those left without energy obliged to cutting wood, which can worsen the problem of deforestation.

*Figure 1-7: Meeting with East and South Kapoeta Governors at Torit*

*Source: This study*

## 1.7 CONSULTATION WITH DIRECTORATE OF RIVER TRANSPORT

Discussion made with the directorate of river transport revealed that though the river transportation is the cheapest form of transportation in terms of load transporting; currently there is no river transport in Baro and Sobat river system. Except very small vessels, big boats are not using this river system. There were some initiatives to improve river transport. In the 2013th EGAD meeting river transportation was raised as one of the interconnection or means of transport between countries. Africa Development Bank also showed interest to fund the river transport development. But none of them so far showed concrete progress.

River transport from Melaka to Nasir is operational between May to September. In dry season due to water level drawdown boats con not float. The major challenges of river transportation are:

- Siltation of river channel,
- Shortage of flow in dry season,
- Absence of defined navigation channel/route,

- Narrowing of width of channel by sedimentation in some areas,
- Massive growth of Water hyacinth
- Sharp curves in the river system
- Shortage of budget for study and design of river transport,
- Lack of maintenance such as dragging of sediment from the channels.

*Figure 1-8: Discussion with River transport directorate (left) and Port on white Nile at Juba (right)*

*Source: This study*

## 1.8 CONSULTATION WITH METEOROLOGY DIRECTORATE

Discussion with the directorate of the Meteorology revealed that the coverage of meteorological station in South Sudan is low and the available data is only for recent time. Practically there are no meteorological stations in the Baro-Akobo-Sobat basin. Functional stations are only five distributed in five major towns. The data are being used mainly for the aviation purpose. There are some automatic stations installed by FAO but due to maintenance problem and war most of them are not functioning. Historic data which were collected before the separation of two countries could be found in Khartoum.

The available data from Juba can be obtained through official request by specifying the data type needed.

Challenges of Meteorological office raised by the directorate include:

- Shortage of equipment,
- Shortage of qualified man power,
- Lack of data processing facilities,
- Low coverage of meteorological stations in the country,
- War and instability of the country.

## 1.9 CONSULTATION WITH THE MINISTRY OF WILDLIFE CONSERVATION AND TOURISM

During the consultation undersecretary emphasized that the conservation of wildlife is very important and necessary. He mentioned the impact of former canal construction project without consulting the wildlife professionals and consequently the canal has been creating adverse impact on the wildlife movement. The canal has hindered the free movement of animals and denies access to larger grazing area. Therefore, this study has to consult wildlife experts before launching any project in the Baro-Akobo-Sobat basin. The basin is one of the richest basins in wildlife.

Wildlife are facing huge problem from poachers and illegal traders (for example illegal people from Somalia kill wildlife for skin and other marketable parts).

Wilde animals are also killed during the seasonal migration. To minimize migration it will be important to provide water points for dry season. According to the undersecretary the integrated water resource master plan project has to incorporate wildlife watering component which could minimize migration of wildlife and promote tourism in the basin.

## 1.10 CONSULTATION WITH WILDLIFE CONSERVATION SOCIETY (WCS)

The following information was obtained:

- The core activity of the organization is wildlife conservation but since this cannot be separated from the environment, they take a wider approach. 2 main kinds of surveys are carried out:
  - Socioeconomic. Understanding communities' livelihood strategies activities, conflicts, what do they need what do they want? What do they use their natural resources for?
  - Ecological surveys. These include some aerial surveys aimed at estimating populations and human activities
- Boma and Badingilo, which have been covered by these surveys, we need to request the results and documentation concerning these areas
- The Gwom wetland is included in the Boma reports. This wetland is very important for pastoralists and wildllife.
- Land-use planning has been done for Boma. Started for Bor county but stopped for security reasons
- They have GIS maps of protected areas (including extension, we took a hard copy). To be requested.
- Nothing has been done in Machar Marshes. The northern half of the country is effectively no-go.
- WCS did the preliminary work (surveys? ) in the Imahong Mountains before AWS took over.
- Tourism. The war has effectively stopped everything. Boma is closed. There is a huge potential in both Boma and Badingilo. A site at Achuma (on border with Ethiopia) had been developed but stopped. There are draft management plans  for Boma and Badingilo.
- Wildlife Management and Toursim policies are all drafted but stuck somewhere. There are draft Toursim regulations, Bill, Policy – to follow up with the Lt Gen.
- Cooperation with Ethiopia. Discussions on the Boma-Gambella landscape started in 2008 and is being discussed. There is cooperation with HOREC who are doing the land-use plan for Gambella (to be available soon).

# 2. STAKEHOLDERS CONSULTATION IN ETHIOPIA

## 2.1 CONSULTATION WITH SNNPR SECTORAL OFFICES

Discussion with the officers and experts in the water and energy office, land utilization and environmental protection office, tourism and culture office, economic and finance bureau, investment agency and early warning response and food security work process of the Southern Nations, Nationalities and Peoples Regional State was conducted on June 18 and 19/2015. The discussion was focused on identifying environmentally and socially sensitive areas, issues and challenges in the Baro-Akobo basin and possible solutions for the identified issues and challenges. In addition, availability of ongoing and planned projects in the basin were assessed.

The consulted officials and experts raised the following environmental and social challenges prevailing in the region:

- Land degradation and soil erosion,
- Lack of organized land use plan in the basin,
- Deforestation of natural forest for the expansion of farm land,
- Expansion of investors beyond the allocated land area and encroaching into forest areas,
- Lack of proper coordination between investment and environmental protection offices,
- Lack of environmental monitoring and follow up after the allocation of land for investment,
- Significant gaps in the implementation of environmental laws,
- Lack of standard buffer zone (e.g, Federal EPA says 1km buffer zone between water bodies and any development, regional office says 2km, International says 150m),
- Construction of roads through high forested areas directly remove trees and create access for timber production and illegal cutting of trees,
- Use of charcoal as main energy source and income by the community,
- Weak setup of institution (Land utilization and administration and Environmental protection organized as one department under the Agriculture bureau which weakened the role of environmental protection)
- Unplanned and unlimited grazing in the forest which is affecting the forest and forest products (coffee, spices, etc),
- Conflicts between communities who are sharing the forest resources in the boundary of two communities,
- Cross-border conflicts due to competition for grazing land and fish farming between local communities and ethnic groups of Southern Sudan. The other cause of the border conflict is cattle raid and killing people.
- Poor communication of study and research outputs in the country.

Activities being done to alleviate these challenges in the region as per the consulted officials and experts include:

- Conduct physical and biological soil conservation works on farm lands,
- Enrichment tree plantation in the forest areas,
- Organize jobless youth in cooperatives to develop forest products (spices, honey, fruit trees, wood work, etc,) and support their livelihood,
- Organize community members above 18 years in 1:5 and mobilize for watershed protection works (construction of terraces, tree plantation in degraded areas, area closures),

- Promote water harvesting and mini irrigation,
- Provide improved seeds,
- Provide training on how to protect environment and forest resources and how to survey and design physical protection structures (terraces, Gabions, etc),
- Delineate forest biospheres (Sheka biosphere and Kefa biosphere) in coordination with NGOs, e.g Nature and Biosphere Union (NBU),
- Provide financial support through microfinance credit for theses who save 20% by their own will be given 80% of the project from the microfinance,

Food security office provides productive food support, family livelihood building and resettlement based on the willingness for those who are food insecure, particularly in Bench Maji zone of the basin.

Additional activities recommended to minimize environmental and social challenges include:

- Providing improved and fuel conserving stoves for the community who depend on the charcoal,
- Improving products of forest such as spices, honey, coffee through research and creating better market for these products (national and international markets),
- Promote solar energy to substitute charcoal so that deforestation will be reduced,
- Provide training to build capacity mainly in the GIS, satellite imagery and GPS use to inventory and delineate forest areas,
- Develop and implement forest management plan.

## 2.2 CONSULTATION WITH GAMBELLA REGIONAL STATE SECTORAL OFFICES

Similar to SNNPRS, discussions were conducted with officials and experts of sectoral offices of the Gambella Regional State. The consulted offices include water and energy office, land utilization and environmental protection office, tourism and culture office, economic and finance bureau and Gambella National Park Office.

The discussion was focused on identifying environmentally and socially sensitive areas, issues and challenges in the Baro-Akobo basin and possible solutions for the identified issues and challenges. In addition, availability of ongoing and planned projects in the basin were assessed.

The consulted officials and experts raised the following environmental and social challenges prevailing in Gambella regional State:

- The region does not have its own environmental policy and guidelines,
- Lack of coordinated protection of environmentally sensitive areas like forest, wetlands and national park,
- Lack of management plan for the Gambella National Park,
- Lack of coordination between investment and environmental protection offices. Investors prepare EIA after they possessed the land and license. In principle, EIA should be a prerequisite for the possession of license. But in case of the Gambella, EIA is prepared just to indicate mitigation measures which makes EIA powerless tool.
- Influx of refugees into the region imposed adverse impacts on forest resources,
- Conflict between different tribes mainly due to cattle raid,
- Conflict between local community and pastoralists coming from Sudan in search of grazing and watering,

- Absence of strong cooperatives to supply farm inputs like fertilizers, selected seeds, etc,
- Shifting cultivation which has impact on forest resources,
- Water pollution by solid and liquid waste,
- Absence of liquid waste treatment plant for Gambella town,
- Absence of trucks to collect and dispose solid waste at the designated disposal site. (The designated solid waste disposal site is located 7km away from the Gambela town).

Activities recommended to minimize environmental and social challenges include:

- Strengthen the coordination between investment office and environmental protection offices,
- Stop shifting cultivation to reduce deforestation,
- Conduct EIA before issuing license for the investment as a prerequisite for licensing,
- Avoid encroaching into National park and wildlife habitat,
- Prepare management plan for the Gambella National Park,
- Ensure availability of appropriate land for investment before inviting investors,
- Avoid allocating land for investment in high forest areas,
- Collect and dispose solid waste at designated place,
- Build capacity of cooperatives involved in solid waste collection and disposal by providing training and trucks
- Collect and threat liquid waste of Gambella town,
- Build capacity of cooperatives involved in supplying farm inputs like fertilizers, selected seeds, etc
- Avoid tribe to tribe and cross boarder conflicts that caused mainly due to competition for grazing land, cattle raiding and watering points.
- Solve civil unrest in South Sudan to reduce influx of refugees.

*Figure 2-1: Discussion with Early warning and disaster prevention expert in SNNPRS*

*Source: this study*

## 2.3 CONSULTATION WITH ETHIOPIAN WILDLIFE CONSERVATION AUTHORITY

Discussion was conducted with Ato Girma Timer, protected areas development and protection senior expert. He indicated that GNP is very important park in terms of biodiversity and being Trans Boundary Park. The park has pressurized by investment activities and resized due to encroachment of farm activities. In terms of management, there is interim management plan and the overall management of the park has given to African parks network centre which is working under Inter government Authority for Development (IGAD).

The government of Ethiopia and South Sudan signed memorandum of understanding to jointly protect and develop trans-boundary parks.

There is also a proposed wildlife reserve area in the BA basin in Bench-Maji zone parallel to Boma national park of South Sudan, which is rich in wildlife species.

The Gambella national park has gazetted and there is map which shows the area coverage and boundaries.

Regarding the impact of the proposed water resource development project on the Gambella National park, Ato girma expressed his fear that if the migratory route between Gambella and Boma national parks is blocked by water resources development the impact on the wildlife and biodiversity would be significant. However, if the project properly designed considering the national parks and wildlife movement corridors, the impact would be minor.

## 2.4 CONSULTATION WITH HORN OF AFRICA REGIONAL ENVIRONMENT NETWORK CENTER

The organization is working on the integrated land use development plan in Gambela region. The project is under the literature review at the time of consultation on October 9/2015. The project also includes preparation of strategic environmental and social Assessment. As part of the consultation scheme, they established consultation units in Gambela region for each type of livelihood projects (eg, consultation unit for aquiculture and fishery, consultation unit for tourism, for small &large scale irrigation, etc.). They are preparing land use map for each zone including Gambela town.

## 2.5 CONSULTATION WITH NABU BRANCH OFFICE AT BONGA

After the study team introduced the BAS IWRDP, Ato Mesfine explained about Kafa forest Biosphere. He clarify that most of the Kafa forest biosphere is located in Omo basin, while some portion of it is situated in BASB. The total area of biosphere is 700,000ha. Out of which 43,150ha is a core conservation area where human interaction is avoided, 289,000ha is delineated as buffer zone while 164,000ha is delineated as transitional zone. There is lion and other wildlife species in the forest area, particularly in core reserve area.

NABU is NOG working on Nature and biodiversity project funded by Germen. The project branch office at Bonga town runs by 3 technical staffs and 10 rangers.

Three pillars of the project are (1) Rehabilitation, (2) Regional development and marketing and (3) Biodiversity campaign.

The project support livelihood of the community by promoting ecotourism, modern bee keeping, introducing energy saving stoves, use of spice and other none timber forest products. By doing so try to minimize encroachment of farm into forest areas.

As per the discussion, constraints faced to protect forest resources in Kafa zone include:

- Poverty of people living in the forest areas;
- Increasing population due to birth rate and immigration from other part of the country;
- Clearing of forest for expanding farm land;
- Allocation of forest land for agriculture investment;
- Climate change;
- Lack of coordination between different government institutes and weak enforcement of rules and regulations pertinent to natural resource conservation and management.

Activities being carried out by NABU to solve these pressures imposed on natural forest and biodiversity include:

- Biodiversity campaign in the community and schools;
- Promoting traditional ways of forest protection; Providing training on biodiversity for volunteers;
- Distributing energy saving stoves;
- Introducing Coffee bricks from coffee husk for energy/cooking;
- Introduce solar lamps for lightning.

NGOs working in the forest conservation and livelihood improvement in Kafa include: MELCA & ECOPIA

## 2.6 CONSULTATION WITH BENCH-MAJI ZONE AGRICULTURE AND RURAL DEVELOPMENT OFFICE

Ato Solomon Kelemwork, the head of Bench-Maji zone agriculture office explained that the woreda is endowed with natural resources. 46% of the land area of the zone is covered with forest and bushes. There is natural forest, gold mine at Dima area. Shako and Guraferda forest is potential area for biodiversity conservation. There is also a controlled hunting area in Gureferda. Tululiga is a regional wildlife protection park found in the Zone. There are also potential wildlife protection areas following the shore of Akobo river, where various wildlife species are dwelling.

Regarding water shed management, Sustainable land management project (SLMP) is working in two woredas since 2015. The conservation work is focused on soil and water conservation and reforestation of degraded areas.

Constraints identified during the discussion include:

- Soil acidity,
- Soil erosion at the highland and steep slope areas;
- Encroachment of farm into natural forest areas;
- Increase in population which is exacerbated by the immigrants from other parts of the country;
- Expansion of agriculture investment (Bebeka coffee plantation), Seka agro industry (3000ha mango plantation); Rubber tree plantation in Guraferda area.
- Lack of proper land administration and certification of land holdings;
- Low capacity in GIS application and use. Current land measuring is based on traditional ways which is not effective.

*Figure 2-2: Discussion with Bench-Maji Agriculure and rural development head at Mizan town*

Source: This study

## 2.7 CONSULTATION WITH YAKI WORED ADMINISTRATION OFFICE

The deputy head of the Yaki woreda explained that Sheka zone has three woredas, namely Masha, Yeki and Anderacha. Yeki woreda is consists of 22 kebeles. The woreda is endowed with natural forest and coffee. The woreda is also known for honey production and spices. Main spices found in the forest are Korerima (Afromom corrorima) and Timiz (Piper capense).

The woreda has also several tourist attractions such as water falls, forest, caves, lakes and culture of people.

As per the discussion, the major problems for natural forest and biodiversity conservation in the woreda are:

- Encroachment of farm into forest areas,
- population growth and influx of people from other parts of the country, primarily for the search of job as daily labour and later on some of them shift to farm by clearing forest areas;
- Expansion of tea and coffee plantation by the investors,
- Failure of law enforcement,
- Weakening of traditional forest conservation practice. Young generation became reluctant to follow the old traditions such as keeping sacred places, worship areas, etc.;
- Resistance of people for new technologies;
- Soil acidity,
- Slope and sliding nature of the soil.

Efforts done to date to protect the natural forest and environment in the woreda include:

- Lively hood improvement work by the government and NGOS. For example wild coffee conservation (WCC) an NGO has been working in the woreda on conservation and alternative lively hood promotion.
- Agriculture growth program (AGP) work on improving productivity through small scale irrigations and cattle productivity.
- Kobo which is traditional mechanism of communal forest protection by the community.

Activities needed to be promoted include:

- Expanding Agriculture productivity growth program in a larger scale;
- Promote community participatory forest development;
- Promote alternative livelihood mechanisms such as spice production and marketing, honey production and marketing, promotion of agro forestry;
- Working to get carbon credit by conserving natural forest as carbon sink.
- Promoting ecotourism development
- Conduct water and soil conservation work in the afro-montane rain forest areas and landslide prone areas.

## 2.8 CONSULTATION WITH MAJENG ZONE

Consultation was made with Ato  Kemtu Tewu Deputy administrator of Majeng zone, and his experts at Majeng zone, Meti town.

The BAS basin Integrated Water Resource Development Study and its objectives were explained by the study team to the zonal administrator and experts working in sectoral offices. After briefing of the project, the study team requested the officials and experts to introduce their zone and existing potentials and constraints regarding natural resources use and management and to identify potential projects that could be considered in the BAS IWRDP.

The participants of the meeting briefed to the study team that Meti the capital of Mezheng zone is about 305 km away from the regional capital, Gambella. The zone consists of only two woredas, namely Godere and Mengeshi. The people of the zone are fully dependent on crop production (farming). The zone is one of the high rainfall receiving areas of the country. Rain fall extended for 9 months. The zone is one of the coffee producing areas of the country. There is about 225,000 ha forest land with high biodiversity.

As per the discussion, the forest resource is diminishing from time to time. There are no protected national or regional wild life parks in the zone.

Main causes of forest and biodiversity degradation are:

- Encroachment into forest areas for coffee plantation and other crop production;
- Illegal settlement;
- Labor attracted by the agro- investment from other parts of the country tend to shift to farming by clearing virgin forest;
- Forest clearance for tea plantation by the Indian Investors. The land allocation policy for investment which allows Federal investment office to allocate land for investors where the required land is more than 5000ha is affecting the natural resource. For instance, the tea investment area is the tower of water for the downstream areas including Alwero dam. Some rivers which were permanent before the impact on forest become seasonal due to the clearance of forest cover, and;
- Lack of proper land use plan.

As per the zonal officials, activities required to minimize forest and biodiversity degradation include:

- Promoting alternative livelihood mechanisms such as modern honey production, none timber forest products, spices and create market link for the products; Stop tea investment from expanding (so far 100ha of forest land has been cleared and planted tea);
- Land allocation for investors should be in consultation with zonal administration and prior EIA recommendation.
- Work to link the forest are with carbon credit;
- Look international market for organic coffee of Majeng.

- Introduce farm technologies that help to produce high production from small farm land;

*Figure 2-3: Discussion with Majeng zone administrator and experts*

*Source: This study*

## 2.9 CONSULTATION WITH SHEKA ZONE ADMINISTRATION OFFICE

The BAS basin integrated water resource Development study and its objectives were explained by the study team to the zonal administrator and experts working in sectoral offices. After briefing of the project, the study team requested the officials and experts to introduce their zone and existing potentials and constraints regarding natural resources use and its management. They explain that Sheka zone is located in the Southern Nations Nationalities and Peoples (SNNP) Regional State. The zone has three woredas, namely Mash, Anderacha and Yeki. The zone covers 2174.25 km$^2$, out of which 47% is covered by forest.

The zone has a UNESCO registered forest Biosphere reserve. The total area of forest biosphere reserve is 238,750ha. Out of which 55,255ha is a core area, 76,395ha is buffer area and the rest 107,100ha is transition zone. The core zone consists of dense natural forest, wetlands and bamboo forest and it is protected from human interaction except for the purpose of research, traditional beehive, religious purposes, ecotourism, scientific training and collection of medicinal plants.

Buffer zone is the forest area where both use and protection go hand in hand. In buffer zone activities which affect ecosystem will not be allowed. However, environmentally friendly land use such as traditional beehives, coffee plantation where the forest is not dense, collection of spices and none timber forest products can be exercised, but settlement, grazing , cutting of indigenous trees, farming on wetlands and clearance of indigenous trees from river sides will not allowed. Transition zone is area where settlement and environmentally friendly agricultural activities will be taken place. But large investment activities will not take place in transition zone.

As per the zonal agriculture expert, the major environmental constraints of the zone include:

- Encroachment of farm into forest area,
- Increase in population and need for farm land;
- Tendency of farmers to use shifting cultivation or tendency of look for virgin land;
- Soil acidity and low production per ha,
- Lack of alternative livelihood system;
- Lack of suitable technologies;
- Lack of electricity for lighting and cooking, which pressurize on forest for fuel wood;
- Immigration of people from other parts of the country and illegally settle in the areas by clearing forest cover;
- Plantation of eucalyptus trees in wetland areas, which dries wetlands and water sources;

- Increased need for timber production;
- Land requirement for agricultural investment (tea and coffee investment), more than 40 investors are registered in the zone and about 18,000ha has been given for the investors;
- Absence of significant benefit from the protection of forest resources for the local communities;

Participants of the discussion suggested the following measures to reverse or arrest environmental degradation of the natural resources, mainly forest:

- Promote small scale irrigation and increase productivity per ha of farm land;
- Develop mini-hydropower schemes in areas away from the main grid to replace fire wood and charcoal need;
- Introduce alternative livelihood system like modern beehives, spice production and marketing, ecotourism (there are about 200 ecotourism attractions in the zone), etc;
- Introduce energy saving stoves and better technologies;
- Promote biological conservation works;
- Protect wetland areas, water towers and bamboo forest areas;
- Strict implementation of forest management plan;
- Work on capacity building and technology transfer;
- Promote fish farm on rivers such as Baro, Ganji, Beku, and Gemedero rivers;
- Reforestation of degraded areas.

NGOs working in natural resources in the zone are: MELCA Ethiopia and Ethio-wetland.

SLM project is working mainly focusing on livelihood improvement in 11kebeles of the zone, forest conservation and awareness creation.

## 2.10 CONSULTATION WITH MELCA AT MASHA TOWN

MELCA representative at Mesha town explained that MELCA is a local NGO established to support sustainable forestry in Ethiopia. MELCA provide awareness on forest conservation, livelihood and education of school children about the use and benefit of natural forest. MELCA prepared land use map of three kebeles in Sheka through participatory action with each kebele communities. It played significant role in the process of registering the Sheka forest biosphere reserve in UNESCO. Promote establishment of cooperatives on spice production and marketing, Beekeeping and marketing and animal fattening. Also formulate club in schools named Sen. The purpose of the club is to create awareness among the school children about the conservation of ecosystem. They select volunteer students and take for five days to forest reserve areas and introduce tree species and their uses such as medicinal use, ecological and habitat uses , etc.

*Figure 2-4: Discussion with MELCA Representative At Masha Town of Sheka zone*

*Source: this study*

## 2.11 CONSULTATION AT METU TOWN, ILUABABORA ZONE

Illuababora zone consists of 22 Rural woredas and two urban kebeles. The zone is rich in water resources and forest. Baro Kela, Geba and Sore rivers are the main tributaries of Baro river originated in Iluababora Zone. Yayu forest biosphere reserve is also located in this zone. The core area of the biosphere is 21,000ha.

There are NGOs working on Wild Coffee Conservation (WCC) and Environmental Coffee Conservation Forum (ECCF) in the zone. SLM project is working in six woredas of the zone.

The existing environmental problems of the zone are:

- soil erosion on farm lands and steep slopes,
- Encroachment of farm into natural forest areas,
- Lack of alternative energy to substitute fuel wood consumption,
- Conversion of wetlands into farm land

Efforts being done to arrest these environmental problems include: Organizing youths in group and assign land area for tree nursery production, honey production, spice production and marketing.

## 2.12 CONSULTATION WITH THE MINISTRY OF ETHIOPIAN ENVIRONMENT, FOREST AND CLIMATE CHANGE

Consultation with protected forest directorate Dr Menassie Gashaye (Tel. 0912093330) was conducted on February 17/2016. He explained that the inventory of forest areas have been conducted and interpretation and analysis of the data is ongoing. The land use land cover map of the country is going to be issued within few months and will be available for the public. Regarding Gambela area, the inventory of forest resources has not been done so far and they are planning to undertake the inventory before finalising the land use land cover map of the country.

## 2.13 Consultation with Ethiopian Wildlife Conservation Authority (EWCA)

Discussion was conducted with Ato Girma Timer, protected areas development and protection senior expert. He indicated that GNP is very important park in terms of biodiversity and being Trans Boundary Park. The park has pressurized by investment activities and resized due to encroachment of farm activities. In terms of management, there is interim management plan and the overall management of the park has given to African parks network centre which is working under Inter government Authority for Development (IGAD).

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Regarding the impact of the proposed water resource development project on the Gambella National park, Ato girma expressed his fear that if the migratory route between Gambella and Boma national parks is blocked by water resources development the impact on the wildlife and biodiversity would be significant. However, if the project properly designed considering the national parks and wildlife movement corridors, the impact would be minor.

## 2.14 Consultation with Horn of Africa Regional Environment Network Center

The organization is working on the integrated land use development plan in Gambela region. The project is under the literature review at the time of consultation on October 9/2015. The project also includes preparation of strategic environmental and social Assessment. As part of the consultation scheme, they established consultation units in Gambela region for each type of livelihood projects (eg, consultation unit for aquiculture and fishery, consultation unit for tourism, for small &large scale irrigation, etc.). They are preparing land use map for each zone including Gambela town.

## 2.15 Consultation with Ethio Wetlands and Natural Resources Association (EWNRA)

The following information was obtained:

- Goal: develop awareness, skill and capacity for sustainable use of wetlands, forests, agro ecosystems and associated natural resources.
- Activities: documentation and information (under taken various studies), integrated wetland-watershed management (projects implementation: agricultural land husbandry, capacity building, community improvement, livelihood diversification, and income improvement, experience exchange visits, mainstream crosscutting issues), awareness and environmental advocacy, clean water and sanitation, participatory forest management, activities in favour of women…
- Record of major impacts on project sites
- Links with EPA for drafting wetland proclamation
- Location: head office at Addis Ababa and 8 field offices (3 within the BAS: Mizan Teferi, Masha, Metu)
- EWNRA brochure

- Expected soft documentation about past and current activities
- Many small wetlands located in the forest area (non-identified by the remote sensing analysis) are significant for upper catchment management (no census available…)

## 2.16 CONSULTATION WITH ETHIOPIAN ENVIRONMENTAL PROTECTION AUTHORITY (EPA)

The following information was obtained:

- EPA is in charge of the Ethiopian forest inventory (remote and field sensing): founded by FAO
- EPA involved in studies of buffer zone around main reservoirs (GIBE-GERD)
- Activities are planned into the GTP, such as forest rehabilitation
- Keep in touch for further documentation when available (forest census)

## 2.17 CONSULTATION WITH AFRICAN PARKS (APN)

The following information was obtained:

- APN is identified to implement the Gambella National Park Management Plan.
- APN has done surveys of Gambella – Omo wildlife.
- HoARECN establish a land use plan of Gambella area with livelihood improvement projects
- “There is currently an attempt to prepare and legalize a land use and development plan for Gambella. This effort is led by the Horn of Africa Regional Environment Center of the Addis Abeba University. It is funded by European Union (EU) through IGAD and relevant ministries is both the Federal and Regional government are members of the steering committee that finally approves the Land use and development plan.
- APN is a major player in the land use plan study, as it is responsible on the identification of a net of areas for wildlife conservation. The Ethiopian Wildlife Conservation Authority (EWCA) and ASU (?) are all stoners in this.”
- Meeting to organize with Martin Rickelton at Addis or Pablo Schapira in Gambella: ample information supported with maps (actual and proposed areas for wildlife protection) should be obtained
- Gambella National Park land use and management plan to be collected when approved
- Ethio-Russian Project: seasonal biological studies include lot of information on aquatic resources

**ENTRO**
**Eastern Nile Technical Regional Office**

# BARO-AKOBO-SOBAT MULTIPURPOSE WATER RESOURCES DEVELOPMENT PROJECT STUDY

## BASELINE, DEVELOPMENT POTENTIALS, KEY ISSUES AND OBJECTIVES REPORT

## ***Annex 3: Socio-economic environment***

*Final version - April 2017*

# CONTENT OF ANNEX 3

# BARO-AKOBO-SOBAT MULTIPURPOSE WATER RESOURCES DEVELOPMENT STUDY - BASELINE STUDY

# Annex 3-A Socio-economic environment in the Ethiopian part of the BAS Sub-basin

# TABLES AND FIGURES

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# ACRONYMS AND ABREVIATIONS

| | |
|---|---|
| AfDB | African Development Bank |
| ACORD | Association for Cooperative Operations Research and Development |
| ACTED | Agency for Technical Cooperation and Development |
| BAS | Baro Akobo Sobat |
| CAMP | Comprehensive Agriculture Development Master Plan |
| CBA | Cost Benefit Analysis |
| CMA | Catchment Management Association |
| CRA | Cooperative Regional Assessment |
| DEM | Digital Elevation Model |
| EEPCO | Ethiopian Electric Power Corporation |
| EHA | Erosion Hazard Assessment |
| EIA | Environmental Impact Assessment |
| ENID | Eastern Nile Irrigation and Drainage |
| ENCOM | Eastern Nile Committee Of Ministers |
| ENPM | Eastern Nile Planning Model |
| ENPT | Eastern Nile Power Trade |
| ENSAP | Eastern Nile Subsidiary Action Plan |
| ENTRO | Eastern Nile Technical Regional Office (NBI) |
| EPA | Environmental Protection Authority |
| FAO | Food and Agriculture Organization |
| GDEM | Global Digital Elevation Model |
| GDP | Gross Domestic Product |
| GEF | Global Environment Facility |
| GIS | Geographic Information System |
| GTP | Growth and Transformation Plan |
| GWh/y | GigaWatt hour/year |
| HEP | Hydroelectric Power |
| IDEN | Integrated Development of Eastern Nile |
| ILWRM | Integrated Land and Water Resources Management |
| IPCC | Intergovernmental Panel on Climate Change |
| IUCN | International Union for Conservation of Nature and Natural Resources |
| IWMI | International Water Management Institute |
| IWRDMP | Integrated Water Resources Development and Management Plan |
| IWRM | Integrated Water Resource Management |
| JMP | Joint Multipurpose Project |
| MAFCRD | Ministry of Agriculture, Forestry, Cooperatives and Rural Development |
| MASL | Meters Above Sea Level |
| MCA | Multi Criteria Analysis |
| MDG | Millennium Development Goals |
| MEDIWR | Ministry of Electricity, Dams, Irrigation and Water Resources |
| MERET | Managing Environmental Resources to Enable Transitions |
| MLFI | Ministry of Livestock and Fisheries |
| MoA | Ministry of Agriculture |
| MoEN | Ministry of Environment |
| MoWIE | Ministry of Water, Irrigation and Energy |
| MSIOA | Multi Sector Investment Opportunity Analysis |
| MTR&B | Ministry of transport, roads and bridges |
| MW | Mega Watt |
| MWC&T | Ministry of Wildlife Conservation and Tourism |
| NB-DSS | Nile Basin Decision Support System |
| NBI | Nile Basin Initiative |
| NCORE | Nile Cooperation for result project |
| NDVI | Normalized Difference Vegetation Index |
| NELSAP | Nile Equatorial Lakes Subsidiary Action Program |

| | |
|---|---|
| NGO | Non-Governmental Organization |
| Nile-COM | Nile Council of Ministers |
| PIM | Project Implementation Manual |
| PLSPP | Policies, Legislation, Strategies, Plans, and Programs |
| PPP | Private Public Partnership |
| PMU | Project Management Unit |
| PRSP | Poverty Reduction Strategy Program |
| RATP | Regional Agricultural Trade and Productivity Project |
| RPSC | Regional Project Steering Committee |
| RSS | Republic of South Sudan |
| RUSLE | Revised Universal Soil Loss Equation |
| SAP | Subsidiary Action Program |
| SEA | Strategic Environmental Assessments |
| SIS | Soil Information System |
| SLMP | Sustainable Land Management Program |
| SNNPR | Southern Nations, Nationalities and Peoples' Region |
| SRFE | Satellite Rainfall Estimates |
| SRTM | Shuttle Radar Topographic Mission |
| SSEA | Strategic Social and Environmental Assessment |
| SVP | Shared Vision Program |
| SWAT | Soil and Water Analysis Tool |
| SWOT | Strength Weakness Opportunity Threat |
| SWSC | Soil-Water Storage Capacity |
| UNDP | United Nations Development Program |
| UNHCR | United Nations High Commissioner for Refugees |
| UNICEF | United Nations Children's Fund |
| USAID | United States Agency for International Development |
| WaSH | Water Sanitation and Hygiene |
| WB | World Bank |
| WBISPP | Woody Biomass Inventory and Strategic Planning Project |
| WCYA | Women, Children and Youth Affairs |
| WEES | Water for Eastern Equatoria |
| WFP | World Food Program |
| WM | Watershed Management |
| WRMA | Water Resources Management Authority |
| WRMD | Water Resources Management and Development |
| WSS | Water Supply and Sanitation |
| WUA | Water Users Association |

# 1. POPULATION DYNAMICS

## 1.1 SIZE

The current population of the BAS basin is estimated to be over 5.7 million. Of this, 53 % of the population lives in Ethiopian part of the basin, while 47 % live in the South Sudanese part of the basin. The remaining population live in the Sudanese, Ugandan and Kenyan parts of the basin.

Some important demographic indicators at national scale (Ethiopia) are shown in Table 1-1 below.

*Table 1-1: Key demographic characteristics - Ethiopia*

| Indicator | Value |
|---|---|
| Population (millions) | 96.6 |
| Rural population (%) | 83.0 |
| Urban population (%) | 17.0 |
| Household size (mean) | 4.6 |
| Average annual growth (%) | 2.9 |
| Total fertility rate (children born/woman) | 5.2 |
| Birth Rate (births/1,000 population) | 37.7 |
| Death rate (deaths/1,000 population) | 8.5 |
| Total dependency ratio (%) | 84.0 |
| Average life expectancy (years) | 63.0 |
| Population density (people per km²) | 87.0 |
| HDI rank | 178 |

***Sources:*** *World Bank, 2015; World Development Indicators (2013); UNDP, Human Development Report 2013; CIA, World Fact Book (2015).*

The Ethiopian part of Baro-Akobo-Sobat sub-basin includes Gambella Regional State and parts of Oromia, SNNPR and Benishangul-Gumuz regions. The combined current population of the these parts of Ethiopia in the BAS sub-basin is estimated at 3.04 million of which 49.8% are males and 50.2% females. The majority (i.e. 88.4%) of the people live in rural areas and the rest 11.6% are urban residents.

*Table 1-2: Proportion of population of administrative level 2 (Zones) within the BAS sub-basin*

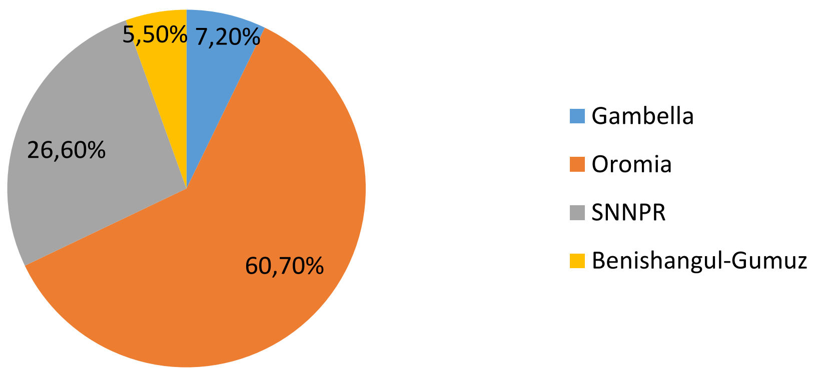
| Regions in Ethiopian Side of the Basin | Administrative level 2 (Zones) in Ethiopian Side of the Basin | Population of administrative level 2 (Zones) within BAS sub-basin | Population of administrative level 1 (Regions) within BAS sub-basin |
|---|---|---|---|
| Benshangul -Gumaz | Asossa | 134,727 | 134,727 |
| Gambella | Agnuak | 145,833 | 362,978 |
| | Majang | 75,078 | |
| | Nuer | 142,067 | |
| Oromia | Ilubabor | 677,592 | 1,750,032 |
| | Jimma | 23,848 | |
| | Kelem Welega | 747,921 | |
| | Mirab welega | 300,671 | |
| SNNPR | Bench Maji | 415,176 | 795,399 |
| | Keffa | 125,885 | |
| | Sheka | 254,338 | |
| | **Total** | **3,043,135** | |

***Source**: CAS (2012): Projected population for 2015*

## 1.2 Population Distribution and Density

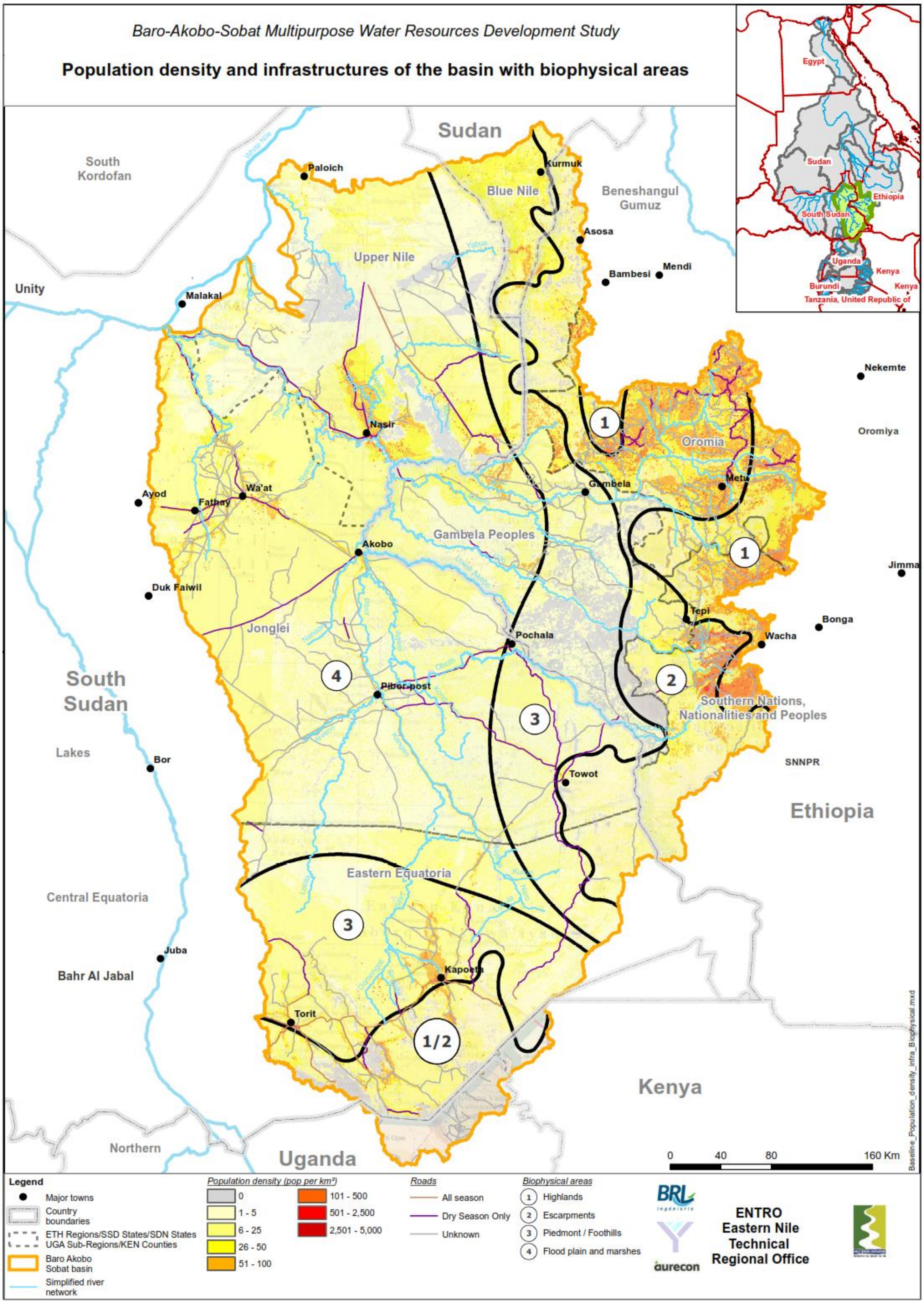
As depicted in **Erreur ! Source du renvoi introuvable.**, Oromia region accounts for about 61% of the proportion of the population within the Ethiopian part of the BAS sub-basin, followed by SNNPR (27%). Gambella and Benishangul-Gumuz regions account for 7% and 5% respectively.

*Figure 1-1: Distribution of the region's population in the Ethiopian part of the BAS Sub-basin*




The highlands of the BAS Sub-basin in Ethiopia (in Oromia and SNNPR) are relatively densely populated with average crude density varying from 43-70 people per $km^2$, whereas areas in the Gambella and Benishagul-Gumuz regions are less populated, with the average crude density varying from 10-16 people per $km^2$ (See Figure 1-2).

*Figure 1-2: Population density in the BAS sub-basin*



### 1.2.1 Population Growth

Ethiopia has a relatively high birth rate of 38 births/1,000 people and death rate of 9/1,000 people. The annual population growth rate for Ethiopia is estimated to be 2.9% in 2014. It is projected that the Ethiopian population will reach 106 million by 2020 (Aynalem, 2014), making Ethiopia the second most populous country in Africa after Nigeria.

An annual population growth rate of 2.9% means that the population of Ethiopia will double in 26 years, i.e. by 2040. Population growth has serious implications for national socio-economic development and use of natural resources. Table A4.4 presents the population growth rates and densities in the Ethiopian area of the BAS sub-basin. The population density in the regions varies from 10 people per km² in Gambella to 70 people per km² in the parts of Oromia region.

*Table 1-3: Annual Population Growth Rate and Density in Regions in the BAS sub-basin in Ethiopia*

| Region | Growth Rate | | Population Density (per km²) |
|---|---|---|---|
| | Rural | Urban | |
| Gambella | 2.71 | 10.3 | 10 |
| Oromia | 2.56 | 17.0 | 70 |
| SNNPR | 2.98 | 9.7 | 43 |
| Benishangul-Gumuz | 2.43 | 16.9 | 16 |

*Source: ENTRO (2009): One System Inventory.*

### 1.2.2 Age Dependency Ratio/Population Pyramid

The age structure of the Ethiopian population is dominated by the youth, with the population under age 15 years accounting for about 45% of the total population. The productive population (15-64 years) makes up 53% of the total population. The youth and elderly dependency ratios are 77.2% and 6.3% respectively. The total dependency ratio is estimated to be 83.5% as of 2014 (CIA Fact-book, 2015). An age structure dominated by young population approaching reproductive age will further support rapid population growth in the decades to come.

### 1.2.3 Mobility and Rural-Urban/Urban-Rural Migration

In Ethiopia, internal migration flows are currently large and substantial, occurring as traditional internal mobility (i.e. for marriage), rural-urban migration, rural-rural migration, resettlements, displacement and refugees. This mobility occurs due to push factors (lack of development or social and economic opportunities, conflicts, natural disasters such as floods and droughts, etc., in the place of origin); and pull factors (economic and social opportunities - both real or imagined - in the receiving areas).

The main push factors in Ethiopia are overpopulation, famine, poverty, land scarcity, governmental agricultural policies and a lack of agricultural resources. Resettlement policies and development initiatives of the government also contribute to internal migration and mobility in Ethiopia. Besides, urbanization in Ethiopia is a growing trend that influences mobility and puts pressure on urban infrastructure and resources (via De Waal, 1991; Ezra & Kiros, 2001).

The BAS sub-basin, especially Gambella and Benishangul Gumuz regions, are experiencing rural-rural migration, resettlements, displacement and refugee flows. The two regions also have a high mobility of their own population. The in-migration rate is significantly higher than the national average. Though limited in size, urban areas in these regions show immigration rates of over 200 per thousand.

Gambella region has received a large number of new settlers and refugees during the last 2-3 decades as a result of government resettlement policies, internal conflicts and civil war in South Sudan. More recently, there has been a growing influx of people into the region due to the demand for labour by large-scale commercial farms as well as people fleeing conflicts in South Sudan.

Urbanization and development in rural settlement in the regions contributed to rural-urban migration and internal mobility in the BAS Sub-basin. Therefore, population mobility and migration have become important development issues, since they exert increasing pressure on existing social and economic services and local livelihood resources.

The main drivers of large involuntary migration include resettlement programs; acquisition or allocation of large tracts of land for investments, intra- and interethnic conflicts; frictions between new settlers and indigenous people, natural hazards (e.g. floods and droughts), political violence, and civil conflicts in South Sudan.

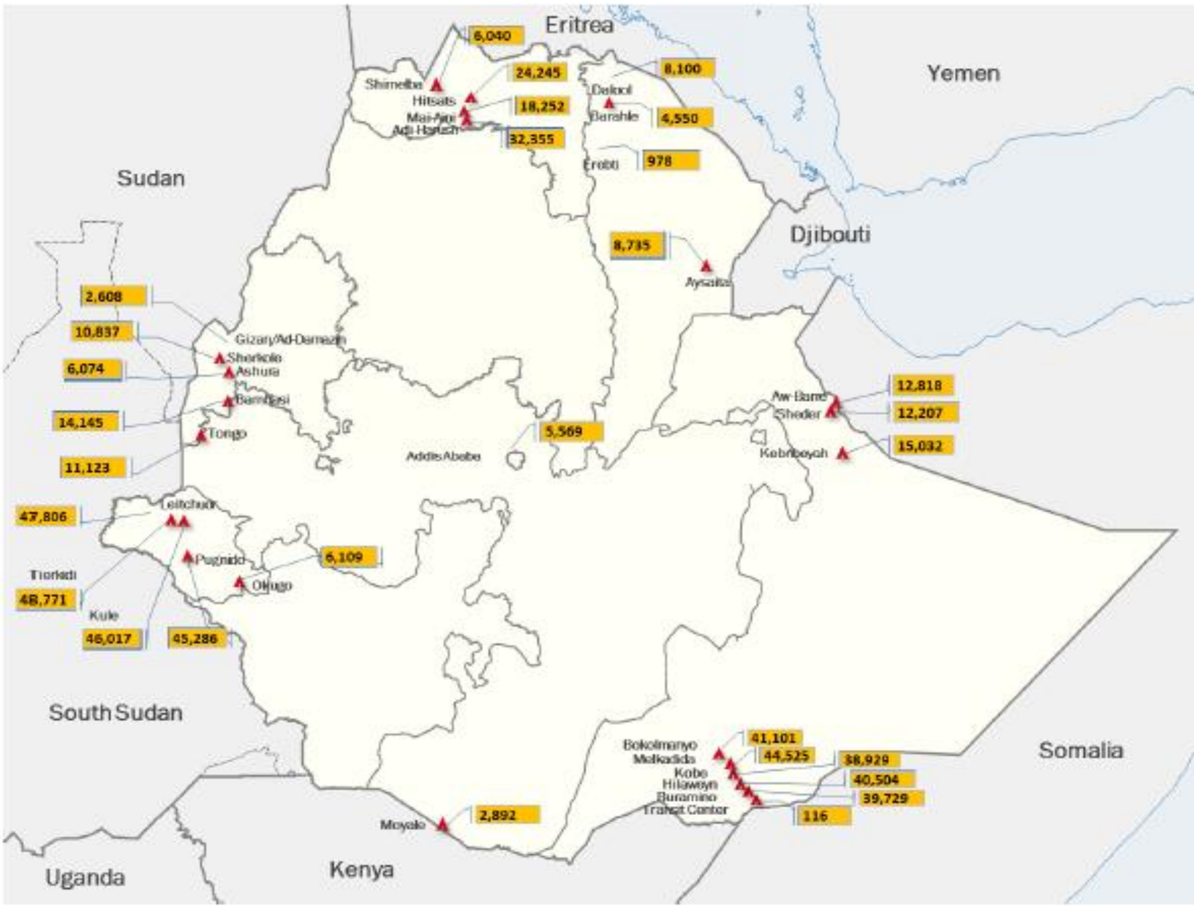
Employment opportunities as well as current urbanization trends and high levels of unemployment are likely to become the major catalysts of migration into the sub-basin in the future. It is likely that migration flows into the sub-basin will continue to increase due to limited employment opportunities, poverty, overpopulation, food scarcity in the sending areas (i.e. the highlands), and conflicts, political instability in receiving areas (i.e. lowlands).

New migrants contribute to labour supply for the growing number of large-scale investments in the sub-basin in Ethiopia, thereby contributing to the local economy. Therefore, future development planning must consider net migration flows into the sub-basin and how the likely impacts of involuntary migration and refugee problems will be addressed to reduce adverse impacts and to enhance the potentially positive effects of population mobility. The likely impacts of these factors on the future development of the BAS sub-basin should be explicitly addressed at both policy, program and specific project levels.

### 1.2.4 Refugees

Ethiopia hosts over 643,010 refugees from other countries, including those from the part of the sub-basin in South Sudan. The largest population groups comprise South Sudanese (39% of the total number of refugees) and Somalis (38%), followed by Eritreans (17%) and Sudanese (6%). In addition, there are persons of concern from Kenya in Moyale, and urban refugees from several other countries including the Democratic Republic of Congo (DRC), Yemen, Burundi, Djibouti, Rwanda and Uganda (about 1% of the population) (See Figure 1-3).

*Figure 1-3: Location and Population of Refugee Camps in Ethiopia*




***Source:*** *ARRA/UNHCR/WFP and Partners (2014): Ethiopia: Joint Assessment Mission Report*

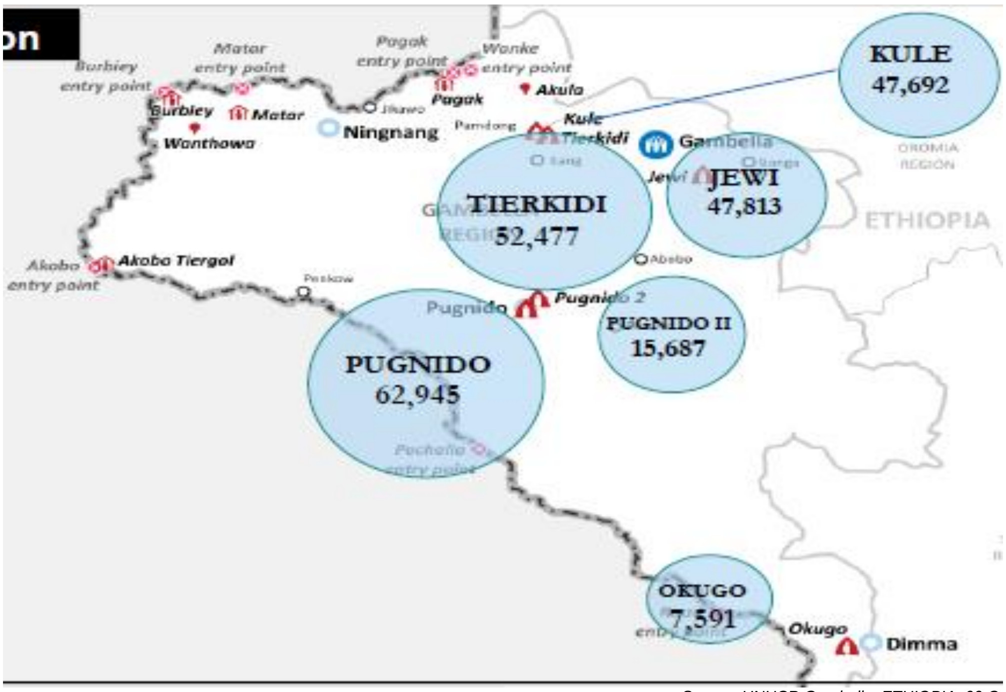
There has been a high influx of refugees into the Ethiopian part of the sub-basin, especially into Gambella and Benishangul-Gumuz regions. These regions receive and host large numbers of refugees, mainly from South Sudan. As of October 2015, the total number of South Sudanese refugees in the Ethiopian part of the sub-basin was 277,757, of which 234,205 were living in camps in Gambella region and 43,552 were living in host communities. The distribution of refugees in camps with a total number of persons in each camp is shown in Table 1-4. Of the persons living in camps, a large majority (i.e. 67%) were children, and 33% were adults.

*Table 1-4: South Sudanese refugee population in Gambella (October 2015)*

| Camp | Children (age <18 years) | | Adults (age >18 yrs) | | Total | % |
|---|---|---|---|---|---|---|
| | Males | Females | Males | Females | | |
| Pugnido | 21,259 | 20,027 | 6,936 | 14,723 | 62,945 | 27 |
| Tierkidi | 18,558 | 17,891 | 3,993 | 12,035 | 52,477 | 22 |
| Jewi | 17,803 | 17,093 | 2,359 | 10,558 | 47,813 | 20 |
| Kule | 15,552 | 14,824 | 6,020 | 11,296 | 47,692 | 20 |
| Okugo | 2,362 | 2,203 | 976 | 2,050 | 7,591 | 3 |
| Pugnido II | 5,298 | 4,991 | 1,729 | 3,669 | 15,687 | 7 |
| Sub-Total | 80,832 | 77,029 | 22,013 | 54,331 | 234,205 | 100 |
| Grand Total | 157,861 | | 76,344 | | | |
| **%** | **67** | | **33** | | | |

***Source****: UNHCR Gambella, Ethiopia; 09 October 2015.*

*Figure 1-4: Refugee Camp Sites and Population in Gambella Region*




Source: UNHCR Gambella, ETHIOPIA; 09 October 2015.

In addition to the 277,757 South Sudanese refugees living in Gambella region, there were 44,787 refugees at refugee camps in Benishangul-Gumuz region as of October 31, 2014.

The total number of registered refugees in Benishagul-Gumuz was 50,926 at the end of January 2016 (Source: UNHCR, February 2016).

The influx of refugees into the Ethiopian part of the sub-basin (i.e. Gambella and Benishagul-Gumuz) has significant but relatively undocumented consequences for the host communities. Although these regions have one of the lowest population densities in Ethiopia, there is, however, a growing pressure on land, particularly the fertile but limited riverine land that supports flood-retreat farming for the Anuak people and provides pastureland for grazing for the Nuer during the dry season.

This phenomenon is particularly pronounced in the Gambella region. Use of this riverine land is contested, not only at the inter-ethnic level but also intra-ethnically, the various Nuer clans have frequently fought over access water points in this area. The protracted conflict between the Jikany and Lou Nuer, and the violent conflicts among the various Gaajak clans are also cases in point.

The leasing of hundreds of thousands of hectares of land to foreign companies with the advent of large-scale commercial agriculture in the region has further increased pressure on land. Refugees might, as was the case in previous times, also seek to access the contested land, further fueling this resource-based conflict. The problem is further compounded as the Nuer to aggregate into kinship groups (clans, sub-clans, etc.).

Another impact is pressure on the environment (see Figure 1-5). This is due to refugees' dependency on wood for energy and construction, as well as clearing of land for habitation, which are serious problems in most refugee camps and leading to rapid deforestation in most areas around the camps. Firewood is commonly used in all camps for cooking. Women spend a significant amount of their time walking long distances in search of firewood, which creates protection related risks and is a source of conflict between refugees and host communities.

The large influx of refugees has also created pressure on existing social services and infrastructure. In addition, health problems and risks to the host or receiving communities are significant in receiving areas. Health risks from the transmission of diseases across borders and from refugee camps are significant risks to both refugees and host communities.

*Figure 1-5: View of refugee camp in Bambasi Woreda, Benishangul-Gumuz Region*

*Source: Shewakena and Harris, D (2105).*

### 1.2.5 Resettlement and Communization (Villagization)

Successive Ethiopian governments since the 1970s have initiated population relocation schemes and villagization to varying degrees. During the Derg (1974-1991) people were forcibly resettled from highlands to the south and southwest, particularly in Gambella, Benishangul Gumuz and in western Oromia (then known as Wellega Province).

The EPRDF (Ethiopian People's Revolutionary Democratic Front), which took over state power from Derg in 1991, was apathetic to the benefits of such schemes (resettlement and villagization). In the early 2000s, however, population relocation schemes were resuscitated and reintegrated into Ethiopia's food security and rural development strategies. To a significant extent, villagization remained on paper until the end of the decade when, in 2009, the Ethiopian government announced plans to "villagize" an estimated 1.5 million individuals by mid-2015 (Fana, 2014).

The government planned to undertake villagization in four regions: Afar, Somali, Gambella, and Benishangul-Gumuz. The plan calls for relocating 1.5 million people (i.e. 500,000 people in Somali; 500,000 in Afar; 225,000 in Benishangul-Gumuz and 225,000 in Gambella. In Afar and Somali this was supposed to be done in a one-year program, while in Gambella and Benishangul-Gumuz it was to be done in a three-year program starting in mid-2010 (Davison, 2011). Villagization and its implementation faces many challenges and criticism from various stakeholders, including local people, donors, financial agencies, activists, human rights groups, research institutes, etc.

*Figure 1-6: Shift of Source of Income in a New Village*

Source: Moti, 2014

The villagization scheme is sometimes seen as a process to create ‘vacant spaces to be leased to investors’ and ‘through its villagization program.’ (HRW, 2012a; OI, 2013). The main issues which are raised are the lack of prior consultation with and consent by the local people. Reports indicate that local populations were sometimes coerced to move to new villages and that implementation is proceeding without obtaining “free and informed prior consent” from the affected population (Fana, 2014; IO, 2013).

### 1.2.6 Resettlement and Villagization in Gambella Region

In the 1980s the Derg Government established large resettlement schemes in the present Gambella region. In 1984, the Derg Government began (sometimes forcibly) resettling highlanders to this area, bringing in more than 150,000 settlers to Gambella from 1984-1988; all were resettled on land customarily claimed by the Annywa people. After the Derg Government, the migration of highlanders has continued, due mainly to the fertile land in the region - and numbers of recent migrants from the highlands has exceeded 60,000 (UNICEF, 2006).

“Voluntary resettlements” were renewed in mid-2000s by the current Government. In 2010/2011, villagization in Gambella region has occurred in woredas such as Gambella, Godere, Gog, Abobo, Dimma, and to a lesser extent also in Itang and Jor. These woredas are for the most part inhabited by Anuak, and are the closest to major infrastructure in the region, such as main roads and larger towns. These are also the areas of most intensive new agricultural land investment (HRW, 2012). In the region the villagization program was completed in mid-2013. All rural households in the region have already been villagized and reports indicate that there are difficulties in returning to old villages. There are not any more relocations, but what remains is the servicing of those already relocated to the new villages (Fana, 2014).

There are also indications that the approach to villagization is not consistently coercive. Some communities voluntarily join the new villages. When government officials failed to convince local people of the advantages of joining the new villages, local people effectively resisted relocation and remained in their old villages (Yonas and Ezra, 2013). Therefore, it was argued that differences could be better addressed by a nuanced approach based on local realities and perceptions. Options should also include a planned and regulated return to old villages, with improved governance and services. Rather than suspending all support to villagization schemes, the adoption of a sectoral approach would serve local communities best. This may include provision of better health services and food aid on humanitarian grounds that could make life more bearable in the new villages in the short term and ensure self-reliance over the long term (Fana, 2014).

### 1.2.7 Resettlement and Villagization in Benishangul-Gumuz Region

The first settlers in the Benishangul Region are now well-established, live in self-contained villages (e.g. around the regional capital Assosa) and farm their land according to traditional highland practices, on small fields using ox ploughs. Since the end of Derg rule in 1991, there has been regular voluntary movement of people from the highlands into Benishangul-Gumuz, due to population pressure in the highlands and available land in Benishangul-Gumuz. Many of these recent settlers rent land from the indigenous people (Shewakena and Harris, 2105):

The official rational for pursuing the villagization program is that the traditional dispersed settlement patterns of the indigenous communities makes it difficult to provide important and basic social services such as health, drinking water, schools, and market infrastructure. Therefore, the main objective of villagisation is to increase communities' access to social services. In Benishangul Gumuz, more than 15,000 households have already been moved to new villages by 2010/2011 (2002/03EC).

The region has planned to relocate 45,000 families. However, reports indicated that some farmers returned to their old villagers, which has created challenges to the systematic land registration process in the region. Figure A4.9 shows Villagisation Centres from where some relocated farmers return back to their original dwelling place.

*Figure 1-7: Scene from a Villagization Centre in Benishangul-Gumuz*

***Source:*** *Shewakena and Harris, 2105.*

## 1.3 MAJOR TOWNS IN THE ETHIOPIAN PART OF THE BAS SUB-BASIN

In the Gambella Region, there are 12 main towns, with a total population of 140,026 (Table below). Towns with over 10,000 inhabitants include Gambella, Kowerneng, Etang, Meti and Pigniwedo. Higher concentration of towns are in the northern part of the region. There is also presence of more road networks (i.e. all weather road and dry weather roads) in this part of the region. The region has high urban rate (31%) which is higher the national average (16.1%) (CSA, 2014).

*Table 1-1:Towns and Their Population in BG and Gambella Parts of the Basin*

| Region | Zone | Town | Total Population |
|---|---|---|---|
| BG | Asossa | Asossa | 49,145 |
| | | Hor Azahab | 1,121 |
| | | Bambasi | 18,563 |
| | | Homocha | 2,659 |
| | | **All towns** | **71,488** |
| Gambella | Newer | Metar | 5,120 |
| | | kowerneng | 11,764 |
| | | Nginngang | 4,062 |
| | | Tergol | 1,087 |
| | Etang special woreda | Etang | 10,706 |
| | Megeng | Meti | 12,828 |
| | Agnuak | Gambella | 70,099 |
| | | Abol | 1,969 |
| | | Abobo | 7,354 |
| | | Pigniwedo | 10,097 |
| | | Shentewa | 1,165 |
| | | Dima | 3,775 |
| | | **All towns** | **140,026** |

*Sources: (1) CSA (2012) Projected Population for 2016 (2) CSA (2014) E Ethiopian's Rural Facilities and Services Atlas 2014 for BG and Gambella Regions*

In the Benishangul-Gumuz region there are 23 main towns, of which only four are in the sub-basin. Towns with over 10,000 inhabitants in Assosa zone are Assosa and Bambasi towns.

In Oromia region, there are some 368 towns, of which nearly 40 are in the BAS sub-basin. Their population size is given in the table below. Towns with over 10,000 inhabitants are 13 towns, and another 12 towns have between 5,000 and 10,000 inhabitants.

*Table 1-1: Towns and Population in Oromia Part of the BAS Sub-Basin*

| Region | Zone | Zone | Total population |
|---|---|---|---|
| Oromia | West Welega | Gimbi | 47,674 |
| | | Ayra | 9,354 |
| | | Begi | 12,150 |
| | | Chekorsa | 2,276 |
| | | Bila | 11,226 |
| | | Geba Defeno | 4,796 |
| | | Guliso | 12,106 |
| | | Guyi | 7,495 |
| | | Homa | 3,822 |
| | | Inango | 15,962 |
| | | Bube | 7,842 |
| | | Debeso | 3,587 |
| | | Yubdo | 3,585 |
| | Kelem | Gidami | 8,618 |
| | | Haro Sebu | 7,263 |
| | | Kake | 21,703 |
| | | Tejo | 2,470 |
| | | Rob Gebeya | 8,556 |
| | | Denbi Dollo | 45,309 |
| | | Mugi | 12,081 |
| | | Nunu | 2,216 |
| | | Lalo | 4,315 |
| | | Qebe | 2,662 |

| Region | Zone | Zone | Total population |
|---|---|---|---|
| | Iluababor | Metu | 44,296 |
| | | Gore | 13,925 |
| | | Nopa | 3,095 |
| | | Yayu | 11,631 |
| | | Suphe | 11,317 |
| | | Berbersa | 2,684 |
| | | Hurumu | 6,953 |
| | | Kumbabe | 11,873 |
| | | Dega | 4,651 |
| | | Bure | 8,430 |
| | | Huka | 2,594 |
| | | Lalo | 1,790 |
| | | Becho | 1,185 |
| | | Dupa | 6,533 |
| | Jima | Chira | 7,303 |
| | | Setema | 7,277 |
| | | Sigmo | 8,482 |
| | | **All towns** | **411,087** |

*Sources: (1) CSA (2012) Projected Population for 2016 (2) CSA (2014) E Ethiopian's Rural Facilities and Services Atlas 2014 for Oromia Region.*

In SNNPR there are some 174 towns, of which 19 are located in the Sub-basin. Towns with over 10,000 inhabitants are seven towns. Another eight towns have between 5,000 and 10,000 inhabitants as shown in the table below.

*Table 1-1: Towns and Population in SNNPR Part of the BAS sub-basin*

| Region | Zone | Zone | Total Population |
|---|---|---|---|
| SNNPR | Sheka | Masha | 13,713 |
| | | Gecha | 5,280 |
| | | Tepi | 50,065 |
| | Benchi Maji | Sheko | 9,751 |
| | | Shay Bench | 8,947 |
| | | Mukutin | 17,528 |
| | | Beftu | 10,068 |
| | | Bachuma | 5,155 |
| | | Jeba | 3,753 |
| | | Tumi | 9,780 |
| | | Kibish | 1,846 |
| | | Buri | 10,774 |
| | | Mizan Aman | 68,682 |
| | | Jemu | 5,619 |
| | Kefa | Deka | 6,921 |
| | | Bita-Genet | 5,553 |
| | | Yadota | 4,097 |
| | | Wacha | 23,528 |
| | | Konda | 2,907 |
| | | All towns | **263,967** |

Sources: : (1) CSA (2012) Projected Population for 2016 ; (2) CSA (2014) E Ethiopian's Rural Facilities and Services Atlas 2014 for SNNPR.

## 1.4 POPULATION-RELATED ISSUES

Following is a summary of issues related to population dynamics in the Ethiopian part of the basin as identified in the foregoing section:

- Rapid population growth, dominated by young population in the country level as well as in the Ethiopian pars of the basin.
- Migration of outsiders into the Ethiopian parts of the sub-basin (i.e. into Gambella and Benishangul-Gumuz regions) affects the demography of the sub-basin.
- Villagisation impacts both the indigenous population and the relocated settlers in terms of disrupting the established land access arrangements and exacerbates the regional food security situation.
- Development/investment-induced involuntary relocation.
- Influx of people and refugees may escalate social conflicts and competition over land, water and other natural resources.
- There is an increased potential for conflicts over resources between new settlers as well as among indigenous people.
- Increased pressure on local resources; social services and infrastructures due to influx of refugees, migrants and large scale allocation of land to outside investors.

Although the Ethiopian side of the basin, mainly Gambella and Benishangul-Gumuz, are low populated areas, the current influx of people and refugees into these areas could lead to population increase, competition over local natural resources and pressure on social facilities and infrastructures. Therefore, population increase, migration, refugees and increased pressures on local resources, facilities and infrastructure are the key development issues in the regions under consideration.

Moreover, the resettlement and villagization programs, which were undertaken hastily and without appropriate planning and consent of the both settlers and hosting communities by the past and present governments, have adverse consequences on the local people and environments of the receiving areas. The local communities lost their lands to the schemes thereby adversely affecting livelihoods of the indigenous people. The schemes also have led to deforestation and land degradation, and thereby fuelling conflicts among ethnic groups over natural resources. Therefore, as the areas under consideration are ecologically and social sensitive ones, future development interventions need to give due attention to such key issues. Future policies, and development programs and projects should be proceeded by a potential impact assessments that would guide for decisions.

# 2. EDUCATION AND HEALTH

## 2.1 KEY EDUCATION INDICATORS

An estimated 45% of the Ethiopian population have no schooling, while 44% have some primary schooling (CSA, 2011). Urban population is more literate (78.6%) compared to rural population (49.1%). Only 0.1% have completed secondary school in rural areas compared to 3.2% in urban areas (CSA, 2011). Key indicators of education status at national level are given in Table 2-1.

*Table 2-1: Key Education Indicators*

| Indicators | Value |
|---|---|
| Literacy rate, adult total (age 15 and older) | 39% (2012) |
| Gross Enrolment Rate for primary (2013/14) | 101.3% |
| Net Enrolment Rate for primary (2013/14) | 92.6% (m=95.1; f= 90.1) |
| Pupil-Teacher Ratio, Primary level | 47 (2013/14) |
| Pupil-Class ratio primary level (2013/14) | 54 |

***Sources:*** *MoE (2015, June ): Eucation Statistics Annual Abstract from 2006 EC (2013/2014GC); WHO (2014): Ethiopia: Factsheets of Health Statistics.*

At country level, the literacy rate (for reading and writing in any language) was 53% for males and 36% for females (CSA and WB, 2013). The literacy rate in the Ethiopian part of the Basin is shown in Table A4.8 below. All areas in the basin have a low literacy level ranging from 18% in Benishangul-Gumuz to 29% in Gambella.

*Table 2-2: Adult Literacy Rate in the Ethiopian Part of the Sub-Basin (%)*

| Region | Literacy (>15 years of age) | | |
|---|---|---|---|
| | Male | Female | Average |
| Gambella | 38.6 | 10.5 | 29.3 |
| Oromia | 29.3 | 16.6 | 22.4 |
| SNNPR | 33.9 | 15.2 | 24.4 |
| Benishangu-Gumuz | 24.9 | 10.5 | 17.7 |

School enrolment in Ethiopia has increased in the last five years. Table 2-3 below presents the current situation and trends in the net enrollment rate (NER) for five years. As noted in the same table, NER increased by 3.3% in 2013/14 from the previous year and by 6.9% from 2009/10.

*Table 2-3: NER Trends at Primary Level (Grade 1-8)*

| Year | Boys | Girls | Total |
|---|---|---|---|
| 2002 EC (2009/10) | 83.7 | 80.5 | 82.1 |
| 2003 EC (2010/11) | 87.0 | 83.5 | 85.3 |
| 2004 EC (2011/12) | 86.8 | 83.9 | 85.4 |
| 2005 EC (2012/13) | 87.5 | 83.9 | 85.7 |
| 2006 EC (2013/14) | 95.1 | 90.1 | 92.6 |

***Source:*** *MoE (2015, June): Education Statistics Annual Abstract for 2006 EC (2013/2014GC)*

Net enrollment rates for secondary education (9-10) and preparatory (11-12) are provided in Table 2-4 here after.

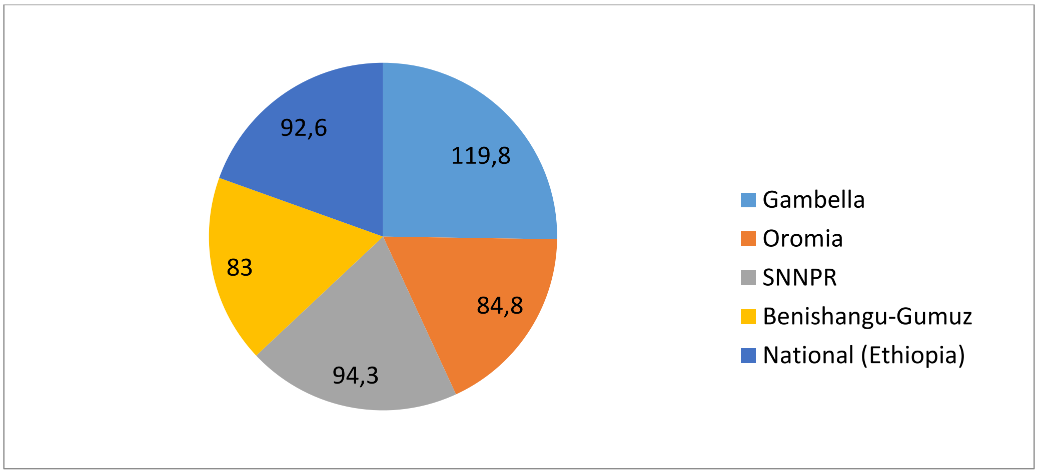
*Table 2-4: Net Enrolment Rates for Secondary School (9-10) and Preparatory (11-12)*

| Year | Secondary (9-10) | | | Preparatory (11-12) | | |
|---|---|---|---|---|---|---|
| | Boys | Girls | Total | Boys | Girls | Total |
| 2002 EC (2009/10) | 16.8 | 16.1 | 16.4 | 4.1 | 2.8 | 3.5 |
| 2003 EC (2010/11) | 16.4 | 16.2 | 16.3 | 4.5 | 3.9 | 4.2 |
| 2004 EC (2011/12) | 16.9 | 17.6 | 17.3 | 5.0 | 4.6 | 4.8 |
| 2005 EC (2012/13) | 18.8 | 20.1 | 19.4 | 5.4 | 5.2 | 5.3 |
| 2006 EC (2013/14) | 19.6 | 20.9 | 20.2 | 5.5 | 5.5 | 5.5 |

*Sources: MOE (2002-2006EC): Educational Statistical Abstracts*

The Net Enrolment Rate (NER) by regions in the sub-basin is given in Figure 2-1 below. SNNPR and Gambella rank above the national average (92.6). The NER in Gambella region exceeded 100% which suggests that the education system should put more effort into this region to enhance the on-time participation of students in primary education.

*Figure 2-1: Net Enrolment Rate in the Sub-Basin Regions (Grades 1-8) (2013/14)*




***Source:*** *MoE (June 2015): Education Statistics Annual Abstract for 2006 EC (2013/2014GC) .*

As can be seen from Table 2-5, as of 2013/14 there were 1,919 Technical Vocational Education and Training (TVET) institutions in Ethiopia. Of this number, 1,350 were public owned, 538 private and 31 owned by NGOs. The number of trainees in 2013 were 404,041, of which 50.2% were males and 49.8% were females. There are 284 TVETs in the Ethiopian side of the sub-basin.

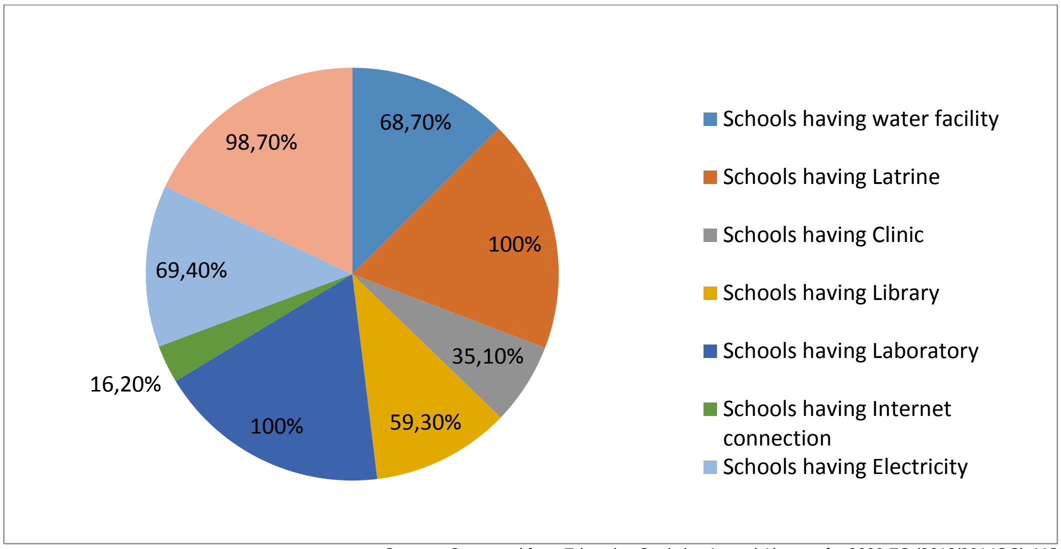
*Table 2-5: TVETs in Ethiopia and the Sub-Basin Regions (2013)*

| Country and Sub-Basin Regions | Distribution of TVETs by Ownership and Basin Regions |
|---|---|
| TVETs in Ethiopia | 1,919* |
| Public | 1,350 |
| Private | 538 |
| NGOs | 31 |
| TVETs in Regions in the Sub-basin | 284 |
| Oromia | 212 |
| Gambella | 3 |
| Behnisahgul_Gumuz | 4 |
| SNNP | 65 |

***Source****: MoE, 2014; MoE (2015, June ): Education Statistics Annual Abstract for 2006 EC (2013/2014GC).*
**The figure includes TVETs from nine regions and from the two city administrations.*

Figure 2-2 shows that nearly all schools have facilities such as latrines, laboratories and TVs. About 69% of schools have water and electricity. Only 16.2% of secondary schools have internet connections, and about 59% have a library.

*Figure 2-2: Availability of Basic Facilities in Secondary Schools*




***Source:*** *Computed from Education Statistics Annual Abstract for 2006 EC (2013/2014GC), MOE, 2015.*

Recent surveys indicate that the literacy level was 60% for males and 43% for females in 2013-2014. For school-age population (7-18 years of age), about 36% of boys and 34% of girls were not in school. Primary and secondary enrolment rates were similar for both sexes. About 60% were enrolled in primary schools and the remainder (less than 4%) were enrolled in secondary school. (CSA and WB, 2015). Generally, literacy levels of the population are still low, both at national and sub-basin levels.

Issues and Indicators:

- Literacy level is still low in the country, as well as in the BAS sub-basin.
- Much of the school age population (about 36% of boys and 34% of girls) still remain out of school.
- On-time participation of students in primary education is low in Gambella and BG.
- Shortage of school facilities such as water supply, toilets, library, internet, etc.

## 2.2 Health Status and Trends

### 2.2.1 Health Status

The Ethiopian population is predominantly rural with limited access to safe water, housing, sanitation, food and health care (Table 2-6). Total expenditure on health was 4.7% of the GDP in 2011. Investment in health through development of health infrastructure and improvement of access to clean water sources and sanitation has kept Ethiopia’s health status on upward trend in recent decades. The key health indicators are summarized in Table 2-6.

The country has a death rate of 9/1,000 people. The average life expectancy has increased significantly from about 49 years in 1994 to 63 years in 2014. The maternal mortality ratio was 950 per 100,000 live births in 1990, and 420 by 2013. The infant mortality rate decreased from 122 per 1,000 live births to 44/1,000 in 2013. Less than half (49%) of the households have access to an improved water source, and only 24% of the population use improved sanitation.

*Table 2-6: Health indicators*

| Indicator | Units and % |
|---|---|
| Death rate | 9/1000 |
| Infant mortality ( in 2014) | 44/1000 live births |
| Life expectancy (in 2014) | 63 |
| Contraceptive prevalence rate (2010/11) | 28.6% |
| HIV/AIDs (adult prevalence rate) (in 2012) | 1.3% |
| HIV/AIDs (people living with HIV/AIDs) (2012) | 758,600 |
| HIV/AIDs – death (in 2012) | 47, 200 |
| Maternal mortality rate (deaths/100,000 live births (2013). | 420 |
| Antenatal care coverage (2013) | 43% |
| Underweight children under the age of 5 (2012) | 29.2% |
| Health expenditures (2011) | 4.7% of GDP |
| Physicians density (physicians/1000 pop. (2009) | 0.03 |
| Hospital bed density (beds/1000 pop.) (2011) | 6.3 |
| Population using improved drinking water sources (2012) | 52% |
| Population using improved sanitation (2012) | 24% |

***Sources*** *(i) WHO, Regional Office for Africa (2014): Factsheets of Health Statistics: Ethiopia (ii) http://www.indexmundi.com/ethiopia/demographics_profile.html*

The health indicators shown above indicates that Ethiopia has made major strides in the past 15 years, investing heavily in health infrastructure and in developing community-based primary care that is sustainable in low-resource settings. By the end of 2010, a total of 33,819 HEWs (Health Education and Welfare) had been trained and deployed, covering 89% of communities in the country. Antenatal coverage (percentage of women receiving at least one ANC visit) has increased from 26.8% in 2000 to 43% in 2013. This gain is partly due to the work of the HEWs.

### 2.2.2 Nutrition

The poor nutritional status of children and women continues to be a serious problem in Ethiopia. The health sector has increased its efforts to support nutritional practices through health education, treatment of extremely malnourished children, and provision of micronutrients to mothers and children. The 2014 Mini-DHS revealed that there has been a substantial decline in the proportion of children stunted and underweight in the last 15 years and a smaller decline in the prevalence of wasting. Some 40% of children under the age of five were stunted, 9% were wasted and 25% underweight in 2014.

Table 2-7 shows a decreasing trend in the proportion of children stunted and underweight over the four DHS surveys. The prevalence of stunting decreased by 31% (from 58% to 40%) between 2000 and 2014. The decline in the proportion of stunted Ethiopian children shows a reduction in chronic malnutrition over the past 15 years. The proportion of children underweight declined even more substantially, by 39% during the same period. There has only been a small decline in the prevalence of wasting over the last 15 years.

*Table 2-7: Trends in Nutritional Status of Children under age 5 (2000-2014).*

| Year | Stunting | Wasting | Underweight |
|---|---|---|---|
| 2000 | 58 | 12 | 43 |
| 2005 | 51 | 12 | 33 |
| 2011 | 44 | 10 | 29 |
| 2014 | 40 | 9 | 25 |

*CSA, 2014: Mini DHS Survey*

### 2.2.3 Health Issues

In Ethiopia diseases responsible for deaths and disability (i.e. disease burden) include malaria, prenatal and maternal death, acute respiratory infection, nutrition deficiency, diarrhea and HIV/AIDs. Communicable diseases are the main cause of mortality in the country that account for about 70% of the causes (WHO, 2013), followed by non-communicable diseases (20%) and injuries (10%)[1].

The main health problems in the Ethiopian part of the Sub-basin are diseases which include tsetse, yellow fever, malaria, Onchocerciasis and Schistosomiasis. These diseases are major constraints to economic and social development in the Sub-basin. In the future, there is a risk that many of these diseases are likely to increase as a result of development interventions such as irrigation, hydropower reservoirs, expansion of human settlements, and influx of people into the basin due to large-scale farm development and investments. There is a risk that malaria will become perennial instead of seasonal; and tsetse will increase with the increase in the livestock population and with the use of animal traction for crop production.

## 2.3 SYNTHESIS OF HEALTH ISSUES

Key determinants of health status, and health systems include the following:

- High prevalence of communicable diseases;
- Unsafe drinking water and poor sanitation facilities;
- Nutritional deficiencies among children and mothers;
- Prevalence of non-communicable diseases (blood pressure; cholesterol) and other risks factors for health (smoking, alcohol consumption) and prevalence of physical inactivity among adults;
- Budget limitations in financing health care;
- Poverty, inequality, and low literacy.

[1] Ethiopia: Health Profile (undated) http://www.who.int/gho/countries/eth.pdf?ua=1

# 3. GENDER RELATIONS

## 3.1 STATUS OF WOMEN IN ETHIOPIA

In its commitment to gender equality, the Ethiopian government has issued a national policy of Women in 1993 that granted equal rights to women in the country's constitution. Various policies and affirmative actions have been taken for improving women's status and for their social, economic and political empowerment. These include amending discriminatory provisions in the civil code; establishing women's affairs offices in ministries and in regional states; affirmative measures during recruitment and employment in government and in education and training; increased proportion of women in the house of peoples' representatives, etc.

Women in Ethiopia have a longer life expectancy than men, living on average to age 65, while men live to 62 years (WHO, 2013). The adult literacy rate for women lags behind that of men, though is slightly higher for the younger generation aged 15-24 (WB, 2012). School enrolment is approaching gender party; boys and girls are attending almost equally. Primary school attendance ratios are 64.3% for boys and 65.5% for girls. Secondary school attendance ratios by sex are almost equal (15.7% of males and 15.6% of females) (WB, 2012).

However, women still have a lower socio-economic status than men in Ethiopia. Out of 136 countries, Ethiopia ranks 118 on the Global Gender Gap Index. In educational attendance, the country is 131 in equity in educational attainment, due to the large gap in literacy rate (29% for women and 49% for men) (WEF, 2013).

## 3.2 GENDERED DIVISION OF LABOUR IN THE BAS SUB-BASIN

### 3.2.1 Gambella Region

Women in the region are mostly engaged in household and farm activities. Involvement in off-farm activity such as petty trading is limited. In addition, women are constrained by a lack of capital, lack of access to credit and lack of time due to the burden of household responsibilities. This prevents them from participating fully in income earning activities.

The role of women and men is in most cases similar from one ethnic group to the other. In Anywa/Anuak culture, there is a division of labor among family members. Anywa women are responsible for cultivation, collecting and preparing food, while men clear and prepare land, grow and sell locally grown tobacco.

Among the Nuer, there is also a division of labor between men and women. Men look after cattle, cultivate crops, and construct huts. Women take care of household chores such as child care, cooking, milking cows, carrying wood and elephant grass for construction. In addition, women are also involved in grinding grain.

### 3.2.2 Benishangul-Gumuz Region

Women in this region are the primary agricultural producers, income earners, and responsible for food preparation and care for the family. They are involved in hard labour and work for more than 16 hours in a day, compared to the lax working culture of men. This overstretched time of women affect their health, reduces time for care of infants and elders and preparation of food. Moreover, they lack access to productive assets such as arable land and inputs for production. They do not have access to participate in local decision-making processes and have no access to credit, or to improved technologies. There are also many traditional practices that still exist and particularly affect women, such as female genital mutilation (among the ***Berta and Shinasha*** people), early, exchange and levirate marriages, polygamy and abduction. The practice of early and exchange marriage denies women the right to participate in education and participation in wider socio-economic development.

Moreover, during childbirth, ***Gumuz*** women culturally leave their home and go to the forest, where birth takes place unassisted sometimes with disastrous consequences. Gumuz women are not allowed to stay at home during menstruation. Food avoidance practices due to cultural taboos (avoiding eating eggs and milk among some clans) mostly affect women.

The practice of scarification of their body (for beauty and identity), smoking and similar practices affect both men and women. Many cultural practices have adverse effects on health including the transmission of HIV/AIDS and other communicable diseases.

### 3.2.3 SNPPR Region

Although the role of men and women from one ethnic group to the other is similar in many respects, in ***Sheckicho (Mocha)*** nationalities, women are prohibited from consuming certain foods, as women do not eat meat, but they only cook. Thus, diets and nutritional status of men and women are determined by gender-based prohibition on preparation and consumption of certain foodstuffs such as meat.

### 3.2.4 Oromia Region

In ***Oromo*** communities, women in most cases do all the work except ploughing and sowing. They participate in all forms of crop production and livestock raising. In the absence of a male child, women have the right to inherit their father’s property. Even when there are male children, they get a small amount of the property.

# 4. SOCIAL STRUCTURE AND ORGANIZATION

## 4.1 CENTRAL, STATE, REGIONAL AND LOCAL GOVERNMENT

Ethiopia has a federal system of government which was established in the 1990s. Ethiopia comprises nine ethnic regional states and two city administrations. The nine states are divided into 84 Zones, 725 Woredas (districts), and 14,817 rural Kebeles (the lowest administrative unit) as shown in the following table and in the administrative map (see Figure 4-1).

*Table 4-1: Zones, Woredas and Urban/Rural Kebeles by Region in the BAS sub-basin*

| Region | Zones | Woredas | Kebeles | | |
|---|---|---|---|---|---|
| | | | Urban | Rural | Total |
| Oromiya | 20 | 278 | 540 | 6,349 | 6,889 |
| Benishangul-Gumuz | 5 | 20 | 30 | 410 | 440 |
| SNNPR | 22 | 145 | 264 | 3,587 | 3,851 |
| Gambella | 4 | 13 | 17 | 207 | 224 |

***Source**: CSA, 2013.*

Each level of administration has an elected head, a council with an executive committee and a sector bureau/office. However, zonal governance structures vary and do not always have a council. Zonal administrators oversee woredas; provide technical assistance to woredas and are responsible for development activities and the provision of public services.

Woredas (districts) are responsible for planning and implementing their own development activities in line with Federal and State policies and plans. They oversee the role and function of kebele administrations under their jurisdiction. Woreda councils consist of directly elected representatives from each kebele in the woreda. The woreda has a dual accountability: upward to its respective zonal and regional executive committees, and downward to its electorate.

The woreda cabinet (also referred as the executive committee) consists of members, mostly from sector bureau chiefs. Woredas also have a court which falls under the authority of regional judicial system. The main constitutional powers and duties of the woreda council and its executive are as follows: (Yilmaz and Venugopal, 2008):

- Preparing and approving annual woreda development plans and budgets, and monitoring their implementation,
- Setting tax rates and collecting local taxes and levies (principally land use tax, agricultural income tax, sales tax and user fees,
- Administering the fiscal resources available to the woreda,
- Constructing and maintaining rural roads, water points and woreda level administrative infrastructure (offices, quarters),
- Administering primary schools, health institutions, and veterinary facilities,
- Managing agricultural development activities, protecting natural resources, etc.

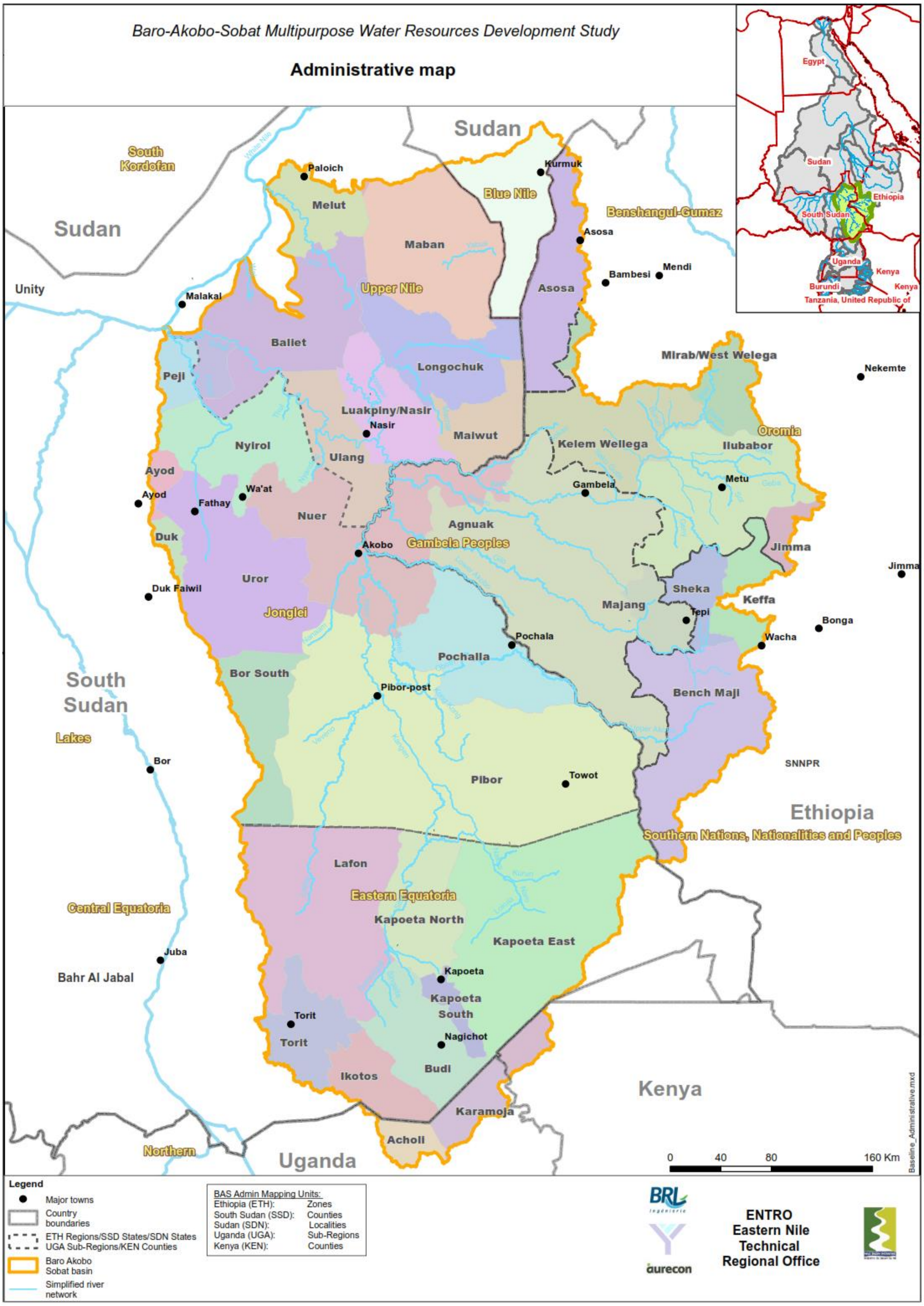
Kebeles are in practice the primary contact level for most Ethiopians. They consist of an elected Kebele Council (in principle 100 members), a kebele cabinet (executive committee of 5-7 persons) a social court (comprising three judges), and the development and security staff posted in the kebele. Kebele executive committees answer to their Woreda Council. The kebeles provide a link between the state and households and are responsible for enforcing the directives from the government ministries. In remote areas, the kebeles may be the only administrative body; and governmental services are delivered through them. The main responsibilities of kebele council and executive committee are (Yilmaz and Venugopal, 2008):

- Preparing an annual kebele development plan;

- Ensuring the collection of land and agricultural income tax;
- Organizing local labour and in-kind contributions to development activities;
- Mobilizing community members for development works (such as road construction);
- Resolving conflicts within the community through the social courts.

Community level governance operates through a twin system of traditional and formal leadership involving elders and the formal kebele administration. Ethnic groups in SNNPR, Oromia, Gambella and Benishangul-Gumuz regions have a traditional governance system based on an age or a generation-based system of seniority. At community level, the most senior members of a community will often be a group of elders who are responsible for making key decisions. However, even elders do not have absolute power of decision-making as decision-making often based on agreement and consensus among a group of elders, with input from other members of the community and the formal kebele administration. At household level, decision making is typically the responsibility of the senior male.

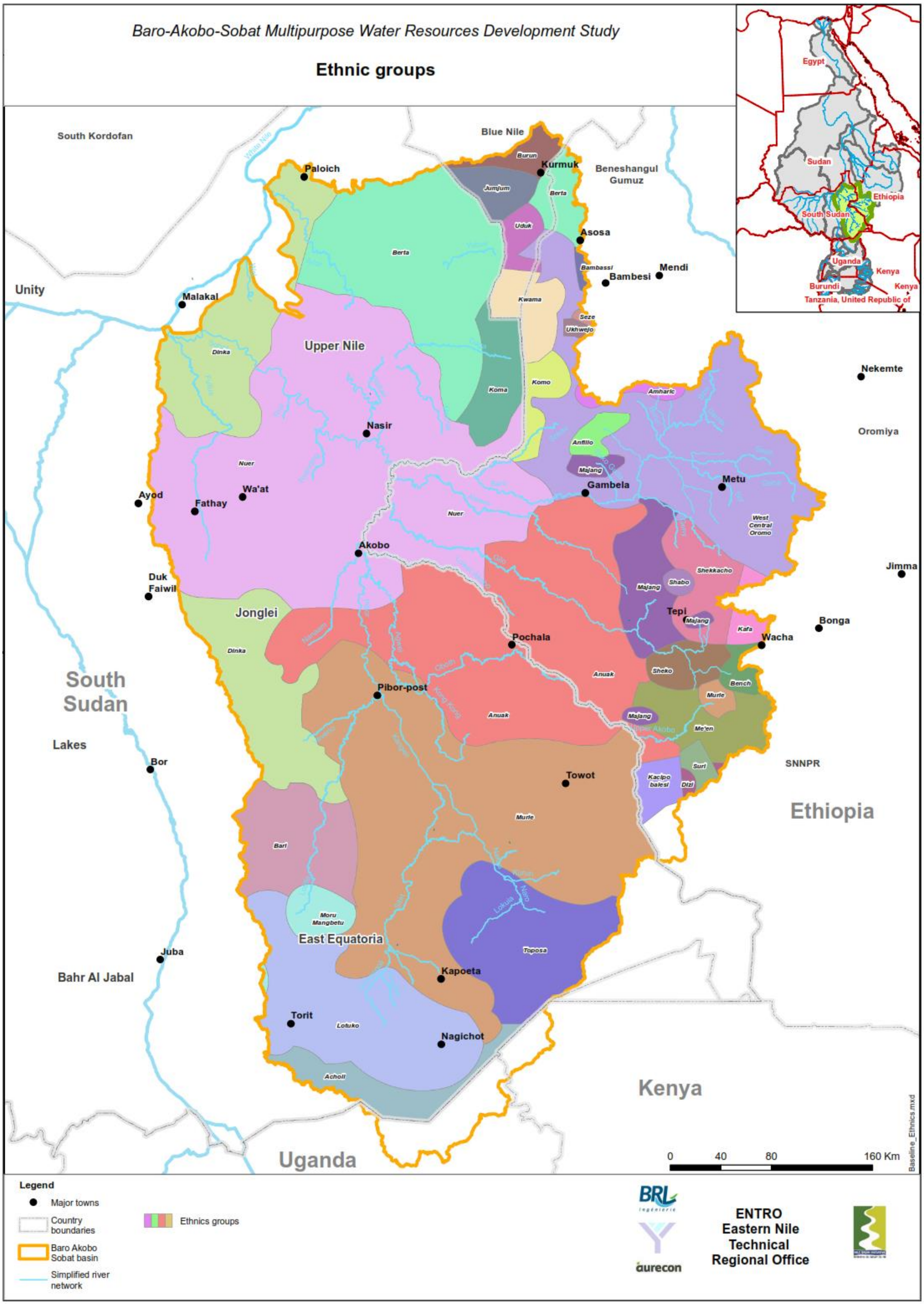
*Figure 4-1: Administrative map of the BAS*



## 4.2 SOCIO-ETHNIC GROUPS IN ETHIOPIAN PART OF THE SUB-BASIN

The Ethiopian part of the BAS Sub-basin includes parts of four regional states. The major socio-ethnic groups inhabiting these regions are presented in the following paragraphs and located in the map next page.

*Figure 4-2: Distribution of the ethnic groups in the BAS sub-basin*



### 4.2.1 Oromia Region

In terms of ethnic composition, the major ethnic groups in the region include Oromo (85%), Amhara (9.1%), and the remaining 5.9% are other ethnic groups (CSA, 2007). Afan Oromo, presently written with Latin characters, is the official language (ONRS, 2011). The large majority in the Oromia part of the sub-basin are Oromo people.

Oromo people occupy compact farming villages on the upland slopes and plateau of Halu Bure Woreda, Alledidu Woreda and Sale Nono Woreda, in the Illu-Ababora zone of Oromia Regional State. Their way of life revolves around subsistence agriculture, trading in local markets, animal husbandry (mainly keeping draught oxen), and the harvest of wild coffee from the forest (NORPLAN, 2006).

Oromos respect their elders and value social responsibility, helping others, bravery, and hard work. Knowledge of history and culture is admired. Oromos can count their family trees through ten generations or more. These values are expressed in *geerarsa* or *mirisa* (singing), storytelling, poems, and proverbs. *Geerarsa* is used to praise good behaviour and discourage inappropriate behavior.

The Oromo regard harmony and solidarity as a virtue that can help create an indissoluble unity. The idea of Oromo unity incorporates harmony and solidarity between nature, God and human beings. The Oromo oral arts and belief systems emphasize that the existence of an individual is reliant on the stability and continuity of the society. It means that the right, value and attribute of an individual is driven from and shaped within the larger society. Yet personal initiatives and action may not be discouraged in so far as they do not violate the socio-cultural standards (Jeylan, 2006).

The Oromo have an indigenous calendar based on skillful readings of the astronomical configurations of the moon and the stars. They have also indigenous systems of resolving social, economic and political conflicts. They have used these systems to live in peaceful coexistence with neighboring tribal and ethnic groups and to negotiate or redefine their relationships with them.

The *Gada* System is the most common among the largest Oromo ethnic groups. The Oromo have a well-developed age-based system grouping upon which the religious, political, economic and social life of the people is based. The *Gada* system organizes Oromo society into age groups and rotates leadership in egalitarian democracy every eight years and is most remarkable and unique.

The socio-political functions of the *Gada* system, a system of an age grade classes that succeed each other in assuming economic, political and social responsibilities. A complete *Gada* cycle consists of five age-grades. The authority held by the elders is derived from their position in the *Gada* system. According to *Gada*, those people who have entered the *Luba* group (individuals in the 40-48 age group) are considered to be elders.

Elders in the Oromo community form a dominant component of the customary mechanisms of conflict management. The *Lubas* (elders) settle disputes among groups and individuals and apply the laws dealing with the distribution of resources, criminal fines and punishment, protection of property, theft, etc. After *Luba*, men automatically retire from *Gada* and move into an advisory role known as *Yuba*. They receive a great deal of respect as wise experienced authorities and repositories of knowledge and law, but their decisions are no longer final as they had been before. At this point they turn their attention to private family businesses or religious activities, while their sons enter *Gada*, the public service (Junior Worldmark Encyclopedia of World Cultures, 1999)

The *Gada* system has always guided the religious, social, political, and economic life of the Oromo people. The institution is still functional in different parts of Oromia along with the modern administration system. In the *Gada* system, elders were responsible for teaching, resolving conflicts, and nurturing Oromo culture. Seniority is thus an important factor in Oromo relationships. The system helps to exercise democracy, participatory government and leadership.

For example, the Borana use their *Gada* leadership to avoid conflict over water resources. The wells are managed by a council of the clan group which includes a retired *hayyuu* (special counsellors or individuals who hold ritual authority to judge, the *Jallaba* (a local lineage of clan elder or special messenger, the *Abbaa Konfi* (trustee of each well), the *abbaa herregaa* (the coordinator of water use and maintenance) and other members of the traditional leadership (Jeylan, 2006).

### 4.2.2 Gambella Region

The Nuer, Anywa, Mejeng, Amhara and Keffa ethnic groups form the largest socio-ethnic groups. The Nuer constitute 46.65%, Anywa 21.17%, Amhara 8.42%, Oromo 4.83%, Mejeng 4%, Kefficho 5.05%, and the rest are Kembata, Shekecho, Bench, Tigrians and others (CSA, 2008).

Nuers are predominantly cattle-breeders but they also cultivate flood recession maize and sorghum to supplement their diet of milk and blood, thus cattle are jointly owned by families. The Nuer are pastoralists and transhumance cultivators. They move from the banks of the rivers to the uplands and vice versa, depending on the seasons and the flooding of rivers. The rivers typically flood the plains from June through August, at which time the Nuer and their livestock move to live in the upper woodland areas and cultivate crops for this season. At the end of the floods in October/November, they return with their livestock to the banks of the rivers and stay there until May to herd their animals and cultivate crops on land enriched by the floods. For the Nuer the rivers are vital for their sustenance as well as the survival of their livestock (Desalegn, 2011).

The seasonal movements in “Nuerland” is mainly to find suitable grazing lands for the Nuer’s cattle, a practice directly threatened by the villagization process. As agro-pastoralists, the majority of Nuer have little experience living in sedentary settlements. Cattle are uniquely dependent on their livelihood strategy, ethnic identity, and cultural patterns. Nuer language is unique within the Gambella region, and cannot be understood by other ethnicities. The Nuer are also well-known for their unique cultural practices, including their ritual scarification (HRW, 2012).

The Nuer people belong to Nilotic ethnic group. The majority of Nuer are found in South Sudan but a significant number of Nuers are found in Gambella Region. They inhabit five woredas of the region and are the largest ethnic group consisting of more than 46% of the population in Gambella.

Until very recently, cattle have historically been of the highest symbolic, religious and economic value for the Nuer. Cattle are particularly important due to their role as bride wealth, where they are given by a husband’s lineage to his wife’s lineage. It is this exchange of cattle which ensures that the children will be considered to belong to the husband’s lineage and to his line of descent.

The Anywa live in dispersed settlements. They are dependent mainly on the cultivation of the land and crop production (maize, sorghum, sweet potato and groundnuts). They also supplement their income with fishing on riverbanks, with hunting as a source of meat, honey production, and access to a wide variety of forest resources and grasslands around them.

Cultivation is based on the use of hoe and other hand tools, and most of the time the produce is not sufficient for the needs of families the whole year round. Therefore, the period from January to May is known as the “hardship season”. April and May is the difficult and “hungry season” and during this period people may be reduced to starvation. During the scarcity of food, families depend on wild foods collected from the forests and to live through the hardship and hunger seasons. The Anywa eke out a precarious existence and depend greatly on the ecosystem and surrounding natural resources for their survival (Desalegn, 2011; UNCEF, 2006).

The Anuak are a Luo Nilotic Ethnic group. The Anuak in Ethiopia are the second largest ethnic group occupying most parts of Anuak zone of Gambella region. The Anuak share some cultural traits with the Nuer and the largest ethnic groups in the region have a mutual understanding. Cultural similarities exist between the Nuer and Anuak, but in a limited extent even though these tribes are both from Nilotic group.

The Mejeng/Majang are found in southeastern Gambella bordering SNNPR. They are the third largest ethnic group accounted for 4% of the Gambella population. The Mejeng inhabit mainly in Godere and Mengesh woredas. They live in scattered communities in the forests of South-western Ethiopia and are often interspersed with other ethnic groups. Their livelihood activities include slash and burn farming, hunting, fishing and bee keeping. They prepare a special drink made by boiling coffee leaves with a mixture of spices. While the Mejeng traditionally shifted their residence often, they have recently established permanent villages.

The Mejeng are shifting cultivators who also practice hunting and extract honey from the forest. They occupy the escarpment west of Met down to Gog, a landscape of broad-leaved tropical rain forests. The Mejeng inhabit the area which is the most densely forested in the region and they depend on forest resources for their livelihood. They cultivate maize, sorghum, godere (cassava), taro, yams and pumpkins, spices, herbs and peppers, sesame, beans, peas and pulses. A principal source of livelihood is bee-keeping. Mejeng families tend numerous hives, often more than fifty. They are particularly noted as good honey producers for which the forest ecosystem is critical. Selling honey and clay pots provides their main - almost only - cash income.

For all population groups the ecosystem provides a variety of essential resources, including wood for tools, grass for homesteads, wild food, medicinal and other useful plants, and access to water resources ( NORPLAN, 2006; Desalegn, 2011).

The Opuo and Komo tribes are smaller in number compared to the major indigenous ethnic groups. The Opuo depend on sedentary cultivation for their livelihood, while the Komo depend on shifting cultivation (NORPLAN, 2006). These people depend heavily on the natural resources for their livelihoods. They cultivate a variety of crops using simple tools and practicing shifting cultivation.

Gambella region is one of the main regions where resettlement programs of the previous government took place. Many highlanders have settled in Gambella, Gog, Jor, Abobo and Godere woredas. Late in 1993, after the demise of the Derg, there were 13,000 settlers in Abobo Woreda with an unknown number in Godere Woreda. In addition, there have been large numbers of refugees settling in Gambella due to the civil war and other conflicts in Sudan (NORPLAN, 2006) and later in South Sudan. A critical issue is the relationship between indigenous people and recent settlers/migrants.

### 4.2.3 Benishangul-Gumuz Region

The region is home to diverse ethnic groups, of which five are indigenous. The indigenous ethnic groups according to size are Berta (26.7%), Gumuz (23.4%), Shinasha (7.0%), Mao (0.6%) and Komo (0.2%. Significant numbers of Amhara (22.2%), Oromo (12.8%) and others (7.1%) also live in the region. There are also significant numbers of settlers in the region from various parts of the country as a result of resettlement programs carried out by previous governments.

“Gumuzland” is endowed with vital natural resources such as abundant land with fertile soils, extensive forest and vegetation with diverse plant species that also serve as a habitat for wildlife, and ample perennial water resources. The Gumuz base their livelihood on these natural resources, deriving their livelihood from agriculture (cultivation of crops and rearing livestock), hunting and gathering wild food. Shifting cultivation alongside gathering wild forest food, raising livestock (mainly goats and chickens), hunting, fishing, collecting honey, handicrafts, and local market exchange are major elements of the Gumuz subsistence economy.

Agriculture accounts for about 93.2% of the people’s livelihood. Individuals also engage in income-generating activities to supplement food gaps. These activities include artisanal mining, sale of firewood and charcoal, day labor, pottery and similar activities.

The Gumuz have a special relationship to their land and the environment. They possess knowledge about their natural resources and environment based on observation and experience. Indigenous knowledge is important to the Gumuz system of natural resource management which can be best understood along with their traditional belief systems. The Gumuz hold that vital natural/land resources are sacred and that natural resources are a gift, blessing and creation of *Yamba* (the supreme deity), which is the source of all life and livelihoods to the past, present and future generations. *Yamba* endows the Gumuz with knowledge of proper use, management and a responsibility of passing the natural resources to the next generation. Different resources have their own *Missa* (poly-spirits) that ensure their proper use and management; violations result in severe punishments and retribution from the respective Missa (Woldesilassie, 2007).

The Berta are mostly Muslim and many speak fluent Arabic. They are very conservative in their religion and culture. Most of them speak Bertigna/Rutanigna - the indigenous language as well as Arabic, Amharic and Oromifa. They have traditional customs that are similar to those of their Nilo-Saharan neighbors. Ritual specialists called *neri*, who have healing and divination powers, still exist and can communicate with evil spirits (*shuman*).

Rain-making rituals are also found among the Berta, as among other Nilo-Saharan and Nilotic communities. In their wedding ceremonies music is played by males with large calabash trumpets (*was'a*). The Berta decorate their faces with scarifications, usually three vertical lines on each cheek, which they consider to be symbols of God (each line is interpreted as the initial letter of Allah, the Arabic *alif*). The Berta are slash-and-burn agriculturalists. Their staple food is sorghum, with which they make porridge in ceramic vessels. Working parties play an important role in Berta society. When somebody needs to build a house or cultivate a field, he calls his neighbors for help and provides then with beer and food.

### 4.2.4 Southern Nations, Nationalities and Peoples Region (SNNPR)

There are about 56 ethnic groups inhabiting SNNPR. These ethnic groups reside in their own administrative/geographical area (zones), special woredas or woredas having unique language, culture and other social values. More than 80 indigenous and non-indigenous languages are spoken in the SNNPR. Among them, about 50 indigenous languages are spoken by different ethnic groups.

The ethnic composition of the population includes seven major languages (Sidamigna, Wolaytigna, Hadiyigna, Siltigna, Goffigna, Guragigna, and Kaffigna) which are widely spoken by 60.7% of the region’s population. Sidamigna and Wolaytigna are the two major languages spoken by 17.3% and 11.1% of the total population, respectively. In urban areas, Amharic is spoken by 39.8% of the total urban population and followed by Wolaytigna and Hadiygna language spoken by 11.8 and 5.2% of the urban population, respectively (Aweke, 2011).

In SNNPR, Benchi Maji, Keffa and Sheck zones fall in the Ethiopian part of the sub-basin. The seven largest ethnic groups in the Bench Maji Zone were the Bench (45.11%), the Me’en (21.36%), the Amhara (8.23%), the KaffichoKafficho (6.55%), the Dizi (5.17%), the Sheko (4.21%), and the Suri (3.88%); all other ethnic groups made up 5.49% of the population. In Keffa Zone the four largest ethnic groups are the Kafficho (82.72%), the Bench (5.05%), the Amhara (3.67%), and the Oromo (3.5%). Other ethnic groups make up 5.09% of the population. The seven largest ethnic groups reported in Sheka zone were the Shakacho (32.41%), the Amhara (22.17%), the Kafficho (20.16%), the Oromo (7.39%), the Bench (5.23%), the Sheko (4.24%), and the Mejeng (1.73%); all other ethnic groups made up 6.67% of the population (CSA, 2007 Census).

The institution of Sera is operative among many ethnic groups on SNNPR. The sera institution has been operative in one form or another among, Gamo, Gofa and among Oromos in some localities. The institution of Sera has been operative among many ethnic groups, particularly in the SNNPR region (e.g. among Sidama, Gurage, Walaita, Kambata, Gamo, Gofa, and Hallaba) and as well as among Oromos in some localities. Traditionally, it is an ethical and moral code. It provides social security to members and provides a means of decision making through consensus. It obliges the individual to accommodate the majority, to seek harmony and consensus rather than an individual opinion and personalized justice.

*Sera* mainly relates to domestic communal life and traditionally is a means of consensus and consent over individualism. It also requires social collaboration and cooperation from its members, for example, when a house is built or a funeral is held. It regulates the contributions and obligations within the community.

### 4.2.5 Religions affiliation

In the 2007 census, the ‘question on region’ included six religions; Orthodox Christian, Protestant; Catholic, Muslim/Islam, traditional and others. Religious groups reported in the 2007 Census in the Ethiopian part of the Sub-basin are shown in Table 4-2 below.

In Gambella region, the majority of the people (70.1%) are protestants; 16.8% Orthodox Christians; 4.8% Muslims, 3.4% Catholic; while 3.8% practice traditional beliefs. Other religious groups make up 1.1 % of the population.

In Benishangul-Gumuz 45% of the population are Muslim, 33.3% Orthodox Christians, 13.5% Protestant, and 7.1% practice traditional beliefs. Other religious groups make up 1.1% of the population.

*Table 4-2: Distribution of Religious Groups in Ethiopian Area of the Sub-Basin*

| Region | Religious affiliation (%) | | | | | |
|---|---|---|---|---|---|---|
| | Orthodox | Protestants | Catholic | Muslim | Traditional | Others |
| Gambella | 16.8 | 70.1 | 3.4 | 4.8 | 3.8 | 1.1 |
| Oromiya | 30.4 | 17.7 | 0.5 | 47.5 | 3.3 | 0.6 |
| SNNPR | 20 | 55.5 | 2.3 | 14.1 | 6.6 | 1.5 |
| Benishangul-Gumuz | 33.3 | 13.5 | - | 45 | 7.1 | 1.1 |

***Source:*** *CSA (2007): Population Size and Characteristics, Part I*

According to the 2007 census, the religious composition of the population of Oromia Region was 47.5% Muslims, 30.4% Orthodox Christians, 17.7% Protestants, and 3.3% traditional, 0.5% Catholic, and 0.6% were followers of other religions. In SNNPR 55.5 % of the population were Protestants and 20% were Orthodox Christians. Of the total population, 14.1% were Muslims, 6.6% traditional worshipers, 2.3% catholic and 1.5% were followers of other religions.

Generally, in terms of religious composition, protestants are the majority in Gambella and SNNPR, while Muslims are the majority in Oromia and Benishangul-Gumuz.

## 4.3 IMPLICATIONS FOR DEVELOPMENT INITIATIVES IN THE BAS SUB-BASIN

The main following social features discussed in this chapter 4 can be summarized as follows:

- Many indigenous peoples, with their distinct cultures, values and belief systems, and cultural heritage, inhabit the Ethiopia part of the sub-basin. The needs, livelihoods and priorities of the indigenous people in the sub-basin are a key factor in development planning.
- The great diversity in culture, language, religion and economic activities of local communities suggests the existence of various interests, demands and potential for conflicts at the local level.
- The existence of a variety of traditional knowledge, natural resource management and conservation systems can be used in planning interventions for protecting and conserving natural resources such as water.
- Relationships among the various ethnic groups are characterized by both cooperation (reciprocity) and conflicts, which vary over space and time, depending on the demographic and socio-economic dynamics in the Ethiopian part of the sub-basin.

- Traditional governance systems and conflict resolution mechanisms can be entry points for addressing inter and intra-ethnic conflicts.
- High dependence of indigenous people, ethnic groups, and communities on natural resources (water, land, forests, etc.) for their livelihoods and economic activities suggests that any development impacting local natural resources would have far-reaching implications on the lives and livelihoods of the indigenous communities.

# 5. CONFLICTS AND NATURAL HAZARDS

Even though there is relative peace and stability in the Ethiopian part of the sub-basin, both inter and intra ethnic conflicts and sporadic border clashes are frequently occurring. The main ones include ethnic/tribal, natural resource-related, and political ones. On the other hand, the Ethiopian part of the BAS Sub-basin (particularly areas in Gambella Region) is affected by natural hazards like flooding and droughts.

## 5.1 CONFLICTS

### 5.1.1 Types of conflicts

As described above, there are a number of ethnic groups in the Ethiopian part of the Sub-basin. Relationships between or among ethnic groups include both cooperation and conflict. Elements of cooperation include reciprocity and complementary socio-economic exchanges. Yet the dominant pattern of inter-groups relations in the basin, especially in Gambella and Benishangul-Gumuz, is conflict which manifests itself in the destruction of villages, riots in schools; attacking public transport to the killing of individuals to humiliate the group to which they belong (Dereje, 2009). Table 5-1 shows the main inter and intra-ethnic conflicts in the Ethiopian part of the basin.

*Table 5-1: Inter-and Intra-ethnic Conflicts in the Ethiopian Area of the BAS Sub-Basin*

| **Region** | **Level of Conflict** | |
|---|---|---|
| | **Inter-ethnic conflict** | **Intra-ethnic conflict** |
| **Gambella** | Anuak and the Nuer | Regional cleave among Anuak clans (Lull/Openo divide). |
| | | Resource conflicts among Nuer clans (i.e. Gaajak and the Gaajok). |
| | Anuak and the Majang | Party politics among the Mejeng clans: (emerging separate identity of the Thiang vis-a-vis the Gaajak). |
| | Anuak with Nuers of Thiang sub-clan | Nures with Chengajawa sub-clan and with Lou Nuers. |
| | | Lou Nuers from South Sudan with Nuers in Gambella. |
| | | Gaajak/Gaajok divide (in South Sudan). |
| | | Resource conflicts among the five Gaajak clans (e.g. Thiang with two Gaajak sections – Cieng Reng and the Cieng Nyajani). |
| **Benishangul Gumuz** | Gumuz and Bertha conflict.<br>Gumuz and Amhara conflict.<br>Conflicts between indigenous people and settlers over land resource.<br>Gumuz and Oromo conflicts.<br>Conflicts between indigenous and migrants. | Intra-clan conflicts among Gumuz.<br>Intra-ethnic conflicts due to adultery.<br>The Bertha inter-familial disputes (intra-Bertha division). |
| **Oromia** | Oromo and Gumuz conflict over regional boundaries. | |
| **SNNPR** | Mejeng and Sheka conflict over land resources.<br>Mejeng and Oromo conflict over land resources.<br>Conflict among Surma, Dizzy and other ethnic groups. | |

Gambella is the most conflict-ridden region in the Ethiopian part of the Sub-basin. Although there are examples of reciprocity and complimentary socio-economic exchanges, the dominant pattern of inter-group relations in the region is conflict.

### 5.1.2 Inter-ethnic conflicts

The Anuak-Nuer conflict is the most prominent of all conflicts in the region. It dates back to the second half of the 19th century when a section of the Nuer (Jikany) migrated to the east from southern Sudan. The main driving force of Nuer territorial expansion are access to and control over vital natural resources, cultivation and pasture lands along the tributaries of the Sobat.

### 5.1.3 Intra-ethnic conflicts

Intra-ethnic conflict in the Gambella region is evident in the regional cleavages among the Anuak; party politics among the Mejeng and the resource conflict among the Nuer clans. The main fault line in Anywaa politics is the Lull/Openo divide, those who live along the Baro River and the forest region, respectively. Struggle for political power among the Anuak is often framed in the language of Lull against Openo.

There is also tension among the Mejeng on issues related to political power within the MPDO (the Mejeng People Political Organisation) and the divergent reactions of the Majang to land encroachments by their neighbours.

The most intense intra-ethnic conflict is among the Nuer. This conflict is expressed at two levels: political competition among the tribal and clan elites and the conflict over scarce natural resources among the villagers. The Nuer who live in the Gambella region (the Jikany) are divided into three tribes: The Gaajak, the Gaajok and the Gaaguang. The mode of political relation among the three tribes is competitive and at times very hostile. This is true particularly between the Gaajak and the Gaajok. The Gaajak resent the dominant political status of the Gaajok in the wider Nuer society particularly in Southern Sudan (Dereje, 2009).

Due to their size in Gambella Region and a higher degree of incorporation into the Ethiopian state system, the Gaajak occupy a dominant status in Nuer politics in Gambella. Intra-ethnic identity politics among the Nuer is also acted out in the emerging separate identity of the Thiang vis-a-vis the Gaajak. Immigration of the South Sudanese Nuers into Ethiopia is a major factor contributing to tension and land conflicts, and often sparks armed inter-ethnic conflicts in which Anyawa have almost always been the losers (UNICEF, 2006).

In Benishagul-Gumuz there are two major interrelated political conflicts that have gripped the region in the last few years - the Bertha and Gumuz dispute regarding political power, and the demands of the non-titular ethnic groups in the Assosa Zone of the region for political representation. There is competition for political dominance and for advancing the economic and political interests of each ethic group. Bertha inter-familiar disputes and intra-Bertha divisions is the political power against the Gumuz which has led to tensions between Bertha and the Gumuz ethnic groups.

In addition, the adoption of the federal system and the creation of the Benishangul-Gumuz region led to changes in inter-ethnic relationships between the titular and the non-titular communities. The different groups accepted the formation of the region differently. The historically marginalised titular ethnic groups not only embraced the new system warmly but also seek to use its structures to advance their economic and political interests at times at the expense of the non-titular communities (Dereje, 2001). The settlers, in contrast, ‘felt that they were treated as second-class citizens with restricted rights to live and work’, Therefore, there have been tensions in the relationships between the two groups.

Intra-ethnic conflicts are mainly caused by adultery, believes, refusal to pay debt, sexual violence, and claims for return or marriage arrangements. Once the intra-ethnic clan conflicts emerge and begin claiming lives, the chance of easy resolution remains difficult due to cyclical revengeful actions. It was observed during in 2010s that lack of security was the prior problem for many people in different woredas.

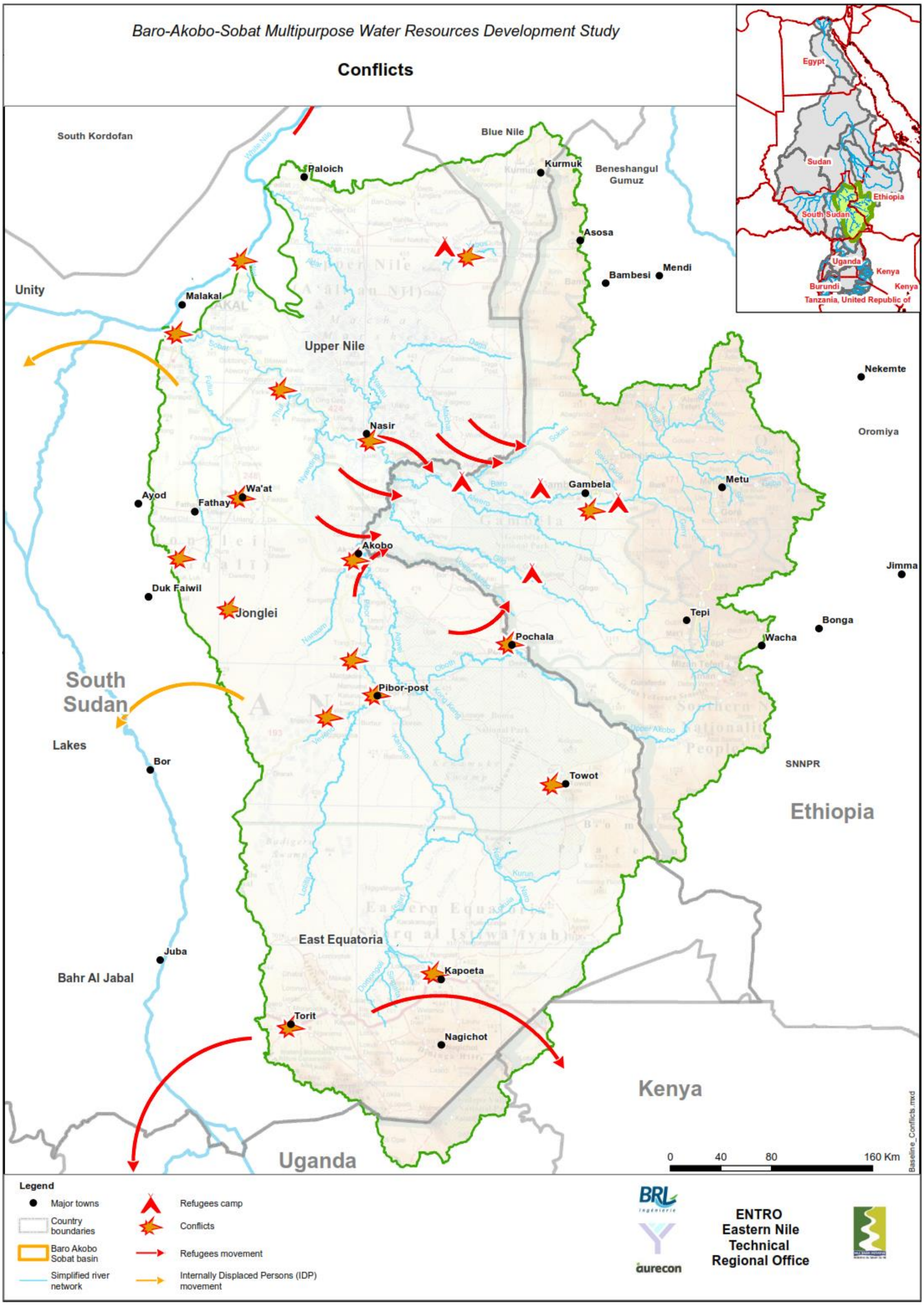
Local-level conflict is an important development issue in woredas such as Dibate and Mandura. Conflict was listed as the number one problem out of eleven socio-economic problems identified by local communities in Dibate and the second important problem in Mandura Woreda. Conflicts are mostly between the indigenous population and resent settlers. Intra-clan conflicts are also common among the indigenous communities. Major causes of conflicts are encroachment, murder, theft and land disputes. Therefore, conflict resolution and management has to be understood and addressed in future development interventions in the Sub-basin.

Natural resource-related conflicts are also common. Major causes of inter-ethnic conflicts are often due to encroachment on land and over the use of natural resources. The influx of government-sponsored settlers during the Derg regime, encroachment by highland farmers and other immigrants into the Sub-basin has created hostile attitudes between the settlers and indigenous people, which often leads to conflicts. Degradation of land resources in resettlement areas and encroachment are forcing settlers to move into the lands which are relatively well preserved, which also creates mistrust and conflict.

In recent years, the expansion of private farms (large-scale investments) and the influx of outsiders has created tension and mistrust between the indigenous people and investors, migrants and laborers. All conflicts have an impacts on production, marketing, loss of lives and assets, disruption of social relationships (like sharecropping, borrowing money, etc.), land use rights of the indigenous population, forest and forest products which the local people depend on for their livelihoods. Conflicts also discourage donors and development partners and negatively affect sustainable development and food security. Therefore, conflict management and resolution should be a part of development and food security strategies. Conflict resolution mechanisms and strategies involving key stakeholders, including the Government will be necessary.

In the Bench Maji zone in SNNPR conflict among the Surma, Dizzy and other ethnic groups is common and has a long history. This conflict is a major causes of human and livestock death and injury. Cattle raids, destruction of property, disruption of livelihoods, environment and displacement of people due to conflicts has been the most frequently observed phenomena in these areas.

*Figure 5-1: Location of main recent conflicts in the BAS sub-basin*



## 5.2 FLOODING, IMPACTS AND COPING STRATEGIES

The Ethiopian part of the Sub-basin, particularly the Gambella plain, is prone to floods. The topography of Gambella Region is divided into two broad classes, i.e. the Lower Piedmonts between 500 to 1900 masl and the Flood Plains of below 500m contours. Flooding affects livestock grazing land result in movement from river side to upland. Most of the people in the lowland areas of Gambella live along the river bank, wetland and at the gentle sloped flood prone low land areas makes them susceptible to yearly flooding, while their livelihood (way of life) is inseparably attached with riverside settlement. The most frequent floods are beneficial because they enrich cultivated river banks and improve grazing land's quality.

Excessive rains from upstream and surrounding regions cause rivers to overflow. The major rivers are the Baro, Akobo, Gilo, and Alwero which flow throughout the year, originating from the highlands. As a result, flooding is the most common natural disaster in the region. In the last ten years the big rivers such as Baro, Akobo, Gilo, Alwero, Jikow, Gnandera, and Koikoye all overflowed each year, with the exception of 2002. As a result, thousands of people were displaced, crops were damaged, and property destroyed. Floods also resulted in deaths, drowning, communicable diseases, and malnutrition, and interruption of social services (GNRS 2011, Samson, et al., 2009; Alemseged, et al., 2012).

The local people employ various coping mechanisms to flooding include, among others the following strategies (Alemseged, et al., 2012):

- ***Measures to reduce impact on house***: The most common coping strategies used the households to reduce impact of flooding on their houses include raising floor level and constructing boundary wall around houses.
- ***Measures to reduce impact on household properties***: Most households keep their properties on ceiling or elevated places in their houses in order to prevent damages that could be caused by floods. For instance, it is a common practice to keep properties on beds, tables and chairs. Protecting household properties from flood impact is one of the major activities that consume the time and energy of many people.
- ***Measures to reduce crop damage***: Despite the huge impact on crops by annual floods, the local people try to harvest premature crops in order to avoid flood damage. Few people change cropping pattern or delay sowing. And others invest less on crop cultivation, if they anticipate extreme flooding.
- ***Measures to reduce livestock damage***: During low and moderate flooding, the local people raise stages and keep animals there for preventing them from damage. Some households also move animals and keep them in schools, stores or other places where flood doesn't reach. When the flood severity increases, they move animals to dry places in other villages or kebeles. Evacuating livestock to other Woredas and selling livestock are used by few people for avoiding flooding damage.

## 5.3 IMPLICATIONS FOR DEVELOPMENT INITIATIVES IN THE BAS SUB-BASIN

The main following social features discussed in this chapter 5 can be summarized as follows:

- There are various forms of social and political conflicts which affect development activities in the Ethiopian part of the Sub-basin. They are also serious threats to the human and physical security of the local communities.
- There are political conflicts among ethnic groups seeking political and economic dominance.
- Resettlement and villagization programs have serious effects on relationships among ethnic groups as well as between settlers and indigenous people.

- There are tensions between local people, migrants and farm laborers due to competition over resources, mainly over land and other economic assets.
- Large-scale land investments can negatively affect local peoples' access to and control over livelihood resources (land, water,  pasture, and forests and forest products, etc.).
- There are conflicts between ethnic groups due to unclear borders of their woredas.
- Spillover effects of conflicts from South Sudan into the Ethiopia part of the Sub-basin affect Gambella and Benishangul-Gumuz in particular.
- In addition to man-made risks (conflicts), flood risk is very high in the basin areas in Ethiopia, particularly the lower part of the Gambella Region.

The Ethiopian part of the Sub-basin, especially Gambella and Benishangul–Gumuz regions, is subject to various forms of conflicts, including inter and intra-ethnic conflicts; natural resource-related conflicts and political conflicts. The first two are common and show an increased trend due to a number factors, including competition over resources; social and culture factors; land allocation for large-scale commercial farms/investments; involuntary relocation of local people; influx of outsiders into the fertile lands in the Sub-basin; flooding and drought; climate change effects, etc. Therefore, conflicts in any form are major constraints to social and economic development of the BAS Sub-basin.

# 6. LAND TENURE

## 6.1 INTRODUCTION

Article 40 (3) of the Constitution provides for the public ownership of both rural and urban land as well as natural resources. The Constitution provides a mandate for the Federal government to enact laws for the utilization and conservation of land and other natural resources, including water resources, while regional states have mandates to administer land and other natural resources in accordance with federal laws. This means that regions have to abide by the laws of the federal government in administering and managing water and land resources in their regions.

In Ethiopia all land is owned by the state. Equal access, use, transfer, administration and control to/over land are provided for in the Constitution. Persons who earn their living by farming have the right to use land freely. Pastoralists have the right to free land for grazing and cultivation. Federal land laws grant all inhabitants in rural areas a right to access land for their livelihoods.

While land can be leased to private individuals, they cannot own it. The Constitution provides for equal access, use, transfer and administration of land. It grants access to agricultural land for rural residents and allows all inhabitants to utilise land for farming. Farmers and pastoralists are granted lifetime ‘holding rights’, giving them rights to the land except for its sale and mortgage.

In Gambella and Benishangul-Gumuz, land, grazing and other resources are typically common property administered at the clan level. Each clan manages its resources collectively based on customary principles and norms. Although each clan member has an inalienable use right over the resources, intra-clan customary laws regulate these use rights. In Gambella and Benishangul-Gumuz land is allocated by the kebele and is administered by clans.

## 6.2 FOOD SECURITY AND HUMANITARIAN ASSISTANCE

In Ethiopia, food security greatly depends on the amount and distribution of rainfall. Agriculture is the foundation of the economy, employing some 80% of the country’s population. Some 85% of the population live in rural areas and is therefore mainly engaged in rain-fed subsistence agriculture. Food production is dominated by small-scale farmers who depend on rain-fed and traditional agricultural practices. This renders farmers highly vulnerable to climate variability. Household food security is largely determined by external factors such as rainfall patterns, land degradation, climate change, population density, low levels of investment and the market for agricultural produce (Ndaruzaniye, 2011).

## 6.3 SECURITY OF LIVELIHOODS

Growing evidence shows that climate change is increasing the frequency and intensity of climate-related hazards, and hence, the level and patterns of interrelated risks, particularly water and food security, exacerbate levels of vulnerability, mainly for rural communities. Ethiopia remains one of the world’s least developed countries, ranking 157 out of 169 in the 2010 UNDP Human Development Index. Climate variability is now imposing a significant challenge on communities in the Sub-basin by affecting water and food security. Changing weather patterns, in addition to other environmental stresses, including overexploitation of land and deforestation, have increased soil degradation and led to water stress, drought, and crop failure (Ndaruzaniye, 2011).

In Ethiopia, securing water for production is integral to obtaining adequate food and income which are necessary for food security. Water insecurity can affect wider household production and income earning opportunities than agricultural production alone. Ethiopia depends greatly on the agricultural sector for income, foreign currency and for the food security (Ndaruzaniye, 2011).

## 6.4 IMPLICATIONS FOR DEVELOPMENT INITIATIVES IN THE BAS SUB-BASIN

From the above discussions, the main following issues have been identified:

- *Land tenure insecurity* due to allocation of land for various development initiatives (land investment, resettlement, villagization, irrigation schemes and hydropower projects; fear of anticipated land distribution, etc).
- Scarcity of water due to competing demand for existing water resources; drought and impacts of the climate change on water sources.
- *Livelihood insecurity* due to loss key resources (farm land, pasture and water), shocks and inflation.
- Increased food insecurity due to failure of crops, impacts of drought, increased food prices, etc.

As such, the objective of any development initiative in the Ethiopian side of the Sub-basin should focus on addressing issues of access to productive resources (land and grazing land), water security, livelihood enhancement and food security.

# 7. ECONOMIC STATUS

## 7.1 OCCUPATIONS AND HOUSEHOLD INCOME

The main occupation of rural households in Ethiopia are farming and livestock rearing. Some households are also engaged in non-agricultural enterprises. Main sources of income are crop and livestock sales. Livestock sale is an important source of cash income for many households. Livestock sales is also an important coping mechanism in coping with shocks. Non-farm activists are also additional sources incomes, especially for households in small towns. These sources of household incomes are briefly described below.

### 7.1.1 Agriculture

A rural socio-economic survey indicated that at national level, 79% of households cultivate land, 76% rear livestock, 72% are engaged in both livestock and farming. The study also showed that 83% of households practice at least either of the two agricultural activities and about 17% of households neither do farming nor rear livestock. Differences exist between rural areas and small and large towns. Around 39% of small town and 87% of households in large town are not engaged in agricultural activities (ERSS, 2015).

The most common livestock type owned is cattle. The ERSS found out that about 90% of livestock owning households reported to own at least one head of cattle.

### 7.1.2 Rural and Urban Employment

#### RURAL EMPLOYMENT

About 94.4% of the active rural household heads are self-employed compared to 51% active household heads in urban areas.

#### URBAN EMPLOYMENT AND UNEMPLOYMENT

High activity rate of population implies the prevalence of huge potential of human resource or human labor that foster economic development. As shown in Table below, urban areas in BG and Gambella regions have high activity rates, i.e. 74 and 70.5 respectively, whereas those in Oromoa and SNNPR regions have slightly lower activity rates i.e. about 64 and 66 respectively. The implication is that the urban areas of BG and Gambella have large number of economically active population. The reason for having lower rates in Oromia, SNNPR and at the national level might be the lion share of population not active were students for these regions and for the national level.

*Table 7-1: Employment Status by Sex and Region*

| Region | All Persons | | Activity Status | | | | Activity Rate |
|---|---|---|---|---|---|---|---|
| | | | Economically active | | | Economically not active | |
| | | | Employed | Unemployed | Total | | |
| BG | Male | 77,083 | 58,730 | 2,830 | 61,559 | 15,524 | 79.9 |
| | Female | 80,627 | 48,323 | 6,901 | 55,224 | 25,403 | 68.5 |
| | Total | **157,710** | **107,053** | **9,731** | **116,784** | **40,926** | **74.0** |
| Gambella | Male | 45,805 | 31,771 | 1,101 | 33,282 | 12,523 | 72.7 |
| | Female | 49,141 | 30,038 | 3,590 | 33,628 | 15,513 | 68.4 |
| | Total | **94,945** | **61,809** | **5,101** | **66,910** | **28,035** | **70.5** |
| Oromia | Male | 1,863,092 | 1,213,723 | 128,166 | 1,341,888 | 521,204 | 72.0 |
| | Female | 2,035,074 | 888,694 | 258,806 | 1,147,501 | 887,573 | 56.4 |

| Region | All Persons | | Activity Status | | | | Activity Rate |
|---|---|---|---|---|---|---|---|
| | | | Economically active | | | Economically not active | |
| | | | Employed | Unemployed | Total | | |
| | Total | **3,898,166** | **2,102,417** | **386,972** | **2,489,389** | **1,408,777** | **63.9** |
| SNNPR | Male | 897,420 | 603,653 | 46,009 | 649,662 | 247,758 | 72.4 |
| | Female | 990,273 | 493,233 | 96,939 | 590,172 | 400,100 | 59.6 |
| | Total | **1,887,693** | **1,096,887** | **142,947** | **1,239,834** | **647,859** | **65.7** |

*Source: CSA (2015) Statistical Report on the 2015 Urban Employment and Unemployment Survey*

### 7.1.3 Non-Farm Activities

Non-farm enterprises (NFE) are important in the lives of households and their number is increasing. Nationally, about 28% of households have one or more NFE. NFEs are much more common in urban than rural areas. About 60% of households in small towns and 34% of households in large towns reported having one or more NFE, compared with 26% among rural households (ERSS, 2015).

Tabl below shows non-farm enterprises (NFE) by type of activity and place of residence. The three most important NFE activities are non-agricultural businesses or services from home including shops (about 8% of households), selling processed agricultural products including food and local beverages (6% of households), and businesses such as selling goods on a street or in a market (about 5% of households).

*Table 7-2: Households reporting one or more NFE by type of NFE, region and place of residence, Ethiopia 2014 %)*

| Region | Any NFE | Non-agricultural business/ services from home/ shop | Processed agricultural products (flour, tella, enjera) | Trading business on a street or in a market | Firewood, charcoal, etc. | Professional | Taxi/ pick-up truck | Bar/ restaurant | Other small business |
|---|---|---|---|---|---|---|---|---|---|
| **Oromiya** | 26.5 | 7.9 | 5.7 | 3.6 | 1.9 | 0.1 | 0.5 | 0.1 | 5.2 |
| **SNNP** | 34.4 | 7.2 | 7.8 | 12.1 | 3.4 | 0.0 | 0.6 | 0.2 | 4.7 |
| **Other regions** | 36.5 | 12.2 | 4.9 | 3.1 | 7.4 | 0.2 | 1.7 | 0.7 | 5.0 |
| **Rural** | 26.0 | 6.7 | 6.1 | 4.7 | 2.3 | 0.0 | 0.4 | 0.1 | 4.1 |
| **Small town (urban)** | 60.4 | 25.3 | 13.7 | 12.0 | 4.0 | 0.5 | 1.4 | 2.4 | 10.4 |
| **Large town (urban)** | 33.9 | 15.5 | 4.1 | 6.0 | 0.6 | 0.4 | 2.3 | 1.3 | 6.2 |

*Source: ERSS, 2015.*

### 7.1.4 Other Sources of Income

The various forms of non-agricultural income received during the 12 months before the survey are shown in Table 7-3. Cash transfers and gifts by relatives remain the most important form of non-agricultural income. Twelve percent of households reported receiving cash transfer and gifts with an average amount of 4,345 Birr. Food transfers and non-food transfers were also received by 8% and 5% of households respectively. With the exception of income from rental of agricultural equipment and tools (7% of households), other sources of income were reported by very few households.

*Table 7-3: Households reporting other income and income received by source, 2014*

| Forms of non-agricultural income. | Households reporting source (%) | Average income received in the last 12 months (Birr) |
|---|---|---|
| Transfers/Gifts (from individuals) | | |
| Cash | 11.7 | 4,345 |
| Food | 8.3 | 995 |
| Non-food/in-kind | 5.2 | 1,508 |
| Rental income from | | |
| Land | 7.3 | 1,569 |
| Shop, store, house, car, truck, other vehicle | 3.8 | 4,381 |
| Transport animals | 0.7 | 1,122 |
| Agricultural tools | 0.8 | 2,084 |
| Pension and investment income | | |
| Interested or other investment income | 1.3 | 1,583 |
| Pension income | 2.0 | 2,646 |
| Revenue from sales of assets | | |
| Income from real estate sales | 1.1 | 4,698 |
| Income from household non-agricultural asset sales | 0.6 | 3,498 |
| Income from household agricultural/fishing asset sales | 0.2 | 3,419 |
| Other income | | |
| Inheritance, lottery, gambling winnings | 0.7 | 8,546 |

*Source: ERSS, 2015.*

The main sources of income are shown in Table. Private transfers are more important in large town than in small towns and rural areas (37% compared to 27% and 15% respectively). Rental income is rare in SNNP and other regions.

*Table 7-4: Households reporting other income by source, region and place of residence, Ethiopia 2014 (%)*

| Region/Residence | Transfers/ gifts | Rental income | Pensions and Investment | Revenue from sale of assets | Other income |
|---|---|---|---|---|---|
| Oromiya | 17.7 | 8.4 | 1.4 | 0.6 | 0.3 |
| SNNP | 18.5 | 4.8 | 1.6 | 5.0 | 0.3 |
| Other regions | 22.1 | 7.9 | 1.7 | 2.1 | 0.0 |
| Rural | 14.9 | 11.5 | 1.9 | 2.0 | 0.6 |
| Small town (urban) | 27.2 | 15.7 | 6.7 | 4.7 | 1.2 |
| Large town (urban) | 37.5 | 14.7 | 9.5 | 1.0 | 1.0 |

*Source: ERSS, 2015.*

## 7.1.5 Public Assistance

Governmental and non-governmental agencies provide food and cash assistances to food insecure households in Ethiopia. One of the programs of assistance is the Productive Safety Nets Program (PSNP) which targets chronically food insecure woredas. About 4% of rural households and 2% of small town households report receiving assistance under the program. Its coverage varies by region, with 12% of households in Tigray, compared with 3% nationally. In addition to PSNP, households also received food and non-food assistance for free or in conjunction with food-for-work or inputs for work programs. Free food was the most prevalent, with coverage of 5% of rural households and 6% of small town households.

*Table 7-5: Households receiving assistance by region and place of residence, 2014 (%)*

| Region/residence | Source | | | | |
|---|---|---|---|---|---|
| | PSNP | Free food | Food-for-work or cash-for-work program | Inputs-for-work program | Other |

| | | | | | |
|---|---|---|---|---|---|
| Oromiya | 0.9 | 4.9 | 1.5 | 0.0 | 0.5 |
| SNNP | 3.3 | 0.5 | 1.1 | 0.0 | 0.5 |
| Other regions | 3.6 | 23.7 | 4.9 | 0.1 | 0.4 |
| Rural | 3.5 | 5.3 | 2.6 | 0.1 | 0.7 |
| Small town (urban) | 1.9 | 6.3 | 1.0 | 0.1 | 5.1 |
| Large town (urban) | 0.7 | 2.0 | 0.2 | 0.0 | 1.0 |

*Source: ERSS, 2015*

## 7.2 EXPENDITURE

### 7.2.1 Food

In rural areas and small towns, the highest household expenditure is on food items. Cereals (rice, sorghum, barley, wheat) are the most important food items with over 90% of households reporting consuming one of these items almost daily. The ERSS survey indicates that households who reported consumption of *teff* daily were 78% in small town and 42% in rural areas. Compared to rural households, urban households consume a more diverse diet.

A substantial proportion of households (85%) also reported consumption of edible oils, fats or butter for six days a week. About three quarters of households also consume beans, lentils or nuts for five days a week on average. Other important food categories that are consumed by over a third of households are vegetables, sugar and sugar products, milk, yoghurt and cheese, potatoes, and meat products, in order of importance.

### 7.2.2 Non-Food Items

As can be seen from Table , clothing and shoes are the most important non-food expenditure in both rural areas and small towns. In a given year, more than 60% of the households spent on average Birr 1,352 (approximately USD 68) on clothing and shoes. Households in large towns areas spent more on clothing and shoes followed by small town and rural areas with a reported average expenditure of about Birr 1,529 (approximately equal to USD 76), Birr 1,349 (approximately equal to USD 67) and Birr 1,316 (approximately equal to USD 67) per year, respectively (ERSS, 2015).

*Table 7-6:: Household expenditure in the last year by place of residence, 2014*

| | Country | | Rural | | Small town (urban) | | Large town (urban) | |
|---|---|---|---|---|---|---|---|---|
| | % of households reporting | Mean expenditure (Birr) | % of households reporting | Mean expenditure (Birr) | % of households reporting | Mean expenditure (Birr) | % of households reporting | Mean expenditure (Birr) |
| ***Clothing:*** | | | | | | | | |
| Clothes, shoes, fabric for Women | 68.4 | 500 | 70.8 | 469 | 57.0 | 476 | 58.0 | 652 |
| Clothes, shoes, fabric for Men | 76.5 | 402 | 79.2 | 377 | 70.5 | 428 | 64.2 | 522 |
| Clothes, shoes, fabric for Boys | 61.5 | 247 | 67.5 | 259 | 49.8 | 219 | 33.8 | 190 |
| Clothes, shoes, fabric for Girls | 58.8 | 204 | 63.9 | 211 | 52.7 | 226 | 35.1 | 165 |
| Linens | 39.1 | 103 | 41.0 | 107 | 39.7 | 117 | 29.7 | 83 |
| ***Taxes, donations, and contributions:*** | | | | | | | | |
| Taxes and levies | 79.0 | 425 | 84.6 | 167 | 63.1 | 802 | 53.3 | 1636 |
| Ceremonial expenses | 76.6 | 772 | 77.2 | 698 | 80.6 | 1041 | 73.6 | 1114 |
| Donations to churches or mosques | 61.4 | 101 | 65.2 | 101 | 72.2 | 183 | 43.0 | 98 |
| Contributions to IDDIR | 60.7 | 76 | 64.2 | 70 | 60.5 | 98 | 44.0 | 103 |
| ***Equipment and furniture:*** | | | | | | | | |
| Kitchen equipment | 37.3 | 52 | 38.8 | 46 | 31.1 | 62 | 30.4 | 80 |
| Furniture | 31.4 | 68 | 32.0 | 54 | 23.7 | 68 | 29.0 | 134 |
| Lamp, torch | 42.5 | 18 | 49.3 | 21 | 30.7 | 14 | 10.9 | 6 |

Note: Mean includes households reporting no expenditure (0) and excludes outliers

Source: ERSS, 2015

Households also spent an substantial amount on laundry soap, kerosene, firewood, charcoal, transport and taxes and levies (table below). The average household expenditure was higher in small towns than in rural areas.

*Table 7-7: Households and average expenditure in the past month by place of residence, 2014*

| | Country | | Rural | | Small town (urban) | | Large town (urban) | |
|---|---|---|---|---|---|---|---|---|
| | % of households reporting | Mean Expenditure (Birr) | % of households reporting | Mean expenditure (Birr) | % of households reporting | Mean expenditure (Birr) | % of households reporting | Mean expenditure (Birr) |
| Laundry soap | 92.2 | 25 | 91.0 | 21 | 97.4 | 35 | 97.7 | 43 |
| Matches | 82.9 | 4 | 80.9 | 3 | 89.5 | 9 | 91.7 | 6 |
| Batteries | 58.5 | 9 | 67.8 | 11 | 39.6 | 6 | 15.5 | 2 |
| Kerosene | 45.9 | 14 | 51.6 | 15 | 30.0 | 7 | 19.7 | 10 |
| Hand soap | 44.8 | 6 | 37.9 | 4 | 58.8 | 8 | 77.2 | 13 |
| Other personal care goods | 33.4 | 5 | 30.3 | 3 | 40.5 | 4 | 48.2 | 14 |
| Candles (tua'af), incense | 31.3 | 3 | 24.2 | 2 | 54.7 | 6 | 63.6 | 7 |
| Transport | 37.3 | 45 | 31.7 | 30 | 39.8 | 56 | 63.8 | 113 |
| Cigarettes, tobacco, suret, gaya | 7.3 | 3 | 8.3 | 4 | 7.0 | 8 | 2.5 | 3 |
| Firewood | 12.6 | 10 | 4.9 | 5 | 53.9 | 53 | 47.0 | 34 |
| Charcoal | 17.5 | 16 | 4.5 | 3 | 59.1 | 46 | 76.9 | 76 |

Source: ERSS, 2015

***Taxes and Levies*** are also important expenditure items. About 85% of rural areas, 63% of small towns and 53% of households in large town paid taxes and levis. On average, rural households paid Birr 167 (approximately USD 8) per year in taxes and small town households paid Birr 802 (approximately equal to USD 40) per year while households in large towns paid Birr 1,635 (approximately USD 82).

***Ceremonial expenses*** are another major non-food expenditure. More than half of rural, small and large town areas households had expenditure on ceremonial activities. These include weddings, birthdays and funeral expenses. In rural areas, household level expenditure on these activities was Birr 698 (approximately USD 35) per year and in small town areas it was Birr 1,041 (approximately equal to USD 52) per year while it was Birr 1,114 (approximately  USD 56) in large towns. Over half of households also made contributions to religious establishments and *iddir* in rural areas and small towns, while contributions of household in large towns was more than 40%.

## 7.3 ASSET OWNERSHIP

Asset ownership is an important indicator of welfare; and assets are an indicator of improving living standards. Depletion of assets, on the other hand, would mean declining household wealth and thus a decline in welfare. The 2014 ERSS survey collected information on ownership of assets such as modern and traditional farm implements, furniture, communication and entertainment equipment, household durables and other items such as automobiles, bikes and jewelry. Table shows households' ownership of assets.

*Table 7-7: Asset Ownership by Place of Residence, 2014*

| | Country | *Place of Residence* | | |
|---|---|---|---|---|
| | | Rural | Small town (urban) | Large town (urban) |
| **Farm implements** | | | | |
| Sickle (Machid) | 69.8 | 82.3 | 35.8 | 12.2 |
| Plough (traditional) | 57.6 | 69.5 | 10.7 | 3.3 |
| Pick Axe (Geso) | 42.2 | 49.8 | 26.7 | 6.9 |
| Axe (Gejera) | 34.5 | 40.3 | 27.8 | 7.4 |
| Plough (modern) | 1.6 | 1.7 | 0.8 | 0.8 |
| Water storage pit | 3.0 | 3.3 | 4.5 | 1.4 |
| **Furniture** | | | | |
| Blanket/Gabi | 89.6 | 88.3 | 95.4 | 95.3 |
| Mattress and / or Bed | 72.3 | 67.3 | 92.2 | 95.1 |
| Shelf for storing goods | 16.2 | 9.9 | 35.5 | 44.8 |
| Mitad-power saving (modern) | 8.8 | 4.0 | 21.9 | 30.6 |
| Kerosene stove | 6.7 | 2.1 | 16.7 | 28.1 |
| Wardrobe | 8.2 | 2.6 | 12.7 | 35.0 |
| Sofa set | 5.6 | 0.7 | 8.7 | 28.6 |
| Refridgerator | 4.7 | 0.3 | 7.5 | 25.1 |
| Electric Stove | 5.3 | 0.6 | 10.2 | 27.4 |
| Biogas stove (pit) | 0.3 | 0.2 | 0.2 | 0.7 |
| Butane Gas Stove | 0.8 | 0.0 | 0.0 | 4.5 |
| Mitad-Electric | 5.1 | 0.2 | 8.7 | 28.0 |
| **Electronics** | | | | |
| Radio/radio and tape/tape | 32.0 | 27.6 | 49.4 | 52.4 |
| Television | 12.0 | 2.5 | 39.9 | 56.0 |
| CD/VCD/DVD/Video Deck | 8.0 | 1.4 | 26.7 | 38.7 |
| Satellite Dish | 6.3 | 1.1 | 25.2 | 30.4 |
| Mobile telephone | 46.4 | 37.2 | 74.9 | 88.4 |
| Fixed line telephone | 3.8 | 1.1 | 14.5 | 16.3 |

*Source: ERSS, 2015*

The  rural socio-economic survey carried out in 2012-2013 asked households, about asset ownership such as productive assets (farm implements; tools, machinery); entertainment and communication equipment, personal items such as jewelry, as well as vehicles. Farm implements are important assets in most rural households. On the other hand, households in small towns own more diversified set of assets. Furniture and electronic items are more common among households in urban areas (ERSS, 2015).

Subsistence agriculture is a primary economic activity in almost all rural areas. Most rural households own traditional farming tools such as sickles, axes, *Mofer, Kenber*, and other traditional ploughs. Only a few rural households have modern plows and improved farming equipment and machinery such as carts and water pumps. (ERSS, 2015).

Other common durable goods are mobile phones and radios. Three-quarters of households owned a mobile phone in small towns and 37% of rural households. Ownership of mobile phones in rural areas has increased 13% compared to 2011. While 17 percent of large town households own land lines, it is less than one percent for rural areas (ERSS, 2015).

## 7.4 POVERTY LEVELS, DISTRIBUTION AND TRENDS

In 2000 Ethiopia had one of the highest poverty rates in the world, with 56% of the population living below US$1.25 PPP a day, and 44% of its population below the national poverty line. Ethiopian households have experienced a decade of progress in wellbeing. As shown in the table below, in 2005, 38.7% of Ethiopians lived in extreme poverty. Five years later this had declined to 29.6%, which is a decrease of 9.1%. This was mainly due to economic growth that brought with it positive trends in reducing poverty in both urban and rural areas.

Table 7-8: *Key Indicators of Poverty and Inequality in Ethiopia (2000-2011)*

| Indicators | 2000 | 2005 | 2011 |
|---|---|---|---|
| National absolute poverty headcount (National Poverty Line) | 44.2% | 38.7% | 29.6% |
| - Urban | 36.9% | 35.1% | 25.7% |
| - Rural | 45.4% | 39.3% | 30.4% |
| Number of people living beneath the national poverty line (thousands) | 28,064 | 27,523 | 25,102 |
| International extreme poverty headcount (US$1.25 PPP Poverty Line) | 55.6% | 39.0% | 30.7% |
| Poverty depth (National Poverty Line) | 11.9% | 8.3% | 7.8% |
| Poverty severity (National Poverty Line) | 4.5% | 2.7% | 3.1% |
| Gini coefficient | 0.28 | 0.30 | 0.30 |
| - Urban | 0.38 | 0.44 | 0.37 |
| - Rural | 0.26 | 0.26 | 0.27 |

***Source****: World Bank, 2015*

Table 7-9 below presents the poverty headcount ratio by region. Positive trends have been observed at regional level, however Tigray, Afar, Amhara, Somali and Gambella regions have poverty ratios that are higher than the national ones.

*Table 7-9: Poverty Headcount Ratio by Region*

| | National poverty line per adult | | | |
|---|---|---|---|---|
| | **1996** | **2000** | **2005** | **2011** |
| Oromia | 34.0% | 39.9% | 37.0% | 28.7% |
| Benishhangul-Gumuz | 46.8% | 54.0% | 44.5% | 28.9% |
| SNNP | 55.9% | 50.9% | 38.2% | 29.6% |
| Gambela | 34.2% | 50.5% | | 32.0% |

*Source: WB (2015): Ethiopia: Poverty Assessment*

As can be seen from above tables, household poverty and food poverty rates have fallen in recent years. However, this trend does not reflect the actual situation on the ground. A more realistic picture is portrayed by the poverty head count which takes population growth into consideration. In this case, poverty reduction and food poverty reduction are significantly less marked. Between 1995/96 and 2010/11 the number of poor Ethiopians dropped by 1.8 million people, while the decrease in the number of people suffering from food poverty is even less with a decrease of about 0.8 million people. Furthermore, looking at regional population figures, the number of poor Ethiopians in fact increased over the 15-year period in 7 out of 11 regions as shown in Table 7-10.

In Gambella region, the number of poor people increased by over 50% between 1995/96 and 2010/11. SNNPR region has seen a substantial reduction in the number of poor.

Poverty was higher in Gambella. As depicted in Table 7-10, the number of people under poverty line has increased over 50% in Gambella and in Oromia by 28.3%.

*Table 7-10: Population below the poverty line and Change by Region (1995-2011)*

| Region | 1995/96 | 1999/00 | 2004/05 | 2010/11 | % change 1995/96-2010/11 |
|---|---|---|---|---|---|
| Gambella | 65 | 107 | NA | 100 | 53.9 |
| Oromia | 6.725 | 8.919 | 9.280 | 8.630 | 28.3 |
| Ben/Gumuz | 226 | 290 | 264 | 233 | 3.1 |
| SNNPR | 6.139 | 6.370 | 5.381 | 4.861 | -20.8 |

*Source: CSA and WFP, 2014, March*

As depicted in Table 7-11, the number of people suffering from food poverty has increased in Gambella and Oromia regions, with the largest increase in Gambella (50%). Food poverty has decreased in Benishangul-Gumuz and SNNPR with a decrease of 25.2% and 1.1% respectively.

*Table 7-11: Population below the food poverty line and percentage change (1995/96 and 2010/11) in the Ethiopian Part of the Sub- Sub-basin.*

| Region | 1995/96 | 1999/00 | 2004/05 | 2010/11 | % change 1995/96-2010/11 |
|---|---|---|---|---|---|
| Gambella | 54 | 121 | NA | 81 | 50.0 |
| Oromia | 8.287 | 8.495 | 92.261 | 9.953 | 20.1 |
| Ben/Gumuz | 286 | 296 | 264 | 283 | -1.1 |
| SNNPR | 5.688 | 6.846 | 5.211 | 4.53 | -25.2 |

*Source: CSA and WFP, 2014, March*

A recent Poverty Assessment (WB, 2105) revealed that an agricultural growth drove reductions in poverty, bolstered by pro-poor spending on basic services and effective rural safety nets. However, although there is some evidence of manufacturing growth starting to reduce poverty in urban centers, structural change has been remarkably absent from Ethiopia. The same document asked 'what would be needed to end extreme poverty in Ethiopia'?. In addition to the current successful recipe for agricultural growth and pro-poor spending, the role of the *non-farm rural sector*, *migration, urban poverty reduction* and *agricultural productivity gains* for women need further consideration (WB, 2015).

The main drivers for the decline of poverty are the following factors (WB, 2015):

i. High and consistent economic growth driven by high levels of public investment and growth in services and agriculture in the last ten years.

ii. Growth was broad-based and thus has been the main driver of reductions in poverty over the fifteen-year period from 1996 to 2011.

iii. Growth in agriculture was particularly inclusive and contributed significantly to poverty reduction.

iv. Manufacturing growth and urban employment contributed to poverty reduction in more recent years.

v. Although the impact of service sector growth on poverty reduction was small relative to growth in value added by the service sector in national accounts, there is some evidence that agricultural growth may drive poverty reduction in part by encouraging rural service sector activity.

vi. The direct transfers provided in the Productive Safety Net Program (PSNP) have also had an effect on poverty reduction. In addition to the direct impact of transfers on poverty, PSNP transfers have been shown to increase agricultural input-use among some beneficiaries thereby supporting agricultural growth.

Poverty reduction among rural, self-employed, agricultural households accounts for the major share of poverty reduction from 1996 to 2011. (WB, 2015).

In addition to the successful mix of agricultural growth and investments in the provision of basic services and direct transfers to rural households, additional drivers of poverty reduction will be needed, particularly those that encourage the structural transformation of Ethiopia's economy. Structural transformation will entail the transition of labour from agricultural activities into non-agricultural activities and it may also entail the movement of people from rural to urban areas. Although non-farm enterprise ownership in rural areas, and rural to urban migration are important realities in Ethiopia today, both have remained quite limited. Neither have been significant contributors to poverty reduction as they have in some other countries in the region and elsewhere[2].

## 7.5 IMPLICATIONS FOR DEVELOPMENT INITIATIVES IN THE BAS SUB-BASIN

From the above discussions, the main following issues have been identified:

- Livelihoods of the local people depend on the use of natural resources.
- The local economy (crop production and livestock) is subsistence-oriented depending highly on rainfall and employing low technology.
- There is increasing trend for engaging in non-agricultural enterprises, as supplementary sources of income.
- Income expenditure is more on food than productive assets, which confirms the highly subsistence nature of the local economy.
- Scarcity of water for crop production, livestock and drinking water.
- Land tenure insecurity due to land deals for investments; encroachment into community land; relocation of farmers/and pastoralists (i.e. villagization).
- Food poverty and food insecurity are still high in the Sub-basin.
- Social well-being/welfare (i.e. access to decent housing, water supply, sanitation, social security) is still very low.
- Physical and human security is not fully guaranteed due to recurrent political and ethnic conflicts in the Ethiopian part of the Sub-basin.

[2] For example the role of non-farm enterprises in Rwanda and Uganda and elsewhere; and another example is the role of rural to urban migration in China.

# 8. SOCIAL SERVICES AND INFRASTRUCTURE

## 8.1 WATER SUPPLY AND SANITATION

Increasing access to improved drinking water is one of the Millennium Development Goals. The source of water is an indicator of whether it is suitable for drinking. Sources providing water suitable for drinking are identified as improved sources that include piped source within the dwelling, yard or plot; a public tap/standpipe; borehole; a protected well; a protected spring; and rainwater (WHO and UNICEF, 2010).

The majority of the population lives in rural areas. As shown in Table 8-1 below, more than half of households (57%) have access to an improved source of drinking water, with a much higher proportion (94%) among urban households than rural households (46%). The most common source of improved drinking water in urban households is piped water, used by 87% of urban households. In contrast, only 18% of rural households have access to piped water. Some 16% of rural households have access to drinking water from a protected well, and 11% have access to drinking water from a protected spring (CSA, 2014).

*Table 8-1: Households by Source of Drinking Water by Place of Residence (2014)*

| Characteristic | Households | | | Population | | |
|---|---|---|---|---|---|---|
| | Urban | Rural | Total | Urban | Rural | Total |
| **Source of drinking water** | | | | | | |
| **Improved source** | **94.3** | **46.4** | **56.9** | **92.0** | **44.8** | **52.7** |
| Piped into dwelling | 2.6 | 0.0 | 0.6 | 2.5 | 0.0 | 0.5 |
| Piped to yard/plot | 52.4 | 0.9 | 12.2 | 48.5 | 0.7 | 8.7 |
| Public tap/standpipe | 32.0 | 16.7 | 20.1 | 32.3 | 16.9 | 19.5 |
| Borehole | 0.0 | 0.3 | 0.3 | 0.0 | 0.4 | 0.3 |
| Protected well | 4.6 | 16.4 | 13.8 | 5.3 | 15.0 | 13.4 |
| Protected spring | 2.2 | 11.3 | 9.3 | 3.0 | 11.0 | 9.6 |
| Rain water | 0.0 | 0.6 | 0.5 | 0.1 | 0.8 | 0.7 |
| Bottled water | 0.5 | 0.0 | 0.1 | 0.2 | 0.0 | 0.0 |
| **Non-improved source** | **4.7** | **53.1** | **42.5** | **7.2** | **54.7** | **46.8** |
| Unprotected well | 1.3 | 5.0 | 4.2 | 2.2 | 5.4 | 4.8 |
| Unprotected spring | 0.9 | 31.6 | 24.8 | 1.0 | 32.4 | 27.1 |
| Tanker truck/cart with tank | 0.6 | 0.3 | 0.4 | 0.7 | 0.3 | 0.4 |
| Surface water | 1.9 | 16.3 | 13.1 | 3.2 | 16.7 | 14.4 |
| **Other source** | **1.0** | **0.5** | **0.6** | **0.8** | **0.4** | **0.5** |
| **Total** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |
| Using an improved source of drinking water (%) | 94.3 | 46.4 | 56.9 | 92.0 | 44.8 | 52.7 |
| Weighted number | 1,861 | 6,614 | 8,475 | 6,720 | 33,384 | 40,104 |
| Unweighted number | 2,556 | 5,919 | 8,475 | 9,563 | 30,436 | 39,999 |

*Source: CSA, 2014*

## 8.2 ENERGY SOURCES AND SUPPLY

### 8.2.1 Power Generation

Ethiopia has a considerable renewable energy endowment, with an abundant hydropower potential, solar and geothermal, as well fossil fuels. Hydropower constitutes almost 92.5% of the total energy mix and thermal energy comprise of 7%. Despite the huge potential to exploit renewable; historically only a very small portion has been developed owing to lack of financial resources amongst other factors.

Currently, Ethiopia has around 2,000 MW of installed power generating capacity, out of which 1,980 MW (99%) is generated from hydropower plants. The remaining 12 MW (0.6%) and 8 MW (0.4%) comes from thermal and geothermal sources respectively. With the coming five years the electricity generating capacity is expected to reach 10,000 MW from the current level of 2,000 MW thereby, the electricity coverage of the country will be 75%.

### 8.2.2 **Energy Policy and Strategy**

The Energy Policy was published in February 2013 as a policy document previous to the Energy Proclamation. It recognizes that Energy is critical for economic development and its objectives are among others to:

- Develop and utilize the country's energy resources on the basis of Ethiopia's overall development strategy priority along with the introduction of energy conservation and efficiency strategy.
- Raise efficiency of the energy sector and develop the necessary institutional and manpower capabilities by introducing appropriate incentive measures, to undertake energy development programs.

The energy policy places high emphasis on hydropower resource development and encourages energy mix with renewable such as solar, wind and geothermal to be developed given their cost competitiveness. Currently, hydropower, diesel and geothermal systems account for 88%, 11% and 1%, respectively of total electricity generation in the country.

#### ENERGY PROCLAMATION NO. 810/2013

The Energy proclamation was enacted on 19th November 2013, and proclaimed on 27th January 2014. It replaces the Electricity Proclamation No. 86/1997. It main impact in the energy sector is that it contains the regulatory frameworks for “economic and technical regulation” of the energy sector and EE&C. It also created the Ethiopian Energy Authority (EEA) as a regulatory institution with the mandate to promote competitiveness in the energy sector; ensure efficient, reliable, fair, economical, and safe electricity supply; and promote and implement EE&C programs. The EEA should therefore as a matter of priority:

- develop a strategic plan to design and implement energy efficiency measures;
- develop the human and institutional capacities at the federal and regions levels;
- develop minimum energy efficiency standards, and a labeling and consumers information program;
- promote EE research, development & demonstration centers;
- build testing facilities for energy performance;
- enforce mandatory energy saving targets setting.

#### STRATEGY FOR ENERGY EFFICIENCY

The Energy Efficient Strategy (EES) is intended to serve as a roadmap for implementing the energy efficiency policy as established in the Ethiopian Energy Proclamation. Ethiopia from 2015 until 2045, the EES contains short (1-5 years), medium (5-10 years), and long (10-20 years) term actions designed to enhance the implementation of the policies and goals. The specific activities contained in the EES will foster policy reforms, energy conservation and energy efficiency and Education and Awareness. The EES contemplates an Institutional Organization and two specific strategies:

- Component 0: Institutional Organization
- Component I: Energy Conservation & Energy Efficiency

- Component II: Education and Awareness

With the implementation of these strategies Ethiopia expects to reduce in 2025, 10% of its overall energy intensity compared to 2015 values.

### 8.2.3 Energy Sources for Households

In rural Ethiopia, 85% of the population use biomass energy sources and share of these sources about 99%. The biomass source comprises firewood (90.7%), animal dung crop residues and others (8.1%) and charcoal (0.2%). All these energy sources are used for cooking, baking, heating, lightening etc. As seen from the table below, the main sources of energy in the Ethiopian part of the BAS Sub-basin are firewood (56%), animal dung (16%), charcoal (8%). While 6% of the households used kerosene, only less than 1% of households use electricity and gas.

*Table 8-8: Household Sources of Energy by Region and Rural-urban Areas*

| Source of energy | Households by source of Energy in the Ethiopian Part of the BAS Sub-basin | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | BG | | Gambella | | Oromia | | SNNPR | | Total | |
| | Rural | Urban | Rural | Urban | Rural | Urban | Rural | Urban | Number | % |
| Electricity | 261 | 771 | 534 | 553 | 17,250 | 39,971 | 4,478 | 12,233 | 76,051 | 0.5 |
| Gas | 63 | 51 | 15 | 59 | 3,965 | 5,015 | 1,090 | 2,069 | 12,327 | 0.1 |
| Kerosene | 2,438 | 2,018 | 943 | 462 | 352,971 | 274,084 | 92,294 | 74,358 | 799,568 | 6.0 |
| Charcoal | 8,238 | 15,280 | 1,967 | 10,917 | 258,683 | 525,466 | 49,638 | 163,256 | 1,033,445 | 7.6 |
| Firewood | 126,711 | 22,789 | 36,922 | 14,013 | 4,050,002 | 661,508 | 2,359,888 | 272,271 | 7,544,104 | 55.7 |
| Dung | 8,724 | 2,084 | 5,260 | 575 | 1,446,270 | 197,077 | 458,404 | 21,165 | 2,139,559 | 15.8 |
| Bio-gas | 241 | 80 | 218 | 233 | 16,022 | 2,256 | 9,290 | 1,889 | 30,229 | 0.2 |
| Other | 33,746 | 3,712 | 13,013 | 3,594 | 1,081,063 | 99,704 | 625,553 | 52,710 | 1,913,095 | 14.1 |
| Total | 180,422 | 46,785 | 58,872 | 30,406 | 7,226,226 | 1,805,081 | 3,600,635 | 599,951 | 13,548,378 | 100 |

*Source: CSA, 2007 Population and Housing Census*

The energy sources and energy use pattern in Ethiopia parts of the Sub-basin are also very much similar to that of the sources recorded at the national level. The energy use pattern both at the national and sub-basin levels shows predominance of traditional energy sources that have implications for environment, land degradation, indoor pollution, deforestation, climate change and loss of soil fertility (Alemu, et al, 2008; Yonas, et al., 2013), and Getamsay, 2013:4. Therefore, supplying modern energy (e.g. electricity) is an important aspect not only for economic development and domestic energy supply for households, but also for relieving pressure on natural resources and sustainable use of environment.  This suggest the need for harnessing the potential of hydropower in the Sub-basin for generating modern energy to the local economy and the household energy sources.

## 8.3 RURAL SOCIAL SERVICES AND INFRASTRUCTURE

Social facilities available in the rural areas include education, health and water facilities. Public services are administrative offices, police stations, training centre, and other services. Commercial services flour mills, quarry, market places, gas station, coffee washer, hotel, etc. Infrastructures include dams, bridge, power station, radio station, telecommunication, youth centres, etc. The distribution of existing social facilities, public services infrastructures, and commercial centres in Ethiopian Part of the BAS Sub-basin is shown in the following table.

*Table 8-8: Rural Social Services and Infrastructure by Region and Zone*

| Region | Zone | Education facilities | Health facilities | Water facilities | Public services | Commercial services | Infrastructure |
|---|---|---|---|---|---|---|---|
| BG | Assosa | 203 | 260 | 830 | 178 | 229 | 16 |
| Gambella | Agnuak | 74 | 72 | 160 | 70 | 27 | 2 |
| | Newer | 44 | 45 | 180 | 31 | 14 | 1 |
| | Mejeng | 34 | 34 | 58 | 34 | 30 | 27 |
| | Etang woreda | 31 | 10 | 66 | 36 | 14 | 14 |
| Oromia | Ilubabor | 806 | 702 | 4,096 | 575 | 1,057 | 26 |
| | Jimma | 1,172 | 568 | 6,610 | 700 | 1,628 | 42 |
| | Kelem Welega | 401 | 497 | 1,748 | 390 | 898 | 18 |
| | Mirab welega | 785 | 821 | 3,900 | 669 | 781 | 37 |
| SNNPR | Bench Maji | 325 | 373 | 839 | 269 | 341 | 33 |
| | Keffa | 557 | 408 | 670 | 359 | 835 | 15 |
| | Sheka | 79 | 29 | 198 | 36 | 118 | 8 |

*Source: CSA, 2014: Ethiopian's Rural Facilities and Services Atlas 2014 for BG, Gambella, Oromia and SNNPR*

# 9. AGRICULTURE AND MARKETING

## 9.1 POLICIES ON AGRICULTURE AND FOOD SECURITY

### AGRICULTURAL SECTOR POLICY

Agricultural Development Led Industrialization (ADLI) has been a central pillar of economic policy since 1990s. After the completion of Plan for Accelerated and Sustained Development to End Poverty (PASDEP), the first Five Year Growth and Transformation Plan (GTP I) has been launched. Now the country has been launched the GTP II. In the agricultural sector, Ethiopia has a comprehensive and consistent set of policies and strategies, which reflects the importance of the sector in the Nation's development aspirations.

### AGRICULTURAL SECTOR POLICY AND INVESTMENT FRAMEWORK

Ethiopia's Agricultural Sector Policy and Investment Framework (PIF) is a sectoral national policy applicable for the period of 2010-2020. Its main objective is to sustainably increase rural incomes and national food security producing more, selling more, nurturing the environment, eliminating hunger and protecting the vulnerable against shocks. Four main themes, each with its own strategic objective, are identified within the above overall objective. These are:

- achieve a sustainable increase in agricultural productivity and production;
- accelerate agricultural commercialization and agro-industrial development;
- reduce degradation and improve productivity of natural resources; and
- achieve universal food security and protect vulnerable households from natural disasters (MoAR, 2010)

### AGRICULTURE AND RURAL DEVELOPMENT ISSUES

Increasing productivity in smallholder agriculture is Government's top priority, recognizing the importance of the smallholder sub-sector, the high prevalence of rural poverty and the large productivity gap. Productivity enhancement however, must be complemented by efforts to help farmers graduate from purely subsistence farming to semi-commercial status practicing farming as a business and to adopt more sustainable natural resource management practices in order to arrest and reverse environmental degradation.

The goal of the PIF is to *"contribute to Ethiopia's achievement of middle income status by 2020".* The development objective aim is to *"sustainably increase rural incomes and national food security"*. This objective embodies the concepts of producing more, selling more, nurturing the environment, eliminating hunger and protecting the vulnerable against shocks; all of which are embodied in various national policy instruments, and are expressed in terms of four main themes, each with its own strategic objective as shown below:

*Table 9-9: Strategic objectives of the Ethiopian Agricultural Sector Policy and Investment Framework*

| Thematic Area | Strategic Objectives (SOs) |
|---|---|
| • Productivity and Production | • SO1: To achieve a sustainable increase in agricultural productivity and production. |
| • Rural Commercialisation | • SO2: To accelerate agricultural commercialisation and agro-industrial development. |
| • Natural Resource Management | • SO3: To reduce degradation and improve productivity of natural resources. |
| • Disaster Risk Management and Food Security | • SO4: To achieve universal food security and protect vulnerable households from natural disasters. |

***Source:*** *MoAR (2010): Ethiopian Agricultural Sector Policy and Investment Framework (PIF) for 2010-2020. Draft Final.*

### FOOD SECURITY STRATEGY IN ETHIOPIA

The food Security strategy of Ethiopia was issued in 1996. The strategy adopted three basic pillars. These are to:

- Increase availability of food through increased domestic production;
- Ensure access to food for food deficit households;
- Strengthen emergency response capabilities.

Generally the focus of the strategy is on increase productivity and production thereby ensuring access to foods by all households. Also response capacity, which is nowadays conceptualized as resilience building has been also emphasized in the strategy. In order to meet the main objectives of the stagey, Ethiopia has adopted the food security program which is as described below.

### FOOD SECURITY PROGRAM

The overall objective of the Country's Food Security Program (FSP) is to achieve food security for chronic and transitory food insecure households in rural Ethiopia. To this end, the Program has four components: (i) the Productive Safety Net Program (PSNP), which provides transfers to meet household consumption and protect assets, and builds community assets through public works; (ii) the Household Asset Building Program (HABP) which provides credit and extension services; (iii) the Complementary Community Investment Program (CCIP) which undertakes community infrastructure investments in food insecure Woredas; and (iv) the water-centered Voluntary Resettlement Program (RP) which provides transfers, credit and infrastructure for re-settled households. The raising of households to the level of food security that these components aim to achieve is commonly described as graduation.

## 9.2 MARKETS IN THE ETHIOPIAN PART OF THE BAS SUB-BASIN

There are large markets in the BAS sub-basin in Ethiopia, such as Asosa, Dembidolo, Gambella, Metu, Jimma, Bedelle, Mizan teferi and Maji. Both agricultural and consumer goods are transacted in these markets. Coffee is a cash crop available in the local markets. Cross-border markets play important roles in flow of goods along the border.

The Gambella market[9] is a strategically important market in the BAS basin. This market is a very important source of food supply to the people who live along and near the Ethiopia-South Sudan border. Most of the food supply (90%) comes from neighboring markets, namely Mechara, Bonga, Masha, Nekemte, Mettu, Weliso, Tulubolo and Addis Ababa. There are also other nearby cross-border markets including Lare, Pagak and Dima, Burbe, Akobo and Nasir are the main destination markets in the Sudan. There is also a trade in livestock along this route to South Sudan.

Maize and sorghum are main food commodities in the market and are in transit to South Sudan. The supply of these commodities is good during the harvest season; October to December. Livestock markets along the border are also common. The largest flow of agricultural commodities is from Ethiopia to South Sudan.

Prices of food crops vary with the season. Prices are usually lower during the harvest season; October to April and increase again from May to August. Despite the strategic importance of the Gambella market, there are challenges to its operation that includes limited storage capacity, high municipal charges, seasonal flooding and taxation.

The other cross-border market is Kurmuk on the Ethiopian-Sudan border. Both food and non-food commodities are traded across this border. Edible oil and onion are inflows from Sudan to Ethiopia, while sorghum, maize, faba beans, chickpeas, maize, garlic, groundnuts, cattle and goats are outflows from Ethiopia to Sudan.

Trends in market prices in Ethiopia show fluctuations over the last years. In December 2015, the overall Ethiopian year-on-year inflation rate was 10%; the food and nonfood inflation rate was 12.1% and 7.7% respectively. The inflation rate in Gambella and Oromia was 12.4% and 12.5%, ranking of 4th and 3rd respectively[8]. The general price index in the Baro Akobo area shows an increase in goods and services. The increase in the general price level is higher in Oromia, followed by SNNPR and Gambella as shown in Table 9-1 below.

*Table 9-1: Trends in Price Indexes in Regional Markets (2011-2015)*

| Month / year | Region | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gambella | | | Oromia | | | Benishangul Gumz | | | SNNPR | | |
| | General Price Index | Food and non-beverage | Non-food index | General Price Index | Food and non-beverage | Non-food index | General Price Index | Food and non-beverage | Non-food index | General Price Index | Food and non-beverage | Non-food index |
| Dec 2011 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Dec 2014 | 125.7 | 125.2 | 126.7 | 133.9 | 133.5 | 134.4 | 123.9 | 113.5 | 139.6 | 135.8 | 134.0 | 137.1 |
| Dec 2015 | 140.7 | 139.8 | 142.2 | 150.6 | 155.4 | 145.1 | 136.4 | 130.1 | 146.1 | 143.2 | 145.6 | 141.4 |

*Source: CSA Ethiopia*

According to the WFP report for the month of January 2016, price levels are increasing. The cost of living measured by the Consumer Price Index (CPI) increased by 10.2%. Wholesale prices of maize and sorghum stood above prices in December 2015 and above the five-year average. When compared to the long-term average, national white wheat prices increased by 30%, sorghum by 24% and white maize by 21%. The *teff* price increased by 6% while maize prices in markets in the Sub-basin, namely Gambelia, Meti Lare and Gog in Gambella decreased, and sorghum prices in Gambella either declined or remained stable[11].

## 9.3 MECHANIZATION

Gambella is a region in Ethiopia where agricultural mechanization is progressing. Nearly 30% of the total land area is either delivered or identified for agricultural investment purposes. To date a number of companies have invested in or taken over land for investment as shown below[10].

*Table 9-2: Agriculture Investors, Crops and Area Leased - Gambella Region*

| Investor/company | Origin | Crop | Area (ha) |
|---|---|---|---|
| Ruchi | India | Soybean | 25,000 |
| BHO | India | Edible oil crops | 27,000 |
| Sannati | India | Rice | 10,000 |
| Verdanta | India | Tea | 3,012 |
| Karuturi Agro Products | India | Palm, cereal, rice and sugarcane | 100,000 |
| Saudi Agricultural Development | Saudi | Rice | 10,000 |
| Toren Agro Industries Plc | Turkey | Cotton and soybean | |
| Huana Dafengyuan Agriculture | China | Sugar cane | 25,000 |
| Saber Farm PLC | India | Cotton and soybean | 25,000 |
| Green Valley Agro Plc | India | Cotton farming and related activities | 5,000 |
| JVL Overseas Pvt Ltd | India | Cotton farming and related activities | 5,000 |
| | | **TOTAL** | **235,012** |

## 9.4 POTENTIAL FOR DEVELOPMENT

In the Ethiopian part of the BAS sub-basin, Gambella is the region with the highest potential for mechanization of agriculture. The region has an estimated area of 2,580,201 hectares, of which 30% are allocated for mechanized farming. Gambella attracts interest from large firms due to its fertile soils which are suitable for the cultivation of crops for export such as rice, soybeans, cotton, sugar and tea. Palm oil and pulses also attract a lot of interest[10]. Upper Nile state in South Sudan is the area with the highest potential for future development of mechanized farming.

# 10. KEY ISSUES, CHALLENGES AND OPPORTUNITIES FOR DEVELOPMENT OF THE BAS SUB-BASIN

## 10.1 INTRODUCTION

In the Inception Report it was stated that a more detailed baseline report will identify key social development issues, challenges and opportunities for the development of the BAS sub-basin. Accordingly, critical baseline social data and information in these areas have been collected,

This section summarizes the key issues, challenges and opportunities to be addressed in the IWRDM Plan and to define the framework of the Plan. This picture of Key issues, challenges and opportunities will inform strategic decisions regarding the approach to the development of water resources in the BAS Sub-basin.

## 10.2 KEY ISSUES, CHALLENGES AND OPPORTUNITIES

Important social and socio-economic issues that should be addressed in the development plans in the Sub-basin include the following:

- ***Incidence of poverty and food insecurity*** is still high in the Sub-basin and way of addressing poverty eradication will be a key focus area.
- ***Low level of well-being***: The Sub-basin area has a low level of wellbeing and the development options will consider ways of enhancing the Sub-basin population's well-being.
- ***Low level of provision of social services*** due to weak social and infrastructural services and facilities: Most, if not all, of the basin areas are poorly served in terms of basis social services.
- ***Vulnerable groups*** (pastoral groups, women and children, conflict and war displace people, IDP, refugees, etc.): The basin areas are marginalized from the main stream economy of the countries and have experienced various forms risks (both natural and economic) and as well conflicts which adversely affected vulnerable groups. The issue of protection of vulnerable groups should receive attention in the plan and development options.
- Addressing ***gender inequality*** at household and community levels as women have low access to productive resources, education and health services; and women have high work burden.
- ***Recurrence of various forms, intensity, duration and impacts of conflicts*** in the Sub-basin are the major challenges for future development activities.
- There is a ***potential for influx of people*** (various forms of migration) into the Sub-basin following various development initiatives and interventions (ongoing and proposed ones). The likely consequences of the various development options/alternative on influx of people into the Sub-basin areas should be addressed in development plans. In addition potential effects of population increase, resettlement, increasing investment (commercial farms–leaseholds) will be considered in the plan.
- ***Risks*** (conflicts, flooding, disease outbreaks, economic shocks, insecurity) are common in the area. Therefore, the likely consequences of the various development options, either in exacerbating or reducing these risks will be addressed in the plan.
- ***Land security/Land tenure issues***, regarding the rights of indigenous people will the social and economic issue while designating land for any type of development (commercial farm; large scale irrigation, hydropower, national parks, protected areas). The plan will take into account these issues.
- ***Sub-basin population dynamics place heavy pressure on natural resources*** (e.g. water, land, wetlands and forest) for their livelihoods: Thus, potential impacts of development of any of these resources on people's livelihoods will be adequately addressed in the IWRDM Plan.

- ***Weak institutions, poor coordination and cooperation among existing institutions***: There are varying levels of capacities and resources in the Sub-basin countries and the BAS sub-basin itself. Therefore, the issue of capacity building for coordinating and implementing development programs and plans is important for planning and implementing development activities in the Sub-basin.

These issues and the identified challenges and opportunities are summarized in the table below.

*Table 10-1: Issues, Challenges and Opportunities for Development of the BAS Sub-basin*

| Key issues | Opportunities | Challenges |
|---|---|---|
| Incidence of poverty | availability of good working policy framework and political commitment of the basin countries for poverty reduction | Lack or level of funding<br>Social, economic and natural risks |
| Low level of social services and well-being in the basin | Existence of various efforts and institutional setups for enhancing capacity to design and implement programs and projects. | Lack of funds, and low capacity for evaluation and monitoring programs and projects |
| Social vulnerability (various vulnerable groups ) | Various ongoing programs for poverty reduction and tacking food insecurity | Lack of fund, resources and capacity for implementing programs. |
| Gender inequality | Availability of Gender Mainstreaming Policy and Strategy.<br>Ongoing social development programs in health education, water supply, and wellbeing run by governments and NGOs etc | Social constructed bias and practices that constrains gender equality, and women' s work burden.<br>Lack of funds and resources and capacity for implementing policies, strategies and programs; lack of coordination |
| Migration into the basin. | Enhancing local economy due to commercial farms and labour migration into the area. | Increased pressure on the local natural resources and on existing social and economic services and infrastructures. |
| Various forms risks (conflict, natural disaster, flood, insecurity) | Long-established local level adaptation and coping strategies | Dynamics nature of risks and uncertainty in time, scope and location of most risks. |
| Sustainable use natural resources potential for development. | High natural resources potential in the basin | Various adverse impacts on the natural resources and on the livelihoods that are based these resources. |
| Land tenure | Availability of land for new development initiatives. | Loss of access to traditional or customary land rights, grazing and farmland to other uses like commercial farms, protected areas, etc. |
| Capacity building (human, resources and institutional). | Various ongoing trainings and capacity building activities in the basin countries | Low capacity and poor coordination among institution<br>High turnover of trained manpower |
| Development cooperation and designing win-win programs | Established framework for development cooperation between the basin countries | Low institutional capacity and poor coordination between countries and among institutions within a country.<br>Accommodating Varying interests. |

***Source:*** *Adapted from Inception Study and Updated During the Baseline Study*

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# BARO-AKOBO-SOBAT MULTIPURPOSE WATER RESOURCES DEVELOPMENT STUDY - BASELINE STUDY

# Annex 3-B Socio-economic environment in the South Sudanese part of the basin

# TABLES AND FIGURES

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# ACRONYMS AND ABREVIATIONS

| | |
|---|---|
| AfDB | African Development Bank |
| ACORD | Association for Cooperative Operations Research and Development |
| ACTED | Agency for Technical Cooperation and Development |
| BAS | Baro Akobo Sobat |
| CAMP | Comprehensive Agriculture Development Master Plan |
| CBA | Cost Benefit Analysis |
| CMA | Catchment Management Association |
| CRA | Cooperative Regional Assessment |
| DEM | Digital Elevation Model |
| EEPCO | Ethiopian Electric Power Corporation |
| EHA | Erosion Hazard Assessment |
| EIA | Environmental Impact Assessment |
| ENID | Eastern Nile Irrigation and Drainage |
| ENCOM | Eastern Nile Committee Of Ministers |
| ENPM | Eastern Nile Planning Model |
| ENPT | Eastern Nile Power Trade |
| ENSAP | Eastern Nile Subsidiary Action Plan |
| ENTRO | Eastern Nile Technical Regional Office (NBI) |
| EPA | Environmental Protection Authority |
| FAO | Food and Agriculture Organization |
| GDEM | Global Digital Elevation Model |
| GDP | Gross Domestic Product |
| GEF | Global Environment Facility |
| GIS | Geographic Information System |
| GTP | Growth and Transformation Plan |
| GWh/y | GigaWatt hour/year |
| HEP | Hydroelectric Power |
| IDEN | Integrated Development of Eastern Nile |
| ILWRM | Integrated Land and Water Resources Management |
| IPCC | Intergovernmental Panel on Climate Change |
| IUCN | International Union for Conservation of Nature and Natural Resources |
| IWMI | International Water Management Institute |
| IWRDMP | Integrated Water Resources Development and Management Plan |
| IWRM | Integrated Water Resource Management |
| JMP | Joint Multipurpose Project |
| MAFCRD | Ministry of Agriculture, Forestry, Cooperatives and Rural Development |
| MASL | Meters Above Sea Level |
| MCA | Multi Criteria Analysis |
| MDG | Millennium Development Goals |
| MEDIWR | Ministry of Electricity, Dams, Irrigation and Water Resources |
| MERET | Managing Environmental Resources to Enable Transitions |
| MLFI | Ministry of Livestock and Fisheries |
| MoA | Ministry of Agriculture |
| MoEN | Ministry of Environment |
| MoWIE | Ministry of Water, Irrigation and Energy |
| MSIOA | Multi Sector Investment Opportunity Analysis |
| MTR&B | Ministry of transport, roads and bridges |
| MW | Mega Watt |
| MWC&T | Ministry of Wildlife Conservation and Tourism |
| NB-DSS | Nile Basin Decision Support System |
| NBI | Nile Basin Initiative |
| NCORE | Nile Cooperation for result project |
| NDVI | Normalized Difference Vegetation Index |

| | |
|---|---|
| NELSAP | Nile Equatorial Lakes Subsidiary Action Program |
| NGO | Non-Governmental Organization |
| Nile-COM | Nile Council of Ministers |
| PIM | Project Implementation Manual |
| PLSPP | Policies, Legislation, Strategies, Plans, and Programs |
| PPP | Private Public Partnership |
| PMU | Project Management Unit |
| PRSP | Poverty Reduction Strategy Program |
| RATP | Regional Agricultural Trade and Productivity Project |
| RPSC | Regional Project Steering Committee |
| RSS | Republic of South Sudan |
| RUSLE | Revised Universal Soil Loss Equation |
| SAP | Subsidiary Action Program |
| SEA | Strategic Environmental Assessments |
| SIS | Soil Information System |
| SLMP | Sustainable Land Management Program |
| SNNPR | Southern Nations, Nationalities and Peoples' Region |
| SRFE | Satellite Rainfall Estimates |
| SRTM | Shuttle Radar Topographic Mission |
| SSEA | Strategic Social and Environmental Assessment |
| SVP | Shared Vision Program |
| SWAT | Soil and Water Analysis Tool |
| SWOT | Strength Weakness Opportunity Threat |
| SWSC | Soil-Water Storage Capacity |
| UNDP | United Nations Development Program |
| UNHCR | United Nations High Commissioner for Refugees |
| UNICEF | United Nations Children's Fund |
| USAID | United States Agency for International Development |
| WaSH | Water Sanitation and Hygiene |
| WB | World Bank |
| WBISPP | Woody Biomass Inventory and Strategic Planning Project |
| WCYA | Women, Children and Youth Affairs |
| WEES | Water for Eastern Equatoria |
| WFP | World Food Program |
| WM | Watershed Management |
| WRMA | Water Resources Management Authority |
| WRMD | Water Resources Management and Development |
| WSS | Water Supply and Sanitation |
| WUA | Water Users Association |

# 1. DEMOGRAPHIC AND SOCIO-ECONOMIC ASPECTS

## 1.1 INTRODUCTION

This Chapter presents the main demographic and socio-economic features of the BAS basin in South Sudan, including the following aspects:

- Population dynamics – size, age composition, density, mobility (including migration, resettlement, internal but the displacement and refugees)
- Education and Health Status
- Gender Relations
- Government and Administrative Framework
- Ethnic and Language groups
- Conflicts
- Livelihoods
- Food Security
- Poverty
- Markets
- Development Objectives, Issues and Potentials

The final section of this chapter presents key issues, potentials and objectives related to the development of the BAS basin and identifies indicators that can be used to develop a monitoring framework for the demographic and socio-economic dimensions of the future development of the BAS basin.

## 1.2 POPULATION DYNAMICS

The Baro-Akobo-Sobat Sub-basin includes a large part of the land area of three states in South Sudan; Eastern Equatoria, Jonglei and Upper Nile. This section will present the main demographic features of the BAS basin in South Sudan, including such features as size, density, growth rates, age distribution, household size and mobility.

### 1.2.1 Size and age distribution

The current population of the BAS basin is estimated to be over 5.7 million. Of this, 53 % of the population lives in Ethiopian part of the basin, while 47 % live in the South Sudanese part of the basin. The remaining population live in the Sudanese, Ugandan and Kenyan parts of the basin.

Concerning the South Sudanese part of the basin, Jonglei is the most populous basin state, followed by Upper Nile and Eastern Equatoria, which have almost equal populations, as shown in the following table.

*Table 1-1: Projected Population of Basin States in South Sudan (2016)*

| State | Population | Population in Sub-basin | Percent in Sub-basin[1] |
|---|---|---|---|
| Upper Nile | 1,332,343 | 796,668 | 60% |
| Jonglei | 1,753,272 | 1,111,271 | 63% |
| Eastern Equatoria | 1,333,119 | 761,346 | 76% |
| | | **2,669,285** | |

*Source: Central Bureau of Statistics, 2012*

The BAS sub-basin's population is also overwhelmingly rural, with between 85 and 90% of the population living in rural areas. (NBS, 2010)

## 1.2.2 Population distribution

The population is unevenly distributed across the sub-basin, and its density within the sub-basin shows considerable variation, as can be seen in the map next page.

It can be seen that population density is generally higher in the eastern part of the basin toward the Ethiopian highlands, whereas with the exception of a few urban areas, the population density in the South Sudan part of the basin is generally low, varying from less than 1 per km2 to around 60 per km2, whereas in the Ethiopian part of the basin, population densities reach as high as 500 per km2 in the eastern highlands in Oromia Region.

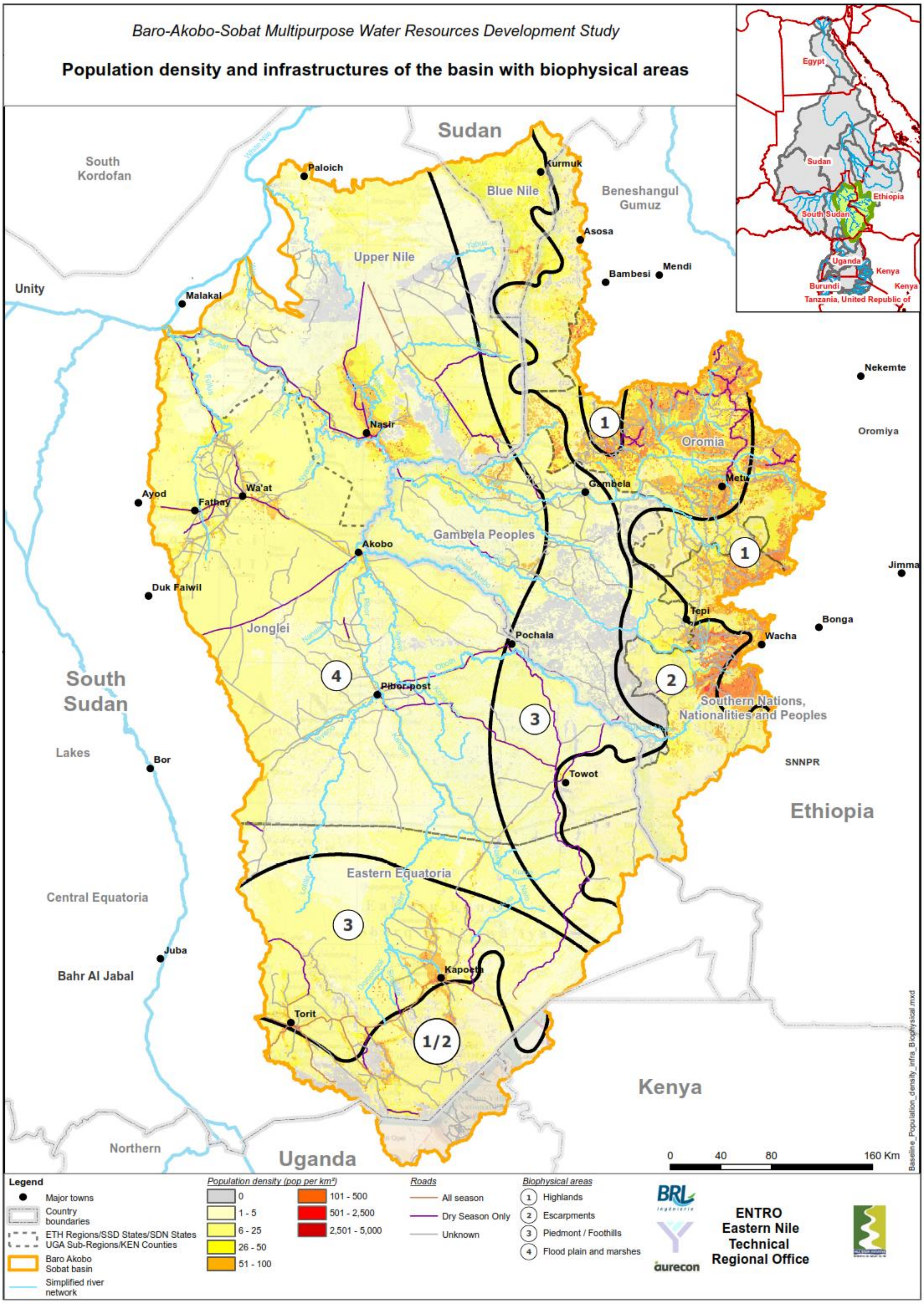
In the South Sudanese part of the basin the highest densities of population are found along rivers, in particular the area along the Sobat River immediately north of the Gambella salient.

Under normal conditions, in areas that are largely rural and agrarian it can be expected that there would be a natural tendency for the population to move from areas of high population density to areas of lower density in search of new land for cultivation or grazing. However, in the present situation in the basin, conflicts and accompanying insecurity in the western part of the basin, primarily in South Sudan, inhibit such a movement.

The relatively sparsely populated area of the basin in southwestern Gambella Region along the border with South Sudan is attracting new settlers from the highlands to the east, primarily from Oromia and SNNP regions, which increases pressure on land and water resources as well as increasing tensions with the indigenous people in the receiving area. This is also the area where large areas of land are being leased to outside investors for agricultural development.

[1] Due to the high proportion of the population of the three basin states that are in the BAS sub-basin, where available, unless otherwise state; data pertaining to the basin states will serve as a close approximation of the conditions in the part of the BAS Sub-basin in that state.

*Figure 1-1: BAS population density*



### 1.2.3 Population Growth Rates

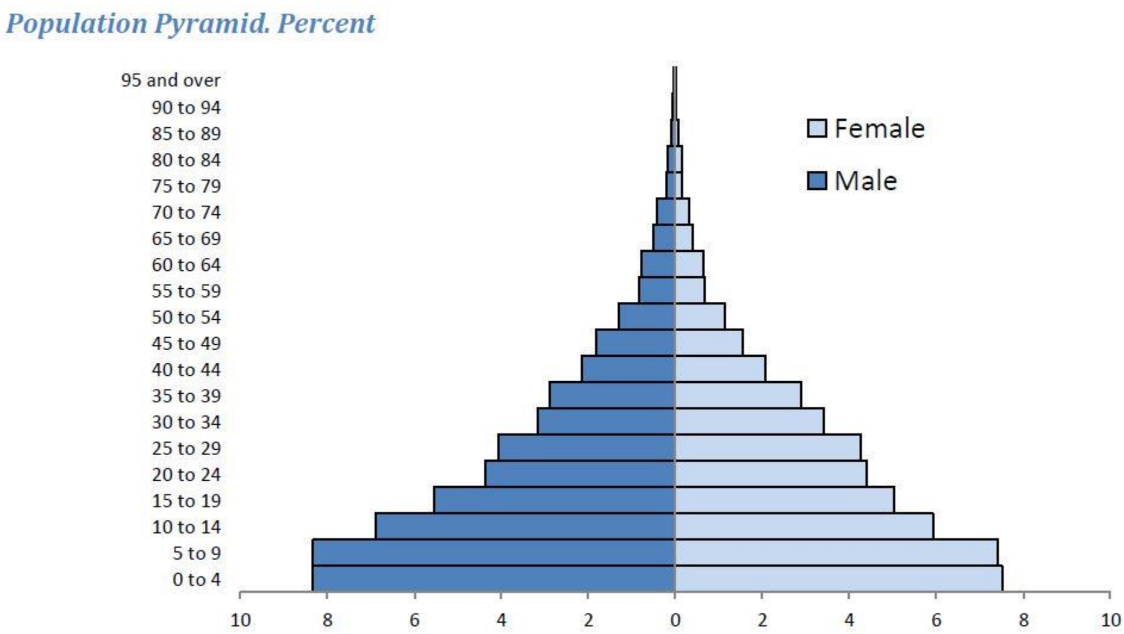
Population growth rates across the sub-basin are also high, ranging from 4.4% per year in Eastern Equatoria State, 3.9% per year in the Upper Nile State to 3.3% per year in Jonglei State[2]. If these growth rates continue, the population of the South Sudanese part of the BAS sub-basin will more than double to 8.4 million by 2040. This growth in population will exacerbate pressure on the natural resources and infrastructure in the basin and can well increase the competition and conflicts over land, water and other natural resources.

### 1.2.4 Age Distribution and Dependency

The BAS Sub-basin's population is very young and is assumed to mirror the national age distribution, where some 48% of the population is below 15 years old, while only 6% of the population is above 54 years old. (National Baseline Household Survey, 2009.) Some 16% of the population is under the age of 5; 32% under 10 years of age; 51% under 18 years and a full 72% of the population under the age of 30. (SSCCSE, 2008).

The sub-basin and South Sudan have a high age dependency ratio (85%)[3] due to its large - and growing - young population and persistently high birth rates. During protracted periods of conflict, the birth rate is usually expected to decline, but in the case of South Sudan, it remains surprisingly high. The age dependency ratio can be derived from the population pyramid, shown below.

*Figure 1-2: Population Pyramid for South Sudan (2014)*




The above population pyramid also shows that there are more males than females in almost all age groups, and particularly in the older age groups, which is very unusual and requires further explanation.

[2] Central Bureau of Statistics, 2010

[3] The age dependency ratio is the ratio of dependents, defined as people younger than 15 or older than 64years old, to the working-age population- aged 15-64, shown as the proportion of dependents per 100 working-age population.

### 1.2.5 Birth Rates and Life Expectancy

Fertility and birth rates are also high, averaging 5 births per woman and a birth rate of over 40 per 1,000 population. The average life expectancy for the sub-basin population is 55.7 and 58.6 years for males and females, respectively.

### 1.2.6 Household size

The average household size by basin state in South Sudan is shown in the following table:

*Table 1-2: Average Household Size in Basin States*

| State | Household Size |
|---|---|
| Upper Nile | 7.6 |
| Jonglei | 6.4 |
| Eastern Equatoria | 5.7 |

*Source: National Bureau of Statistics, 2014*

The above large variation in household size among neighbouring areas is unusual and also requires further explanation. These differences can be at least partly explained by cultural preferences regarding residence patterns of extended family members, livelihoods and occupations that encourage larger numbers of children, among others.

### 1.2.7 Mobility

A dominant characteristic of the population in the BAS sub-basin is its high mobility, which is influenced by both voluntary and involuntary movements. Both immigration and outmigration are common in the basin. The population in the BAS sub-basin is sensitive to changes in socio-economic, environmental and political factors.

Mobility can be of several types, including permanent rural-urban migration, resettlement within rural areas, and displacement due to conflicts. Seasonal mobility is also a defining feature of pastoral livelihood systems, which are found mainly along the border areas between South Sudan and Ethiopia and Sudan.

An important population movement is the internal displacement due to ethnic and political conflicts in "conflicted" states in South Sudan according to the UN classification, which includes Upper Nile and Jonglei states. Over 250,000 people in the basin have been affected by internal displacement since the outbreak of political conflicts in South Sudan in December 2013.

The location and extent of these forms of mobility are discussed in more detail later in this annex.

### 1.2.8 Major towns

It can be seen from the map next page that the BAS Sub-basin covers a large part of the area of three South Sudanese states, viz. Upper Nile, Jonglei, and Eastern Equatoria.

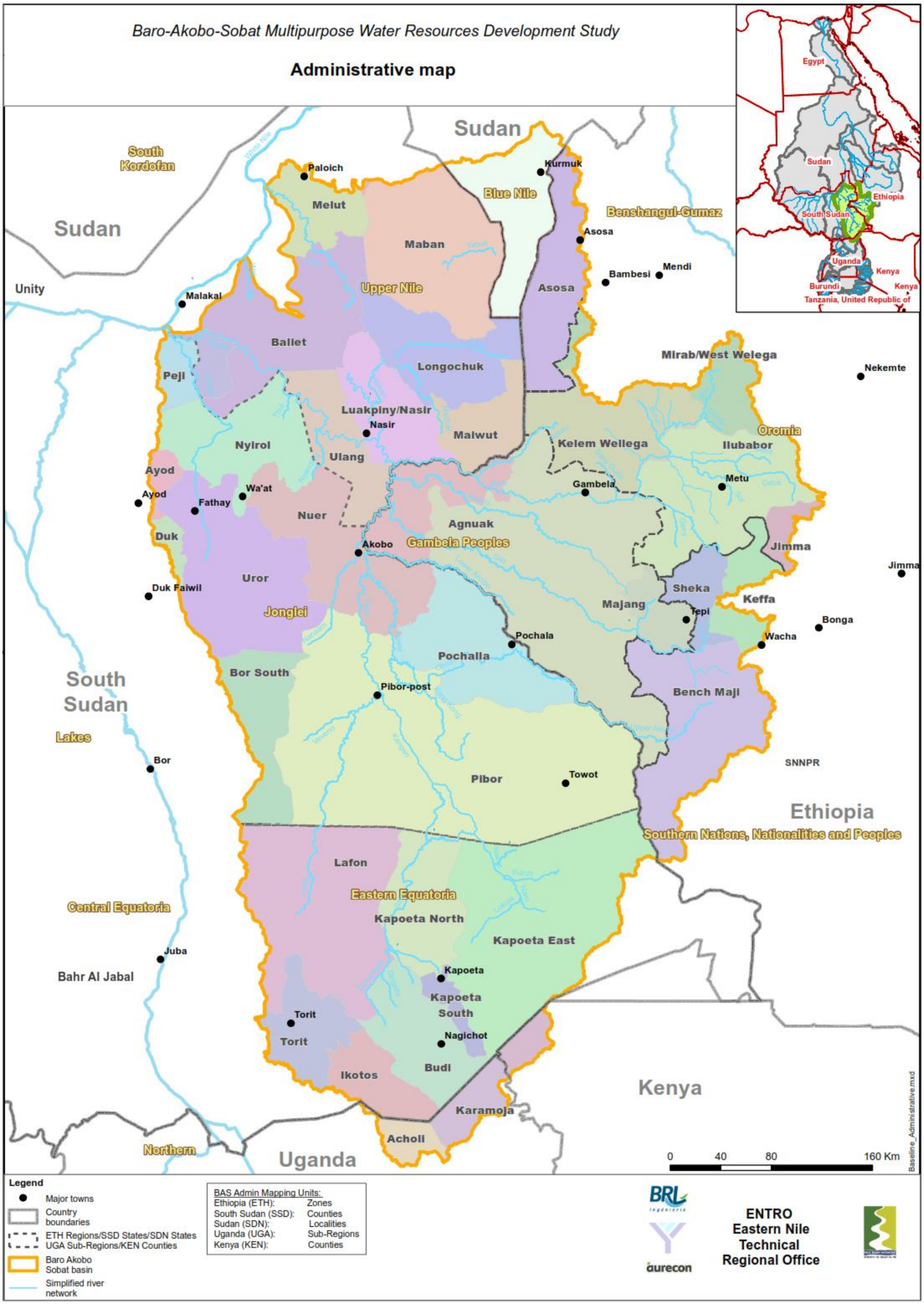
Important towns and market centers in the South Sudanese part of the BAS sub-basin are as follows (see also Figure 1-1).

*Table 1.1: Major towns for each States of the basin*

| Upper Nile | Jonglei | Eastern Equatoria |
|---|---|---|
| Malakal<br>Palolah<br>Nasir | Pibor<br>Ayod<br>Towot<br>Pochala<br>Akobo<br>Duk Fadiat<br>Waat | Kapoeta<br>Torit<br>Naglohot<br>Lofusa |

Of the above towns, Malakal, the capital of Upper Nile State, and Torit and Kapoeta in Eastern Equatoria State, are among the most important, with estimated populations of 139,400, 19,956 and 7,000, respectively, (NBS, 2010).

*Figure 1-1: Administrative Map of the BAS Sub-basin*



# 2. EDUCATION AND HEALTH STATUS

## 2.1 INTRODUCTION

This section presents the education and health status of the population in the sub-basin, including literacy and education enrolment and attendance, nutrition status, infant mortality, access to improved sanitation.

## 2.2 LITERACY AND EDUCATION

### 2.2.1 Literacy

Most of the population in the sub-basin has limited access to education and low literacy and educational attainment. The literacy rates for the states in the BAS sub-basin are shown below.

*Table 2.2: Literacy Rate in Sub-basin States (%)*

| Location | Literacy Rate[1] |
|---|---|
| Upper Nile | 50 |
| Jonglei | 19 |
| Eastern Equatoria | 18 |
| South Sudan | 28 |

[1] Literacy is defined as the ability to read and write a simple text among people 15 years old and above

### 2.2.2 Education

South Sudan has some of the lowest educational indicators in Sub-saharan Africa, with education of girls also being among the lowest. Only one girl in ten completes primary education, and girls comprise just a little over one-third of the secondary school population. Very few girls who complete primary education continue on to secondary school. There are many barriers (cultural, financial, poor infrastructure/quality) that prevent girls from going to and remaining in school. A girl child faces many barriers when she wants to go to school: her family may not be able to pay for her education, or may think education for girls is not important or necessary.

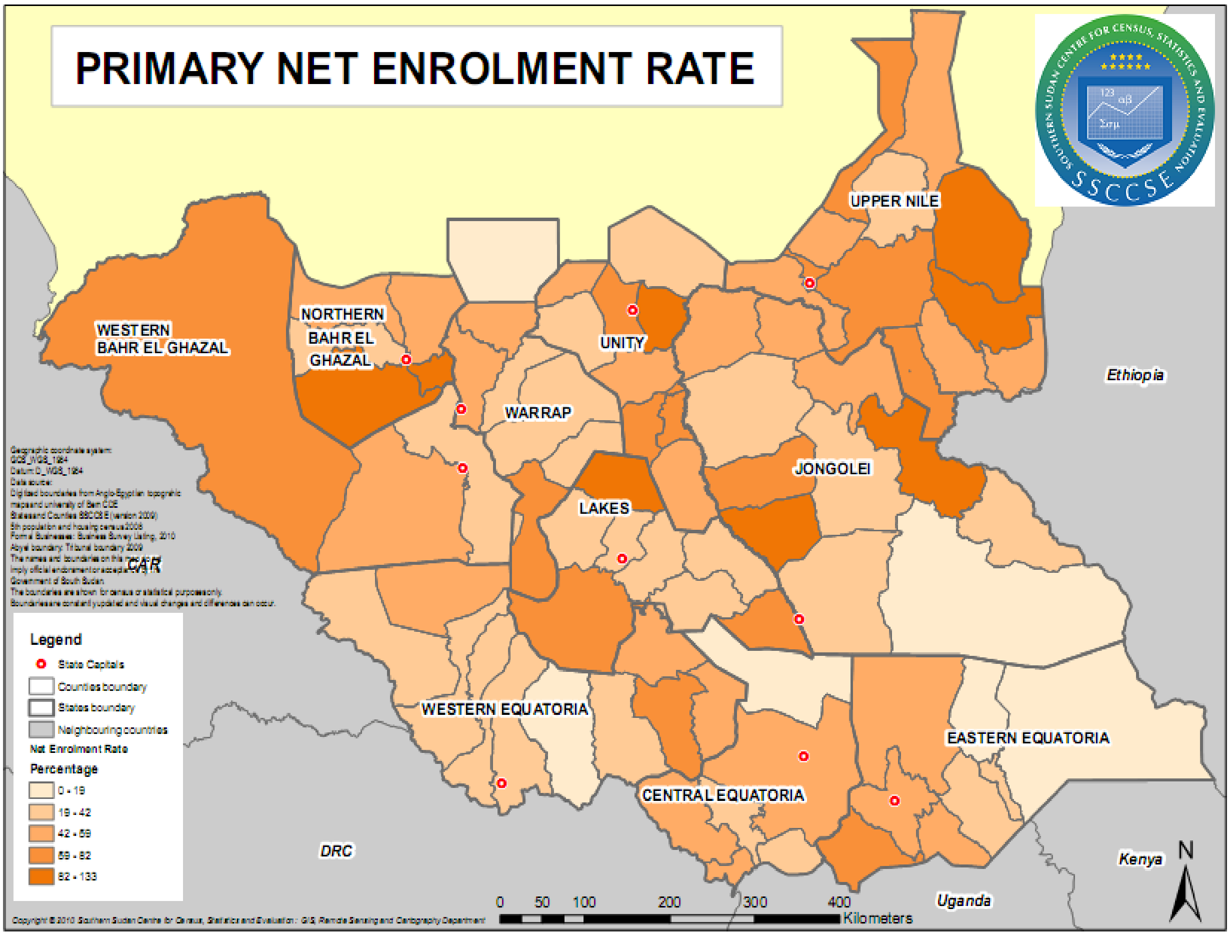
At primary level the distribution of girl and boy pupils is uneven, with girls comprising only 39% of the pupil population nationally in 2011, a pattern which can be assumed to apply to the BAS sub-basin as well.

While the number of students has increased, there has been very little change in gender parity. Some 70% of secondary school students in the country are male. The trend resembles that at the primary level, whereby boys have higher access to education than girls (MoGEI, 2012).

A main challenge to education in South Sudan is to eliminate barriers to girls' education and promote gender equality through and throughout the education system[4]. As shown in the map below, in the sub-basin states the Net enrolment Rate (NER) is highest (i.e. 82-129) in Upper Nile and lowest (below 20%) in Eastern Equatoria.

[4] http://www.girlseducationsouthsudan.org/about-girls-education-south-sudan.

*Figure 2-1: Primary Net Enrolment Rate in South Sudan*




Source: SSCCS, 2009

Most of the population in the sub-basin area has limited access to education. The primary school enrolment rates for males and females in the states in the BAS sub-basin are shown below.

*Table 2.2 Primary School Enrolment Rates*

| Location | Primary School Enrolment (6-13 years) - % | |
|---|---|---|
| | Male | Female |
| Eastern Equatoria | 59.6 | 40.4 |
| Jonglei | 61.2 | 38.8 |
| Upper Nile | 56.7 | 43.3 |

Source: 2008 Census for South Sudan

Another indicator of access to education is the primary school attendance rate, which shows actual attendance and is therefore more accurate than the enrolment rate alone.

*Table 2.2: Primary School Attendance Rate in Sub-Basin States in South Sudan*

| Location | Primary School Attendance Rate (%) |
|---|---|
| Upper Nile | 50.0 |
| Jonglei | 27.0 |
| Eastern Equatoria | 27.0 |
| South Sudan | 37.0 |

The most common reasons given by parents for children not attending school were mostly attributed to poverty - no money to pay school fees (32%) and lack of schools or schools are very far (30%).

**Education Facilities**

South Sudan in general and the sub-basin in particular have an acute shortage of educational institutions and staff and resources to maintain them. Seventy-three percent of the population is illiterate according to the Southern Sudan Centre for Census, Statistics and Evaluation (2014) and nearly one in four civil servants lacks formal education.

In addition, a need exists for vocational and non-formal training to reintegrate thousands of ex-combatants and hundreds of thousands of newly arrived returnees into productive employment and to develop a labour force with the skills to support a growing economy, especially in the areas of construction, mechanics, plumbing and electrical work. In some cases, new returnees arrive in South Sudan with useful skill sets from work experience in Sudan, such as teaching, mechanics or construction. Making effective use of these human resources in the developing economy of South Sudan is a major challenge to making an enabling environment for development.

The significance of present education and literacy levels for the future development of the BAS sub-basin is the absence of a cadre of indigenous basin residents with the knowledge, skills, and experience with access to capital for investment in productive activities to drive development in the basin. In the absence of such an indigenous entrepreneurial class, development is dependent on government, donors and relatively unknown external "investors". Thus there is a high risk that development will depend on externally-driven forces and interests and capital for investment.

## 2.3 HEALTH STATUS

The main health problems in the sub-basin are human diseases which include tsetse, yellow fever, malaria, Onchorceciasis and Shcistosomasis. These diseases are a major constraint to the economic and social development of the basin. In the future, many human health problems are likey to impacted by development interventions such as irrigation, reservoirs, expansion of human setttlments, and inlfux of people into the basin due to large-scale farm development and investment. Malaria could well become perennial instead of seasonal; and tsetse will increase in accordance with the increase livestock population and with use of animal traction for crop production.

The health situation in the BAS basin is characterized by high incidence of preventable diseases, childhood malnutrition, infant mortality and poor sanitary conditions. There is also low access to effective health care and medicines. The following tables show some common indicators of health status of the basin states in South Sudan.

*Table 2.2: Childhood Nutrition Status in Sub-basin States*

| Location | Low Weight for Age (%)[1] |
|---|---|
| Upper Nile | 24.2 |
| Jonglei | 29.3 |
| Eastern Equatoria | 29.2 |
| South Sudan | 27.6 |

[1] Low weight for age is used as an indicator of the nutrition status of children in a population using a comparison with normal weights for each age group

*Source: South Sudan - Household Health Survey, Final Report, National Bureau of Statistics, Ministry of Health, August 2013.*

Another commonly used indicator of the general health status of a population is the infant mortality rate. The infant mortality rate for the states in the BAS basin is shown in the following table.

*Table 2-2: Infant Mortality Rates* for Sub-basin States*

| Location | Infant Mortality Rate (IMR) |
|---|---|
| Upper Nile | 74 |
| Jonglei | 31 |
| Eastern Equatoria | 106 |
| South Sudan | 60 |

*Deaths in the first year of life per 1,000 live births

*Source: South Sudan - Household Health Survey, Final Report, National Bureau of Statistics, Ministry of Health, August 2013.*

Another important indicator of general health conditions in a population is access to adequate sanitation. The following table shows access to improved sanitary facilities by households in the Sub-basin states.

*Table 2.2: Access to Sanitation in Basin States – South Sudan*

| Location | Improved Sanitation (%) | No toilet/open air (%) |
|---|---|---|
| Upper Nile | 7.8 | 71.5 |
| Jonglei | 6.2 | 70.7 |
| Eastern Equatoria | 4.5 | 74.7 |
| South Sudan | 7.0 | 64.1 |

*Source: South Sudan - Household Health Survey, Final Report, National Bureau of Statistics, Ministry of Health, August 2013.*

### 2.3.1 Malaria

Malaria is a leading cause of death of children under age five in South Sudan. From January to October 2015, more than 2.1 million cases of malaria were reported in health facilities in the country, resulting in more than 1,100 deaths. These figures include only deaths at health facilities, and the overall death rate from this disease is likely to be much higher.

Malaria also contributes to anemia in children and is a common cause of absenteeism from school and work. A rough indicator of measures in place to prevent of malaria is ownership of mosquito nets by households. The ownership of at least one mosquito net by households in the sub-basin states is shown in the following table:

*Table 2-2: Ownership of at least one Mosquito Net by Households in Basin States – South Sudan*

| Location | Households (%) |
|---|---|
| Upper Nile | 74.3 |
| Jonglei | 66.1 |
| Eastern Equatoria | 37.0 |
| South Sudan | 60.0 |

*Source: South Sudan - Household Health Survey, Final Report, National Bureau of Statistics, Ministry of Health, August 2013.*

Mortality in the sub-basin has been exacerbated by acute malnutrition and disease, with more than one in five counties surveyed (10 out of 46) having Crude Death Rates (CDR) above the threshold of 1 death per 10,000 people per day. There continue to be deaths from preventable diseases. Malaria is the largest cause of death, with more than 1,100 deaths due to the disease reported in health facilities from January to October 2015.

South Sudan's health situation requires urgent attention and its needs are considerable. Maternal mortality, at 730 women per 100,000 live births, is among the highest in the world and can be part of the explanation for the fewer number of women than men in South Sudan. Contributing to this situation is the fact that 90% of all births occur without a health care professional in attendance. Infant mortality, at 102 per 1,000 live births, is also among the world's highest. Nutritional data from the *2008 Annual Needs and Livelihoods Assessment* revealed that a quarter of all children under five years of age were underweight, and nearly one in five was stunted. Less than 18% of children are fully immunized. Approximately 30% of the population does not have access to a health facility. The increasing prevalence of HIV/AIDS, a "negative peace dividend" resulting from increased traffic from neighbouring countries with higher rates of HIV/AIDS, is a cause for alarm.

# 3. GENDER RELATIONS[5]

## 3.1 INTRODUCTION

South Sudan has more than 60 ethnic groups and 80 languages. Distinctions of ethnicity, language, religion, social class and rural or urban way of life cut across the society resulting indifferent gender relations even within the same overall ethnic group. Principle ethnic groups include the Dinka, Nuer, Bari, Murle and Shilluk. Most South Sudanese are Christian, there are also Muslims, and many South Sudanese practice traditional animist beliefs. The large majority of South Sudanese (some 83%) live in rural areas although there are significant differences between states.

The cattle culture is very important for most South Sudanese ethnic groups. The size of one's herd is a key marker of wealth, and cattle-raiding has been a main catalyst of inter-ethnic violence before the current political conflict erupted. In many parts of South Sudan, cattle are also used for bride price which is required for a man to marry.

Gender relations in South Sudan are shaped by the social and economic realities of being one of the world's Least Developed Countries and by decades of conflict and violence. The starkest results of women's poor health status and life chances are that, unlike many other countries in the world, there are more men than women in South Sudan: 52% male to 48% females, compared to the global average of 51% females to 49% males.

Education rates are low, with 27% of the adult population literate: 40% of men over 15 years compared to 16% of women over 15 years old.

Prevailing cultural norms, especially in rural areas, marginalize women from participation in political activity or decision-making. However, since independence, there have been real changes in national policy and laws on gender equality. The Transitional Constitution and Bill of Rights (2011) provides guarantees for the equality of men and women. It recognizes the historic inequalities between women and men in South Sudan and sets out a 25% Affirmative Action quota for women in legislative and executive bodies. Women currently comprise 26.5% of the National Legislative Assembly in South Sudan.

Women and men, trading women for food or security, traditional practices including 'girl compensation', and forced prostitution/sexual slavery. Domestic violence is also widely accepted by both women and men in South Sudan: 82% of women and 81% of men agreed that "women should tolerate violence in order to keep her family together".

Early marriage is very common: 45% of girls married before they were 18 years old and 7% of girls married when they were younger than 15 years old. Bride price paid by the husband to the girl's family is the norm.

To obtain cattle for the bride price, cattle-raiding has increasingly targeted women and children. Polygamy is very common, with 41% of marriages involving more than one wife. Divorce is extremely difficult for women to obtain: traditionally only men can ask for one and the wife's family have to pay back the bride price.

Masculine identity tied to cattle-raiding, bride-price, a lack access to legal recourse, and customary practices that favor compensation for crimes against women and girls like rape.

Gender relations in South Sudan are complex: the roles and responsibilities of women, men, boys and girls are clearly delineated in traditional cultural norms but sex roles for women and girls are more resistant to change than are the roles of men and boys. The roles of men and boys are being transformed by both new political and longstanding interethnic conflicts over land, water and other natural resources.

5 The following section makes use of information contained in; Gender Brief, CARE, 2014

Women and girls have responsibilities for farming, collecting water and firewood, cooking, cleaning, childcare, and brewing beer. Men and boys have responsibilities as decision-makers for their communities and families, cattle (boys in particular tend to be cattle-herders), hunting, fishing and charcoal making.

In times of conflicts and crisis, gender roles and responsibilities change, survival needs and coping strategies families and individuals must engage in. Gender relations also affect the needs, coping strategies, participation and access of women, men, boys and girls to humanitarian assistance.

There are many female-headed households in the basin, where mothers have full responsibility for raising families while their spouses were “in the bush‘ fighting the war. This gendered burden was acknowledged by the southern Sudanese leadership, which characterized southern women as “the marginalized of the marginalized”.

The results of a gender assessment in South Sudan in 2010[6] made the following findings

- Women do not have the right to own land
- Men get preference in training on traction methods and agricultural machinery
- There has been significant progress through new roads and improved market access
- Girls’ school enrolment has improved but dropout rates remain high
- There has been some improvement in school infrastructure, but water and sanitary facilities are still lacking causing girls to drop out of school
- There is a continued lack of trained female teachers, even with a program specifically to attract women teachers
- There is a need for functional literacy courses for uneducated youth and adults to become employed
- New roads continue to increase access to health centers but the problem remains; rural women still do not have access to health care.
- Women should also be offered opportunities to participate in training that involves mechanized farming techniques, use of tractors, automatic grinding machines, automated threshers, etc.
- Consider gender roles already in place and make sure that opportunities exist for women to reduce the number of hours tasks require through better methods and/or mechanization

## 3.2 National Gender Policy

South Sudan’s first post-independence development plan (SSDP 2011-2013) recognizes the central role of gender equality in development and includes it among the nine cross-cutting issues which all sectors are required to mainstream in all policies, plans and programs. South Sudan enacted a National Gender Policy in 2012[7]. The Policy contains objectives and strategies for addressing eight focus areas as identified by the women and men of South Sudan during the policy consultation processes, These are:

- Gender equality and democratic governance
- Gender, education and capacity development
- Gender equality and health
- Gender and food security
- Gender and women’s economic empowerment
- Gender-based violence

**6** Gender Assessment USAID Southern Sudan, USAID, 2010.
**7** National Gender Policy, Ministry of Gender, Child and Social Development, Juba 2012.

- Gender, peace and security
- Gender environment and natural resources management

The vision of the National Gender Policy for South Sudan is of a country that is just and free from all forms of discrimination and violence where women, men and children enjoy their human rights on the basis of equality and non-discrimination in all spheres of national life.

The mission of the policy is to achieve gender equality and non-discrimination at all levels of society and across sectors for the achievement of peace and sustainable development in South Sudan.

The ultimate goal of this policy is to make gender equality an integral part of all laws, policies, programs and activities of all government institutions, the private sector and civil society so as to achieve equality in the cultural, social, political and economic spheres in South Sudan.

The overall objective of the national gender policy is to serve as a framework and provide guidelines for mainstreaming gender equality and the empowerment of women in the national development process.

## 3.3 Gender and Food Security

All elements of food security (availability, access, utilization and sustainability) have been affected by decades of conflict and insecurity. South Sudan is, therefore, among African countries considered most at risk of food insecurity (African Human Development Report (AHD 2012). While women play a key role in food production and preparation, they and the children are among the first victims in times of food shortage and hunger and often suffer from malnutrition.

The Government has developed a policy framework in the food security related sectors, including agriculture, water, health, transport and trade. These policies, however, need to be more gender-aware and take into consideration the differential contribution and impact on men and women.

There is an urgent need to develop deliberate policies and interventions that recognize and reward women’s multiple roles and unpaid labour and enable them to have better access to productive inputs, markets and food security in a sustainable manner. This requires investing more in education, capacity and skills building in improved agricultural production methods and better access to extension services and inputs for more sustainable production. Equally important is to diversify and extend women’s role beyond subsistence production to other sectors, including agro-business, food preservation, value addition, storage and marketing and acquiring vocational and technical skills.

There is a specific objective and strategies in the National Gender Policy to address the roles of women in food security, as follows:

**Objective**: To promote women-specific projects as a means of addressing women and children’s vulnerability to food insecurity.

**Strategies**:

- Ensure gender mainstreaming throughout the food production sector, including value addition, packaging and marketing.
- Provide targeted investment to support women farmers as the main producers of food.
- Promote organization of women farmers into groups and cooperatives as a way of establishing mechanisms for better access to agricultural inputs, implements, credit and extension services.
- Establish and provide appropriate financial resources and technical services for rural women in the agricultural and food production sectors, such as training in improved farming practices, food storage and preservation, value addition and marketing .
- Invest in research on labor-saving technologies

- Formulate policies and strategies to reduce women and girls' unpaid household workload

## 3.4 Gender, the Environment and Natural Resources Management

South Sudan is among countries in the region that are most susceptible to environmental disasters including prolonged droughts and floods. Women play a critical role in providing food, water, fuelwood and subsistence farming, among other vital services, and are the most affected by environmental degradation and hazards. Their needs and concerns must, therefore, be an integral part of the process of formulating environment and resource management policies and programs.

The following objective and strategies can help to ensure that environmental protection, conservation and management systems for the environment and natural resources, including water, are gender-responsive and able to meet the survival needs of present and future generations. Following is the objective as stated in the National Gender Policy:

**Objective:** To mainstream gender equality in the formulation and implementation of a regulatory framework for environmental and Natural Resources Management

**Strategies**

- Provide women education opportunities and information on environmental and natural resources management in order to take up leadership roles in the sector.
- Invest in research and training of women in the development, production and utilization of energy-saving and environment –friendly cooking methods and materials.
- Make gender analysis obligatory in environmental impact assessments for investment and development projects and programs, including large-scale agriculture, dam building, and within the petroleum industry.
- Collaborate with the private sector, including the petroleum industry, to meet their corporate social responsibility by supporting women-led environment protection and rehabilitation activities.
- Develop and implement gender-responsive and sustainable environment protection and conservation policies and programs and regulations.
- Conduct research on effects of environment change related to nat. resource management on women and families
- Gender dimensions of mismanagement and over-use of natural resources on women and links to conflict management and peace building

## 3.5 Implications for Development

It is important to include the important issues of women's roles in food security and natural resources management and identify ways to enhance women's contributions in these important areas as well as to formulate a specific objectives and strategies to achieve this in the future development of the BAS sub-basin.

As well as being a national development objective, the largely unrealized role and contribution of women to the country's development process is both a key issue and one of the most important potentials to be addressed in subsequent phases of this study.

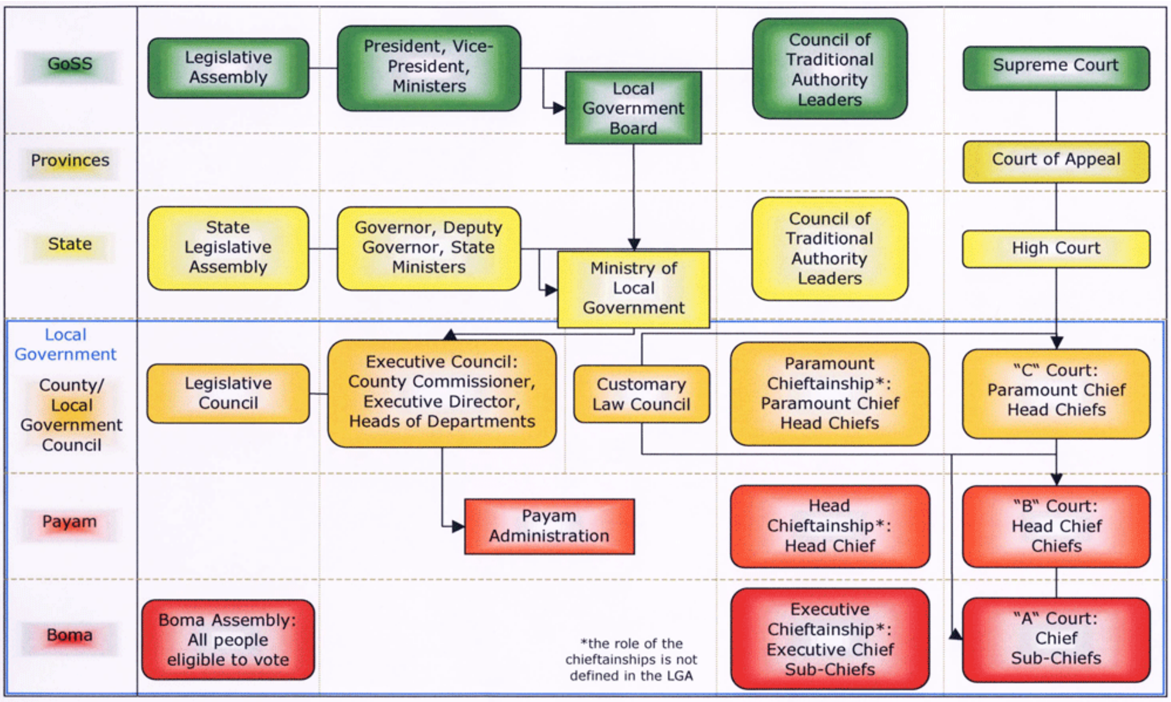
# 4. GOVERNMENT AND ADMINISTRATIVE ORGANIZATION

As has been described previously, South Sudan is divided into 10 states with each state further divided into a number of counties.

In South Sudan, counties are divided into smaller administrative units called *payam*, which are in turn divided into *bomas*, the lowest administrative level of the South Sudan state.

The administrative structure of the South Sudan state is based on the principle of decentralization and is shown in the diagram here after.

*Figure 4-1: Administrative Organization of Government*




*Source: Decentralisation Hybridized, Annina Aeberli, Graduate Institute Publications, 2012*

As can be seen from the above diagram, the South Sudan state's structure contains a parallel hierarchy of traditional chiefs, which itself contains both an executive and a judicial arm based on a vertically aligned system of courts that apply and enforce both customary and formal laws. In addition, in many areas, traditional social customs and norms are enforced by a network of tribal, clan and sub-clan elders operating at the local level.

# 5. ETHNIC AND LANGUAGE GROUPS

## 5.1 ETHNIC GROUPS

The BAS sub basin is home for a large share of the some 60 main indigenous ethnic groups. Major ethnic groups in the South Sudanese part of the BAS sub-basin include the Dinka, Nuer, Azande, Bari, Shilluk, Lotuho, Toposa, Lou, Moru, and Murle. the map next page shows the distribution of the major ethnic groups in South Sudan, including the groups in the BAS sub-basin.

The ***Dinka people*** are organized into several independent, but interrelated clans. They form the largest ethnic group in South Sudan, accounting for 35.8% of the population. They are predominately pastoral people, but also practice shifting cultivation, growing millet, maize and occasionally cotton.

The ***Nuer people*** live in states of Upper Nile, Jungle and Unity. They are the part of Nilotic group and are the second largest group in South Sudan, representing 15.6% of the population. The Nuer are pastoralists or, more properly, agro-pastoralists.

The **Bari people** occupy the savanna lands of the White Nile Valley. They embrace a cattle culture; the components of a typical traditional Bari dowry are made up of live animals, averaging 23 heads of cattle (cows, calves and bulls), 40 goats and sheep. Dowry is handed over when betrothed are of marrying age, followed by a Christian wedding.

The ***Shilluk people***, mainly live in upper Nile state in South Sudan. Shilluk are sedentary and practice rainfed cultivation of sorghum, maize, groundnuts, beans and tobacco near their villages. Shilluk people possess fewer cattle and depend less on cattle products. Thus they are not obliged to migrate with the seasons. Fishing is an important component of their economy.

The ***Lotuho*** are primarily a pastoral people and are located in Eastern Equatoria State. Their religion is based on nature and ancestor worship. Land is held in trust by the community. They make gardens in a certain places, and the group decides the boundaries of each person's garden. Certain areas are fallow (for up to 10 years in the mountains) and other areas open to cultivation (for up to 4 years in the plains), with fallow areas being used for grazing livestock.

The ***Toposa people*** primarily live in Eastern Equatoria.Traditionally they lived by herding cattle, sheep and goats, low-level warfare (mainly cattle raids against neighbors), and have always engaged in cattle raiding. They are mainly pastoralists, keeping cattle, camels, goats and sheep, but also cultivate some maize and sorghum.

The ***Murle people*** live primarily in the State of Jonglei in South Sudan as well as in neighboring regions of Ethiopia. The Murle (like the Dinka and Nuer) have a tradition in which men can only marry when they pay a dowry of several dozen cows.

**Nuers** are predominantly cattle-breeders, but they also cultivate flood recession maize and sorghum to supplement their diet of milk and blood. Cattle are jointly owned by families.

Pastoral groups depend on seasonal migration to seek water and grazing for the herds. The following map shows main annual pastoral migration routes in South Sudan and neighbouring areas in Sudan.

*Figure 5-1: Distribution of Major Ethnic Groups in the BAS sub-basin*

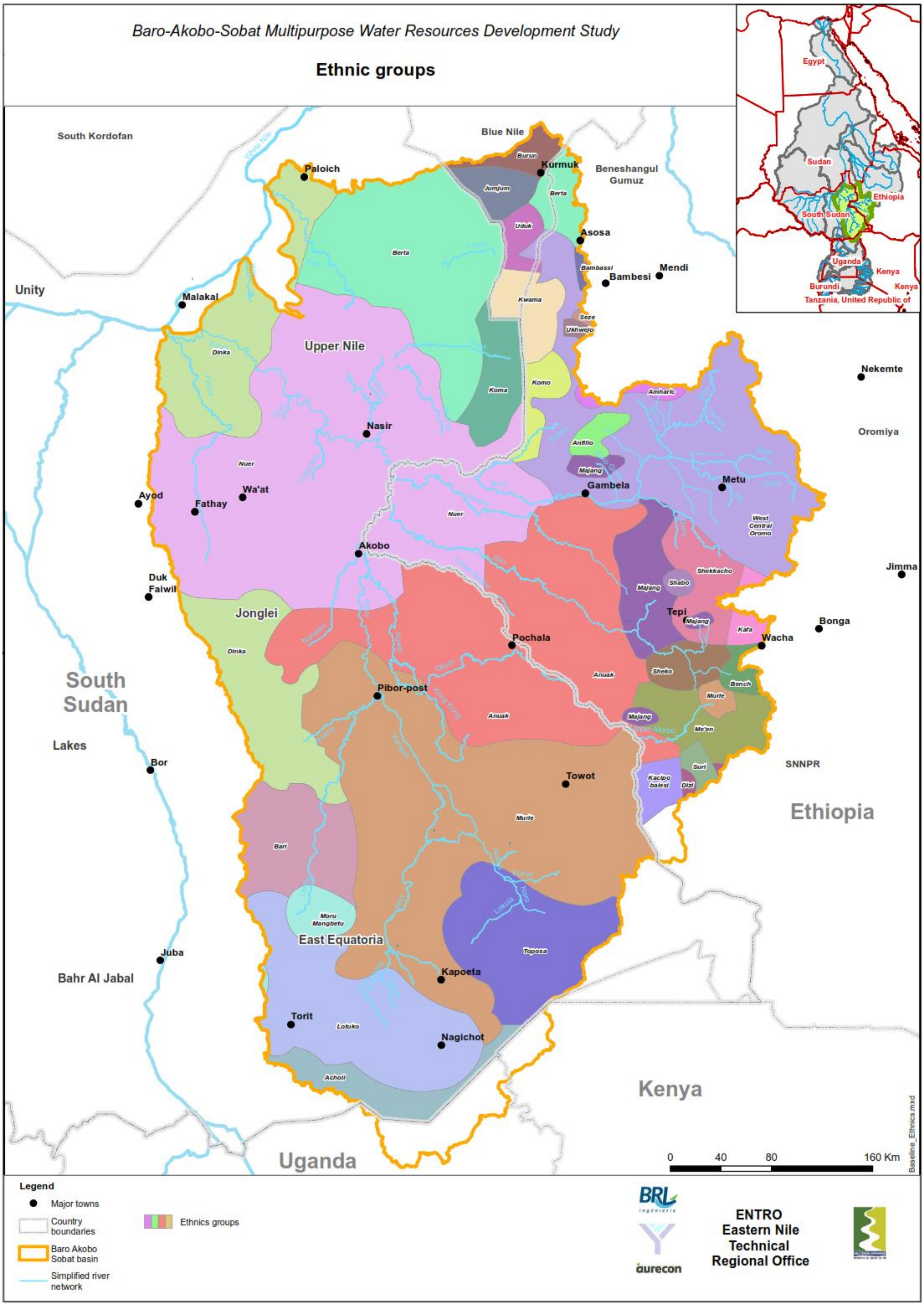


*Figure 5-2: Main annual pastoral migration routes in the BAS sub-basin*

The above map shows that the main pastoral migration routes in the South Sudanese part of the basin are located in Eastern Equatoria State in the southern part of the basin and transecting Jonglei and upper Nile states. Migration routes are determined by the seasonal availability of water and pasture for livestock and are very sensitive to changes in rainfall and climatic patterns, as well as political and interethnic conflicts.

## 5.2 LANGUAGE GROUPS

The South Sudan part of the basin is highly linguistically diverse. Not surprisingly, language is closely correlated with ethnicity and locality, except in the cases of the two main link languages, Arabic and English which serve as a means of communication across ethnic boundaries and by the State's administrative apparatus, international organizations and businesses that have transactions across states or nationally. The language distribution is quite similar to the ethnic distribution (see figure above).

As can be seen from this map, the main languages spoken in the basin are Nuer, Dinka, Murle, Anuak, Toposa, Lotuko, Turkana, Berta and Shifter, with a number of dialects and languages spoken by smaller ethnic groups. Language is closely associated with identity and most of these languages are not used or understood across ethnic or geographic boundaries.

Indeed, the state in South Sudan could not exist or function without a common language(s) that are understood among horizontal elites across all parts of its national territory. Where there are two or more languages spoken by large ethnic groups within a country's territory, the choice of an "official" language can be problematic and lead to conflicts. In such a situation, bridge languages such as English or Arabic can serve as official languages, even if they are used by a minority of the country's population.

# 6. CONFLICTS AND DISPLACEMENT

## 6.1 POLITICAL CONFLICTS

South Sudan has experienced various forms of conflicts for many years: political, inter and intra-ethnic conflicts, border conflicts, and other traditional/social conflicts. The country was at war with Sudan for almost three decades, during which hundreds of thousands of civilians were killed, displaced and/or suffered various forms of trauma. After independence in July 2011, the country enjoyed a brief period of peace, during which a number of development programs were launched in collaboration with development partners.

However, in December 2013, growing political tensions among the leaders in South Sudan erupted in violence, only three years after the country gained independence from Sudan in an internationally-supported public referendum. While the political dispute that triggered this crisis was not overtly based on ethnic identity, it overlapped with pre-existing ethnic and political grievances that sparked armed clashes and targeted ethnic killings in the capital, Juba, and beyond.

Fighting between forces loyal to President Salva Kiir and forces loyal to former Vice President, Riek Machar, and among armed civilians, has resulted in a security and humanitarian emergency that, according to some analysts, may be drawing the world’s newest country into another civil war (Blanchard, 2014). More than 200,000 civilians have been internally displaced by the violence, including more than 60,000 who sought refuge at U.N. peacekeeping bases[8]. As many as 40,000 people have fled to neighbouring countries.

A major military confrontation between different SPLM factions erupted on 16 December 2013, three weeks after the end of the CFSA Mission. It spread quickly from Juba to Bor (Jonglei), Bentiu (Unity) and Malakal (Upper Nile) remained the major hotspots of conflict. A study conducted by the FAO/WFP assessment mission came up with different finding regarding the people affected by the recent war between the two forces.

A ceasefire was signed on 23 January 2014. In the few days after the signing of the cease-fire, confrontations took place in Jonglei, while tensions remained high elsewhere. The direct effects of this conflict have been more serious in Jonglei, Upper Nile Unity and Central Equatoria states. (FAO/WFP, 2014)

The number of people in crisis and a state of emergency has increased more than threefold (from 1 million to 3.2 million) during 2014 and 2015. The population in a state of emergency requires immediate humanitarian assistance for their survival.

More than 2.3 million people - one in every five people in South Sudan - have been forced to flee their homes since the conflict began, including 1.66 million internally displaced people (with half estimated to be children1) and nearly 646,000 refugees in neighbouring countries.

Therefore, conflict management and resolution is a critical issue for the future development of South Sudan. More than anything else, seeking a political solution to the current conflicts is an urgent matter to avert a looming civil war and to allow people’s lives to stabilize. To address traditional as well as new conflicts, workable institutional arrangements at grassroots level and appropriate conflict management mechanisms/strategies that involve all actors are required.

The following map shows the number of refugees by state and originating from South Sudan in neighbouring countries at the end of January 2016.

Looking at the three basin states, it can be seen that the number of refugees is by far the highest in Upper Nile State, followed by Jonglei State. Using the numbers of refugees and displaced people as a proxy

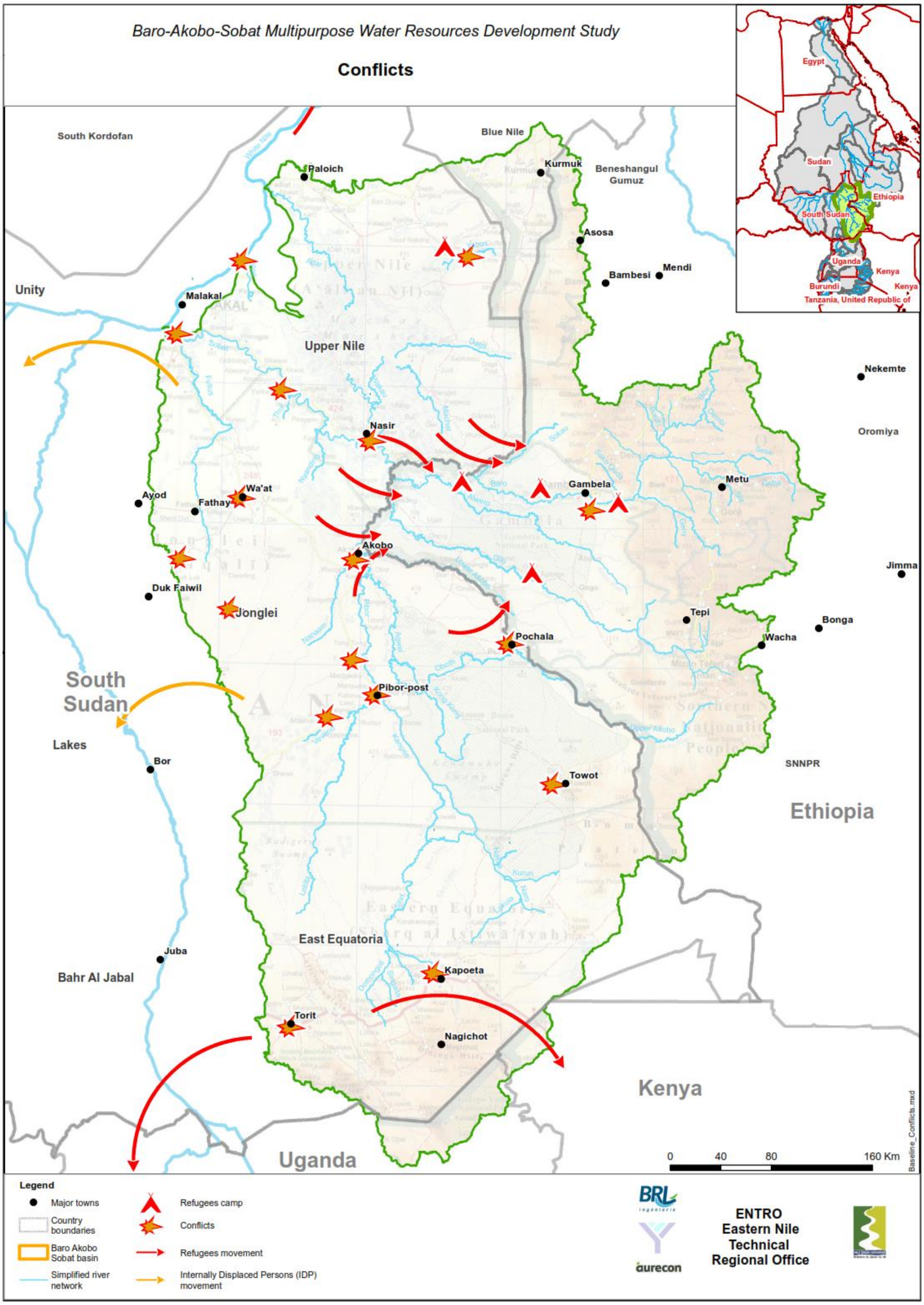
8 U.N. Office for the Coordination of Humanitarian Affairs (UNOCHA), “South Sudan Crisis: Situation Report January 2014,” Report Number 8, January 7, 2014.

indicator of stability, it can be concluded that instability is highest in Upper Nile State and lowest in Eastern Equatoria State. It is also relevant for this study that there are over 227,000 South Sudanese living as refugees in Ethiopia. It can be assumed that the majority of this number are living in camps in the basin regions of Gambella and Benishangul-Gumuz. These figures are dynamic and are subject to frequent change as flash points and the location of incidents change in the South Sudan landscape.

Since the most recent political conflicts started in mid-December 2013, South Sudan's population size and geographical distribution has seen significant changes. According to OCHA and UNHCR, by early February 2015, about 2 million people had been forced to flee their homes due to insecurity, including 1.5 million IDPs and half a million people seeking refuge in neighbouring countries (Ethiopia, Uganda, the Sudan and Kenya). Most South Sudanese refugees originate from Jonglei (mainly from South Bor, North Bor and Akobo counties) and Upper Nile states (especially from Latjor County). Over 400,000 people left the country during a six-month period in 2014.

Such "spontaneous" and involuntary population movements negatively impact farming activities, as only a small fraction of displaced people are able to cultivate their fields. In addition, the unplanned influx of large concentrations of IDPs in some counties significantly increase local food demand, which has led to higher food deficits and prices. Refugees' livelihoods depend on food, medicine and other forms of assistance from humanitarian organizations, as well as from "host" communities. The presence of large numbers of refugees in an area places added pressure on resources such as firewood, water, wild foods and construction materials.

*Figure 6-1: Conflicts and population displacement in the BAS sub-basin*



## 6.2 HISTORIC ETHNIC/TRIBAL CONFLICTS

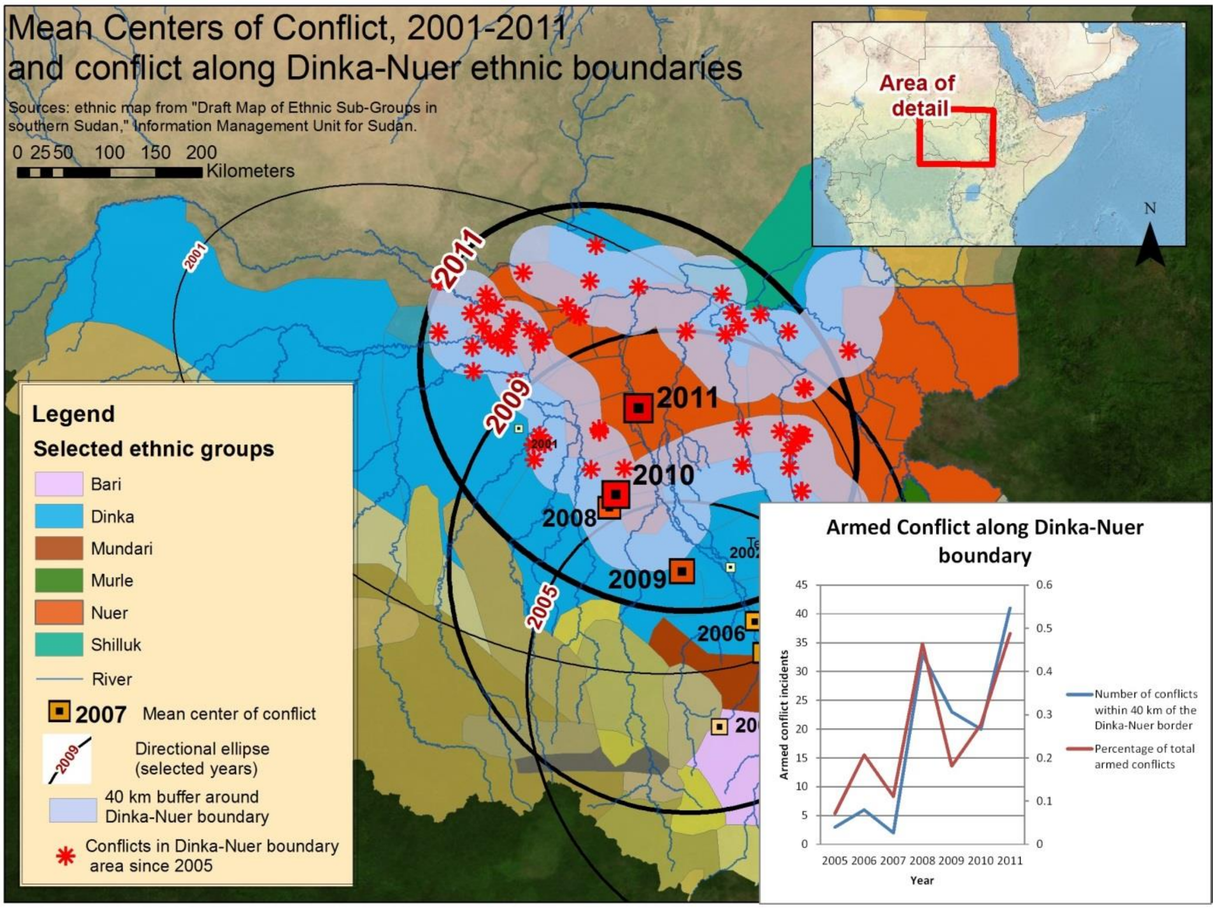
Inter-communal and inter-ethnic conflicts are prevalent in many local communities and among ethnic groups in the basin. Most conflicts revolve around cattle raiding and peaks during the dry season. The major causes of inter-ethnic conflicts are mostly various forms of encroachments on land and over the use of natural resources, including water.

Pastoralist lifestyles have a potential for conflicts due to the need to migrate over long distances seeking limited water and pasture resources. According to a representative from South Kapoeta in Eastern Equatoria State, nearly all major inter and intra-communal conflicts are linked either to cattle raiding and the subsequent spiral of violent retribution, or conflict among pastoralists and farmers over migration routes and access to water and pastureland. Providing adequate water points along major grazing routes will contribute to solving the present conflicts.

While all ethnic groups have conflict resolution mechanisms for internal conflicts which serve to maintain the internal legitimacy and cohesion of the group, no effective mechanisms exist to mediate inter-tribal conflicts and disputes. By default, this task falls to the national police force and formal courts, which are often ill-equipped and reluctant to handle such conflicts.

The following map shows the location and trends in armed conflicts and conflicts along the interface between Dinka and Nuer territory during a 10-year period, as an example of historic inter-ethnic conflict in the basin.

*Figure 6-2: an example of historic inter-ethnic conflict in the basin.*




*Source; Information Management Unit for Sudan, n.d.*

# 7. CROP PRODUCTION

## 7.1 INTRODUCTION

Crop production (agriculture) is one of the natural resources practices, as means of earning cash and foodstuff for sustaining livelihoods. Agricultural practices in the basin vary considerably across agro-ecological and livelihood zones. However, similarities exist in farming systems across national borders where historical ethnic and cultural affiliations. The main farming systems are rainfed and irrigated cropping. Rainfed agriculture is the most common farming system, ranging from small-scale subsistence production to large-scale farming (ENTRO, 2009).

Mixed cropping, poultry and livestock production are other common practices, along with shifting cultivation. In both highland and lowland areas in the basin , the use of agricultural inputs such as fertilizers, agro-chemicals, improved seeds, tractors and other machinery is still minimal.

## 7.2 TRADITIONAL SMALL-SCALE RAINFED AGRICULTURE

In the highlands, traditional rainfed systems can be divided into cereal and enset-root based crop production. The enset-root based system is common among the Mocha (Sheka) people, living mainly in the highest parts of the Ethiopian highlands, cultivating enset as a co-staple crop with cereals and tubers. The common crops grown here include enset, root crops, yam, taro and sweet potato, pulses, vegetables, spices, teff, rice, cassava, maize, sorghum, cowpeas, groundnuts. Below 2,000 meters above the sea level coffee is produced in Ethiopia. Coffee, teff, maize, sorghum, cotton and root crops are the important cash crops (ENTRO, 2012; 2009).

The Anuwak, Opo and Komo peoples cultivate the banks and levees of the Baro, Akobo and Sobat rivers rather than woodlands on the interfluves. Crops grown are mainly maize, beans and sorghum. The average cropped area for maize is 1-2 hectares with 1 hectare of long season sorghum. The first maize and bean crops are grown on wetter soils where there is residual moisture. The second crop is grown during the rainy season on the high and better-drained levee soils with the sorghum and bean crops (ENTRO, 2012; 2009).

The Shilluk occupy a narrow strip of land along the banks of the Sobat River northwards to White Nile State. Around the villages, rainfed cultivation of sorghum, maize, groundnuts, beans, vegetables and tobacco occurs. The Shilluk possess far fewer cattle and depend less on cattle products than the Baggara, Dinka and Nuer, who are agro-pastoralists. They are not forced to migrate with the seasons. Fishing is an extremely important component of the Shilluk economy.

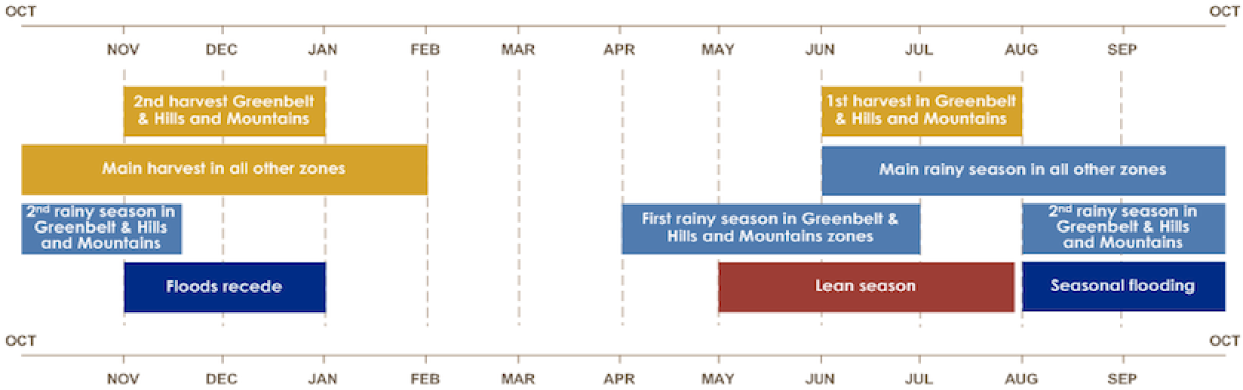
## 7.3 SMALL-SCALE IRRIGATED CROPPING

Traditionally, wetland areas have been avoided due to the presence of diseases such as typhus fever for humans and liver fluke for cattle. Limited wetland edge cultivation for maize practiced in the wetland areas. In addition, in the northern and eastern parts of the upper Baro-Akobo sub-basin, there is also a well-established cultivation of *taro* (*Colocasiaesculenta*) in wetlands in Bench Maji Zone around Mizan Teferi, and in Sheka zone around Tepi.

This practice does not require much active water management, as this crop is tolerant of flooding. However, water management occurs in some places because farmers realize that yields can be increased in this manner with flooded areas and water availability improved before and after the rains (ENTRO, 2012; 2009).

Following is a typical agricultural calendar for the sub-basin area in South Sudan:

*Figure 7-1: Typical Annual Agricultural Calendar - South Sudan part of the Sub-Basin*




Source: Annual Needs and Livelihoods Analysis 2014-2015,GOSS,UN, FEWS, 2015

It should be noted that the so-called "lean" season typically occurs from May to August each year where food and income is scarce and households are forced to resort to a variety of coping strategies to survive. These strategies are described in more detail in the section on livelihoods below.

## 7.4 FISHERIES

Capture and aquaculture fisheries sectors are among the renewable natural resources supporting a substantial population whose livelihood depends on direct and indirect exploitation of the fisheries resources of the basin. Fisheries are widely regarded in the basin as an important economic backbone to the inhabitants of the basin, such as the Anuwak, Nuer, Dinka, Bari, Shilluk and the Falata. Aquaculture potential is regarded high in the basin wetland ecosystem.

## 7.5 FORESTRY

Wood fuel and charcoal form important sources of domestic energy consumption in the South Sudan part of the basin. Woodlands provide all building materials in rural areas. They provide livestock feed as browse; and they also supply a number of non-timber forest products, the most important of which is Gum Arabic. In addition to these products, woodlands provide a number of services which have no direct monetary value, such as environmental protection, increase in crop production, conservation of soil fertility, biodiversity, protection of cultural heritage, forming habitat for wildlife and eco-tourism attraction and conservation of water catchment areas (ENTRO, 2009).

In Ethiopia, in the Baro-Akobo-Sobat basin some 7.95 million $m^3$/year of fuel wood and charcoal (wood equivalent) are consumed as fuel forming about 65% of domestic energy consumption. The official figures for timber production do not include timber and poles produced and used outside the official market, in particular, for use for construction and other purposes in rural areas. (ENTRO, 2009).

## 7.6 AGRO-FORESTRY

The main components of agro-forestry are the harvesting of Gum Arabic, Gum Acacia and browse for livestock. The Gum Arabic Belt (GAB) in the Baro-Sobat-White Nile Sub-basin comprises the major part of the low rainfall savannah grassland zone extending from the border with Ethiopia through to North Kordufan west of the White Nile sub-basin on the sandy soils. The Gum Acacia belt is the savannah woodland zone extending from Eastern Equatoria through Upper Nile and South Blue Nile States. There is a distinct difference between the clay and the sand provenances of *GumAcacia and Gum Arabic* in terms of their water-use efficiency and gum yield. The clay gum produced in Eastern Equatoria and Upper Nile States were distinctly superior to the sand States of White Nile and North Kordufan in all traits studied, especially in their basal diameter and crown width. The Gum Acacia are adapted for fast growth rates and high biomass and gum productivity than the Gum Arabic (ENTRO, 2009).

There are a number of direct (production) and indirect (environmental) benefits from gum production. Direct benefits from trees are as fodder for cattle, sheep, and goats. Older trees (i.e. 15+ years), which no longer produce good quality gum, are often felled for fuel wood and for charcoal production. Indirect benefits are from deep taproots and extensive lateral root system which reduces soil erosion and runoff and stabilizes soils.

Its leguminous characteristics also fix nitrogen which encourages grass growth for grazing by livestock. The trees can act as windbreaks and can assist in the stabilization of shifting sand and moving dunes. Moreover, seasonal labourers from other parts of South Sudan and Sudan migrate to the Gum Belt seeking employment. Thus its production system supports and extends livelihood strategies to many people. They also gather shea nut and honey.

In the Ethiopian part of the basin, agro-forestry takes the form of coffee growing under shade. Some on-farm Eucalyptus planting is taking place in the Kaficho-Shakiso Zone where the forest has largely been cleared. In other highland areas considerable numbers of indigenous trees remain in and around cropland.

## 7.7 LIVESTOCK

In the Baro-Akobo-Sobat basin the political boundary between South Sudan and Ethiopia is mirrored by socio-cultural and physical affiliations. Many people have traditionally embraced pastoralist and agro-pastoralist livelihoods, keeping livestock has been deeply rooted in their lifestyle, and is now the source of both individual, cultural and even national identity, others who for one reason or another lost their livestock have become, sedentary farmers.

A number of groups in the basin retain their original way of life, but with some modifications. These include, among others, the Nilotic groups of Nuer, Dinka, Shilluk, Anuwak, Murle, Mundarin and other Bari speaking groups. The Nuer, Dinka and Murle are pastoralists keeping long-horned variated colored *nilotic cattle*.

Other groups can be classified as agro-pastoralists such as the Shilluk, Anuwak and Bari groups which keep the dwarf and compressed *Mangala* cattle (known for their resistance to tetse fly) and these later groups are mainly sedentary cultivators.

The Taposa people live mainly in Kapoeta County in Eastern Equatoria, which experiences lower rainfall. The Taposa depend mostly on the Pibor catchment. They are mainly pastoralist keeping *Taposa* cattle, sheep and goats. They also cultivate maize, sorghum and engage in artisanal mining.

The Shilluk, Nuer and Dinka who mainly occupy riverbanks, alternate their economic activities with fishing to supplement their food and economic security. The Anuwak are also agro-pastoralists, and are found in both Ethiopia and South Sudan interacting with each other in the Gambella plain. They typically occupy the high levees along the Sobat River and its eastern tributaries in Ethiopia. They cultivate sorghum and maize on flood retreat soils below the levees. Fishing is also an important element of their livelihoods.

It is an urgent task of Governments, especially in South Sudan, to create a legitimate and overarching national identify and institutions which encourage the assimilation of diverse ethnic groups to a common purpose.

# 8. LIVELIHOODS

## 8.1 INTRODUCTION

The inhabitants of the BAS sub-basin predominantly engage in agriculture (crop production), livestock husbandry, fishing, forestry, gathering wild foods, wildlife (hunting), some mining, etc. People are highly dependent on locally available natural resources and the products they provide for their livelihoods.

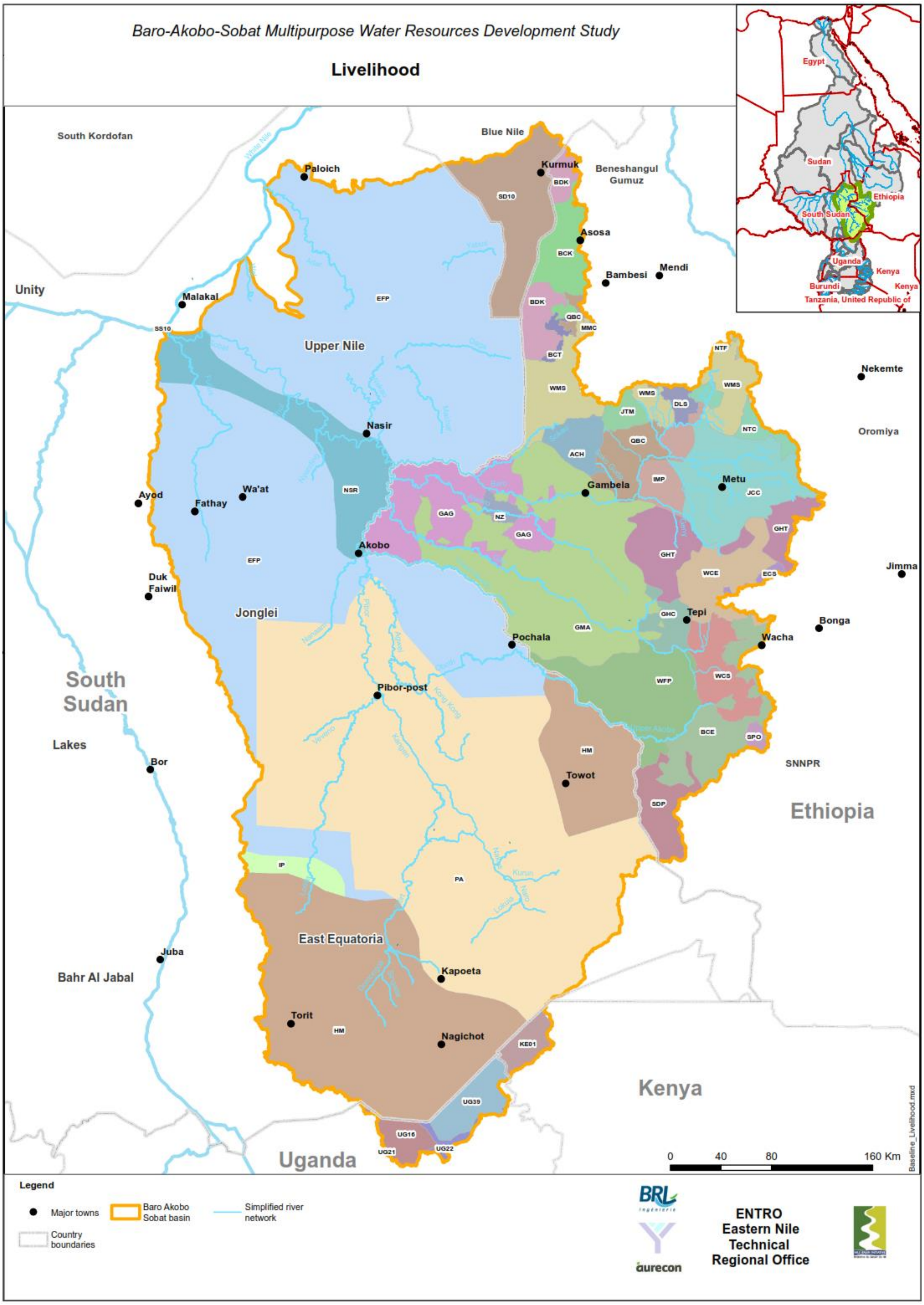
Accordingly, the renewable and non-renewable natural resources sectors influencing livelihoods in the basin include agriculture, fisheries, forestry, livestock, mining and wildlife. Therefore, a relevant approach to sustainable development in the basin should target communities whose lives almost entirely depend on the exploitation of these resources for their wellbeing, although sustainability and environmental management remains a challenge.

The following sections describes the main economic activities in the basin and their reliance of use of natural and environmental resources in the basin.

## 8.2 LIVELIHOOD ZONES

The map next page shows the main livelihood zones in South Sudan. The dominant livelihood zones in the BAS sub-basin are the Eastern Flood Plains, the Nile-Sobat Rivers area, Semi-arid Pastoral and Hills and Mountains zones.

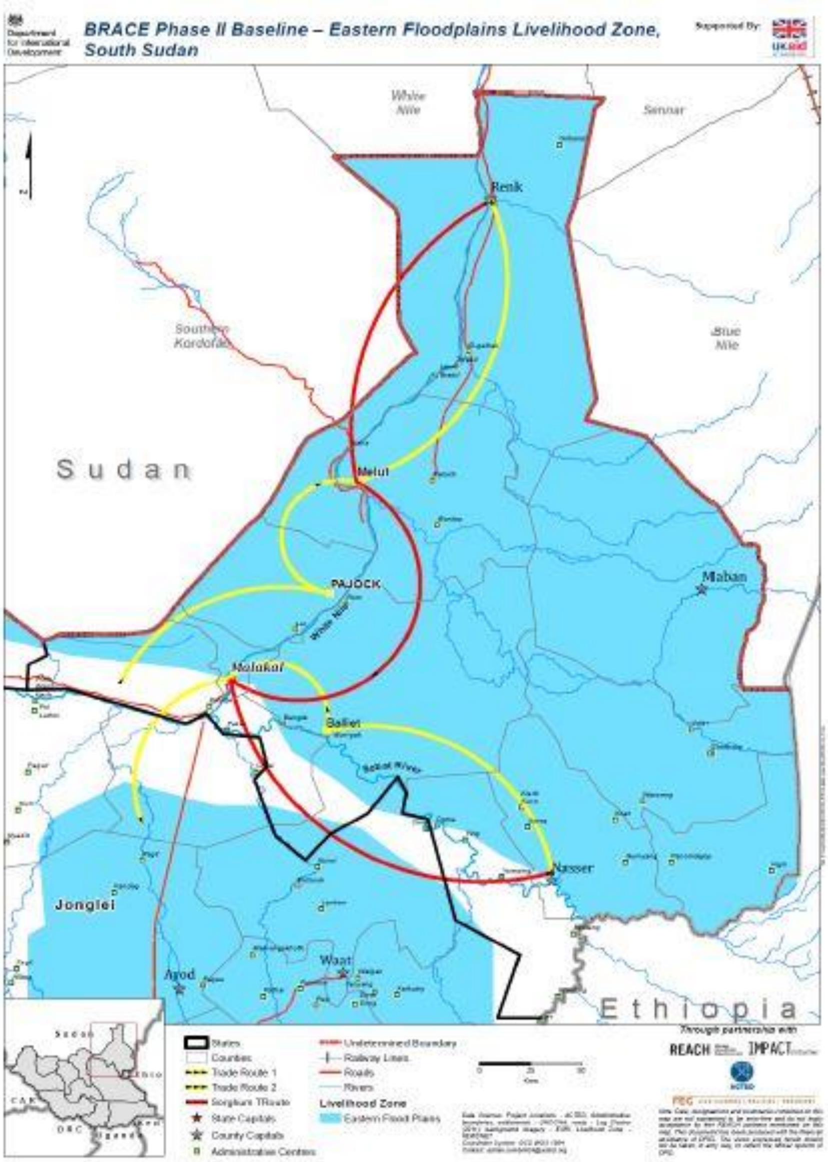
*Figure 8-1: Livelihood Zones in the BAS sub-basin*



## 8.3 EASTERN FLOODPLAINS LIVELIHOOD ZONE

A more detailed picture of livelihoods can be obtained from smaller-scale area maps. Following is a more detailed map of the Eastern Floodplains livelihood zone.

*Figure 8-2: Eastern Floodplains Livelihood Zone*




*Source: Building Resilience through Asset Creation and Enhancement" ATEP/Impact, 2013*

The above map shows thatthe main trade routes in the Eastern Floodplains livelihood zone which includes a large part of Upper Nile State and extends into the northern part of Jonglei State, are from east to west from Nasir to Maliakai and north-south from Renk in the north, through Meluk to Malakal. The prevalent livelihoods and market flows for the Eastern Floodplains are provided in the following sections.

### 8.3.1 Markets

Food purchases from the market are affected by both market access and food availability. Access is typically poor in Upper Nile State as there are few all-season roads. During the rainy season, roads are often washed out and villages are usually inaccessible by vehicle for about seven months of the year.

This affects trader flow as well as raises the cost of goods. With regards to food availability, sorghum, the staple grain, is supplied to local markets from local farms. Sorghum is also imported from neighboring Sudan.

Maize and cowpeas are also supplied locally, although these items are not usually available from March to August. Prices for the staple foods fluctuate greatly during the year due to the poor condition of road infrastructure combined with limited access to cross-border trading with Sudan. During the baseline assessment, some households paid SSP 7-12/kg of sorghum between June-August 2012 when prices hit their peak. By contrast, post-harvest, at the end of 2011, sorghum sold for SSP 3/kg. Wheat flour and other non-staple foods are imported from neighboring Ethiopia. Other goods, such as household items, are typically imported from Ethiopia, Sudan and Kenya. A few commodities are sourced from Uganda through intermediate markets such as Juba.

Fish is an important commodity in the zone that is sold locally and is also exported. Fresh fish is available throughout the year in all local markets. Dry fish, by contrast, is sold only during the dry season. The main intermediate market for exporting dry fish north to Sudan is Nasir town. Nasir town is a major hub for fish traders coming from neighboring livelihood zones or across the border where dried fish is packed and transported by river to Sudan.

Cattle, goat and sheep are traded in the local market. There are two main trade routes for livestock. The first route is north along the White Nile through Melut to Renk (Fagag → Pajok → Melut → Renk). The second route is along the Sobat River through Nasir → Baliet → Malakal → Jonglei. The trade route for sorghum isenk → Melut → Malakal → Nasir. This route follows both the White Nile and the Sobat Rivers. Both the South Sudanese Pound (SSP) and the Ethiopian Birr (ETB) are functional currencies particularly in counties bordering Ethiopia.

### 8.3.2 Seasonal Calendar

There are three main seasons in the Eastern Flood Plains livelihood zone. The main rainy season is between May and October. This is followed by a wet-dry season from November to January and then the dry season from February to April. The crop cycle begins with land preparation in April and May, followed by planting of sorghum and maize at the end of May and into June. By August, maize is typically ready to be eaten fresh (or green) from the fields. The harvest starts in October and carries on into November. If there is a late onset of rain, the sorghum harvest may extend into January (see Table 4, next page).

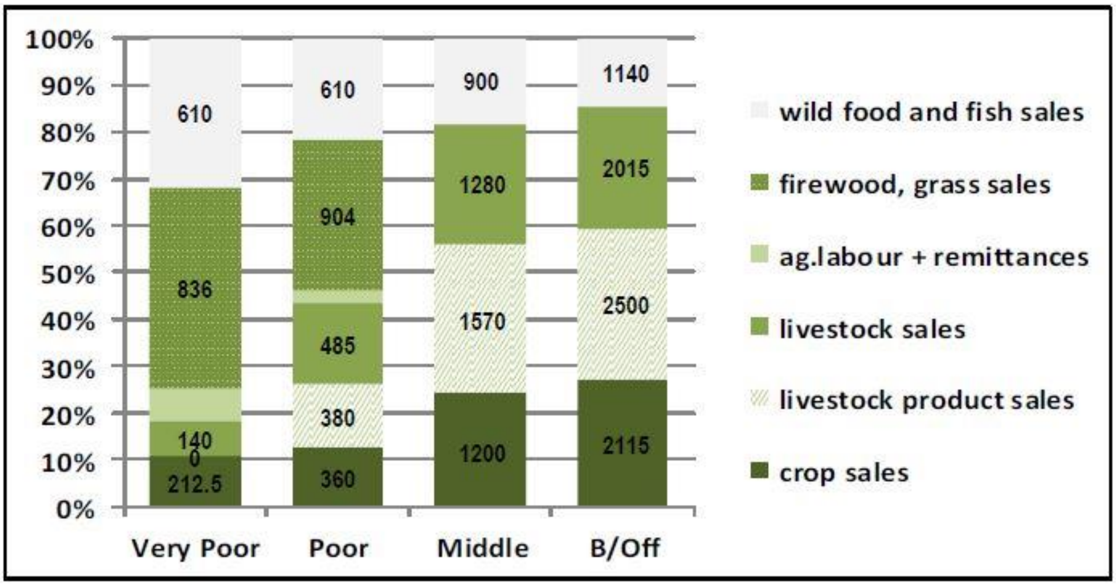
Milk production is highest during the rainy season when grass is plentiful. The main heat period for livestock starts after the germination of grasses during the rainy season. Livestock sales are common throughout the year but sales increase during the rainy season from July to August as more households need cash to purchase food. Livestock migration occurs during the dry season within the livelihood zone from *gok* (elevated areas) to the *toic (*swampy areas). Livestock return to their *yom* (settlement area) during the first rains.

Other productive activities also have defined seasons. The sale of firewood and grass for cash income occurs mainly during the dry season. Wild foods like *thou (*desert date*), lang (ziziphus* fruit*)* and *koat* or *cuei (*tamarind seed*)* are typically collected by the very poor and poor households for consumption and cash income between November to April (the wet/dry season). Fishing from the rivers is also most frequent from November to April. During the wet season, fishing activities switch to swamps and ponds instead of directly from the river.

Diseases such as malaria typically peak during the wet season from May to October. On the other hand, water-borne diseases are highest in the dry season when water is scarce.

The following figure shows the sources and relative size of the monthly income for different wealth groups in the Eastern Floodplains Livelihood Zone.

*Figure 8-3: Source and size of monthly household income – Eastern Floodplains*




*Source: Building Resilience through Asset Creation and Enhancement" ATEP/Impact, 2013*

### 8.3.3 Hazards

Drought, livestock disease and pests are main hazards affecting crop and livestock production. Stock borer aphids, crickets and birds are the major pests affecting crops. Trypanosomiasis, pneumonia and foot-and-mouth disease are the major diseases that affect livestock in the livelihood zone. Erratic rainfall such as late onset or uneven rainfall distribution and excessive rainfall and flooding are the principal climatic hazards that affect both livestock and crop production and leads to food insecurity for households at risk.

### 8.3.4 Coping strategies

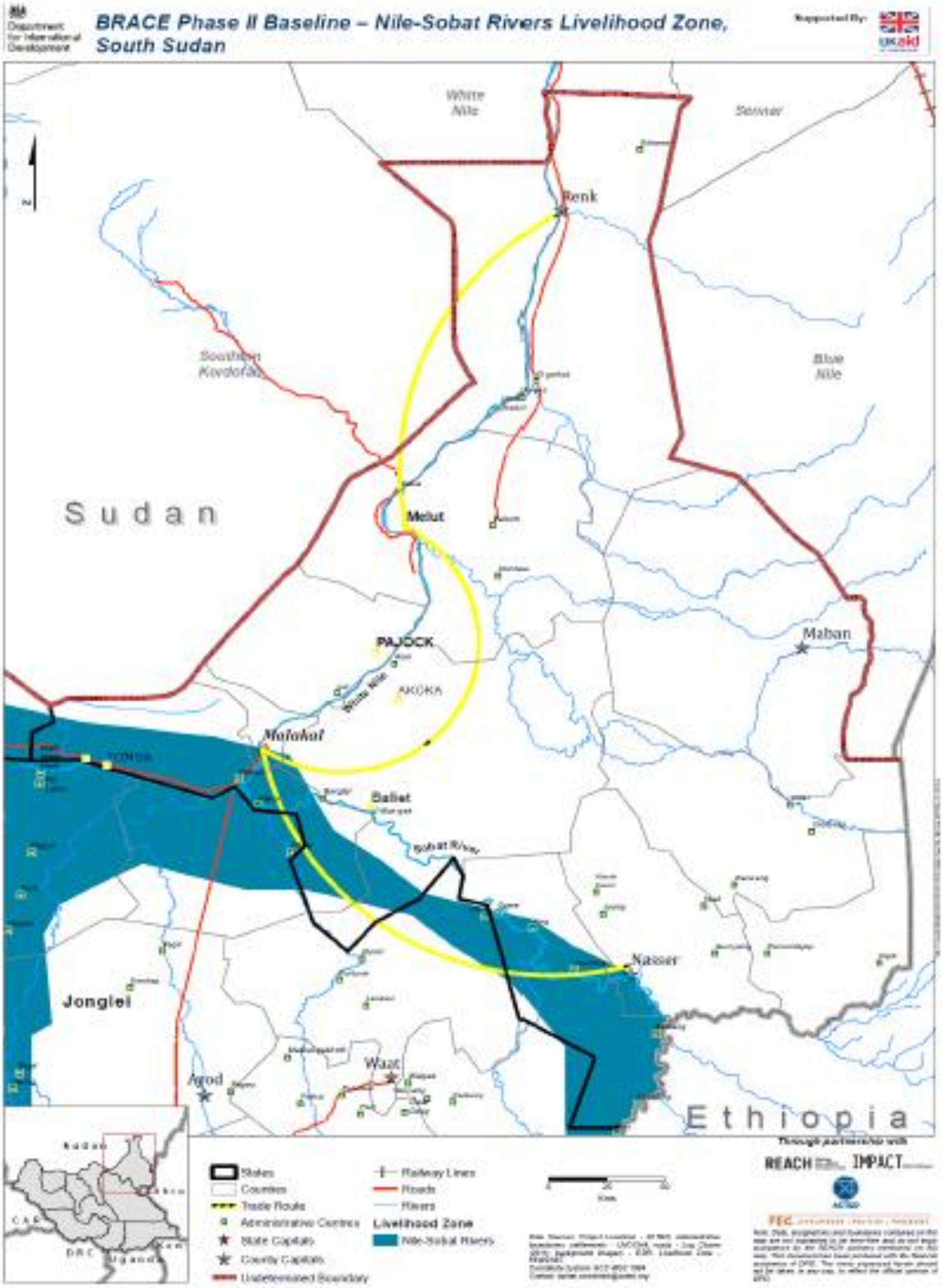
In response to shocks, households use different strategies based on their wealth status. Better-off and middle-income households typically sell livestock or barter cattle for grain. They also reserved any crops harvested or fish caught (including dried fish) for own-consumption rather than for sale. Another strategy was to minimize expenditure on clothes and some household items.

Poor and very poor households cope with shocks in different ways than wealthier households. Poorer households increase fishing and wild food collection to make up food gaps from poor crop yields. Another strategy is to increase sales of firewood and grass to raise income for food purchases. Finally, young men may migrate to urban areas in neighboring Ethiopia to search for work. The very poor also appeal for gifts or loans from better-off clan members and relatives.

## 8.4 The Nile-Sobat Livelihood Zone

The Nile-Sobat Livelihood Zone makes an important contribution to the economy of the basin. Following is a detailed map of the Nile-Sobat Livelihood zone.

*Figure 8-4: Map of the Nile-Sobat livelihood Zone*




*Source: Building Resilience through Asset Creation and Enhancement" ATEP/Impact, 2013*

## 8.4.1 Livelihoods in the Nile-Sobat Zone

The economy of the Dinka, Nuer and Shilluk people of the Nile and Sobat Rivers is based on four key elements. During years of relatively good rainfall, agriculture is the principal economic activity but is supplemented by livestock production, fishing and gathering. The rivers are the zone`s major natural resource and productive asset. Fishing takes place towards the end of the rainy season in the swamps. As the river subsides, people fish from the rivers directly. The riverine area also provides essential pasture, browse and water for livestock. This area is treated as communal property.

The Nile and Sobat Rivers Zone is a lowland area, and is susceptible to flooding, with mainly clay soils. Agriculture is rain-fed and depends on a single rainy season from May to October. Rainfall ranges from 1,000-1,500 mm per year.

Sorghum and maize, supplemented by pumpkin, cowpeas and sesame, as well as vegetables such as okra, tomatoes and cabbage, are the main crops grown by households. Cultivation practices are simple: land is cleared of bush or crop residues and seed is sown. Very little weeding is done. The common measurement for land in the area is *feddan* which is almost equal to half a hectare. Farming is carried out with hand tools so the amount of land cultivated by a household is determined by how much labor – either family or hired – the household can access and/or can afford. There are no specific crops grown for cash per se but households do sell their crops at markets when they are accessible.

Better-off households keep relatively large herds of cattle, goats and sheep. Livestock are milked and the milk is consumed at home as well as sold and/or given to the poor. Villagers do not migrate far distances with their livestock as both water and pasture are relatively plentiful along the rivers. Livestock are sold when cash is required and bartering also occurs occasionally. Bartering was more common prior to the Peace Agreement when the cash economy was extremely limited. Livestock are mainly used for dairy and for sale, as well as to pay for bride wealth in marriage. Rearing livestock for transportation is not common in the zone. Items that need to be transported either to or from markets are simply carried even for long distances.

### 8.4.2 Markets

In the Nile and Sobat Rivers zone, main roads are seasonal and market access is often difficult. Most villages are inaccessible by vehicle during the rainy season. The local population does not use pack animals for transport goods. The absence of pack animals places a particular burden on women as they are responsible for transporting water, food and other items purchased in towns. Women usually carry these items on their backs and heads, sometimes walking several days. During the rainy season, the main means of transporting goods are by boat or small ships that sail on the Nile and Sobat Rivers.

Only villagers along the main road that crosses the county from Malakal to Nasir (on the Ethiopian border) have access to main markets in towns throughout the year. The major markets in this livelihood zone are the county towns of Malakal, Akoka, Ulang and Panyikang (Tonga). The major trade routes are Renk → Malakal, and Malakal → Nasir.

Every day is market day in the Nile-Sobat livelihood zone. Local markets have seasonal supplies of local sorghum, maize and cowpeas from September to January as well as milk from July to January. Local fish and livestock are also sold in village markets. During lean years and during months preceding the harvest, sorghum is brought in by traders from neighbouring areas, such as Renk in Upper Nile State or from Gambella across the border in Ethiopia. Traders also collect sorghum from local markets as well as fish at riverside landings from where they transport the goods to markets in Nasir or Malakal. Main food and non-food commodities available in local markets are sorghum, wheat flour, tea leaves, okra, meat, milk, sugar, salt, oil, clothes, imported soft drinks, and small quantities of soap, utensils and tools. Charcoal and grass are also commonly sold in local markets by poorer households.

Bartering used to be widespread, but cash transactions are now the most common form of exchange. Nonetheless, bartering is still practiced in the livelihood zone.Typically, livestock are exchanged for sorghum. Additionally, livestock are exchanged for other types of livestock (e.g. males for productive females). Labor other than local agricultural work is very scarce.Individuals do not usually migrate to other areas in search of work but stay within the zone.

### 8.4.3 Seasonal calendar

The seasonal calendar in the Nile-Sobat Rivers Zone is similar to the neighboring Eastern Flood Plains. The rainy season usually starts in May and continues until October. Rainfall patterns also determine the cropping calendar. Land preparation is carried out in April before the rain starts or when the first signs of approaching rains are seen. This is followed by planting as the rains begin.

The consumption of green maize normally begins in August and lasts for about one month. Vegetables such as okra, cabbage and pumpkin, as well as early maturing maize, are ready in September. Other early maturing crops, such as cowpeas and sesame and sorghum, are harvested in October. Late maturing sorghum is not harvested until December or January although some may be eaten fresh (or green) in November. A second crop of okra is often harvested in April.

Livestock production also follows the rainy season. The best time for births is once pasture is established around July. The milking season peaks for several months (July to December) but from January milk production becomes very low or negligible. Livestock sales are highest when cash needs are highest, typically between March and July, when farmers need to pay for agricultural inputs (including labor) and purchase food from the market.

During the wet/dry season and into the dry season, households supplement crops with fish and seeds, tubers and fruit gathered from the bush of forests. Swamp and pond fishing is carried out in August and September but households engage in river fishing when water levels subside around January.

Fishing typically continues until April. The period from January to April/May is when households supplement their diet with wild foods. A wide variety of bush foods are available for harvest. The most common of these are *thou (*desert date*), buaw (*wild tuber*), nur, koat* (tamarind fruit*) and lew* are typically gathered and consumed from January to May.

Food purchases are highest between March and July. Cash income to buy food is earned by gathering and selling grass, charcoal and firewood. Cash or food is also earned from agricultural labor during this period. The harvest period (September-January) is when demand for local labor is at its highest.

### 8.4.4 Wealth breakdown

In the Nile-Sobat Zone, about 50% of households are considered to be either very poor (23%) or poor (27%). Households categorized as very poor or poor are low income earners with few assets. Crop production provides staple food for about five months of the year. Very poor and poor as households typically cultivate about half a hectare (or 0.75 – 1.25 *feddans*) of land. Most own a few (one to five) cattle for milk, and some poor may also own an ox. The majority of the poor own small livestock (1-5 goats and 1-5 sheep). Most poor do not own fishing nets, but have a few fishing hooks and/or a fishing spear.

In contrast, the middle-income and better-off households cultivate about 1-1.5 hectares (2-3.5 *feddans*) of land on which they produce sufficient be food for the household for 8-10 months of the year in an average production year. The majority of middle-income and better-off households own a pair of oxen or two as well as 5-15 cows (middle-income) or 15-25 cows (better-off).Annual household income is two to three times greater than the poor’s income.

The better-off support larger households (8-10 members compared to 5-6 members in poor households). Middle-income and better-off households comprise about 50% of households in the zone. Due to larger household sizes, wealthier groups are an estimated 61% of the total population(19% are from better-off households and 42% are from middle-income households).

The wealth characteristics of the population in the Nile-Sobat Livelihood Zone are shown in the following table:

*Table 8-1: Wealth Group Characteristics for the Nile-Sobat Livelihood Zone*

| Wealth Group Characteristics | | | | | |
|---|---|---|---|---|---|
| Wealth Group | Proportion of population belonging to Wealth Group | HH Size | Land Area Cultivated | Crops Cultivated | Livestock/Asset Holding |
| Very Poor | 23% | 4-6 | 0.5-1 feddan | Maize, sorghum, cowpeas, sesame, pumpkin, okra | 1-3 cattle, 1-3 goats, 0-3 sheep, 2-4 hens, 0-1 fishing spear |
| Poor | 27% | 5-7 | 1.01-1.5 feddan | Maize, sorghum, cowpeas, sesame, pumpkin, okra | 3-5 cattle, 3-6 goats, 3-5 sheep, 4-6 hens, 1 fishing spear |
| Middle | 37% | 7-9 | 1.51-2.5 feddan | Maize, sorghum, cowpeas sesame, pumpkin, okra, tomatoes | 5-15 cattle, 6-12 goats, 5-10 sheep, 6-10 hens, 0.5-1 fishing net, 1-2 fishing spears |
| Better-off | 13% | 8-12 | 2.51-4.5 feddan | Maize, sorghum, cowpeas, sesame, pumpkin, okra, tomatoes | 15-25 cattle, 12-20 goats, 10-15 sheep, 10-18 hens, 1 fishing net, 1-2 fishing spears |

*1 feddan = 0.42 hectare*

*Source: Building Resilience through Asset Creation and Enhancement" ATEP/Impact, 2013*

### 8.4.5 Coping strategies

Households in the Nile-Sobat Zone use a number of strategies to respond to hazards. Their first priority is survival of their animals. Household members migrate with their animals to find grazing land along the Nile and Sobat Rivers in pursuit of better water and pasture. The main strategy for obtaining cash to purchase food is increased livestock sales. Wealthier households are in a better position to use this strategy as they own more livestock.

Households can also reduce non-essential expenditure on items such as tea and clothes in order to spend more money on staple food items. However, expenditure on such items is minimal, so this is a limited strategy. Households consume more wild foods, fish and meat during lean years. Increased consumption of meat happens when animals are weak and likely to die, but are instead are slaughtered for their meat. Finally, poor households increase the sale of charcoal and grass; seek additional work either locally or in towns**;** and beg better-off kin or neighbors for food and cash.

## 8.5 EASTERN SEMI-ARID PASTORAL ZONE

This livelihood zone is mainly located in Eastern Equatoria and parts of Jonglei State. It is a large plain extending to the foothills of the mountainous ranges near the Ethiopian border. Vegetation is characterized by dense thickets, bush shrubs and savanna grasslands, which are more suitable for livestock than agriculture. Boma National Park, one of the main tourist attractions of this area, is also located in this zone.

This zone has a unimodal rainfall pattern, with average annual precipitation of about 500-600mm. There are two seasons,the rainy season lasting from around May to November and the dry season from December to April. Average temperatures are 38-40° C, with a minimum of 32° C in December-January and maximum of 42° C in March.

Soils in this area are mainly black cotton clay. Though suitable for crop farming, the semi-arid conditions limit crop production. Average land cultivated per household is only about 0.4 hectares. This zone is sparsely populated and is occupied mainly by the Toposa, Didinga and Murle tribe.

The dominant production system in this zone is pastoralism, with only limited crop production. The main food crops produced are sorghum and on a small scale okra and other vegetables. Livestock include cattle, camels, goats, and sheep and to a lesser extent poultry, and are mainly for household consumption.

In the dry season inhabitants move in search of water and pasture into neighboring Ethiopia and Kenya. The main determinant of wealth in the zone is number and type of livestock owned.

The poor produce approximately two months of their need for staple foods from their own crop production, and the better-off group slightly more. All households depend on market purchases of staple foods, supplemented by milk, meat and animal blood, especially during the rainy season. Milk is consumed throughout the year, although the quantity consumed are higher during the rainy season.

However, most livestock products consumed by the poor are obtained through in-kind labor payment (herding livestock) for the better-off group. There is also hunting small animals, and wild foods and honey are also collected, although these do not contribute much to the annual diet.

Sales of livestock are the most important source of cash income for the poor and better-off group. The better off group also obtain income from the sale of milk and milk products and gold mining. Much of the milk is sold during seasonal movements in search of water and pasture. The poor group obtains income from the sale of livestock, and is also engaged in charcoal making, firewood sales, and wild food sales as a supplementary source of income. Both wealth groups engage in gold extraction to complement their income.

External traders also travel to sell maize, grain and vegetables locally and trade livestock to Ethiopia and Uganda. Households also exchange livestock for grain and other household items with Murle cultivators in neighboring areas with whom they have strong economic links.

Hazards include drought, livestock diseases and periodic conflicts with other pastoral groups. The heavy dependence of livelihoods on livestock and trade for staple foods makes these vulnerable to interruptions in market access, particularly during seasonal livestock movement, when there is less milk and animal blood for consumption for people who do not move with the animals and in drought years to falling livestock prices. The zone experiences frequent food shortages.

The poor purchase sorghum from October until July the following year. These purchases also cover the lean months (January to April), when the only source of income is sale of charcoal. This is the only cash income used to purchase sorghum during the lean months. Other priority expenditure includes health care (especially during the rainy season, due to malaria) and school fees, paid at the beginning of the school year between the months of March and April.

## 8.6 HIGHLAND FOREST LIVELIHOOD ZONE

This zone is located along the mountain ranges of the Greater Equatorial region and the border with Ethiopia. The topography is characterized by highlands and foothills with a mixture of forest, bush shrubs and grasslands.

The zone has a unimodal rainfall pattern, with average precipitation of about 900-1,100mm per annum. There are two distinct seasons; a rainy season from April to November and a short dry season from December to March. Average temperatures in this area reach a maximum of 42° C in February and minimum of 30° C in December and January.

Soils include sandy soils, clays and loam, and are relatively fertile compared to neighboring zones, especially the Eastern Semi-Arid Pastoral zone. The area also has wild honey and shea butternut trees.

The population density in this zone is medium. The average area cultivated per household is about 1.25 hectares. The inhabitants are mainly Murle and Kachipo, the former being mainly cultivators and pastoralists, especially the hill Murle living in parts of the highlands. The Kachipo have strong economic relationship with cattlekeeper Murle’s in the Eastern Semi-Arid Pastoral zone, including areas such as Pibor, Ikotos and Pochalla. The Badingilo National Park is also located in this zone, although the animal population has been largely depleted during the civil war.

Reliable rainfall and fertile soils support rainfed crop farming with sedentary cultivation and lower reliance on livestock. The main food crops are maize, grown mainly in the eastern parts of the zone, short and long-term varieties of sorghum, millet, sesame, cow peas/green grass. Other crops grown on a smaller scale include sweet potatoes and cassava and groundnuts.

The livestock owned are mainly goats, a few sheep and poultry, with relatively few cattle mainly owned by the better-off group.

In a typical year, all wealth groups depend mainly on their own crop production supplemented by wild foods, dry fish and for the poor, by market purchases. The better-off hire labor and cultivate more land and can produce a surplus production for sale.

A wide variety of wild food plants are available in the hills and mountains, which include roots, fruits, berries and leafy vegetables gathered by all groups to supplement household food.

For the better-off group, the main source of income is from the sale of maize, followed by sorghum and millet. Some income is also from retail sales and the sale of timber outside the zone. The poor group mainly depend on their own labor and sale of natural products such as charcoal and bamboo. Otheractivities include hunting and seasonal fishing along the Oboth, Pibor and Gilo rivers, which are tributaries of the Sobat River along the border to Ethiopia. There is also some artisanal gold mining, although only at a low level because of the lack of tools and equipment.

Due to its favorable climate, this zone usually has a good harvest, but lacks access to markets and reliable trade linkages with neighboring livelihood zones. The main markets for the sale of local products, including labor, include Pochalla, Boma and Pibor in the eastern part of the country. In the central parts of the zone there is reliable access to regional markets in Juba and Torit. In the eastern part of the zone there is cross-border trade with Ethiopia. The trade with Ethiopia increases during the dry season. Household incomes are limited by a lack of roads, hilly and mountainous terrain and poor road conditions, which limits access to markets.

The rainy season starts in April and ends in November. Rains are normally adequate for crop production. The main staple crops are sorghum and maize, with maize more common in the eastern part of the zone. The lean season is usually from June to August, when green crops are still not ready for consumption. Agricultural work starts with land preparation during January to March, followed by sowing or planting from April to mid-June. Weeding starts at the peak of the rainy season in June to July. Harvesting of all crops, including green consumption starts in August and continues until December when long maturing sorghum is harvested.

Lambing, kidding and calving take place in the dry season from November to February the following year. Peak milk production is during rainy season. There is no seasonal livestock movement in this zone.

The most serious hazards in this zone are droughts and dry spells, landslides and floods that damage or even The main hazards in this zone are droughts and dry spells, mudslides and floods that cause crop failure.

The poor purchase sorghum during the lean months (April to August). Sorghum and maize are bought from March and April until August, when the new harvest is ready. In the lean season main sources of income are sale of labor and livestock and gold mining, especially goats and sheep. The main expenditure is health care during the rainy season when malaria is prevalent, and school fees in March and April.

The main hazards in this zone are droughts and dry spells, mudslides and floods that can damage or even cause the complete crop to fail.

## 8.7 CHARACTERISTICS OF LIVELIHOOD ZONES

The following table presents a number of characteristics of livelihood zones in South Sudan, including those in the BAS sub-basin:

*Table 8-2: Characteristics of Livelihood Zones in South Sudan*

| Agro-ecological Zones \ Characteristics | % of areas to the national total | % of population to the national total | Population density*1 (persons/km²) | Average precipitation (mm/year) | Average elevation (m) | Land use (% to each Agro-ecological Zone total area): Agriculture land | Grassland | Shrub land | Trees/forest land | Road development status*2: Road density by population (Km/1000 persons) | Road density by area (Km/100 km²) | % of all season road |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Eastern Flood Plains | 21% | 17% | 10.51 | 788 | 399 | 4% | 31% | 52% | 12% | 1.40 | 1.47 | 30% |
| Greenbelt | 12% | 14% | 15.00 | 1,353 | 677 | 5% | 11% | 32% | 52% | 1.62 | 2.43 | 60% |
| Hills and Mountains | 9% | 12% | 16.88 | 937 | 697 | 2% | 16% | 61% | 21% | 1.44 | 2.43 | 62% |
| Ironstone Plateau | 23% | 8% | 4.47 | 1,075 | 553 | 1% | 10% | 18% | 71% | 4.72 | 2.11 | 41% |
| Nile-Sobat Rivers | 9% | 14% | 19.67 | 837 | 393 | 4% | 35% | 47% | 12% | 2.24 | 4.41 | 14% |
| Pastoral | 11% | 5% | 5.60 | 778 | 489 | 0% | 35% | 52% | 13% | 2.85 | 1.60 | 20% |
| Western Flood Plains | 14% | 29% | 26.00 | 899 | 412 | 8% | 27% | 41% | 23% | 1.26 | 3.26 | 48% |
| All Agro-ecological Zones | 100% | 100% | 12.96 | 955 | 506 | 4% | 23% | 40% | 33% | 1.82 | 2.36 | 39% |

Note: 1) Population densities are calculated with 2008 census population. 1) Road density is for the total length of primary, secondary, and tertiary all-season and dry season-only roads. "The percentage of all season road" also indicates the portion of all season road to the total of primary, secondary and tertiary roads. The roads data is assembled from 2013 data from WFP.

Source: NBS, National Baseline Household survey, NBS and CAMP TT

The above table shows that the main livelihood zones in the basin, i.e. the Eastern Flood Plains, Nile-Sobat Rivers, Pastoral and Hills and Mountains, contain some 48% of the country's population. The Nile-Sobat and Hills and Mountains zones are the most densely populated zones, but still have a relatively low density of 19.67 and 16.88 persons/km$^2$ respectively, especially when compared to the significantly higher population densities found in the Ethiopian part of the basin.

A striking feature in the table is the extremely low area in all zones that is cultivated and the very low road density. Also, the Nile-Sobat Zone has a very low percentage (14%) of all-weather roads. This further reinforces that there is a high potential for agricultural development in the basin in South Sudan, but also underscores the fact that that the poor road network will be a serious constraint on efforts to develop agriculture in this part of the basin.

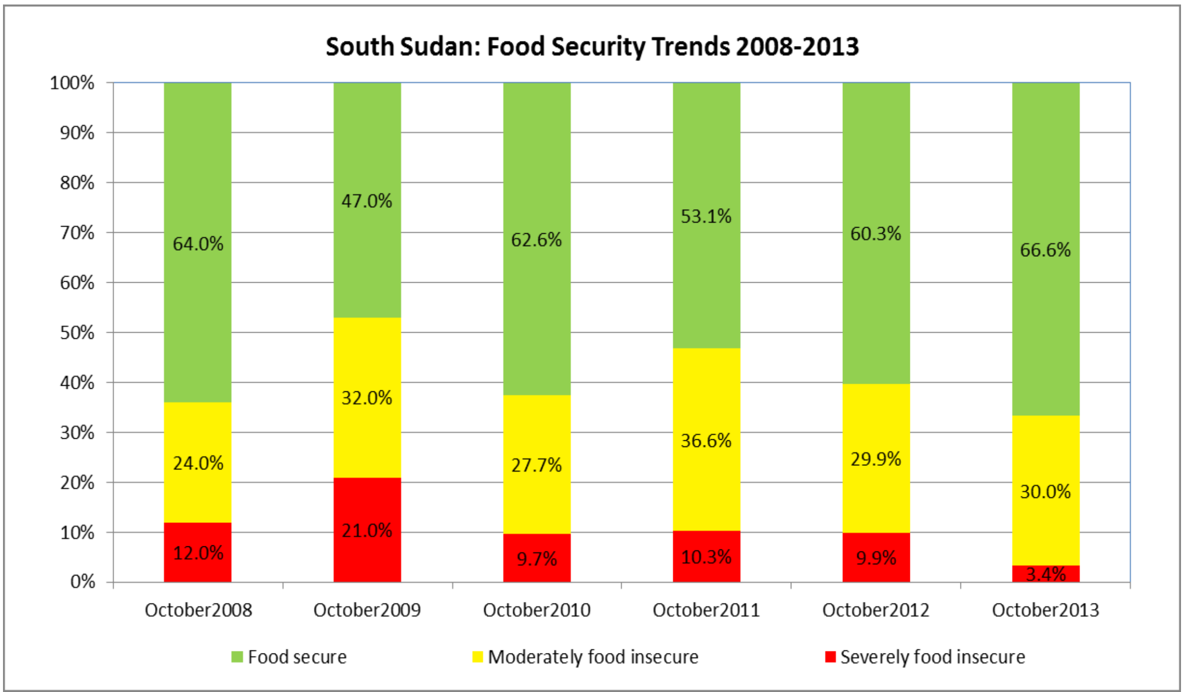
# 9. FOOD SECURITY

## 9.1 STATUS

There were 3.9 million South Sudanese (about one-third of the country's population) experiencing severe food insecurity and 3.6 million who were considered to be 'stressed', in September2015. This is an 80% increase compared to the same period in 2014. If the present conflict continues, food availability and access will deteriorate and

increase the risk of food emergencies or in the worst case, famine. In addition, some 304,000refugees in South Sudan are expected to need food assistance during 2016. The following figure shows trends in food security during a recent five-year period.

*Figure 9-1: Trends in Food Security at harvest time, 2008-2013*

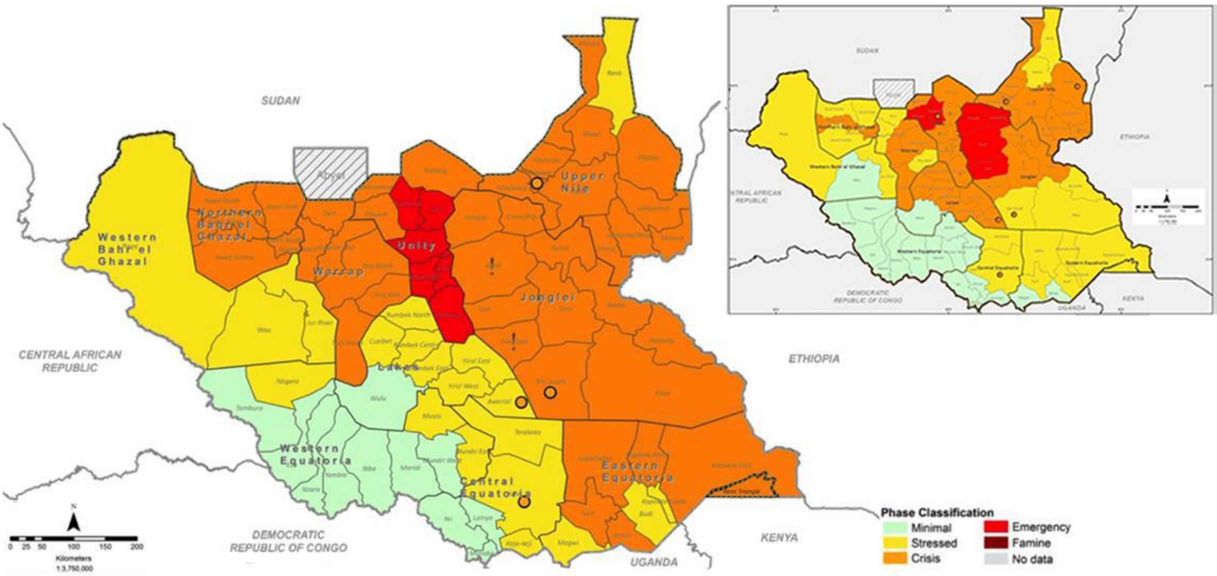



*Source: Food Security Assessment, FAO/WFP, 2014*

As can be seen from the above figure, the proportion of moderately food insecure population has remained largely constant during the five-year period, while the proportion of severely food insecure population has declined at the national level. It should be noted that concentrations of severely food insecure people still exist in specific areas which need to be addressed as an urgent priority. It should also be noted that these figures are very sensitive to climate and rainfall and can therefore fluctuate from year to year.

In March 2016, there were some 2,800,000 people who required need food assistance in South Sudan. This represents about 28% of the total population of the country. The following map shows the projected food security situation in South Sudan during the period January-March 2016.

*Figure 9-2: Food Security Situation – South Sudan (March 2016)*




Source FAO, 2016

*Figure 9-3: Phases of food security*

| | Phase 1 Minimal | Phase 2 Stressed | Phase 3 Crisis | Phase 4 Emergency | Phase 5 Famine |
|---|---|---|---|---|---|
| Phase Name and Description | *More than four in five households (HHs) are able to meet essential food and non-food needs without engaging in atypical, unsustainable strategies to access food and income, including any reliance on humanitarian assistance* | *Even with any humanitarian assistance at least one in five HHs in the area have the following or worse:<br><br>Minimally adequate food consumption but are unable to afford some essential non food expenditures without engaging in irreversible coping strategies.* | *Even with any humanitarian assistance at least one in five HHs in the area have the following or worse:<br><br>Food consumption gaps with high or above usual acute malnutrition<br>OR<br>Are marginally able to meet minimum food needs only with accelerated depletion of livelihood assets that will lead to food consumption gaps.* | *Even with any humanitarian assistance at least one in five HHs in the area have the following or worse:<br><br>Large food consumption gaps resulting in very high acute malnutrition and excess mortality<br>OR<br>Extreme loss of livelihood assets that will lead to food consumption gaps in the short term.* | *Even with any humanitarian assistance at least one in five HHs in the area have an extreme lack of food and other basic needs where starvation, death, and destitution are evident.<br><br>(Evidence for all three criteria of food consumption, wasting, and CDR is required to classify Famine.)* |

Source: FAO, 2013

The above map shows that almost all the basin area in South Sudan is classified as being in a state of "crisis", where the map in the insert from a year earlier (February 2015) shows that the southern part of the basin in Jonglei and Eastern Equatoria states were classified as being in a "stressed" state. A crisis state means that farmers and herders are extremely vulnerable to the potentially devastating and cumulative effects of conflicts, climatic shocks and economic disruption.

Drivers of food insecurity in the basin include the occurrence of various shocks (socio-economic shocks, high food prices, illnesses, drought, insecurity), inter-communal and inter-ethnic conflicts; extensive flooding; remoteness and poor road networks; expensive fuel and food prices; unfavourable exchange rate and taxes (both official and unofficial); and pressure from refuges and IDPs.

Various illnesses are also prevalent, while drought and insecurity continue to be major constraints to development in the basin. Among socio-economic shocks, high food prices are the most important issue for households, and are consistently ranked highest among shocks across all states. Food prices spiked in June 2012, due to the poor harvest in 2011 and the disruption of trade flows with Sudan.

Inter-communal and inter-ethnic conflicts have caused important but localized impacts on the food security of households. The incidence of internal conflicts(mostly inter-communal) tends to increase after relatively quieter periods. Most traditional conflicts revolve around cattle raiding and tends to peak during the dry season. Jonglei has consistently been a hot spot of conflict, with major displacements of population, especially in Pibor Country. Major conflicts from December 2013 and recent military conflicts have had a major impact on the food security status of many households in the basin in South Sudan.

Extensive flooding, mostly occurring before the harvest of the first crops, has also impacted crop yields, whereas late maturing varieties and waterlogging resistant crops benefit from the increased soil moisture. Floods in Jonglei State in 2013 and again in September 2015 led to the displacement of a large number of people.

## 9.2 RESPONSE TO FLOODS AND DROUGHTS

While some flooding is seasonal and even expected and welcomed by local farmers, in the event of extreme flooding or prolonged droughts, whose location, frequency, duration and extent can vary widely, residents employ a number of coping mechanisms including, but not limited to the following:

- Increased reliance on extended family, clan members and friends for food, shelter, money and other needs
- Reduction in the number, size and content of meals
- Increased consumption of wild foods, bush meat and forest products
- Sale of livestock and other assets to raise cash
- Reliance on food aid/humanitarian assistance
- Begging in the local community or nearby towns
- Relocation to a safer area/resettlement or permanent migration to towns as a last resort

*Figure 9-9-: Flooding in Jonglei State in 2015*

# 10. POVERTY

## 10.1 POVERTY CHARACTERISTICS

The recent Poverty Assessment (World Bank, 2015) revealed that an agricultural growth drove reductions in poverty, bolstered by pro-poor spending on basic services and effective rural safety nets in Ethiopia. Even though this finding was in Ethiopia, it can also equally well be applied to South Sudan.

In South Sudan households whose monthly consumption expenditure falls below 74 South Sudanese pounds, are considered to be living in absolute poverty. According to this measure, half of the country's population is considered to be extremely poor. Table 10-1 below shows the national poverty indices for country with a poverty line at a monthly expenditure of 74 South Sudanese pounds in 2011. (Abebe and Verdire-Chouchane, 2012).

*Table 10-1: Poverty Characteristics in South Sudan*

| Unit/Area | Poverty Dimension[9] | | |
|---|---|---|---|
| | **Incidence** | **Depth** | **Severity** |
| Male-headed household | 48% | 23% | 14% |
| Female-headed household | 57% | 27% | 16% |
| Urban areas | 24% | 9% | 5% |
| Rural areas | 55% | 26% | 16% |
| South Sudan | 51% | 24% | 14% |

*Source: Abebe and Verdire-Chouchane, 2012.*

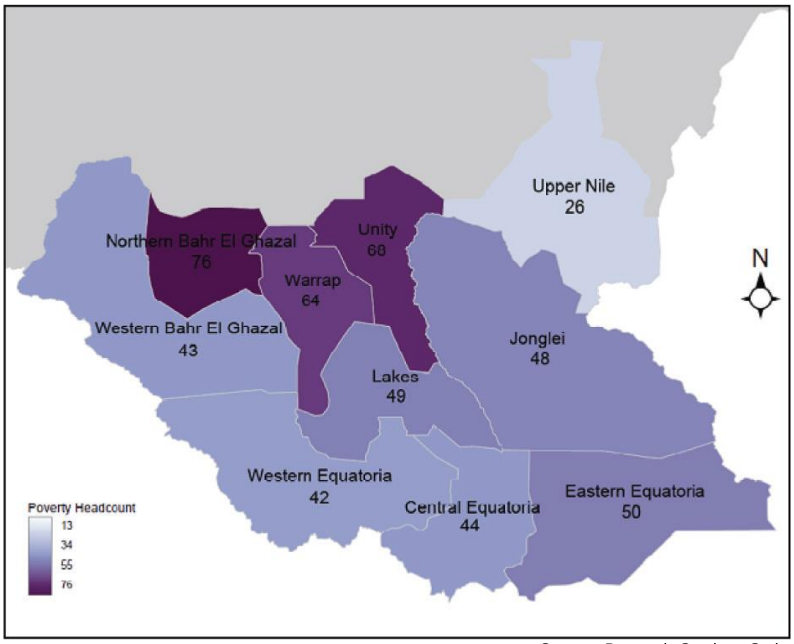
South Sudan's per capita GDP has doubled during the last decade following the discovery of oil in the country. GDP growth, however, has had little impact on reducing poverty. Not only is poverty widespread in the country, it is also so deeply rooted that the average per capita monthly consumption expenditure of the poor is 48% lower than the official poverty line. This suggests that most poor people are still extremely deprived (Abebe and Verdire-Chouchane, 2012).

As can be seen from above table, female-headed households have a poverty incidence that is 9% higher than male-headed households, and in all income groups females earn lower income than their male counterparts. Moreover, poverty is exacerbated in areas where there are large numbers of displaced persons, refugees and returnees.

Poverty affects the areas in the sub-basin unevenly. The poverty headcount ranges from 26% in Upper Nile to 50% in Eastern Equatoria. South Sudan also has a skewed income distribution. According to estimates from NBHS data, the Gini-coefficient is 45.5% (urban, 41.85% and rural 44.13%) in South Sudan, which is slightly higher than the Sub-Saharan Africa average (42% in 2009) (Abebe and Verdire-Chouchane, 2012).

[9] Poverty Incidence is the proportion of families/individuals whose per capita income fall below the per capita poverty threshold. Poverty depth is the distance below an agreed poverty line. Poverty severity is the sum of the gaps between the agreed poverty line and the average income of a poor household or group. The greater the gap the more severe the poverty.

*Figure 10-10-: Poverty Incidence by State (2010)*




***Source:** Poverty in Southern Sudan: Estimates from NBHS (2010)*

The large majority of poverty in South Sudan can be attributed to prevailing conditions in rural areas (low and unreliable incomes from subsistence agriculture, low productivity of labour, low access to health care and education, safe drinking water, sanitation, electricity and other basic services, as well as weak infrastructure.

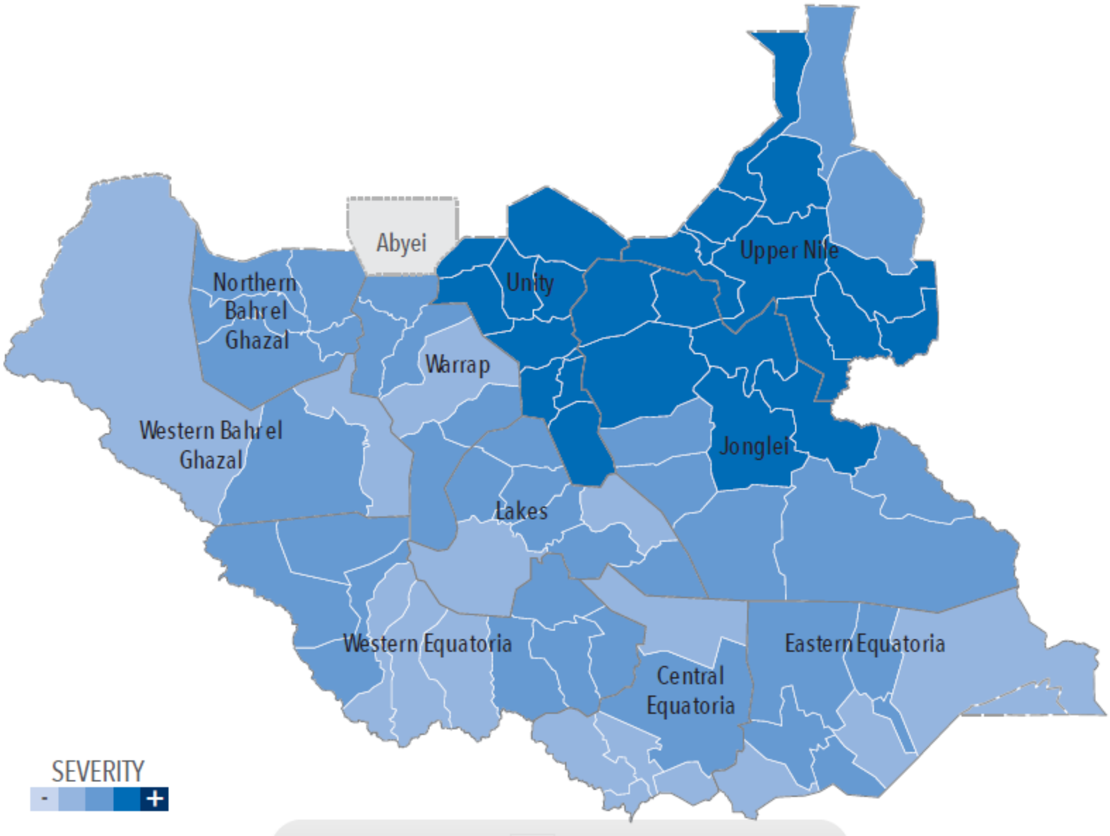
There is a large variation in the incidence of poverty among the basin states, with the incidence of poverty in Eastern Equatoria and Jonglei states being almost twice as high as in Upper Nile State. Reasons for this large difference need to be the subject of further study, but can be at least partly due to the presence of oil and a large-scale irrigation scheme in Upper Nile State.

The above figures suggest that increasing farm productivity and education should be high priorities for the future development of the sub-basin in South Sudan. (Abebe and Verdire-Chouchane, 2012).

### 10.1.1 Severity of Need in South Sudan

The following map compares the severity of humanitarian needs in each county using a composite set of indicators such as mortality, morbidity and vulnerability, including: the number of displaced people, food insecurity and malnutrition rates, number of hazards, violent incidents and casualties, functioning health facilities, disease outbreaks, vaccination coverage and number of schools destroyed or closed.

*Figure 10-10: Severity of needs in South Sudan (2015)*




*For details see: http://bit.ly/1OpSKry*
*Source: OCHA and humanitarian partners, 2015*

The above map shows that the most severe need for development interventions in the basin states are Upper Nile State and northern Jonglei State.

## 10.2 VULNERABILITY CRITERIA

A number of factors need to be considered to target interventions to those whose livelihoods are at risk of being seriously affected and need to be restored. These include siting of interventions based on the percentage of households who are food insecure as well as the extent of food insecurity, based on the conditions of their livelihood systems. Some of the vulnerability risk factors are

- Households who are headed by females and have no household members who are capable of bringing income in the household;
- Returnee/Returnee household (vulnerability among returnees differs and need to be assessed on the basis of factors, such as ownership of productive assets, dependency ratio; etc);
- Orphaned households;
- Household whose head of household is chronically ill or elderly;
- Households whose main livelihood has been destroyed, without any significant support;
- Systems such as availability of markets; no kinship support or lack of opportunities to engage in bartering.

# 11. AGRICULTURAL POTENTIAL AND MARKETS

## 11.1 INTRODUCTION

Agriculture is the main source of livelihood for people in the basin (Ethiopia and South Sudan). Rainfed and irrigated cropping are the two main types of farming systems across the basin. Rainfed agriculture is the most common traditional system of farming for small-scale subsistence to large-scale semi-mechanized and mechanized farming[1] The traditional highland rain-fed farming system in Ethiopia consists of cereals and *enset* production. *Enset r*oot-based production is common among the Mocha (*sheka*) people and a co-stable crop with cereals and tubers. This practice is also found in the Sudanese highlands and rainforests. Root crops, yam, taro and sweet potato, pulses, vegetables, spices, *teff,* rice, cassava, maize, sorghum, cowpeas, groundnuts and sesame are major crops grown in the BAS sub-basin[1].

In South Sudan, seasonal food insecurity is common among farmers and pastoralists characterized by chronic and transitory food insecurity[2]. A significant proportion of the population is extremely vulnerable to food insecurity due to direct and indirect impact of conflicts, disruption of livelihoods, high dependence on markets and exposure to food price volatility. According to the Food Security Monitoring System conducted between October 2013 to October 2014, Jonglei and Upper Nile states faced the highest degree of food insecurity, with an average of above 20%, while the lowest rates of food insecurity for the same period was 16%[4].A significant proportion of the same population live below the poverty line[3]. (BAS Appraisal Report, 2012).

## 11.2 AGRICULTURAL POTENTIAL

According to the Comprehensive Agriculture Master Plan (CAMP)[10], over 95% of the total area of South Sudan is considered suitable for agriculture, 50% of which is prime agricultural land where soil and climatic conditions allow for production of a wide range of agricultural products, including annual crops such as grains, vegetables, tree crops such as coffee, tea, and fruits, livestock, fishery and various forest products. Despite of this potential, only 4% of the total land is under cultivation most of which are rain fed while the largest part of the country is still under trees and shrubs (62.6%). This fact holds true for states in the BAS basin, i.e. Jonglei, Upper Nile and Eastern Equatoria.

The Eastern Flood Plains encompassing Upper Nile and parts of Jonglei states and the green belt encompassing part of western and central equatorial are the two major crop producing regions in South Sudan, accounting for 17.6% and 26.2% of national cropland respectively[2].Part of Upper Nile state has medium agricultural potential with low population density, while the northern part of the Statehas low agricultural potential and low population density. The same is true for Jonglei State, where most of its area (except  the northern part) are areas of medium agricultural potential with low population density. Eastern Equatoria State has high agricultural potential with low population density[2].

## 11.3 MARKETS IN UPPER NILE, JONGLEI AND EASTERN EQUATORIA STATES

Food and livestock markets in South Sudan and the basin in particular tend to be highly inefficient and fragmented as a consequence of the poorly developed road network, transport and storage facilities. The problem is even more serious during the rainy season when road conditions deteriorate resulting in increased transportation costs as small loads are transported over long distances. With the exception of the Juba market, which can rely on regular supplies of locally produced and imported commodities, food and livestock prices experience high volatility. High taxation, time spent at customs, check points and road blocks also contribute to increases in the prices of goods and services[7].

Market prices are subject to frequent change and fluctuations. For instance, the retail price of sorghum dropped at the end of 2013 and abruptly increased in January 2014 due to the onset of commercialized

[10] Ministry of Agriculture, Forestry, Cooperatives and Rural Development, Government of South Sudan, 2015

farming that increased production, and conflicts respectively. Similarly, the price of wheat shows seasonal variations based on the prevailing situation. Market prices are very sensitive in conflict-affected areas like Upper Nile due to the destruction of infrastructure, looting of stores and stock and reduction in number of traders[7].

Markets in Upper Nile, Jonglei and Eastern Equatoria states consist of temporary and permanent stores where wholesellers tend to have permanent stores while retailers operate from temporary stores. While most goods are imported, there are some locally processed products like maize, cassava and wheat flour. Merchants are typically from local areas and neighboring countries as shown below[2]

*Table 11-1: Merchants and Markets in Basin States in South Sudan*

| Location | Markets | Merchants |
|---|---|---|
| Eastern Equatoria | Magwi and Torit | The majority of merchants at Torit Main Market are Ugandans and Kenyans. |
| Jonglei | Bor | The majority of merchants at the main market in Bor are Sudanese retailers. However, there are significant proportions of foreign retailers such as Ugandan, Ethiopians, Kenyans, and Eritrean retailers. |
| Upper Nile | Malakal Renk | Majority of merchants of Malakal Main market and a main market in Renk are Sudanese retailers. |

The agricultural input market in South Sudan is at an early stage due to the limited development of commercial and mechanized farming. Labour is the largest agricultural input expenditure, which suggests that there is a growing demand from larger, commercial farms[2]. Agricultural input markets can be considered in relatively fertile areas like the Eastern Flood Plains and Nile-Sobat river zones. The Greenbelt is another possible target area due to its high agricultural potential[2].

Agricultural products are often imported from neighbouring countries. Locally produced crops like maize, cassava and groundnuts are sold in local markets. Vegetables having high demand normally sell at higher prices than cereals. Farmers recognize the importance of vegetable cultivation and marketing, which should be promoted and supported and has a high potential for future development.

Market routes and linkages in the states of South Sudan in the basin are similar throughout the year, with the exception of in Upper Nile State during the rainy season. In the dry season, many traders bring agricultural products from Sudan and Ethiopia by road. In the rainy season, traders use boats to bring agricultural products from Juba. The frequency of supply decreases in the dry season, and the cost of transportation is higher in the rainy season. Distribution channels in the basin states is summarized below[2].

*Table 11-2: Distribution Channels for Main Crops in Basin States in South Sudan*

| Location | Local crops | Products and trade routes |
|---|---|---|
| Eastern Equatoria | Maize, sorghum, cassava, sesame, cowpea, Jew's mallow, eggplant , okra, amaranthus | Many products such as maize, cassava, groundnuts and sesame are brought from Magwi County.<br>Cassava, Jew's mallow, eggplant, cowpeas, okra and amaranths are grown and sold within the state. |
| Jonglei | Sorghum, groundnuts, cowpea, maize, sesame, okra, pumpkin, onion, rocket | Most agricultural products are grown locally and brought to local markets.<br>Some agricultural products are brought from other parts of the country. |
| Upper Nile | sorghum, finger millet, maize, sesame, onion, tomato, okra, cotton, rocket, Jew's mallow | Many agricultural products are grown and brought to local markets |

## 11.4 THE JUBA MARKET

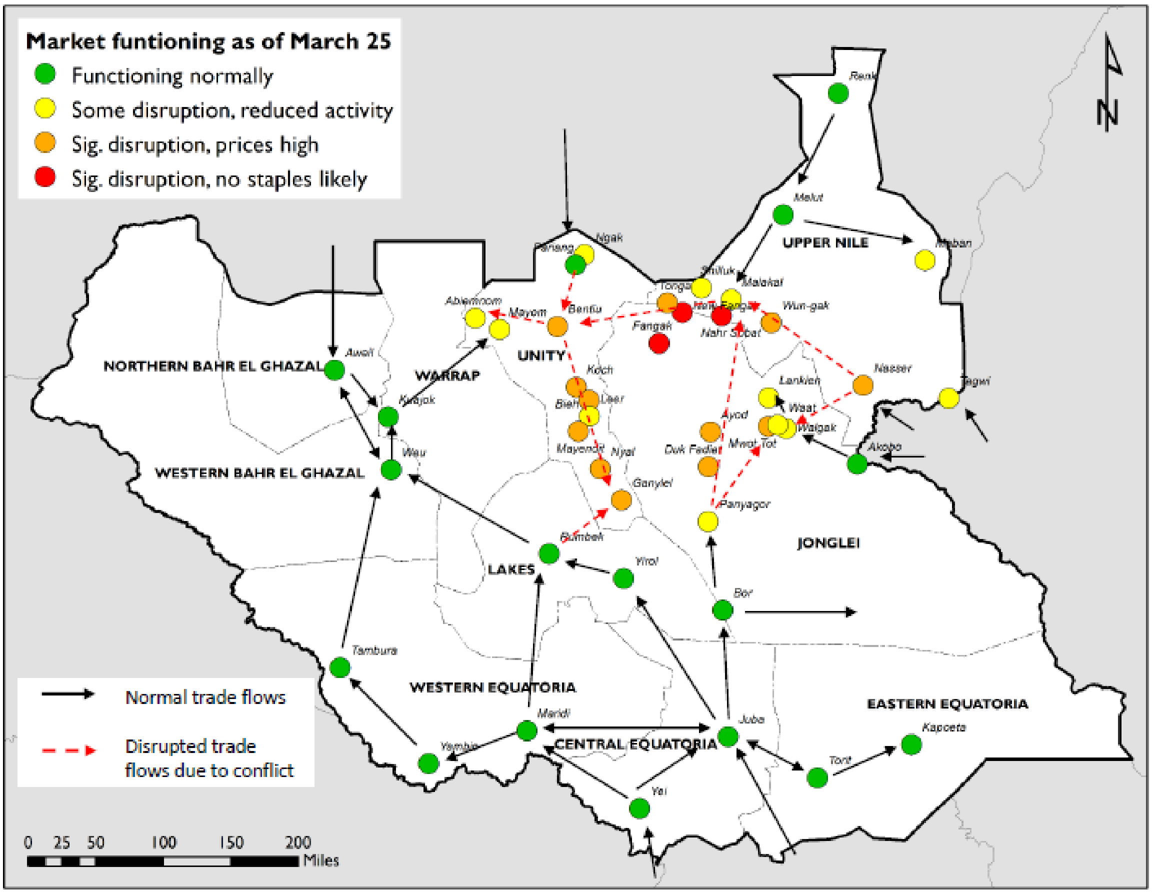
The Juba market is a strategically important regional market for products from the southern part of the BAS sub-basin. It receives imported consumer goods from neighbouring countries and distributes them to smaller markets throughout South Sudan. A large volume of agricultural products from Uganda reaches the Juba market. Large-scale traders are the major actors in the cross-border trade and purchase goods in larger quantities to reduce the transaction and transportation costs due to the long distance to Juba[2].

In the Juba market, traders are predominantly non-South Sudanese, and include a high proportion of Ugandan nationals. The participation of South Sudanese women in agricultural marketing is relatively low; they are active mainly in small-scale trade of non-agricultural goods. The use of rented shops or storage space is common, and sharing of shop space among several traders is also practiced.

The Juba market is relatively well organized and regulated. Payment is in most cases immediate; mainly within a day and in cash, with very limited credit and almost no payments by cheque or other forms of payment.

The following map shows the location of normal and disrupted trade flows in South Sudan during the month of March 2015.

*Figure 11-1: Status of Trade Routes in South Sudan (March 2016)*




It can be seen from the above map that the majority of trade and market disruptions during the period shown are located in the northeast part of the country, in the triangle formed by Jonglei, Upper Nile and Unity states. The most serious of these disruptions result in increased business risks, scarcity, higher prices and in the worst case total cutoff and non-availability of goods and produce. It should be noted that trade and market disruptions are subject to frequent changes according to the location and intensity of incidents.

## 11.5 MARKET CONSTRAINTS FOR LOCAL PRODUCE

Imported agricultural commodities are dominant in the larger markets such as Juba. There is also local produce including sorghum, groundnuts, okra and other local vegetables, while most of the other commodities are imported. Markets in Juba respond to seasonal patterns and variations in transaction costs, which are highest in the wet season and low in the dry season. Domestic production does not respond well or in a timely fashion to market signals due to dependence on fragmented inputs such as labor, fertilizer and transportation, which constrain the ability of small-scale local producers to respond[2].

The domestic supply of agricultural produce is at a significant disadvantage due to poor roads, high administrative costs to collect domestic produce and multiple taxes. Taxation is the second highest business expense after transportation, and can accounts for anywhere between 15-50% of marketing costs.

## 11.6 AGRICULTURAL MECHANIZATION

### 11.6.1 Baseline situation

Mechanized agriculture in South Sudan is mostly rain-fed cultivation that includes (1) demarcated, large-scale farmers in Upper Nile State with multiple aggregations of 500 *feddans* (about 200 ha) known as *mushroor*, in Upper Nile State from Renk to Malakal, (2) undemarcated traditional farms in units up to 50 *feddans* (about 20 ha) alongside large-scale farmers and hiring their tractors and equipment. Inputs not available locally are obtained from Kosti in Sudan. Access to credit for purchasing inputs is limited[2].

The Renk Irrigation Scheme, in Upper Nile State was operated by the Sudanese government before independence of South Sudan. There are 23 sub-schemes in the scheme, and recently nine sub-schemes are operated by the government and the rest by private farmers. There is no operational irrigation in the scheme due to breakdown of pumps and insufficient funds for operation provided by the government. Farmers mainly grow sorghum, sesame, millet and groundnuts. However, farmer-traders in Kosti receive loans from a Khartoum-based bank. These farmer-traders are moving to conflict free areas to avoid risks[2].

On large-scale farms, harvesting is opportunistic. The farmer will assess which parts of the crop to harvest and which parts to abandon, is any, taking into consideration the cost of harvesting. If the cost of harvesting is higher than the estimated income from the yield at the prevailing market prices, the crop is abandoned. Production in the mechanized agricultural sector in Upper Nile State in 2014 is shown in the following table.

*Table 11-3: Characteristics of Mechanized Agriculture in Upper Nile State (2014)*

| Scale | Area cultivated (ha) | Area harvested (ha) 50% of cultivated area | Yield (tons/ha) |
|---|---|---|---|
| Large | 87,423 | 43,711 | 0.58 |
| Small | 56,000 | 38,000 | 0.65 |

### 11.6.2 Agricultural Potential in South Sudan

South Sudan's diverse ecology provides a growing season ranging from 280-300 days in the southwestern parts (known as the Greenbelt) to 130-150 days per annum in the northern states due to bimodal and unimodal rainfall regimes. The bimodal areas cover much of the Greater Equatoria (Western, Central and parts of Eastern Equatoria), while the rest of the country has a unimodal regime. Agricultural performance consequently varies markedly depending primarily on latitude, with the possibility of two and even three harvests per annum from the same plots in the Greenbelt in the Greater Equatoria, and a single harvest in the unimodal areas further north.

With almost all agricultural production being rainfed, rainfall variability in terms of quantity and distribution is the major factor in determining crop performance. Usually, rainfall increases in a north-easterly to south-westerly *direction* culminating in the Greenbelt along the border with the Central African Republic, the

Democratic Republic of Congo and Uganda; but there are considerable variations in rainfall from year to year and from location to location within the same year in all areas. In lowland areas, flooding/water-logging is a common occurrence, while many areas, especially those towards the northern border with the Sudan and southeast corner of the country, are susceptible to prolonged dry periods. Hence, good soil and water management are keys to increased crop yields.

Crop production is mostly conducted on small, hand-cultivated plots farmed by women-headed households, with a membership of five to seven persons that belong to larger family aggregations, reflecting the polygamous nature of most communities. Notwithstanding an abundant availability of land throughout the country, the area cultivated by households has, hitherto, been limited by a combination of (a) the size of the household labour force and/or the ability of households to provide in-kind payment (essentially food/beer) for the mobilization of traditional working groups (*nafeer)* and (b*)* security of access.

In recent years, average farm sizes have increased with stead-based farm areas merging with faraway-fields where farmers use animal traction; and, with the emergence of commercially-orientated farmers cultivating larger areas in cereals, groundnuts and cassava for sale using combinations of tractor services, labor gangs and oxen, depending on location.

During the past 20 years, animal traction has been promoted by FAO and NGOs in Eastern Equatoria State to increase the area cultivated by households. However, lack of spare parts, skills to maintain mould-board ploughs, raw materials for local blacksmiths and low levels of operator skills still limit expansion; as does lack of resources to capitalize on the increased area through improved weeding, transportation and marketing.

During 2015, secure access to land throughout the season was the defining characteristic of farmed areas in Upper Nile State and bordering counties where large numbers of IDPs sought refuge. Access was denied in many counties in Upper Nile and Jonglei states where communities fled their homes. Even if they remained, they were often too traumatized and frightened to farm. However, in states not directly affected by conflicts, planting expanded in both numbers of households and cultivated areas for all crops.

Rainfed mechanized cereal production is normally practiced on a large scale in the Upper Nile counties of Renk, Manyo, Melut, Baliet, Fashoda and Malakal following patterns of land occupancy and use established before independence by traders/farmers from Sudan. Elsewhere, limited numbers of both private and GRSS tractors provide ploughing services to individuals and farmer-groups at prices ranging from SSP 50 (GRSS subsidized) to SSP 350 per *feddan* for a single pass. Mechanization applies only to one pass preparation and sowing on a second pass with a seed drill positioned over the disc harrows. Other operations to harvesting are done manually.

Major problems are unreliable and expensive supply of fuel and spare parts, operator skills and maintenance, and repair capabilities, severely limiting the efficiency of the tractor service. Pilot programs to introduce and support the use of two-wheeled walking tractors offer a financially sustainable alternative to the distribution of large four-wheeled tractors that become prematurely out of service due to inadequate maintenance.

Three planting assessments were conducted from March to July 2014 as part of the CFSAM Roadmap. (FAO, 2014) They confirmed that sorghum is the main crop cultivated by the traditional sector, comprising some 70% of the area sown in cereals. Regarding sorghum, preferred seeds are the many local landraces with lengths to maturity fitting agro-ecological niches ranging from short-season (<90 days) to very long-season (>220 days).

There are also several improved, short-term varieties of sorghum from the Sudan that have become well-established in the northern states of the country in both large-scale mechanized farms in Upper Nile State and hand-cultivated farming areas with cross-border access to the Sudan located from Renk to Abyei to Aweil.

Maize is estimated to be planted in about 27% of the cereal area. However, this percentage breakdown is not universally applicable to product availability due to regional differences. Maize is the most popular cereal in the Greenbelt, where Longi varieties are grown in series in two crops per year on the same land.

Maize is also the main cereal grown along the Sobat River in Upper Nile State and in the eastern Jonglei counties near the Ethiopian border, where mixed *Longi* and local landraces and Ethiopian releases are noted. Elsewhere, maize is only cultivated in very limited areas close to homesteads, where it is consumed green with the first early sorghums in August-September.

The crops of most importance to food security include cassava and groundnuts, sweet potato and yams. Groundnut areas range from 5 to 15% according to location. Groundnut is usually cultivated on sandier soils and, after cereals, makes the most important contribution to household diets throughout the northern states, where it is also the main cash crop.

Okra, cowpea, green-gram, pumpkin, bambara nut and tobacco are also widely grown around homesteads in the basin. Vegetables such as onions or tomatoes are not commonly grown in rural areas, but are increasingly cultivated near cities to supply urban markets.

With the exception of farmers near the Sudan or Uganda border and vulnerable households receiving food aid, almost all farmers use their own seed from the previous year's harvest or seeds purchased from local markets or borrowed from relatives.

# 12. ENERGY

## 12.1 INTRODUCTION

Current energy needs in South Sudan are predominantly met by biomass, consisting of the burning of charcoal, wood, grass, cow dung and agricultural residues. According to the National Baseline Household Survey in 2012, over 96% of the population use firewood or charcoal as the primary fuel for cooking (which typically constitutes 90% of the energy used in a rural household).

The energy needs in South Sudan are predominantly met by biomass, consisting of the burning of charcoal, wood, grass, cow dung, agriculture residues, etc. According to the National Baseline Household Survey, over 96% of the population use firewood or charcoal as the primary fuel for cooking (which typically constitutes 90% of the energy used in a rural household). An average household in South Sudan burns about 3 tons of woody biomass per year for cooking, emitting nearly 2 tons of carbon dioxide equivalent per year, as cooking is done mainly using three-stone open fires. Only about 1% of the population of the country has access to grid electricity. Most of these consumers are in Juba, with the remaining in Wau and Malakal.

Almost all households in rural areas and small towns cook with firewood or charcoal, the vast majority using charcoal. In urban low-income areas households spend 10-15% of their average monthly household income on charcoal. Firewood is the most used source for lighting  used by 35% of population. Grass (15%) and kerosene lamps (13%) are the second and third most used source for lighting. Some 27% of the population has no source of lighting.

The fuel mainly used for cooking in rural areas in the sub-basin is firewood collected from forests and bushes, mainly by women and children, sometimes as far as 6 km away. Large tracts of unutilized bush land that is used as a source of firewood and charcoal are a common feature of the sub-basin. The *following* table shows the sources of energy for the sub-basin states in South Sudan.

*Table 12.12: Main Fuel Sources for sub-basin states in South Sudan*

| Source/Location | Upper Nile | Jonglei | Eastern Equatoria |
|---|---|---|---|
| Firewood | 63.2 | 92.0 | 94.1 |
| Charcoal | 21.5 | 3.5 | 5.7 |
| Grass | 13.9 | 4.4 | 0.0 |

*Source: National Baseline Household Survey, 2009*

The available electricity networks are three isolated distribution systems located in Juba, Wau and Malakal totaling about 15 km of 11 kV lines plus some electrified commercial centres and industries. In and near the sub-basin there is a 8.0 MW distribution system in Malakal and a 0.88 MW system in Kapoeta.

Installed capacity for the entire country is about 30 MW, of which about 22 MW is currently operational. The total number of customers connected to the network is about 22,000. Per capita electricity consumption in South Sudan is about 1-3 kWh, the lowest compared to  neighboring countries. The average per capita electricity consumption in Sub–Saharan Africa is about 80 kWh. The current demand for electricity is estimated to be 300 MW, which is expected to rise to over 1,400 MW by 2030.

Since February 2013, the available generation capacity has been adversely affected by the lack of fuel and spare parts for the thermal power plants as a result of austerity measures following the oil shutdown shortly after independence and reduction of oil revenues from Sudan as well as lower prices for oil on international markets.

The Ministry of Electricity and Dams (MED) has drafted a national electricity policy that prioritizes the use of indigenous energy resources, mainly crude oil and hydropower, to supply power to new industries and households.

The power sector in South Sudan is highly subsidized The total number of customers connected to the electricity network is 22,000 which includes 1,500 customers of NRECA/USAID trained cooperatives in towns of Yei, Wau and Malakal. These who are connected to the grid have to pay a high cost for the service, the average tariff being US$ 0.22/kWh. This price is not cost reflective, as the production cost is around USD 0.70/kWh.. It is important to note that the big customers mainly the Government institutions, military barracks, airport, hospitals do not pay their electricity bills.

There is a solar PV for water pumping to supply water to 55,000 people in Akobo, Jonglei state, in northeastern South Sudan, near the Ethiopian border. The project was financed by the International Committee of the Red Cross (ICRC) to supply water to displaced people.

## 12.2 RENEWABLE ENERGY

The BAS sub-basin has a potential for renewable energy to generate electricity, including small-scale and large scale hydropower, solar photovoltaic, and wind, biomass, geothermal and waste-to-energy. The share of renewable energy in the national generation mix is very low at present. However, a number of hydro projects are in pipeline including large scale, mini and micro hydro projects as the country is rich in hydropower resources.

Biomass energy remains the most used renewable energy in South Sudan and the situation is likely to remain so for the coming decades. Biomass fired power plant could be an option for increasing generation capacity in the future.

## 12.3 POWER SECTOR STRATEGY AND PLAN

The national electrification strategy prioritizes the use of indigenous resources, namely oil and hydropower to provide electric power for basic services and to meet the increasing development needs of the country.

The Strategic Plan 2013-2016 (GoSS, 2012) focuses on grid-based expansion to 48,000 customers (all 10 state capitals will be electrified) from 22,000 customers, investment in expansion of thermal generation capacity to 96 MW, as well as the expansion of distribution networks. The SSDP also includes plans to import 140 MW power from Sudan via a 220 kV interconnector line.

The Power Sector Development Action Plan for the coming ten years contains six key components:

1. To meet existing and projected demand for power, undertake a major program of expansion in generation capacity from the current 30 MW (22 MW available) to about 580 MW by 2025;

2. Extend the national transmission and distribution grid to link all ten state capitals and link the South Sudan grid to those of Ethiopia, Kenya and Uganda;

3. Expand access to electricity to provide 75% of urban households with access to electricity from the national grid by 2025, compared with only 1% at present;

4. Complete a major restructuring of the SSEC to convert it into a financially sound state enterprise that has the capacity to enter into contracts with private suppliers of electric power;

5. Strengthen the enabling environment for private investment in power generation and attract private investors to operate as independent power producers (IPPs) within South Sudan; and

6. Strengthen existing regulatory arrangements for the electricity sector.

It remains to be seen how and to what extent this strategy and plan will be implemented and the time frame for realizing its ambitious targets. In any case, its implementation will require a large injection of external assistance, and its impact in rural areas of the sub-basin in South Sudan are likely to take a long time to be realized. In the meantime, the vast majority of the rural population in the sub-basin will continue to rely on biomass for their fuel and energy needs.

# 13. DEVELOPMENT OBJECTIVES AND PRIORITIES

## 13.1 OBJECTIVES

The foregoing description of the baseline situation in the BAS sub-basin supports the conclusion that ongoing and planned development interventions in the sub-basin should:

- Contribute to peace and security in the basin as a precondition for sustainable development
- Reduce inter-ethnic conflicts and competition over natural resources
- Promote transition from reliance on emergency assistance to development
- Increase food production, storage and marketing
- Increase access to basic services (e.g. safe drinking water supply to small towns, market centers and rural villages)
- Increase access to health services and prevent malaria and other debilitating diseases
- Increase technical and vocational education, also for girls and women
- Increase labor and agricultural productivity (e.g. larger farms and mechanization)
- Improve rural access, transportation and efficiency of markets

## 13.2 DEVELOPMENT ISSUES

The information presented in this chapter can be used to identify a number of issues and derive a set of priority interventions, among which are:

- Conflict resolution, stability and security, including food security.
- Development plans should be made in close consultation with the indigenous people
- There is a need to transform the agriculture sector by promoting medium and large-scale farming through mechanization.
- Supply adequate water points at locations in major grazing areas and along migration routes will help resolve conflicts between communities.
- Promote settlement and shift from a pastoralist life style to a mixed farming system can improve the livelihoods of people.
- Small-scale irrigation using surface or groundwater can also improve the livelihood of people.
- Water shortage is common in rural towns. Boreholes with solar pumps can be a solution, but training local technicians in operation and maintenance is necessary.
- Another constraint for development is the lack of and poor condition of infrastructure. Road access to and within rural areas of the BAS sub-basin is a crucial problem. Road density is very low and during the rainy season most rural roads are impassable.

The number of internally displaced people as a result of the ongoing political conflict leads to unplanned land acquisition and expansion of settlements, putting increasing pressure on water, forest and land resources and infrastructure. People lacking alternative sources of energy cut wood for firewood and construction, which worsens the problem of deforestation.

## 13.3 MONITORING INDICATORS

It is recommended that the following indicators be monitored to understand the extent and impact of food insecurity and food needs in the sub-basin:

- Food prices in regional markets (mainly cereals, livestock and livestock products);
- Physical access to markets;
- Coping Strategies;
- Water availability and accessibility;
- Disease outbreaks (human and livestock);
- Rainfall and input availability (seed);
- Population movements;
- Crop performance, including hazards;

Insecurity.

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# BARO-AKOBO-SOBAT MULTIPURPOSE WATER RESOURCES DEVELOPMENT PROJECT STUDY

## BASELINE, DEVELOPMENT POTENTIALS, KEY ISSUES AND OBJECTIVES REPORT

## *Annex 4: policies, legal and institutional arrangements in the basin: current situation and key issues*

*Final version – April 2017*

# BARO-AKOBO-SOBAT MULTIPURPOSE WATER RESOURCES DEVELOPMENT STUDY - BASELINE STUDY

# Annex 4: policies, legal and institutional arrangements in the basin: current situation and key issues

# 1. INTRODUCTION

Institutional and organizational arrangements, based on relevant legal grounds as well as policy and strategy documents, are a key issue when it comes to practical considerations of implementation of such an ambitious and complex IWRDM plan for the Baro Akobo Sobat river basin.

Challenges that might be encountered while developing the IWRMDPlan may include, but not limited to:

- How to address the multipurpose (i.e. inter-sectoral) nature of the Plan?
- How to properly and efficiently cooperate when activities with transboundary effects are planned?
- How to address the short, medium and long terms for a Plan which will certainly be developed over several decades and which will be certainly updated from time to time based on needs, development opportunities and emerging water resources issues?
- Which institutional arrangement is at the same time robust and flexible and could also be adapted in the medium and long term if necessary (based on the monitoring and evaluation feedbacks)?

Having these questions in mind, this section first depicts the current institutional background and framework at national and international scale, and then identifies key issues as well as preliminary ideas for the future. These ideas are aimed at being discussed with stakeholders and further developed in the Plan itself.

This section has been elaborated on the basis of key documents as quoted below and a series of face to face interviews with major stakeholders concerned by the BAS and the IWRMD Plan.

# 2. NATIONAL POLICIES AND INSTITUTIONS

## 2.1 ETHIOPIAN NATIONAL POLICIES AND INSTITUTIONS RELATED TO IWRM

### 2.1.1 Water management, development and IWRM

#### *2.1.1.1 General framework for IWRM*

Ethiopia is endowed with a long series of legal documents addressing the water resources in general and their management in particular. In chronological order, it is worth mentioning:

- The water policy, 1999
- The water strategy, 2001
- The water resources proclamation, 2000
- The water resources regulation, 2005
- The proclamation on river basins Councils and Authorities, 534/2007
- The definition of powers and duties of the executive organs, proclamation 691/2010

Without entering into all the aspects of these references, it is important to go into details of at least the two last documents.

The proclamation 691/2010 establishes for all Ministries the detail of duties and power. Regarding the Ministry in charge of water (at that time, Ministry of Water and Energy), these are the following:

a) promote the development of water resources and energy;

b) undertake basin studies and determine the country's ground and surface water resource potential in terms of volume and quality, and facilitate the utilization of same;

c) determine conditions and methods required for the optimum and equitable allocation and utilization of water bodies that flow across or lie between more than one regional states among various uses and the regional states;

d) <u>undertake studies and negotiations of treaties pertaining to the utilization of boundary and trans-boundary water bodies, and follow up the implementation of same</u>;

e) cause the carrying out of study, design and construction works to promote the expansion of <u>medium and large irrigation dams</u>;

f) administer dams and water structures constructed by federal budget unless they are entrusted to the authority of other relevant bodies;

g) in cooperation with the appropriate organs, prescribe quality standards for waters to be used for various purposes;

h) support the expansion of potable water supply coverage; follow up and coordinate the implementation of projects financed by foreign assistance and loans;

i) undertake studies concerning the development and utilization of energy; and promote the growth and expansion of the country's supply of electric energy;

j) promote the development of alternative energy sources and technologies;

k) set standards for petroleum storage and distribution facilities, and follow up the enforcement of same;

l) issue permits and regulate the construction and operation of water works relating to water bodies referred to in paragraphs (c) and (d) of this sub-article;

m) in cooperation with the appropriate organs, determine the volume of petroleum reserve and ensure that it is maintained;

n) ensure the proper execution of functions relating to meteorological services.

It can be seen from this long list that the ministry in charge of water has a very broad spectrum of responsibilities, now including in addition the development of irrigation in a more general manner. It is also clearly stated that the Ministry is the institution in charge of transboundary negotiations and related implementation of actions.

#### *2.1.1.2 River Basins Authorities in Ethiopia*

The most specific characteristic on how IWRM is addressed in Ethiopia is the ongoing process of creating River Basin Authorities, according to the proclamation 534/2007.

Duties and powers of the river basin Authorities according to this proclamation are:

1) Initiate and submit to the basin High Council policy measures needed to create a conducive environment for the implementation of an integrated water resources process within the basin and follow up the implementation of the same upon approval,
2) Undertake activities necessary for and facilitate the implementation of IWRM in the basin,
3) Ensure that projects, activities and interventions related to water. in the basin are, in their content; schedule, impacts and management are in line with the integrated water resources
4) Prepare, and submit to the Basin High Council, <u>the basin's plan</u> and monitor its implementation upon approval
5) Without prejudice to the power given to Regional State by law, <u>issue permits</u> applicable to the basin's water use and water works in accordance with Article 15 of this Proclamation, and ensure that the terms of the permits are complied with
6) Collect, compile, analyze and disseminate information for proper planning, administration and steering of water resources in the basin
7) Develop and use <u>a river basin model</u> in order to guide and support its basin water resources strategic planning and water administration functions
8) Give advice and technical support to the Basin High Council and the Ministry on dispute resolution in relation to the allocation and use of water resources of the basin
9) Set up a forum for effective networking among stakeholders
10) Collect water charges from users;
11) On the basis of instructions of the Basin High Council, <u>prepare and provide necessary information for the concerned body in charge of negotiations with other countries concerning trans-boundary river basins</u>;
12) Undertake studies, surveys and researches that are deemed necessary to carry out its functions;
13) Own property, enter into contracts, sue and be sued in its own name;
14) Carry out other functions necessary for the implementation of its objectives.

From this list, it can be seen also that river basin Authorities have a wide range of duties and power, including those underlined in the quotation, i.e. i) prepare a basin Master Plan and monitor its implementation ii) set up a river basin model for strategic planning purposes iii) support the body in charge of transboundary aspects by delivering proper information.

Therefore, as a summary, IWRM at Ethiopian basin scale pertains to the river basin Authorities while the active role for transboundary aspects belongs strictly to the Ministry. The proclamation 534/2007 gives provisions how to address the transboundary aspects by the High Council and the river basin Authorities as well as relationships between regional States in Ethiopia. A specific department is in charge of transboundary aspects within the MoWIE.

Today, there are already three River Basin Authorities officially created, i.e. Abbay, Awash and Rift Valley Lakes Authorities.

Baro Akobo, Tekeze and Omo Authorities will be set up shortly. The proclamation for setting up the Baro Akobo Authority is already drafted (copy given to the Consultant).

Awash river basin will be complemented with Danakil and Aisha river basins to form one single Authority together.

Genale Dawa, Wabi-Shebelle and Ogaden will form one single river basin Authority in the future.

There will be a total of seven river basins Authorities purely at national scale.

Regarding the Baro Akobo river basin, the priority for Ethiopia is to properly address sharing of water between the four regional States concerned by the catchment (i.e. Benishangul-Gumuz, Oromia, Gambella and SNNP) before considering transboundary aspects.

#### *2.1.1.3 Environment protection organs*

The main document of reference is the proclamation 295/2002. This proclamation gives a series of definition, and especially the organs mentioned in the title, i.e.

- "Competent Agency" means any federal or regional government organ entrusted by law with a responsibility related to the subject specified in the provisions where the term is used;
- "Environment" means the totality of all materials whether in their natural state or modified or changed by human, their external spaces and the interactions which affect their quality or quantity and the welfare of human or other living beings, including but not restricted to, land atmosphere, weather and climate, water, living things, sound, odor, taste, social factors, and aesthetics;
- "Environmental Protection Organs" means the Authority, the Council, the Sectoral and Regional environmental units and agencies
- “Regional Environmental Agency" means any regional government organ entrusted, by that Region, with a responsibility for the protection or regulation of the environment and natural resources.

At federal stage, is established the “Environmental protection Authority” (EPA). Among a long list of duties and powers (26), it is worth focusing on what are the most prominent aspect of the BAS sub basin development plan, which are:

- Prepare as necessary environment policies and laws in consultation with competent organs and the public at large
- Establish a system for EIA as well as social and economic development policies, strategies, laws and programs
- Review inter-regional EIA and notify its decision, and follow up the conditions set out in case of authorization
- in consultation with competent agencies, take part in the negotiations of international environmental agreements and, as appropriate, initiate or cause the initiation of a process of their ratification;
- in consultation with the competent agencies, formulate, or initiate and coordinate the formulation of policies, strategies, laws and programs to implement international environmental agreements to which Ethiopia is a party; and upon approval, ensure their implementation;

The EPA is steered by a Council, placed under the authority of the Prime Minister acting as the chairman.

Sectoral environmental units and regional environmental agencies are created to translate and enforce the law in each sector and region under the guidance of the EPA.

#### *2.1.1.4 Rural land administration and land use*

This field of administration is governed by the proclamation 456/2005. Section 1 gives a detailed list of definitions on rural land, land administration, farmers, peasants, pastoralists…

Section 2 is more specific and addresses the "right to hold and use rural land". Among others:

- It is stated that "farmers, peasants, pastoralists engaged in agriculture for a living shall be given rural land free of charge".
- It is also stated that the Government is the owner of rural land, status which can be changed to private ownership as may be necessary.
- Private investors that engage in agricultural development shall have the right to use rural land in accordance to laws and policies at national and regional levels.
- Specific provisions are given regarding rural land measurement, registration and holding certificate
- There is no time limit for land use
- In case of eviction for purpose of public use, the holder of rural land shall be given compensation or substitute land
- Specific provisions are given for the transfer of rural land including possibility of lease and transfer to family members through inheritance
- Distribution of rural land is the subject of several provisions, including irrigation schemes where the principle of equity is central
- Specific provisions are given regarding the minimum land holding size and encouraging land consolidation
- Dispute resolution: in case a dispute would arise, it is recommended that the parties find an agreement on their own. At a last solution, the dispute will be solved according to the laws of the Region.

Section three relates to "rural land use restrictions" and mostly to land use planning and proper use of sloppy, gully and wetlands.

A series of recommendations and restrictions are formulated in this general purpose. Note two specific provisions: i) "the biodiversity in rural wetlands shall be conserved and utilized as necessary, in accordance to a suitable land use strategy" and ii) "a strategy of settlement, villagization and development of social services […] shall be formulated"

Section four relates mainly on the sharing of responsibilities between the federal Ministry of Agriculture (MoA) and the Regions.

At federal stage the MoA is in charge of:

- Implementing this proclamation by providing the necessary support and doing coordination,
- Initiate […] new policies ideas and amendments, as necessary,
- Create the system for exchange of information between the regions and the Federal Government

At regional stage the duties are:

- Each regional council shall enact rural land administration and Land use law, which consists of detailed provisions […]
- Regions shall establish institutions at all levels that shall implement rural land administration and Land use systems […]

### *2.1.1.5 Irrigation*

Irrigation in Ethiopia has been a national endeavor for several decades.

The policy is very ambitious and as quoted and summarized in an article[1] dated 2006, it can be expressed with the following objectives.

- Development and enhancement of small scale irrigated agriculture and grazing lands for food self-sufficiency at household level
- Development and enhancement of small, medium and large-scale irrigated agriculture for food security and food self-sufficiency at national level including export earnings and to satisfy local agro-industrial demand.
- Promotion of irrigation study, planning and implementation on economically viable, socially equitable, technically efficient, environmentally sounds basis as well as development of sustainable, productive and affordable irrigation farms.
- Promotion of water use efficiency, control wastage, protection of irrigation structures and appropriate drainage systems.
- Ensuring that small-scale, medium-scale and large-scale irrigation potential projects are studied and designed to stage ready for immediate implementation by private and/or the government at any time.

In 2001 the “Ethiopian Water Sector Strategy” set up the basis, among other fields related to water, of the strategic framework for irrigation development.

From a purely institutional point of view, the components of this strategy were expressed as:

- Strengthen institutional and regulatory frameworks at the federal and regional levels,
- Reactivate and reinforce the role of the federal government and regional states in the development of small, medium and large scale irrigation schemes,
- Enhance greater participation of the regional states and federal government in the development of large scale irrigated schemes and farms in high water potential basins where there is low population density (with compensations),
- Ensure operational sustainability of the small scale irrigation schemes by establishing O&M departments within the regional bureaus,
- Establish self-financing autonomous public institutions to undertake O&M activities of large scale irrigation schemes. Involve major stakeholders in the BOD of these institutions,
- Encourage the participation of private sector, specially for the O&M and management phases of medium and large scale irrigation schemes

The MOWIE is the Ministry in charge of developing irrigation (see the organogram below).

[1] MoWR/MoARD:USAID/IWMI workshop - Solomon Cherre

From the situation today, it can be seen that this policy and strategy are being actively implemented, including real involvement of the private sector and extensive use of lowlands. In the BAS sub basin irrigation of all sizes is developing quickly and this is a challenge to continue such a development together with commitments regarding the compensations to the people displaced as well as the safeguards for the natural environment and biodiversity.

#### *2.1.1.6 Energy*

The MOWIE is also the Ministry in charge of energy. Referring to the proclamation 691/2010 “definition of powers and duties of the executive organs”, the duties and organization related to energy can be summarized as follows.

The Ministry of Water and Energy shall have the powers and duties to:

a) promote the development of water resources and energy

b) administer dams and water structures constructed by federal budget unless they are entrusted to the authority of other relevant bodies;

c) undertake studies concerning the development and utilization of energy; and promote the growth and expansion of the country's supply of electric energy;

d) promote the development of alternative energy sources and technologies;

e) set standards for petroleum storage and distribution facilities, and follow up the enforcement of same;

f) issue permits and regulate the construction and operation of water works relating to water bodies referred to in paragraphs (c) and (d) of this sub article

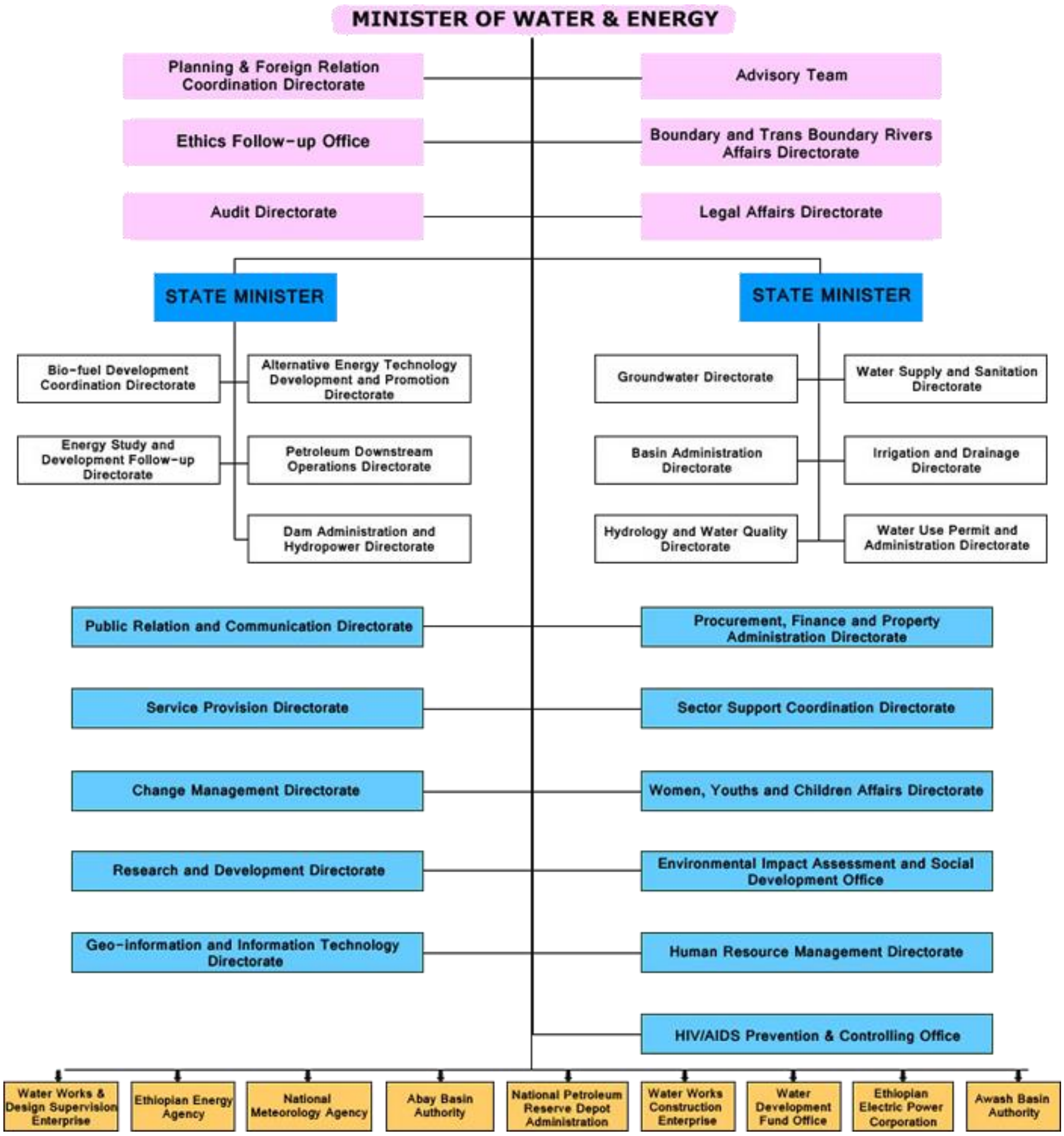
g) in cooperation with the appropriate organs, determine the volume of petroleum reserve and ensure that it is maintained;

The powers and duties given to the Ministry of Water Resources and the Ministry of Mines and Energy, with respect to energy, by the provisions of other laws, currently in force, and with respect to rural electrification, to the Ministry of Agriculture and Rural Development and the Ethiopian Rural Energy Development and Promotion Center and fund under Proclamation No. 317/2003 are hereby given to the Ministry of Water and Energy.

Apart these general duties, it is worth mentioning that Ethiopia has embarked in an ambitious strategy and realization of major HP plants would it be around lake Tana and the future GERD. To this respect EEPCO (Ethiopian Electricity Production Corporation) is a major player in charge of implementation for the GoE and an operator as well for production and operation.

The very large duties and powers of the MOWIE are reflected in the general organogram of the Ministry, with specific mention of two arms i.e. water and energy, each of them steered by a State Minister.

*Figure 2-1: Organization of the Ministry of Water and Energy*




### 2.1.1.7 Health

Health is still a permanent concern in all countries, and it is certainly more than serious in the BAS sub basin. Among specific aspects regarding health challenges in the BAS su basin, it is important to mention, not being exhaustive:

- A high density of population in the highlands with still new comers; this is making this part of the sub basin prone to infectious diseases and accurately focus on the challenge of WASH
- A high proportion of poor people, or even very poor and high population of refugees
- The development of water infratructures may favor water borne diseases
- The weak network of health centers and the way of life of pastoralists in the lowlands are major challenges
- Insecurity at last is obviously a very high impediment to any sound health practices

Hereunder, some extracts of the Ethiopian policy and strategy, relating to the effects and challenges of development and the present situation are quoted.

## General Policy

i. Development of the preventive and promotional components of health care.

ii. Development of an equitable and acceptable standard of health service system that will reach all segments of the population within the limits of resources.

iii. Promoting and strengthening of inter sectoral activities.

iv. Assurance of accessibility of health care for all segments of the population.

v. Working closely with neighboring countries, regional and international organizations to share information and strengthen collaboration in all activities contributory to health development including the control of factors detrimental to health.

vi. Provision of health care for the population on a scheme of payment according to ability with special assistance mechanisms for those who cannot afford to pay.

vii. Promotion of the participation of the private sector and non-governmental organizations in health care.

## Priorities of the Policy

i. Emphasis shall be given to:
- The control of communicable diseases, epidemics and diseases related to malnutrition and poor living conditions;
- The promotion of occupational health and safety;
- The development of environmental health;
- The rehabilitation of the health infrastructure
- The development of an appropriate health service management system;

ii. Appropriate support shall be given to the curative and rehabilitative components of health including mental health.

iii. Due attention shall be given to the development of the beneficial aspects of Traditional Medicine including related research and its gradual integration into Modern Medicine.

iv. Applied health research addressing the major health problems shall be emphasized.

v. Provision of essential medicines, medical supplies and equipment shall be strengthened.

vi. Development of human resources with emphasis on expansion of the number of frontline and middle level oriented training shall be undertaken.

vii. Special attention shall be given to the health needs of:
- The family particularly women and children;
- Those in the forefront of productivity;
- Those hitherto most neglected regions and segments of population including the majority of the rural population, pastoralists, the urban poor and national minorities,
- Victims of man-made and natural disasters.

## GENERAL STRATEGIES

i. Inter sectoral collaboration shall be emphasized particularly in:
- Formulating and implementing an appropriate food and nutrition policy.
- Acceleration the provision of safe and adequate water for urban and rural populations.
- Developing safe disposal of human, household, agricultural, and industrial wastes, and encouragement of recycling.
- Undertakings in disaster management, agriculture, education, communication, transportation, expansion of employment opportunities and development of other social services.

ii. Health Education shall be strengthened generally and for specific target populations through the mass media, community leaders, religious and cultural leaders, professional associations, schools and other social organizations for:
- Inculcating attitudes of responsibility for self-care in health and assurance of safe environment.
- Encouraging the awareness and development of health promotional life-styles and attention to personal hygiene and healthy environment.
- Enhancing awareness of common communicable and nutritional diseases and the means for their prevention.
- Inculcating attitudes of participation in community health development.
- Identifying and discouraging harmful traditional practices while encouraging their beneficial aspects.

iii. Availability of Drugs, supplies and Equipment shall be assured by:
- Preparing lists of essential and standard drugs and equipment for all levels of the health service system and continuously updating such lists.
- Encouraging national production capability of drugs, vaccines, supplies and equipment by giving appropriate incentives to firms, which are engaged in manufacture, research and development.
- Developing a standardized and efficient system for procurement, distribution, storage and utilization of the products.

iv. Traditional Medicine shall be accorded appropriate attention by:
- Identifying and encouraging utilization of its beneficial aspects.
- Coordinating and encouraging research including its linkage with modern medicine.
- Developing appropriate regulation and registration for its practice.

v. Family Health Services shall be promoted by:
- Maintaining breast-feeding, and advocating homemade preparation, production and availability of weaning foods at affordable prices.
- Expanding and strengthening immunization services, optimization of access and utilization.
- Encouraging early utilization of available health care facilities for management of common childhood diseases particularly diarrheal diseases and acute respiratory infections.

vi. Health Legislations shall be revised by.
- Updating existing public health laws and regulations.
- Developing new rules and regulations to help in the implementation of the current policy and addressing new health issues.
- Strengthening mechanisms for implementation of health laws and regulations.

vii. Financing the Health services shall be through public, private and international sources and the following options shall be considered and evaluated.
- Raising taxes and revenues.
- Formal contribution or insurance by public employees.

## 2.2 SOUTH SUDANESE NATIONAL POLICIES AND INSTITUTIONS

### 2.2.1 General framework to water management, development and IWRM

Despite being a young independent State, South Sudan has prepared several documents of importance addressing water resources and their management, including provisions on institutional arrangement and trans-boundary aspects. The most important to be mentioned are:

- The Water Policy, GoSS November 2007 (i.e. before the independence, after the 2005 Comprehensive Peace Act)
- The Rapid Water Sector Needs Assessment and a way Forward, the World Bank January 2013
- Draft Water Bill, GoSS September 2013

***The Rapid Water Sector Needs Assessment and a way Forward***

This document explores into detail the Water Policy (2007), delivers some recommendations and identifies a way forward.

The report stresses different important aspects, such as:

- The great attention paid to the WASH sector which gave rise to a specific “Sector Strategic Framework” dated 2011. This is easy to understand as being one of the major priority for the GoSS due to the situation of drinking water supply and sanitation in the country.
- A limited approach to IWRM and inter-sectoral aspects with general principles and provisions in the 2007 Water Policy, to be further developed
- Also, mention of transboundary aspects, limited to principles of cooperation. This is quite understandable since in 2007 South Sudan was not fully independent and not in a position to apply to international bodies such as NBI and ENSAP/ENTRO.
- An important need to generate additional/complementary knowledge relating to water resources as well as the planning and management procedures.

As a summary, the way forward is synthetized in a series of key actions and initiatives to put into force:

- Implementing the WASH strategic framework
- Creating irrigation policy and strategy framework
- Developing major hydropower
- Monitoring the social and environmental impacts of water resources management
- Generating and adapting complementary knowledge
- Assessing the water resources integrated catchment planning and water allocation
- Integrating catchment planning and water allocation

***Draft Water Bill, September 2013***

This document is much more comprehensive and encompasses a series of specific provisions relating to water resources management as well as transboundary aspects. It remains to ascertain the legal status of this bill and whether and how all provisions have been put into force.

The draft Water Bill comprises five sections, 22 chapters, three schedules and 169 articles.

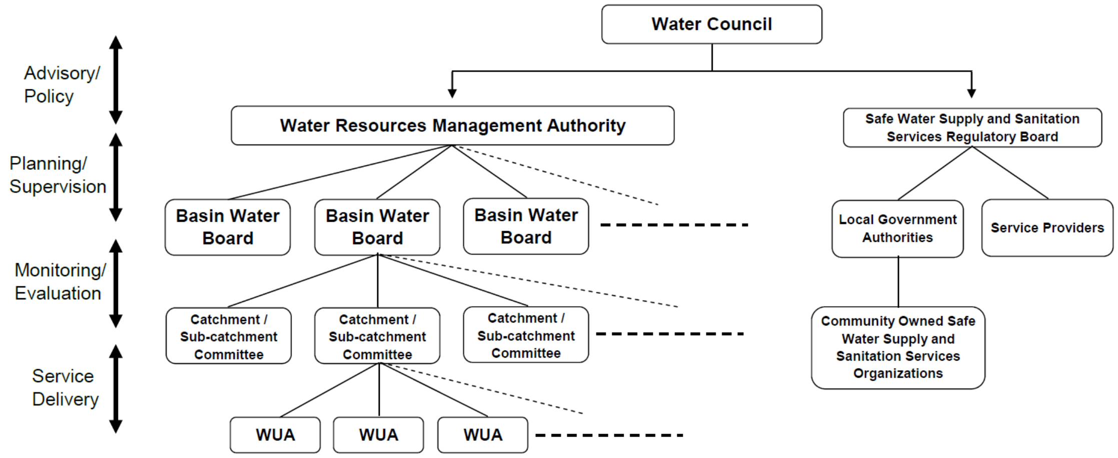
Not going into details (general provisions, transitional aspects etc.), it is worth mentioning the most prominent new arrangements envisaged.

- Section 2, chapter 2 gives provisions for establishment of a Water Council: in brief, the Water Council is under the authority of the Minister in charge of water. Its main purpose is to coordinate inter-sectoral approaches at the highest level. It is also supervising the Water Resources Management Authority (see below) and is endowed with a dedicated secretariat.
- Section 2, chapter 3 relates to duties and powers of the Minister (in charge of water): the Ministry of Electricity, Dams and Water Resources - MEDIWR). Among others, the Minister shall be responsible for RSS policy and strategy formulation and for ensuring the proper execution; Ensure and safeguard RSS interest on trans-boundary water resources; Provide for the safe construction of and management of dams; Appoint members of the Water Resources Management Authority; Appoint Basin Water Boards
- Section 2, chapter 5, articles 16 to 18 relate to the Water Resources Management Authority; among other provisions: this Authority is a corporate body under the authority of the Minister and acting for several concrete activities relating to IWRM. One specific duty is to *Liaise with other regional, RSS and international bodies for the better assessment, management, development and use of the water resources*; also this Authority is in charge of determining the basins catchments and sub-catchments. Upon its proposition, the Minister creates Basins Water Boards in the basins and sub-basins.

These Basin Water Boards are the acting arm at local scale in catchments and sub-catchment. Each is accompanied by a specific Committee appointed by the Minister

A summary of this organization is shown on the following sketch:

*Figure 2-2: Organization of the Basin Water Boards*



#### 2.2.1.1 Environment protection

The most recent information to refer to is the draft "National Environment Bill" dated 2014. Most of the description below is extracted from this draft bill.

This is also quite a long and comprehensive document comprising 13 chapters and 120 articles. Not entering into all provisions, it is of interest to have a quick look at the general structure of the bill.

- Chapter 1: Preliminary
- Chapter 2: Guiding principles goals and objectives
- Chapter 3: Governance
- Chapter 4: Management of natural resources
- Chapter 5: Climate change
- Chapter 6: Promoting environment rule of law
- Chapter 7: Institutional and human capacity building
- Chapter 8: Funding environment programs
- Chapter 9: Environmental planning
- Chapter 10: Natural heritage
- Chapter 11: Environmental education information and public awareness
- Chapter 12: Corporate social and environmental responsibility
- Chapter 13: Miscellaneous

**Governance**: a Ministry of Environment is established at national level. Each state will also be endowed with a State Ministry in charge of the Environment. At local scale (county, city council) it will be established a local environment department. The roles and duties of NGOs, CBOs, and private sector are also detailed. The Ministry is in charge of coordination, monitoring an evaluation.

**Management of natural resources**: chapter four states that i) nobody can cut trees or forests, except with official authorization ii) all wetlands, rivers, lakes and other water resources shall be protected natural assets and their use shall be regulated by law iii) the Ministry and the relevant government agencies shall ensure protection of habitats and ecosystems to preserve rare species and biodiversity of fauna and flora

**Environmental planning and land use**: chapters 9 and 4 identify the commitment of the Ministry to prepare in close consultation with partners (including other ministries) a land use plan as well as an environment plan.

**Environment impact assessment**: provisions are given for the necessary EIA

***Comments***

It is of great interest that such a bill would be passed. However, full enforcement on the field remains a major challenge due to the situation in South Sudan.

### 2.2.1.2 Land administration and land use

There is currently a land policy initiative supported by the African Union. Land is now classified into three groups:

- Public
- Communities
- Private

Public land (as per the colonial era) is managed by the Government of South Sudan; this comprise the national territory up to international borders, navigable rivers, sub terrain surfaces deeper than 3 m, wildlife including national parks, game reserves…etc.

Digging wells of building dams requires the consultation with local communities in order to secure a social cooperation.

Individuals and communities can acquire public lands.

A new Land policy is under preparation at the Parliament to refresh and update the land act dated 2009 (before the independence)

It does exist a procedure for land registration but it needs major improvement which is expected to be possible through the new land policy.

The situation today is an improper general land registration which will need great efforts to pay. Many old registers are still in Khartoum….

Akobo should be considered as a priority region for such a process of registration.[2]

In preparation to the expected new land policy, a draft version was issued in 2010. It is of interest to have in mind the road map expressed in this draft (under the denomination of "Policy statements"):

viii. The government shall promote secure land tenure for all legally-recognized rights holders and protect their rights

ix. Secure land rights are a fundamental enabling condition for poverty reduction

x. Government at all levels will work closely with traditional authorities and civil society organizations to develop durable solutions for land and property restitution in the event of return, or resettlement of refugees and IDPs

xi. Government at the federal and state levels will establish and implement laws, regulations, and procedures that foster transparent and accountable land administration

xii. Government is entrusted with the authority to administer land in the public interest

xiii. The GOSS and State governments will establish laws and regulations that recognize the role of and provide opportunities for public participation and protect the right of citizens and rights-holders to present their views on land-use and development decisions that affect their rights.

xiv. Government will establish and implement laws and programs that expand awareness, recognition, and protection of women's land rights.

xv. Customary land rights and tenure arrangements will be retained and their legal status strengthened and protected

xvi. Government should support education, training and research that expands awareness and understanding of land rights and land issues among all stakeholders in South Sudan

[2] Personnal communication with the head of land commission

xvii. Government agencies at various levels and customary authorities will assist in mediation of land rights conflicts

xviii. GOSS and State governments will maintain accurate records of held under leasehold and freehold tenure in efficiently managed and publically-accessible data bases.

xix. Orderly, transparent and efficient land markets will be encouraged

xx. The government recognizes that the allocation and use of land for private investment is a legitimate and potentially effective means for national economic growth, but must be done with in accordance with provisions that protect the public's interests.

#### *2.2.1.3 Irrigation*

Irrigation in South Sudan is under the authority of the MEDIWR, with involvement of the different states as well.

An "Irrigation Development Master Plan" (IDMP) was completed and released quite recently (2015-2016), which formulates a lot of recommendations and ambitions for the sector, with detail for each of South Sudanese states.

Not entering in many specific institutional aspects, it is of interest to understand the sharing of responsibilities (who does what) according to task to be performed and the size of the irrigation schemes envisaged. The following table summarizes this as a snapshot.

*Table 2-1 : proposed sharing of duties for irrigation in South Sudan*

| **Programme** | **Scheme/ Farm Size** | **Definition** | **Responsible Organization for Land Allocation** | **Ownership** | **Technical Assistance** | **Capital Investment i.e. funding source for implementation** | **O&M (Short-term)/a** | **Supervision of Scheme/Farm Management (Short-medium term)/b** |
|---|---|---|---|---|---|---|---|---|
| National Irrigation Scheme Development Programme (NISDP) | 500 ha or more | Large scale | National/ Community | Land property acquired by National Government | National/ DPs | National/Private Sector (Bank)/ International Development Bank/DPs (grant) | National/IB/ WUA | National |
| State Irrigation Scheme Development Programme (SISDP) | Up to about 500 ha | Medium scale | State/ Community | Land property acquired by State Government | National/ DPs/ | State/ National/ Private Sector (Bank)/ International Development Bank/DPs (grant) | National/ State/IB/ WUA | State/ National |
| County Irrigation Scheme Development Programme (CISDP) | Up to about 200 ha | Small scale | County/ Community | Land property acquired by Local Government | National/ State/DPs | County/State/ National/ Private Sector (Bank)/DPs (grant)/ NGOs | National/ County/IB WUA | County/ State/ National |
| Community Irrigation Farms Development Programme (CIFDP) | Up to about 200 ha | Small scale | Community | Land property acquired by Community group | National/ State/ County/ DPs/ NGOs | Community/County/State/National/ Private Sector (Bank)/DPs (grant)/ NGOs | National/ State/ County/ Community/ IB/WUA | Community/ County/State/ National |
| Private Sector Investment Promotion in Irrigation Development Programme (PSIPIDP) | Undefined | Undefined | National/ State/County/ Community | Land property acquired by Private Sector Organization | Private Consultants/ Government Facilitation | Private Sector, Government Support and Community Contribution | Private Sector WUA, IB, BW & C/SC | Private Sector |

#### 2.2.1.4 Energy

So far, there is no policy regarding energy in South Sudan.

Energy is widely coming from biomass source as well as from thermal plants and oil, and electricity generation is close to non-existence despite a fair potential in the country.

Electricity is managed by a directorate of the Ministry of Energy Dams and Water.

It is recommended strongly that, as soon as possible, a general master plan for energy will be elaborated and that this document will consider on the long term the development of the BAS sub basin and its potentials for HP generation.

The World Bank released a note dated April 2013 “Electricity Sector Strategy Note for South Sudan”, where three steps are identified:

- **Short term**: laying the foundation of growth. Planning, legal and regulatory framework, capacity building, continuation of emergency generation program, transmission and distribution program
- **Medium term**: implementing strategic projects, initiation of diverse mix generation with special attention to large HP projects, reinforcement of ageing network and planning for participation in power pools
- **Long term**: scaling up of expansion programs, including higher generation and diverse mix of resources including large HP projects; engage in regional power trade; interconnect grids and consider off-grid programs

#### 2.2.1.5 Health

Even more than for other sectors (above), the situation of health in South Sudan is more than critical. A description of what should have been the Health Sector Development Program is however given below. It should have been under the auspices of the Ministry of Health (document dated for the period 2011-2015)

Strategic Objectives

xxi. To increase access to quality primary health care services

xxii. To strengthen prevention and control of communicable and non-communicable diseases

xxiii. To improve Prevention of HIV/AIDS and Care for clients

xxiv. To improve maternal, newborn and child health

xxv. To improve nutritional status of the population, especially women and children

xxvi. To improve hospital services and complement the referral system especially for mothers

xxvii. To improve Management and Governance of the health sector

xxviii. To Strengthen Human resources production, management, distribution, development and retention:

xxix. To create an enabling environment to ensure availability and management of quality pharmaceuticals and supply systems

xxx. To rationalize distribution and improve the infrastructure of health services delivery points to ensure quality health care delivery

xxxi. To improve Health Sector Financing

xxxii. To enhance evidence based decision making through establishing HMIS and M&E systems and promoting a culture of data use

xxxiii. To further strengthen the health system through addressing a set of cross cutting priorities:

# 3. REGIONAL INSTITUTIONS, PROGRAMS AND FRAMEWORKS

## 3.1 NILE BASIN INITIATIVE

The Nile Basin Initiative (NBI) was founded in 1999 by the Council of Ministers of Water Affairs of the Nile Basin States. It includes all Nile countries and provides an agreed basin wide framework to fight poverty and promote socioeconomic development in the region. It is guided by a shared vision: *“to achieve sustainable socioeconomic development through the equitable utilization of, and benefit from, the common Nile Basin water resources*.”

The program of actions is based on collaborative action, exchange of experience, and capacity building and includes a set of projects:

- **Nile Transboundary Environmental Action Project:** The objective is to provide a strategic framework for environmentally sustainable development of the Nile River Basin and to support basin-wide environmental action linked to transboundary issues in the context of the NBI Strategic Action Program.
- **Efficient Water Use for Agricultural Production** to provide a conceptual and practical basis to increase water availability and efficient water use for agricultural production.
- **Nile Basin Regional Power Trade.** The objective is to establish the institutional means to coordinate the development of regional power markets among the Nile Basin countries.
- **Water Resources Planning and Management.** The project is to enhance the analytical capacity for basin-wide perspective to support the development, management, and protection of Nile Basin waters.
- **Confidence Building and Stakeholder Involvement.** With the aim to develop confidence in regional cooperation under the NBI and ensure full stakeholder involvement in the NBI and its projects.
- **Applied Training.** The objective is to strengthen institutional capacity in selected subject areas of water resources planning and management in public and private sectors and community groups and create or strengthen centres with capacity to develop and deliver programs on a continuing basis.
- **Socioeconomic Development and Benefit Sharing.** The aim is to strengthen Nile River basin-wide socio-economic cooperation and integration through:
  - joint identification, analysis, and design of cooperative development options and priorities, development of criteria, methods, and frameworks for sharing benefits/costs, and managing attendant risks.

Parallel to these programs, groups of countries in the Eastern Nile and in the Nile Equatorial Lakes region have identified investment opportunities at the sub-basin level and developed subsidiary action programs, respectively:

- **The Eastern Nile Subsidiary Action Program (ENSAP)**, which includes the countries of Egypt, Ethiopia, Sudan and South Sudan.
- **The Nile Equatorial Lakes Subsidiary Action Program (NELSAP)** that includes the countries of Burundi, Democratic Republic of Congo, Egypt, Kenya, Rwanda, Sudan, Tanzania, and Uganda.

## 3.2 ENSAP

The Eastern Nile Subsidiary Action Program (ENSAP), investment program developed by the NBI, is to promote poverty alleviation, economic growth and reversal of environmental degradation from a joint action of Egypt, Ethiopia, Sudan and South Sudan.

It is led by the Eastern Nile Council of Ministers (ENCOM) representing the four countries.

The first ENSAP project is referred to as the Integrated Development of the Eastern Nile (IDEN) project. Its objective is to initiate a regional, integrated, multipurpose development project that confirms tangible win-win gains and demonstrates joint action for the Eastern Nile countries.

IDEN comprises the following seven subprojects: Eastern Nile Planning Model (ENPM), Baro-Akobo Multipurpose Water Resources Development, Flood Preparedness and Early Warning, Ethiopia-Sudan Transmission Interconnection, Eastern Nile Power Trade Investment, Irrigation and Drainage, and Watershed Management.

- **Eastern Nile Planning Model (ENPM).** The long-term objective of this project is to strengthen the capacity of Egypt, Ethiopia, and Sudan to identify, prepare, and implement cooperative development projects that provide mutual benefits in the Eastern Nile. The ENPM will serve as an agreed common analytical tool for the joint planning of multi-purpose, multi-country win-win projects in the Eastern Nile. It will be an important element of the overall planning framework as it provides a common analytical basis for identifying, and assessing options, quantifying benefits and impacts, evaluating tradeoffs, and analyzing and managing information.
- **Baro Akobo Sobat Multipurpose Water Resources Development**. This is the present study, which concerns Ethiopia and South Sudan sharing the catchment of Baro Akobo Sobat. The main Components are: Multipurpose Water Resources Infrastructure, Integrated Water Resources Management, Environmental Management and Protection, Socioeconomic Development, and Regional Cooperation.
- **Flood Preparedness and Early Warning Project (FPEW).** The development objective is to reduce human suffering and damages from, and capture the benefits of, flooding in the Eastern Nile. The project focuses on flood risk management and non-structural approaches to managing the impacts of floods: including floodplain management and flood mitigation planning; flood forecasting and warning; and emergency response and preparedness at regional, national, local and community levels. This will contribute to the longer term goal of establishing a comprehensive regional approach to flood management that integrates watershed, river and floodplain management, and incorporates a suite of structural and non-structural flood mitigation measures within a broad multi-purpose framework.
- **Ethiopia-Sudan Power Interconnection.** The immediate objective is to facilitate cross-border power trade between the two countries and thus optimize utilization of existing and planned generation capacity. The expected output is a high-voltage transmission line connecting the two countries, which would be the first step in realizing an integrated power system in the Eastern Nile.
- **Eastern Nile Power Trade Program Study.** The objective of the Study is to promote regional power trade and create an enabling environment for coordinated planning and development through: 1) comprehensive identification of potential opportunities for regional benefits, 2) prioritization of power generation and transmission interconnection projects or scenario, 3) conduct pre-feasibility studies of three dam sites (Mandaya and Border dams in Ethiopia and Dal-1 in Sudan, 4) developing a strategy for power trade for the Region, and 5) conducting feasibility study of regional transmission interconnection.
- **Irrigation and Drainage Project.** The study will include two components: 1) Engineering sub-study: Ethiopia and Sudan development Projects and 2) CRA sub-study.
- **Watershed Management.** The immediate objective of the Eastern Nile Watershed Management project is to establish a sustainable framework for the management of selected watersheds in order to improve the living conditions of the people, create alternative livelihoods, enhance agricultural productivity, and protect the environment, and in the long term reduce sediment transport and situation of infrastructure, and prepare for sustainable development investments.

## 3.3 ENTRO

The Eastern Nile Technical Regional Office (ENTRO) was established by ENCOM in June 2002 in Addis Ababa as the executive arm of the ENSAP. Initially the countries were three (Egypt, Ethiopia and Sudan) and since the independence of South Sudan in 2011, ENSAP and ENTRO comprise four countries. ENTRO manages, coordinates and supports ENSAP projects through: capacity building in social development, input to project design, formulation of guidelines, initiation of pilot and background studies and analysis; and networking with stakeholders.

ENTRO is funded by the Eastern Nile countries and several foreign donors: among others, the African Development Bank, the NEPAD etc.

The roles of ENTRO are summarized as follows:

- Providing technical expertise and adopting best practices for the coordinated identification, preparation and possible implementation of regional development programs and projects in the Eastern Nile;
- Enhancing capacities of ENSAP institutions;
- Building and strengthening networks among the stakeholders; and
- Enabling people from the Eastern Nile to work together.
- Facilitating Eastern Nile Dialogue and Consultations
- Promoting EN Water Resources Management (knowledge management & planning), and
- Promoting EN Water Resources Development

*Summary of transboundary initiatives relating to water*

**The Nile Basin Initiative (NBI)** was founded in 1999 by the Council of Ministers of Water Affairs of the Nile Basin States. It includes all Nile countries and provides an agreed basin wide framework to fight poverty and promote socioeconomic development in the region. It is guided by a shared vision: *"to achieve sustainable socioeconomic development through the equitable utilization of, and benefit from, the common Nile Basin water resources*."

Parallel to the programs developed by the NBI, groups of countries in the Eastern Nile and in the Nile Equatorial Lakes region have identified investment opportunities at the sub-basin level and developed subsidiary action programs, in particular the Eastern Nile Subsidiary Action Program (ENSAP), which includes the countries of Egypt, Ethiopia, Sudan and South Sudan. ENSAP is to promote poverty alleviation, economic growth and reversal of environmental degradation from a joint action of Egypt, Ethiopia, Sudan and South Sudan.

The first ENSAP project is referred to as the Integrated Development of the Eastern Nile (IDEN) project that comprises the following seven subprojects: Eastern Nile Planning Model, Baro-Akobo-Sobat Multipurpose Water Resources Development, Flood Preparedness and Early Warning, Ethiopia-Sudan Transmission Interconnection, Eastern Nile Power Trade Investment, Irrigation and Drainage, and Watershed Management.

## 3.4 THE COOPERATIVE FRAMEWORK AGREEMENT (CFA)

The Member States of the NBI have worked, discussed and negotiated for years with the aim of establishing a general agreement on water resources in the Nile river basin. This resulted in a document named “Cooperative Framework Agreement” which was completed in 2010, with, among others, the purpose of setting up a “Nile river basin Commission”. However, at that time Egypt and Sudan decided to withdraw from any negotiation and definitely not to sign the CFA.

To enter into force, the CFA requires signature by the Member States, plus ratification. One provision of the CFA (article 42) is relating to the entry into force of the CFA as *“The present Framework shall enter into force on the sixtieth day following the date of the deposit of the sixth instrument of ratification or accession with the African Union”.* So far, three ratifications are still missing to meet such a condition and the CFA is not yet activated.

In addition to the great interest lying in institutional provisions expressed in the CFA, article 31 of the CFA addresses the *“sub basins organizations and arrangements”*, recognizing their utility. This article could be of high interest if the CFA is put into force, for the BAS river basin. However, this article is a very general provision, mainly addressing existing sub-basin organization (LVBC for example), and would need a very specific work and details on how new sub-basins could be considered and set up.

# 4. RELEVANT INTERNATIONAL AGREEMENTS

## 4.1 TRANSBOUNDARY WATER AGREEMENT

More generally, it is worth mentioning the UN "*Convention on the Law of the Non-navigational Uses of International Watercourses*" 1997. This convention was put into force only in 2014 when the 35$^{th}$ state ratified it (Vietnam), according to the related provision.

The convention expresses general principles of management and protection of water resources, summarized as:

- Principles for sharing transboundary water,
- General obligation to cooperate,
- Protection of the environment,
- Participation of the public,
- Prevention and settlement of disputes.

This convention certainly inspired many initiatives of transboundary water resources arrangements/agreements, and still constitute a reference to that extent.

However, the NBI and the preparation of the CFA went much further into the actual situation of the Nile river basin and the convention cannot help much in this context. It is also noticeable that none of the countries sharing the Nile river basin has signed nor ratified this convention.

## 4.2 AFRICAN DEVELOPMENT BANK'S INTERNATIONAL POLICIES AND STRATEGIES

### *POLICY FOR INTEGRATED WATER RESOURCES MANAGEMENT (2000)*

The AfDB issued its IWRM policy in 2000. This policy is mainly composed of i) the assessment of the existing situation, problems and constraints and ii) the IWRM policy itself. The section on the existing situation may be perceived as somehow outdated, but the policy principles do remain and it is worth mentioning that it addresses:

- Basic principles and objectives,
- Institutional strategies,
- Technical strategies,
- Economic strategies,
- Social strategies, and
- Environmental strategies.

Regarding water resources development and IWRM, the AfDB policy summarizes major recommendations and preferred arrangements such as:

*"Responsibilities for development and management of water resources can either be fully or partially transferred to restructured public agencies, private agencies or water users associations. To perform their functions effectively, however, these institutions must be accountable and autonomous. […]. In addition, central government should ensure that activities in the water sectors are coordinated given the broad range of actors in the sector, their area of intervention, and their varying operational policies and procedures. The role of the government should be to facilitate dialogue, broad participation and consensus building among all stakeholders. The Bank will support water resources management activities that promote policy consultation among all stakeholders, and seek broad participation."*

Still few water bodies that cross or form international borders in Africa are managed jointly. *"In this context, the dependency of downstream countries on upstream ones for access to and development of water resources is a potential threat to regional stability and peace. An integrated approach to water resources management calls for regional cooperation for the joint management of international watercourses. The effective functioning of trans-boundary river basin organizations at the regional and international level is a major priority. The Bank will support joint efforts of riparian countries in developing strategies for integrated water resources management and will assist in providing financial resources for multinational and regional organizations and river basin authorities."*

***THE AFRICAN WATER FACILITY (AWF)***

Hosted by the AfDB, the AWF was created in 2004 by the African Ministers' Council on Water (AMCOW) in response to the need to catalyse the development of the water sector, by increasing the number and the quality of sustainable water projects to meet water development goals throughout the continent.

Target goals of AWF include increased water, food and energy security, and socio-economic growth.

Typically, AWF focuses on the three core areas that are complementary and synergetic: Project Preparation, Water Governance (including enhanced regional cooperation) and Water Knowledge.

The AWF funds the development of Integrated Water Resources Management (IWRM) plans to improve the governance of the water sector, attract investment and to foster regional cooperation and integration.

# 5. ASSESSMENT OF THE ROLES AND FUNCTIONS TO BE PERFORMED FOR LARGE IWRM PLANS

It is of high interest to identify the main functions which will to be performed for large IWRM plans, from the very beginning to operation stage. In front of this list of functions (possibly to be enriched), a first attempt of suggestions and comments can be made according to the specific situation of the BAS river basin. The table below summarizes this approach.

*Table 5-1: Main functions to be performed by the BAS IWRMDPlan – suggestions and comments*

| Functions for BAS IWRMD plan | Detail of Functions | Actors - comments |
|---|---|---|
| Policy Formulation & Cooperation | Develops basin-wide policies for water management | This should be a major output of the BAS IWRMD Plan. In addition it should be imagined that the two countries sharing the BAS catchment dedicate specific means (in depth studies, coordination meetings…etc.) in view of ensuring harmonization of coordinated water management policies in the BAS catchment. This could be naturally supported and facilitated by NBI/ENSAP/ENTRO |
| Strategic Planning | Develops medium to long-term strategic options for basin-wide water development and management. | This is the BAS IWRMD Plan. The key point is to ensure that both countries and stakeholders are committed and willingfull for implementation. |
| | Develops strategic options for sector development and/or management | This relates to the multi-sector nature of the BAS IWRMD Plan. This requires a coordination in each country under the auspices of the Ministries in charge of water, as well as a bilateral coordination at least for some items: hydropower generation, watershed management etc. |
| Water Resources Management | Coordinates member states re. land and water management activities (can include agricultural water use) | This depends on the accuracy and willingness stemming from strategic options as above mentioned. The quality and the frequency of bilateral coordination between the two states will determine the efficiency of this function (example of big dams to be operated for the lager benefits). |
| | Water Allocation/Quota Management | The water allocation/quota issue is still controversial in the Nile Basin and especially the ENSAP region. A specific attention must be paid to this issue in order to build a safe arrangement in the future. This would be under the auspices of NBI/ENSAP. A specific effort is to be paid (first rank priority) to improve and densify the hydro-meteorological network especially in South Sudan. |
| | Water Quality Management | This remains a field of very limited knowledge and understanding. Monitoring of quality will need specific preparation and investment specifying parameters, means and cooperation agreements between the two countries, and in line with NBI/ENSAP activities |
| | Protecting and conserving ecosystems and environment | The SVP NTEAP provided a strategic environmental framework for the management of the transboundary waters and environment challenges in the Nile River Basin.<br>The ENSAP Watershed Management Project Established sustainable framework for the management of selected watersheds to improve living conditions of the people, enhance agricultural productivity, protect the environment, reduce sediment transport and siltation of infrastructure, and prepare for sustainable development oriented investments.<br>However, a specific research program anticipating future specific ESIA is to be set up in addition, specially aiming at a better understanding of the functioning of wetlands and marshes. These particular ecosystems could possibly be heavily impacted by some activities (big dams) and they are of international interest. The two countries together should consider carefully this issue under the umbrella of NBI/ENSAP. |
| | Operational rules and procedures (e.g. flow management) | Operation rules and procedures regarding water quantity should be considered especially for the medium and long term when large infrastructures are likely to be implemented. This should be at least on a bilateral basis, but not ignoring that other member states of ENSAP are concerned which will eventually lead to a more general discussion |

| | | |
|---|---|---|
| | Emergency Measures (floods, spills, droughts...) | The ENSAP FPEW project strengthens the existing capacities of the EN countries in flood forecasting, mitigation and management. In addition specific provisions for future large infrastructures must be addressed by the two countries. |
| Knowledge Management | Collects and/or collates basin information and manages quality assurance - Develops & Operates Decision Support Systems | The SVP WRPM project developed the Nile-DSS, which includes a large information management system.<br>However, in depth research for the BAS IWRMD Plan study demonstrates that there are many gaps in basic knowledge of hydro-meteorology in the basin. Any initiative and implementation will need to collect significant additional data over a sufficient period of time. This is especially true for wetlands and marshes of South Sudan where no data are available. This is a first priority action to be considered in the Plan with support of IGAD HYCOS and donors. |
| | Protocols for harmonizing/sharing data, and KM programs | Depends / relates with the previous item when operationalized |
| Water Resources Development | Mobilizes resources for water resources development projects | Each country (Ethiopia and South Sudan) expresses the intention to keep autonomous and address activities/projects on a case by case approach. However, it is sure that acting in a cooperative manner and benefiting of the umbrella of ENSAP will greatly enhance opportunities and chances for resources mobilization. |
| | ESIA *(develop criteria – harmonize, develop criteria, supervision)* | Joint ESIA are needed as soon as activities have transboundary nature. The recommendation would be that ESIA will not be limited to separate studies but will address cumulative effects. Support of ENSAP/ENTRO is a real opportunity. |
| | Mitigation measures for transboundary impacts (including ESIA.) | Depends / relates with the previous item when operationalized. Specific involvement and strong commitment of BAS countries is necessary. |
| | Safeguard measures such as relocation… | Depends / relates with the previous item when operationalized. Specific involvement and strong commitment of BAS countries is necessary. |
| | (Pre) Feasibility and design studies of specific developments | Depending on the nature of activities and developments, each country could be directly in charge on its own territory. For developments with transboundary effects, it is desirable that a bilateral arrangement would be set up or use the vehicle of ENTRO. |
| | Decision making to implement on various components of the BAS IWRMD Plan | Components with effects in one country only would pertain to the said country. Components/activities with transboundary effects should be decided on basis of sound design studies and ESIA by the two countries together (and even possibly other countries). The umbrella of ENCOM/ENSAP/ENTRO would therefore to be used for facilitating the dialogue and support an agreement. |
| | Engineering, Procurement & Construction | Activities in one country only without transboundary effects would pertain to the country alone (e.g. program of boreholes for water supply). ENTRO could support the engineering activities. Procurement and construction, as per the countries' views, would remain the duty of each country . |
| | Owns | As per the views expressed by the two countries, ownership would be lying strictly in each country |
| | Operates or Manages Infrastructure (e.g. dams) | As soon as large infrastructures are at stake with transboundary effects, the recommendation would be to set up a dedicated permanent technical Committee aimed at evaluating and when necessary adapting operation rules (yearly at least) |

# 6. POLICIES, LEGAL AND INSTITUTIONAL ARRANGEMENTS IN THE BAS BASIN: IDENTIFICATIONS OF KEY ISSUES AND CHALLENGES

As a provisional conclusion and before defining options to be scrutinized by the stakeholders, the Consultant proposes to address the situation under the format of a tentative SWOT analysis.

***Strengths***

The major strength lies obviously in the existence of NBI/ENSAP/ENTRO. This is at the same time a legal framework and a source of various services developed since the establishment of these bodies. As an example, it is easy to mention the constitution of the Nile DSS: this tool has been developed and is shared by all riparian countries. Many other activities have been performed either in the frame of the SVP by the NBI or at the Eastern Nile scale by ENSAP/ENTRO.

It is worth underlining the existence of ENTRO as a major strength: ENTRO is endowed with full legal status and is able to conduct directly or to steer numerous and various activities (like the present IWRM Plan study). It is recommended that ENTRO would continue to manage and steer different studies which will be needed pursuant to the BAS multipurpose water resources development study. Indeed, ENTRO as an institution and the persons belonging to ENTRO have gained high experience for years on the situation of the BAS, the stakeholders expectations etc. and this is to be properly enhanced.

Another strength is that the BAS river basin is almost pristine in the meaning of the absence of large hydraulic infrastructures and more generally a low use of water resources. This keeps the door wide open for formulating development strategies and even for organizational arrangements to support such strategies.

The BAS river basin is also endowed with multiple natural resources, not only water but also land, the natural environment, fishes etc. This brings the idea in mind that a real IWRM process can be imagined and set up with a true integrated approach. There is the potential to address the nexus food-energy-environment, with significant benefits shared by the two countries and various categories of stakeholders.

***Weaknesses***

Purely from an institutional point of view, it is to be stressed that the Cooperative Framework Agreement has not been put into force. This is certainly a gap in itself and beyond this situation, it appears that very little institutional organization has been developed since 2010. This situation is not counterbalanced by other mechanisms such as possible bilateral agreement relating to development based on water resources, nor future management and operation of activities having transboundary effects.

Due, among others, to the insecure situation of South Sudan in the most recent years, there is little preparedness for large developments based on water in general. Despite several master plans have been issued recently at national scale (agriculture, irrigation…), it is doubtful that grass root level consultation of stakeholders was possible. When the security situation comes back to normal, it will be of higher importance to determine the priorities with the stakeholders.

One major weakness is relating to data, for water resources and many other items. A lot of data are old or totally missing and the literature references often cross quote each other. This is first a technical issue, but not only. This is also an organizational issue when considering that developing a much more extensive and reliable monitoring network should be put at the first rank of priorities (hydro-meteorology especially). As an example, the Machar marshes are almost not known at all, except from qualitative description, most often old. Due to the extreme value of this ecosystem, of international importance, which is also a source of livelihood for many people, any large hydraulic infrastructure will need very careful evaluation (ESIA, possibly resettlement action plan…). This can only be envisaged in the frame of a close cooperation between the two countries, through: exchange of data, water information system, global ESIA (not case by case) etc.

***Opportunities***

Among opportunities, it is of importance to underline that the two countries sharing the BAS river basin are confident to each other. One highly positive and concrete aspect of this confidence is the simple fact of conducting such a big strategic study on the BAS in good cooperation.

Important outputs of this study will be: i) setting up a strategic vision on the long term and ii) address and study priority projects. Preparation of organization of these priority projects should be launched quite rapidly between the two countries.

One particular opportunity, or more generally conducive conditions, is the fact that the two countries sharing the BAS river basin own some comparable administrative and institutional organization as far as water is concerned, i.e. i) the Minister in charge of water is responsible for transboundary aspects ii) the two countries are organized on basis of regional states iii) the two countries have set up a water council or high water council which are in charge of the multi sector approach, that is fostering the IWRM philosophy iv) in both countries, the catchments (or river basins) and possibly sub-catchments are the key institutions for managing water. Ethiopia is well advanced in this direction with three River Basin Authorities already created, three others to be created in the short term, including the BAS.

Another aspect to be considered as an opportunity is the idea of keeping flexible in building an institutional arrangement. It is actually difficult to make propositions and imagine solutions ahead of a development program. The nature and the magnitude of activities incorporated in such a program will widely determine the requested ad hoc arrangement. In particular, would the program consider medium and long term investments for large infrastructures, this could leave enough time to decision makers to organize and negotiate the most appropriate mechanism. In the short, a simple mechanism could be used, serving as a transitional arrangement to be revisited and strengthened when and if necessary.

***Threats***

In such an ambitious endeavour, threats are potentially numerous and of high impact. Some of them deserve to be identified.

Case by case approach and implementation remaining in charge of each country separately: several stakeholders expressed this idea during consultations. If this idea may prove efficient for some “simple” activities (for instance, developing drinking water supply on basis of boreholes), as soon as the transboundary nature of the BAS is concerned, this will be much more complex or even hazardous (example of a series of big dams). A series of activities are to be carefully planned and conducted at river basin scale, such as:

- Feasibility studies, ESIA
- Detailed design, in depth mitigation measures, regime of storage/release, environmental flows, cost benefit analysis and optimal/equitable sharing of effects
- Decision to do the considered development
- Financial resources mobilization
- Construction
- Operation and maintenance

This last item is crucial as the previous steps. In fact it is not the reality that one could rely on a single initial rule of operation of big dams. There are plenty of possible situations which will need to adapt, even slightly, operation at least on a yearly basis. Let's think about plentiful hydrology one year, likely to give rise to floods; on the contrary we can imagine dryer years which would request anticipation in storage. In other words, a specific hydro-meteorological model is strongly requested, and, as part of the regular exchange of information/data, both countries will be concerned in that example. One option is certainly to create a specific joint committee in that purpose.

Another important threat is related to thinking the long term. Most people are really enthusiast with the perspective of generating development and responding to the huge needs of the population in various sectors. However, it must be clearly understood that implementation of such a plan may be over several decades, which is an intrinsic feature. The more carefully planned institutional arrangement from the beginning (not excluding several successive steps), the easier will be the capacity to address the long term, organize efforts and secure resources mobilization.

The present study is addressing strictly the BAS; the original idea and intention was to incorporate the White Nile up to Khartoum, as previously done in preliminary studies. For financial resources obstacles, this was not made possible. The question remains of the relationship and fair discussions with the downstream countries along the Nile. The suggestion is that this could be organized at early stage when the first drafts of the Plan are available.

ENTRO
Eastern Nile Technical Regional Office

NILE BASIN INITIATIVE
Initiative du Bassin du Nil

BANQUE AFRICAINE DE DEVELOPPEMENT
AFRICAN DEVELOPMENT BANK

# BARO-AKOBO-SOBAT MULTIPURPOSE WATER RESOURCES DEVELOPMENT PROJECT STUDY

## BASELINE, DEVELOPMENT POTENTIALS, KEY ISSUES AND OBJECTIVES REPORT

## *Annex 5: Water balance*

*V.1 March 2016*

BRL Ingénierie

aurecon

# CONTENT OF ANNEX 5

# Annex 5-a: Flow data

## FLOW DATA CHRONOGRAM

| | FLOW STATION NAME | SOURCE | CALENDER YEAR 1903-09 | 1910-19 | 1920-29 | 1930-39 | 1940-49 | 1950-59 | 1960-69 | 1970-79 | 1980-89 | 1990-99 | 2000-09 | 2010-2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| To be used for calibration | Alwero at Abobo | EMP | | | | | | | | | | | | |
| | Baro at Burebeiy | NBRP | | | | | | | | | | | | |
| | Baro at Gambela | NBI | | | | | | | | | | | | |
| | Baro at Gambela | NBRP | | | | | | | | | | | | |
| | Baro at Gambella | EMP | | | | | | | | | | | | |
| | Baro at Itang | NBI | | | | | | | | | | | | |
| | Baro at Kella | NP | | | | | | | | | | | | |
| | Baro at Masha | NP | | | | | | | | | | | | |
| | BirBir at Yubdo | NBI | | | | | | | | | | | | |
| | Geba at Suppi | NBI | | | | | | | | | | | | |
| | Pibor at Pibor Post | NBE | | | | | | | | | | | | |
| | Pibor at Pibor Post | NBI | | | | | | | | | | | | |
| | Pibor upstream of Khor Gila mouth | NBE | | | | | | | | | | | | |
| | Pibor upstream of Khor Gila mouth | NBI | | | | | | | | | | | | |
| | Sobat at its mouth into White Nile (at Hillet Doleib) | NBE | | | | | | | | | | | | |
| | Sobat at Nasser | NBE | | | | | | | | | | | | |
| | Sor at Metu | EMP | | | | | | | | | | | | |
| | Sor at Metu | EMWE | | | | | | | | | | | | |
| Auxiliary Stations | Abu Tong cut at its mouth into White Nile | NBE-NBI | | | | | | | | | | | | |
| | Adura at its head downstream of Baro-Adura bifurcation | NBE-NBI | | | | | | | | | | | | |
| | Adura downstream of Khor Makwai mouth | NBE-NBI | | | | | | | | | | | | |
| | Agwei at its mouth into Pibor | NBE-NBI | | | | | | | | | | | | |
| | Akobo at its mouth into Pibor | NBE-NBI | | | | | | | | | | | | |
| | Assua at its mouth into Bahr el Jebel | NBE-NBI | | | | | | | | | | | | |
| | Baro at its mouth into Sobat | NBE-NBI | | | | | | | | | | | | |
| | Baro downstream of Baro-Adura bifurcation | NBE-NBI | | | | | | | | | | | | |
| | Baro downstream of Baro-Adura junction | NBE-NBI | | | | | | | | | | | | |
| | Baro downstream of Khor Jakau mouth | NBE-NBI | | | | | | | | | | | | |
| | Baro downstream of Khor Machar head | NBE-NBI | | | | | | | | | | | | |
| | Baro downstream of Khor Makeir head | NBE-NBI | | | | | | | | | | | | |
| | Baro upstream of Baro-Adura bifurcation | NBE-NBI | | | | | | | | | | | | |
| | Baro upstream of Baro-Adura junction | NBE-NBI | | | | | | | | | | | | |
| | Baro upstream of Khor Jakau mouth | NBE-NBI | | | | | | | | | | | | |
| | Baro upstream of Khor Makwai head | NBE-NBI | | | | | | | | | | | | |
| | Khor 18 kms upstream of Machar head at head | NBE-NBI | | | | | | | | | | | | |
| | Khor 18.5 kms upstream of Machar head at head | NBE-NBI | | | | | | | | | | | | |
| | Khor 3.5 kms upstream of Machar head at head | NBE-NBI | | | | | | | | | | | | |
| | Khor 4.3 kms downstream of Machar head at head | NBE-NBI | | | | | | | | | | | | |
| | Khor 4.8 kms upstreamof Machar head at head | NBE-NBI | | | | | | | | | | | | |
| | Khor 6.5 kms upstream of Khor Jakau mouth at its head | NBE-NBI | | | | | | | | | | | | |
| | Khor Atar at its tail into White Nile | NBE-NBI | | | | | | | | | | | | |
| | Khor Barakwich at its mouth into Baro, 7 kms downstream of Machar head | NBE-NBI | | | | | | | | | | | | |
| | Khor Fullus at its mouth into Sobat | NBE-NBI | | | | | | | | | | | | |
| | Khor Geni at its mouth into Pibor | NBE-NBI | | | | | | | | | | | | |
| | Khor Gila at its mouth into Pibor | NBE-NBI | | | | | | | | | | | | |
| | Khor Jakau at its mouth into Baro | NBE-NBI | | | | | | | | | | | | |
| | Khor Lolle at its mouth into White Nile | NBE-NBI | | | | | | | | | | | | |
| | Khor Macap at its mouth into Pibor | NBE-NBI | | | | | | | | | | | | |
| | Khor Machar at its head (offtake from Baro) | NBE-NBI | | | | | | | | | | | | |
| | Khor Makeir at its head | NBE-NBI | | | | | | | | | | | | |
| | Khor Makwai at its mouth into Adura | NBE-NBI | | | | | | | | | | | | |
| | Khor Mokwai at its mouth into Pibor | NBE-NBI | | | | | | | | | | | | |
| | Khor Nyanding at its mouth into Sobat | NBE-NBI | | | | | | | | | | | | |
| | Khor Twalor at its mouth into Sobat | NBE-NBI | | | | | | | | | | | | |
| | Khor Wakau at its mouth into Sobat | NBE-NBI | | | | | | | | | | | | |
| | Pibor at its mouth into Sobat | NBE-NBI | | | | | | | | | | | | |
| | Pibor downstream of Akobo mouth | NBE-NBI | | | | | | | | | | | | |
| | Pibor downstream of Khor Gila mouth | NBE-NBI | | | | | | | | | | | | |
| | Pibor downstream of Khor Makwai mouth | NBE-NBI | | | | | | | | | | | | |
| | Pibor upstream of Akobo mouth | NBE-NBI | | | | | | | | | | | | |
| | Pibor upstream of Khor Makwai mouth | NBE-NBI | | | | | | | | | | | | |
| | Sobat at 2 kms downstream of Nyandig mouth | NBE-NBI | | | | | | | | | | | | |
| | Sobat at its head | NBE-NBI | | | | | | | | | | | | |
| | Sobat downstream of Khor Twalar mouth | NBE-NBI | | | | | | | | | | | | |
| | Sobat upstream of Khor Twalar mouth | NBE-NBI | | | | | | | | | | | | |
| | White Nile At Kosti | NBE-NBI | | | | | | | | | | | | |
| | White Nile at Malakal | NBE-NBI | | | | | | | | | | | | |
| | White Nile at Melut | NBE-NBI | | | | | | | | | | | | |
| | White Nile at Mogren (Khartoum) | NBE-NBI | | | | | | | | | | | | |
| | White Nile at Renk | NBE-NBI | | | | | | | | | | | | |
| | White Nile downstream of Jebel Aulia Dam | NBE-NBI | | | | | | | | | | | | |
| | White Nile downstream of Lake No | NBE-NBI | | | | | | | | | | | | |
| | White Nile upstream of Maya Berboi head | NBE-NBI | | | | | | | | | | | | |
| | White Nile upstream of Maya Sinyora Gauge | NBE-NBI | | | | | | | | | | | | |

| LEGEND | |
|---|---|
| | All Months Data Availab |
| | 6 Months Data Available |
| | 1 Months Data Available |
| | No Data Available |

*Locations of selected flow gauging stations*

## INITIAL SELECTION OF FLOW GAUGES

| Flow Gauging Station | Source | Catchment area (km$^2$) | Lat | Long | Record Period (Unpatched) | Analysis period |
|---|---|---|---|---|---|---|
| Agwei at its mouth into Pibor | NBI | 13 727 | 7.64 | 33.02 | 1934-1939, 1942-1944 | |
| Alwero at Abobo | EMP | 2 859 | 7.84 | 34.55 | 1976-1990 | 1976-1990 |
| Baro at Burebeiy | NBRP | 38 602 | 8.42 | 33.23 | 1929-1932 | 1929-1932 |
| Baro at Gambela | NBI | 23 541 | 8.25 | 34.58 | 1904-1910, 1929-1932, 1990-2009 | 1904-1957, 1967-2009 |
| | NBRP | 23 541 | 8.25 | 34.58 | 1906-1928 | |
| | EMP | 23 541 | 8.25 | 34.58 | 1906-1957, 1967-1989 | |
| Baro at Itang | NBI | 24 692 | 8.18 | 34.27 | 1974-1982 | |
| Baro at its mouth into Sobat | NBI | 38 602 | | | 1929-1933, 1941-1963, 1967-1970, 1972-1981 | 1929-1932 |
| Baro at Kella | NP | 4 737 | 8.23 | 34.97 | 1987 | |
| Baro at Masha | NP | 1 729 | 7.57 | 35.48 | 1990, 1995, 1997, 1999-2003 | |
| BirBir at Yubdo | NBI | 1 858 | 8.95 | 35.48 | 1985-1990 | |
| Fullus at its mouth into Sobat | NBI | 17 492 | 9.31 | 31.60 | 1929-1931, 1933-1934, 1938-1939 | |
| Geba at Suppi | NBI | 3 735 | 8.48 | 35.65 | 1986-1991, 1993-2005 | 1986-1991, 1993-2005 |
| Gilo at its mouth into Pibor | NBI | 12 081 | 8.14 | 33.20 | 1929-1939, 1941-1944, 1946-1960, 1962-1963, 1973-1977 | 1929-1933 |
| Khor Machar at its head | NBI | - | 8.47 | 33.52 | 1928-1939, 1941-1963, 1968-1970, 1972, 1974-1978 | |
| Khor Mokwai at its mouth into the Adura | NBI | 7 572 | 8.34 | 33.54 | 1946-1956 | |
| Khor Mokwai at its mouth into Pibor | NBI | 1 814 | 8.33 | 33.22 | 1929-1933, 1943-1963, 1974-1977 | |
| Nyanding at its mouth into Sobat | NBI | 7 197 | 8.67 | 32.68 | 1934, 1938-1939, 1941-1962, 1969-1970, 1978-1980 | |
| Pibor at mouth into Sobat | NBI | 132 041 | 8.14 | 33.20 | 1929-1933 | |
| Pibor at Pibor Post | NBE | 71 426 | 6.80 | 33.13 | 1928-1932 | |
| Pibor d/s of Akobob mouth | NBI | 117 179 | 7.81 | 33.05 | 1929-1933 | |
| Pibor d/s of Gilo mouth | NBI | 129 260 | 8.15 | 33.19 | 1929-1933 | |
| Pibor d/s of Mokwai mouth | NBI | 132 041 | 8.35 | 33.22 | 1929-1933 | |
| Pibor u/s of Akobo mouth | NBI | 89 266 | 7.80 | 33.03 | 1929-1939, 1941-1945 | |
| Pibor u/s of Khor Gila mouth | NBE | 117 179 | 8.13 | 33.19 | 1929-1939, 1941-1944, 1946-1963, 1973-1977 | |
| Pibor u/s of Mokwai mouth | NBI | 129 260 | 8.34 | 33.21 | 1929-1933, 1945-1963, 1973-1977 | |

| Flow Gauging Station | Source | Catchment area (km$^2$) | Lat | Long | Record Period (Unpatched) | Analysis period |
|---|---|---|---|---|---|---|
| Sobat at mouth into White Nile (at Hillet Doleib) | NBE | 207 308 | 9.36 | 31.59 | 1905-1983 | 1905-1983 |
| Sobat at Nasir | NBE | 170 991 | 8.61 | 33.06 | 1929-1963, 1968-1972, 1978-1981 | 1929-1963, 1968-1972 |
| Sor at Metu | EMP | 1 712 | 8.30 | 35.60 | 1967-1993 | 1967-2006 |
| | EMWIE | | 8.30 | 35.60 | 1985-2006 | |
| Twalor at mouth into Sobat | NBI | 1 346 | 8.55 | 32.96 | 1934-1939, 1941-1962, 1970 | 1945-1950 |

**Sources:** NBRP: Nile Basin Research Programme; NBE: Nile Basin Encyclopaedia; EMP: Ethiopian Master Plan Studies; NBI: Nile Basin Initiative; NP: Baro 1 and 2 Feasibility Studies (Norplan, 2006); EMWIE: Ethiopian Ministry of Water, Irrigation and Energy

## FLOW DATA QUALITY CONTROL

Data quality checks were conducted on the flow records at the selected stations including tests for stationarity, an assessment of the period of data availability and the extent of data gaps, and correlation analyses.

### Stationarity

Cumulative flow graphs (single mass plots) were used to evaluate the stationarity and extent of missing data of the flow records.

Baro at Masha is missing a significant amount of data over its record period. Geba at Suppi is missing a significant amount of data between 1991 and 1995, and the gradient of the cumulative flow plot changes at 2001. The flow at Gambela is stationary, however, there is a gap in the flow record between 1958 and 1967. The record at Baro at its mouth into Sobat contains several gaps, however there is a complete record between 1929 and 1933 which is stationary.

The record at Gilo at its mouth into Pibor contains missing years, however, the period from 1929 to 1933 is complete and stationary. The cumulative flow plot for Agwei at its mouth into Pibor shows that the record is not stationary and contains missing data, which suggests that this gauge should be excluded from this study.

The record at Pibor at its mouth into the Sobat, as well as Pibor d/s of Gilo mouth, has a complete and stationary record from 1929 to 1933. Pibor Post, Pibor d/s of Akobo mouth, Pibor u/s of Akobo mouth, Pibor u/s of Gilo mouth, contain missing data and are not stationary records.

The gauge at Sobat at Nasir gives a good quality, stationary flow record between 1929 and 1963. Similarly, the gauge at Sobat at Hillet Doleib provides a good record from 1919 to 1963.

The gauges at Fullus at its mouth into Sobat and Nyanding at its mouth into Sobat contain missing data, and do not have stationary flow. The gauge at Twalor at its mouth into Sobat also contains missing data and is non-stationary for most of its record, however, there are a few years of good, stationary flow data between 1945 and 1950.

### Missing data

The gauge on the Baro River at Gambela is the most complete of all the stream flow gauges and has a long record from 1904 to 2009 with a few years of missing data between 1958 and 1967 and some missing data after 2007.

In the upper Baro catchment, there are flow records at four gauges on the Baro, Birbir and Geba rivers (between 1986 and 2005, with missing data) and at one gauge on the Sor River (1966 to 2005). The Baro at Masha gauge has missing peak flow as well as missing low flow data. The Baro at Kella gauge has only one year of flow data. The Geba at Suppi gauge has missing data, with only a few years of complete records. The flow record on the Birbir River at Yubdo is mostly complete. The Sor at Metu has an almost complete record from 1967 to 2006.

The gauge at Baro at its mouth into the Sobat provides five years of complete flow data between 1929 and 1933, while the remainder of the record period has missing base flow readings in the dry months.

The Alwero River at Abobo has a record from 1976 to 1990. However, it is characterised by missing data.

The gauge on the Pibor River, at Pibor Post has significant missing data during its short record period of 1928 to 1933. The gauge at Pibor mouth into the Sobat gives four full years of flow data from 1929 to 1932, with some additional flow peaks measured in 1933. The other gauges along the

Pibor River (upstream and downstream of the Gilo, Akobo and Mokwai mouths) give fairly complete flow records between 1929 and 1933, however, many of the years are missing base flow records in the dry months.

The gauge at Khor Gilo mouth into the Pibor gives a complete record between 1931 and 1933, with the remainder of the dataset missing base flows in the dry months. Similarly, the gauge at Agwei mouth into the Pibor gives base flow values for 1935, but is missing base flows for the remainder of the record period.

The Nyanding at its mouth into Sobat and Twalor at its mouth into Sobat gauges are characterised by missing data. While the gauges record peak flows for over 20 years, there are no complete years (mostly missing base flow values). Khor Fullus only has six years of data, however, 1930 and 1933 give a full year of flow data.

The stations on the Sobat River downstream of the Baro-Pibor junction at Nasir (1929 to 1963) and Hillet Doleib (1905 to 1983) have long flow records with almost no missing data.

## Correlation analysis

### *Upper Baro sub-basin*

The flow records at gauges in the upper Baro sub-catchments were expected to be more or less similar as these gauged catchments are similar in size and location. On this premise, the flows for Birbir at Yubdo, Geba at Suppi, Sor at Metu, Baro at Masha and Baro at Kella were compared for an overlapping time period (see Fig 1). The catchment areas for Birbir at Yubdo, Sor at Metu and Baro at Masha are comparable at 1858, 1712 and 1729 km$^2$ respectively. The gauges at Baro at Kella and Geba at Suppi measure flow from larger catchments of 4737 and 3735 km$^2$ respectively. The plot in Fig 1 highlights inconsistencies in the Masha data with regard to apparent missing peaks, while wet season flows at Yubdo appear to be too low compared to the peak flows of the surrounding sub-catchments of similar size.

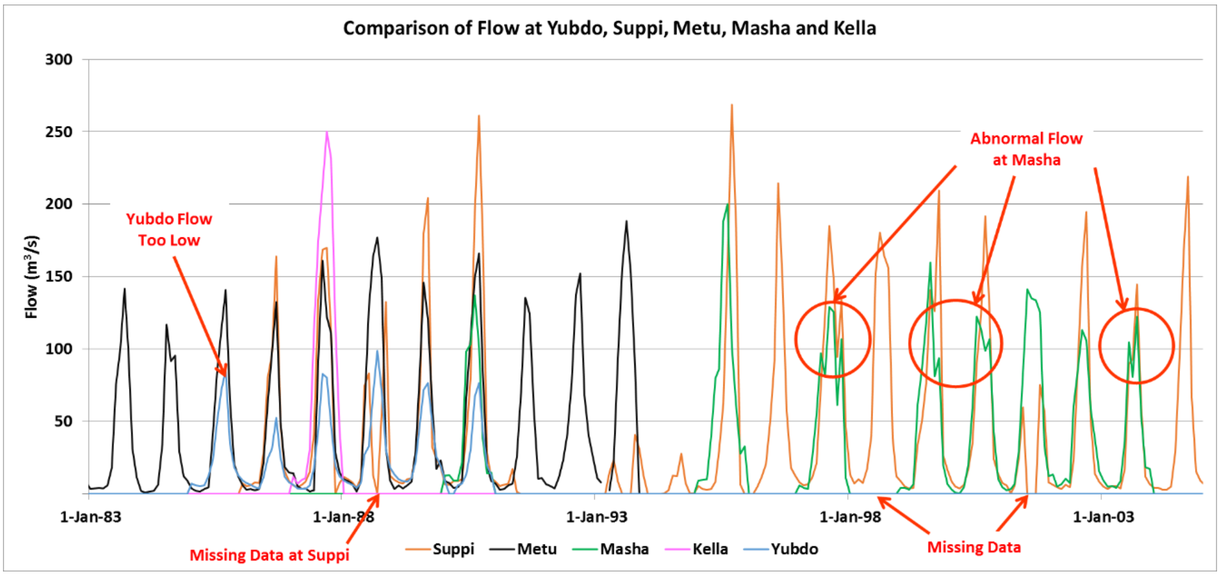



*Figure 1: Comparison of flow records at Suppi, Metu, Masha, Kella and Yubdo*

The unit runoff was calculated for each of the upper Baro sub-catchments and plotted against the corresponding Mean Annual Precipitation values for each catchment, as shown in Figure 2. The unit runoff for Birbir at Yubdo appears too low compared to similar sub-catchments.

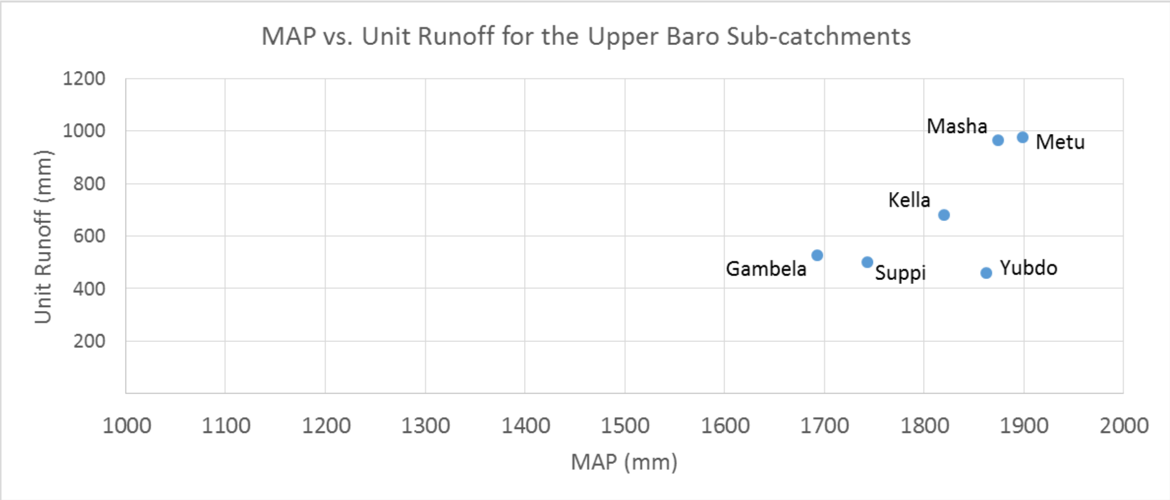



*Figure 2: Comparison of MAP and unit runoff for the upper Baro sub-catchments*

### *Lower Baro River*

The flow records at Gambela and Itang were expected to be similar as Itang is located directly downstream of Gambela. A comparison plot of these two records is shown in Figure 3. The flow records show good agreement for the overlapping record period, with the exception of two or three apparent anomalies as indicated.

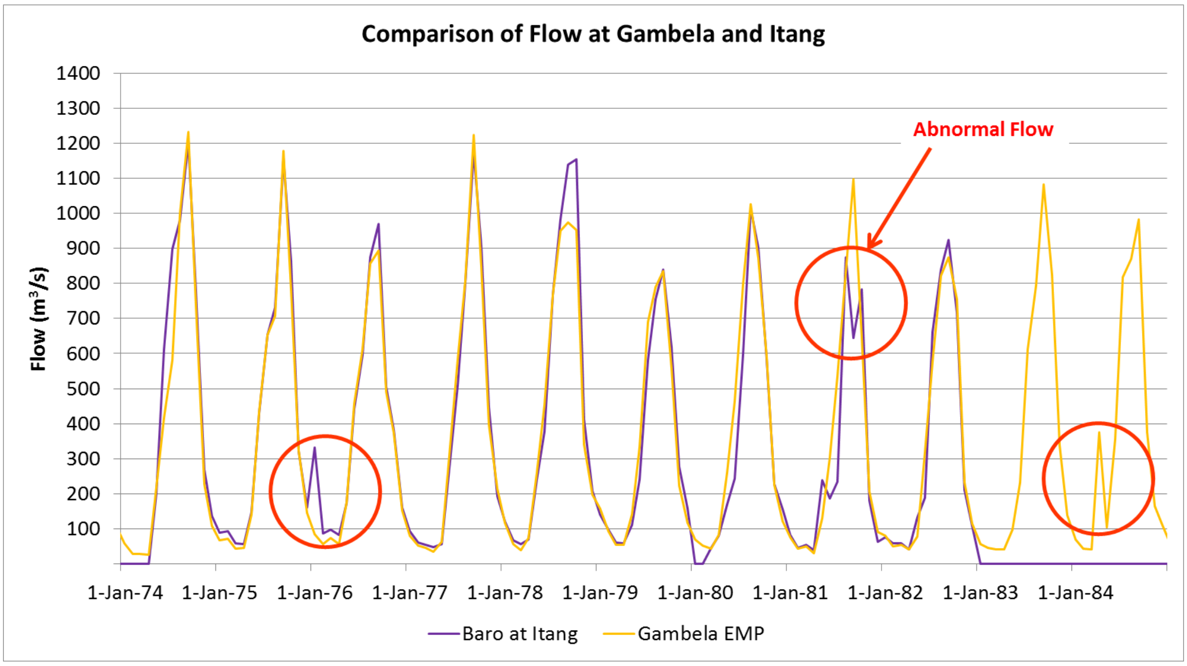



*Figure 3: Comparison of flow records at Gambela and Itang*

### *Lower Sobat*

The flow records at Nasir and Hillet Doleib on the Sobat were expected to be similar as most of the flow at Hillet Doleib comes from the contribution from Nasir. The Sobat tributaries (Twalor, Nyanding, Beguyang and Fullus Rivers) also contribute to the total flow recorded at Hillet Doleib, and water may be spilled from the Sobat upstream of Nyanding to the Wal River. A comparison plot of Hillet Doleib and Nasir is shown in Figure 4. The flow records show good agreement for the overlapping record period. The flow record at Nasir has missing values from 1964 onwards. The plot also highlights possible missing peak flows at Hillet Doleib where the shape of the hydrograph appears abnormal. The years which indicate greater flow peaks at Hillet Doleib could be due to high flows from the Sobat tributaries.

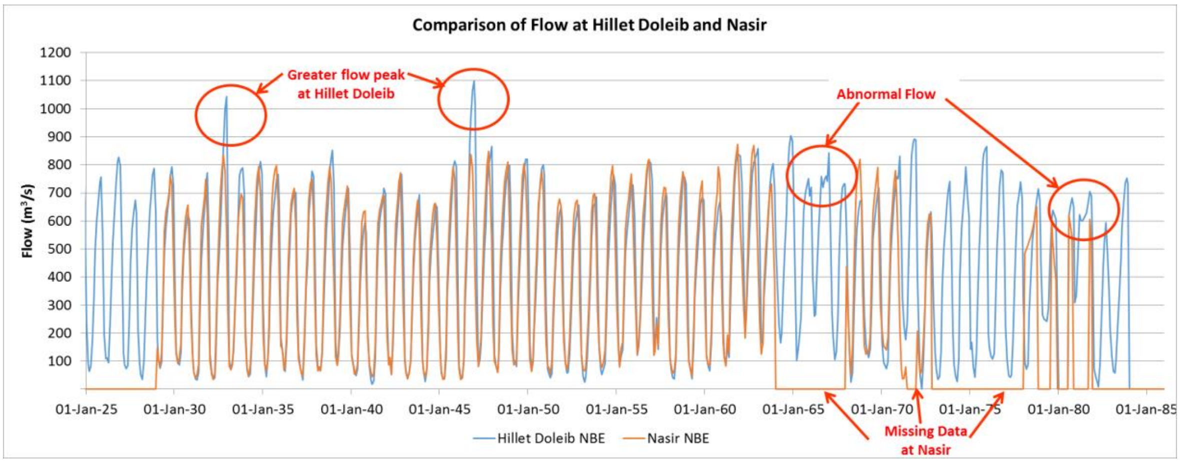



*Figure 4: Comparison of flow records at Nasir and Hillet Doleib*

### *Lower Pibor*

The flow records at key gauging stations along the Pibor River were plotted for an overlapping period and compared, as shown in Figure 5. The flows downstream of the Akobo mouth and the flows upstream of the Gilo mouth show a good match, as expected. The flows upstream of the Akobo mouth are lower than the flows downstream of the Akobo mouth, and the two flow records have similar shaped hydrographs, as expected. The flow record at Pibor Post is short and contains missing data for the later years.

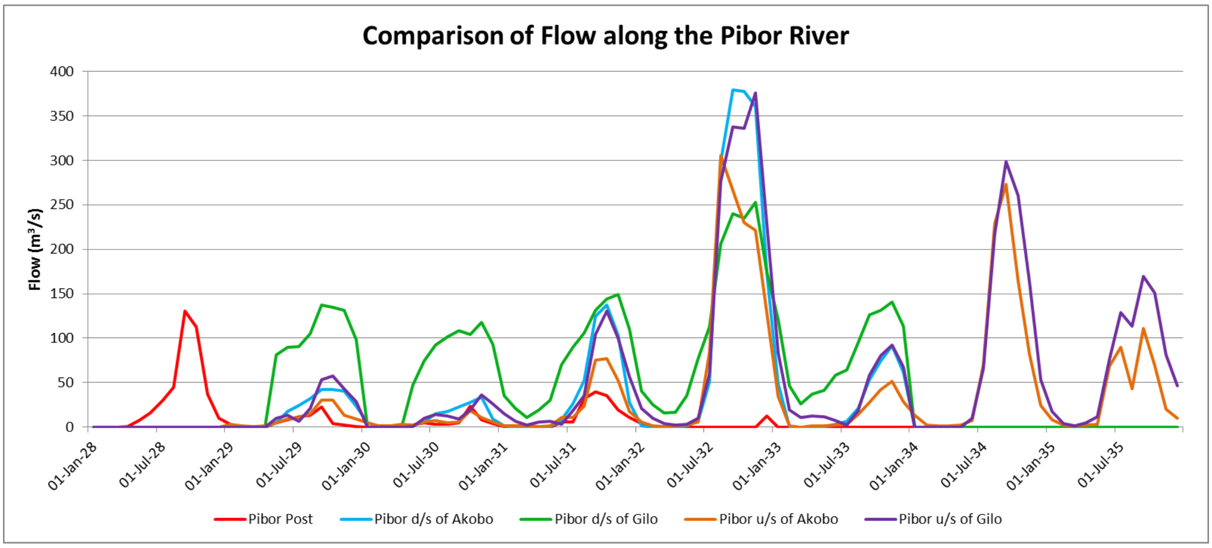
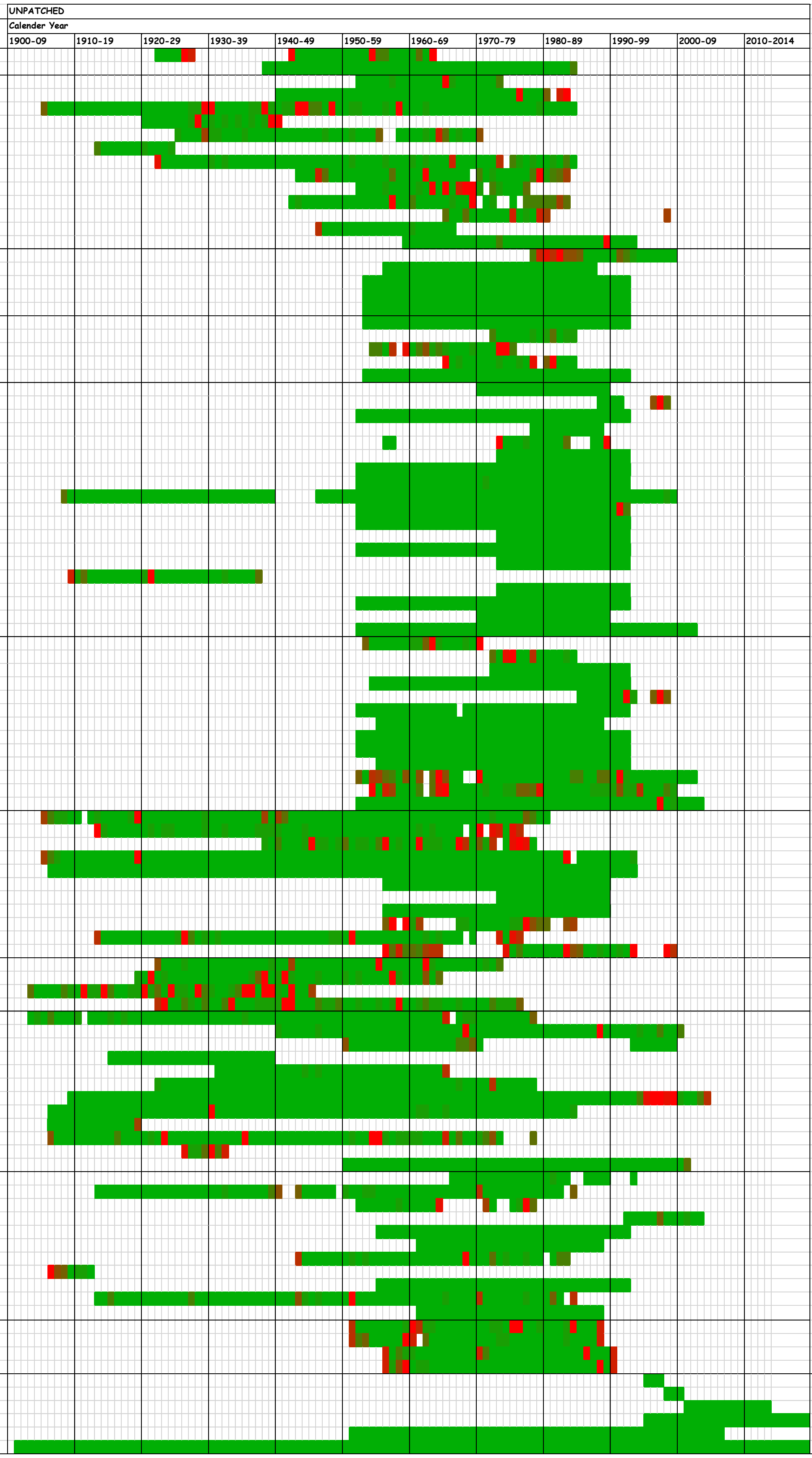


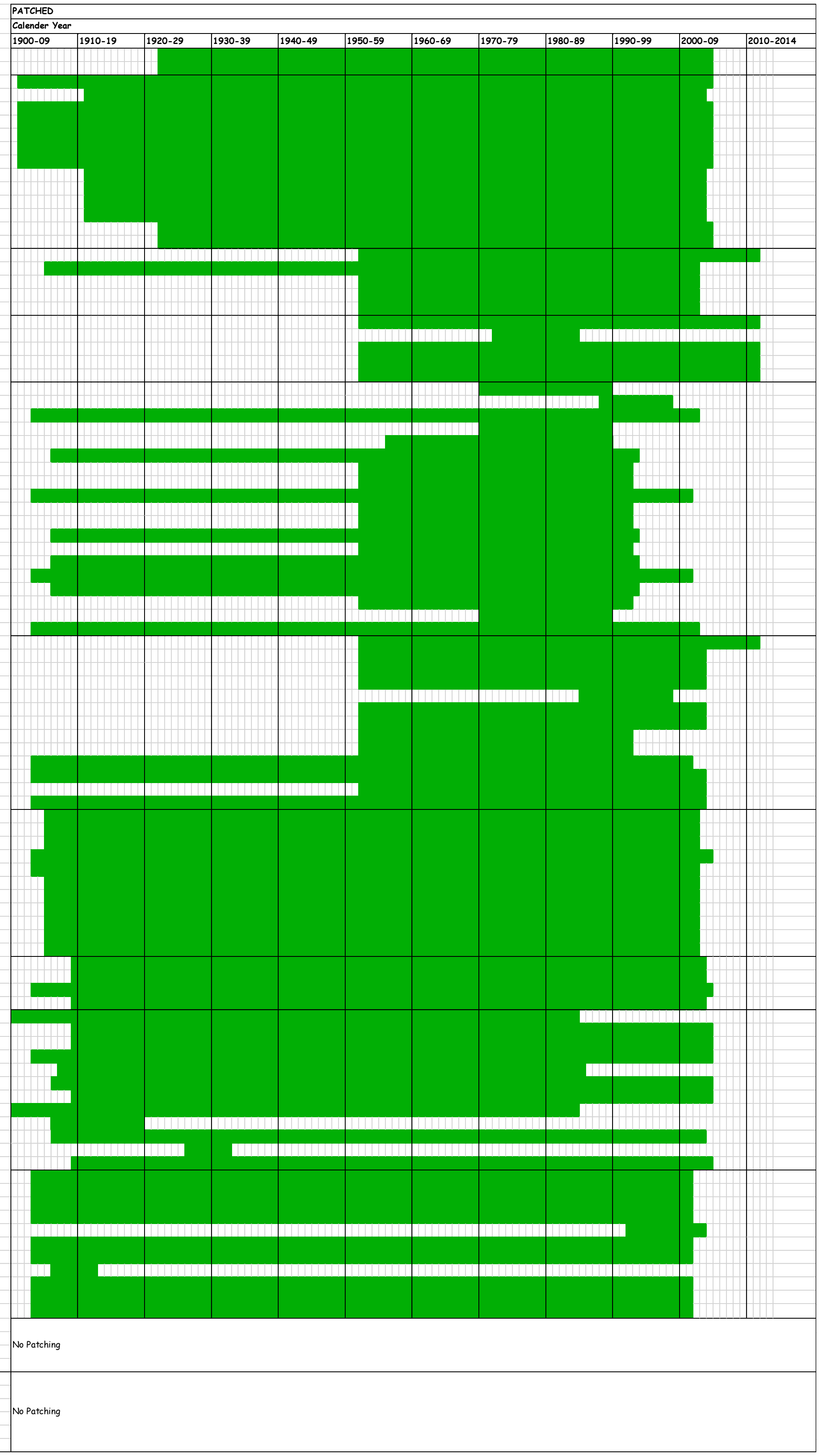

*Figure 5: Comparison of flow records along the Pibor River*

# Annex 5-b: Rainfall data

## RAINFALL DATA CHRONOGRAM

| GROUP | RAINFALL STATION NAME | SOURCE | PATCHED MAP |
|---|---|---|---|
| Upstream of Pibor Post | 1224Nagi_Shot | DST | 1094 |
| | 1937Kapoeta | FAO | 766 |
| Adjacent to Upstream of Pibor Post | 1220Mongalla | DST | 895 |
| | 1490Agoro | GHCN | 918 |
| | 1580Bor | NBE | 889 |
| | 2123Malek | NBE | 862 |
| | 2439Terakeka | NBE | 922 |
| | 2447Tombe | NBE | 849 |
| | 2454Torit | NBE | 1016 |
| | 2584Orom | MWE | 944 |
| | 2585Karenga | MWE | 970 |
| | 2586Naam | MWE | 994 |
| | 2588Madi_Opei | MWE | 977 |
| | 2591Kaabong | MWE | 723 |
| | 3312Lokichokio | NBRP | 501 |
| Abobo, Gilo, Akobo Headwaters | 730Mizan_Teferi | DST | 2293 |
| | 1448Abobo | EMP | 1137 |
| | 2180Mizan_Teferi_School | EMP | 2164 |
| | 2438Tepi | EMP | 1592 |
| | 2535Yeki | EMP | 1581 |
| Adjacent to Abobo, Gilo, Akobo Headwaters | 1577Bonga | EMP | 1786 |
| | 1797Gojeb | GHCN | 1336 |
| | 2112Maji | GHCN | 1650 |
| | 2376Shebe | GHCN | 1587 |
| | 2525Wush-Wush | EMP | 1803 |
| Upstream of Gambela | 1496Alem_Teferi_School | EMP | 1634 |
| | 1498Alge | FAO | 1037 |
| | 1610Bure | EMP | 1279 |
| | 1642Chanka | EMP | 1480 |
| | 1676Dembi_Dollo | GHCN | 544 |
| | 1677Dembi_Dolo | EMP | 1234 |
| | 1691Dongoro | EMP | 2122 |
| | 1791Gimbi_HS | EMP | 1844 |
| | 1806Gore | GHCN | 2115 |
| | 1847Hurumu | EMP | 2037 |
| | 2172Metu_Hospital | EMP | 1839 |
| | 2191Mugi | EMP | 1723 |
| | 2267Nolekaba | EMP | 1960 |
| | 2324Rob_Gebeya | EMP | 1417 |
| | 2352Saiyo | NBE | 1258 |
| | 2377Shebele | EMP | 1513 |
| | 2530Yayu | EMP | 1602 |
| | 2539Youbdo | EMP | 1583 |
| | 3611Gore | NBRP | 2163 |
| Adjacent to Upstream of Gambela | 1488Agaro | GHCN | 1657 |
| | 1507Anger_Gutin | GHCN | 1380 |
| | 1508Anger_Gutin | EMP | 1559 |
| | 1512Arjo | EMP | 2138 |
| | 1560Bedele | FAO | 1386 |
| | 1649Chora_Kumbabe | EMP | 1765 |
| | 1781Getema | EMP | 1412 |
| | 1837Henna | EMP | 1963 |
| | 1867Jarso | EMP | 1735 |
| | 2163Mendi | EMP | 1608 |
| | 3233Nekemtewelega | NBRP | 2009 |
| | 3238Sibusirewellega | NBRP | 1363 |
| | 3673Nedjo | NBRP | 1634 |
| Lowlands Upstream of Nasir | 1192Gambela | DST | 1238 |
| | 1198Pibor | DST | 889 |
| | 1494Akobo | NBE | 938 |
| | 1764Gambela | FAO | 1219 |
| | 1766Gambella | EMP | 1262 |
| | 1864Itang | EMP | 883 |
| | 1874Jikawo | EMP | 798 |
| | 2290Pakwo | EMP | 1037 |
| | 2291Pakwo | GHCN | 1047 |
| | 2294Pibor_Post | NBE | 914 |
| | 3542Ganbella | NBRP | 1059 |
| Lowlands Upstream of Hillet Doleib | 1197Nasir | DST | 765 |
| | 1462Abwong | NBE | 754 |
| | 1839Hillet_Doleib | NBE | 795 |
| | 2242Nasser | NBE | 778 |
| Adjacent to Lowlands Upstream of Hillet Doleib | 1193Kodok | DST | 758 |
| | 1194Malakal | DST | 754 |
| | 1195Malakal_MofA | DST | 789 |
| | 1196Malakal_Town | DST | 796 |
| | 1207Shambe | DST | 708 |
| | 1211Fangak | DST | 900 |
| | 2118Malakal_Aero | GHCN | 778 |
| | 2162Melut | NBE | 629 |
| | 2432Taufikia | NBE | 733 |
| | 2448Tonga | NBE | 868 |
| | 2546Zeraf_Cut | NBE | 572 |
| | 3441Malakal | NBRP | 778 |
| Machar Marshes | 1177J_Maiak | DST | 716 |
| | 1178El-Kurmuk | DST | 922 |
| | 1201Yabus_Bridge | DST | 927 |
| | 1261J_Dinduro | DST | 485 |
| | 1523Asosa | EMP | 1155 |
| | 1562Begi_School | EMP | 1387 |
| | 1641Chali | GHCN | 744 |
| | 1705El_Keili | NBE | 843 |
| | 2005Kiltukara | EMP | 1596 |
| | 2060Kurmuk | NBE | 936 |
| | 2061Kurumuk | EMP | 831 |
| Daily | GHCND_ET000063403_Gore_Prec | GHCN | |
| | GHCND:ET000063402_JIMMA_Prec | GHCN | |
| | GHCND:SU000062941_Jua_Prec | GHCN | |
| | GHCND:SU000062840_Malkal_Prec | GHCN | |
| Satellite Rainfall | RFE1.0 Decadal | | |
| | RFE1.0 Daily | | |
| | RFE2.0 Daily | | |
| | SimCLIM | | |
| | Swedish Meteorological and Hydrological Institute | | |
| | Climatic Research Unit | | |



*List of patched rainfall stations in the vicinity of the Baro-Akobo-Sobat Basin*

| ID | Station name | Lat | Long | Source[1] | StartDate | EndDate | Accuracy[2] |
|---|---|---|---|---|---|---|---|
| 1 | Gojeb | 7.250 | 36.230 | DST | 3/31/1972 | 3/31/1994 | 1 |
| 2 | Mizan Teferi | 6.560 | 35.200 | DST | 1/31/1978 | 12/31/1999 | 3 |
| 3 | GAMBELA | 8.250 | 34.583 | DST | 8/31/2005 | 12/31/1980 | 2 |
| 4 | KODOK | 9.883 | 32.117 | DST | 1/31/2003 | 7/31/1978 | 3 |
| 5 | MALAKAL | 9.550 | 31.650 | DST | 1/31/1940 | 9/30/2000 | 2 |
| 6 | MALAKAL (M. OF A.) | 9.500 | 31.667 | DST | 7/31/1950 | 12/31/1999 | 2 |
| 7 | MALAKAL TOWN | 9.533 | 31.650 | DST | 1/31/2015 | 12/31/1939 | 3 |
| 8 | NASIR | 8.617 | 33.067 | DST | 6/30/2022 | 9/30/1973 | 2 |
| 9 | PIBOR | 7.333 | 33.222 | DST | 12/31/2013 | 11/30/1976 | 2 |
| 10 | YABUS BRIDGE | 9.933 | 34.167 | DST | 1/31/1952 | 12/31/1978 | 3 |
| 11 | JUBA | 4.867 | 31.600 | DST | 1/31/1949 | 9/30/2000 | 3 |
| 12 | JUBA TOWN | 4.850 | 31.617 | DST | 6/30/2024 | 12/31/1949 | 4 |
| 13 | LOA | 3.800 | 31.950 | DST | 1/31/1945 | 12/31/1963 | 2 |
| 14 | MONGALLA | 5.250 | 31.833 | DST | 1/31/1952 | 9/30/1973 | 3 |
| 15 | NAGI SHOT | 4.267 | 33.567 | DST | 1/31/2022 | 11/30/1963 | 3 |
| 16 | OPARI | 3.917 | 32.050 | DST | 1/31/2029 | 4/30/1973 | 2 |
| 17 | TORIT | 4.417 | 32.550 | DST | 1/31/2023 | 12/31/1984 | 3 |
| 18 | Abobo | 7.850 | 34.550 | EMP | 1/31/1956 | 12/31/1987 | 2 |
| 19 | Abwong | 9.117 | 32.200 | NBE | 1/31/2019 | 12/31/1964 | 2 |
| 20 | AGARO | 7.900 | 36.900 | GHCN | 4/30/1953 | 10/31/1970 | 3 |
| 21 | AGORO | 3.800 | 33.000 | GHCN | 1/31/1940 | 7/31/1984 | 2 |
| 22 | Akobo | 7.800 | 33.050 | NBE | 1/31/1938 | 12/31/1978 | 2 |
| 23 | Alem Teferi School | 8.900 | 35.233 | EMP | 1/31/1970 | 12/31/1989 | 1 |
| 24 | ANGER GUTIN | 9.400 | 36.400 | GHCN | 5/31/1972 | 12/31/1984 | 3 |
| 25 | Anger Gutin | 9.367 | 36.367 | EMP | 1/31/1972 | 12/31/1992 | 3 |
| 26 | Arjo | 8.750 | 36.500 | EMP | 1/31/1954 | 12/31/1992 | 1 |
| 27 | Bambessi | 9.750 | 34.733 | EMP | 1/31/1955 | 12/31/1997 | 2 |
| 28 | Bedele | 8.450 | 36.333 | EMP | 1/31/1952 | 12/31/1992 | 1 |
| 29 | Begi School | 9.350 | 34.533 | EMP | 1/31/1961 | 12/31/1988 | 2 |
| 30 | Bonga | 7.217 | 36.233 | EMP | 1/31/1953 | 12/31/1992 | 1 |
| 31 | Bor | 6.200 | 31.550 | NBE | 6/30/2005 | 12/31/1992 | 2 |
| 32 | Bure | 8.283 | 35.100 | EMP | 1/31/1952 | 12/31/1992 | 2 |
| 33 | Chanka | 8.833 | 35.133 | EMP | 1/31/1978 | 12/31/1988 | 1 |
| 34 | Chora Kumbabe | 8.417 | 36.133 | EMP | 1/31/1952 | 12/31/1992 | 1 |
| 35 | Dembi Dolo | 8.533 | 34.800 | EMP | 1/31/1973 | 12/31/1992 | 3 |
| 36 | Dongoro | 9.267 | 35.683 | EMP | 1/31/1952 | 12/31/2000 | 2 |
| 37 | GAMBELA | 8.250 | 34.580 | FAO | 8/31/2005 | 11/30/1993 | 2 |
| 38 | Gambella | 8.250 | 34.583 | EMP | 8/31/2005 | 12/31/1993 | 2 |
| 39 | Getema | 8.900 | 36.467 | EMP | 1/31/1955 | 12/31/1988 | 1 |
| 40 | Gimbi H S | 9.167 | 35.783 | EMP | 1/31/1952 | 12/31/2003 | 2 |
| 41 | GORE | 8.150 | 35.530 | GHCN | 5/31/2008 | 5/31/2004 | 2 |
| 42 | HARO | 9.900 | 36.500 | GHCN | 4/30/1970 | 12/31/1984 | 3 |
| 43 | Henna | 9.417 | 35.583 | EMP | 1/31/1952 | 12/31/1992 | 2 |

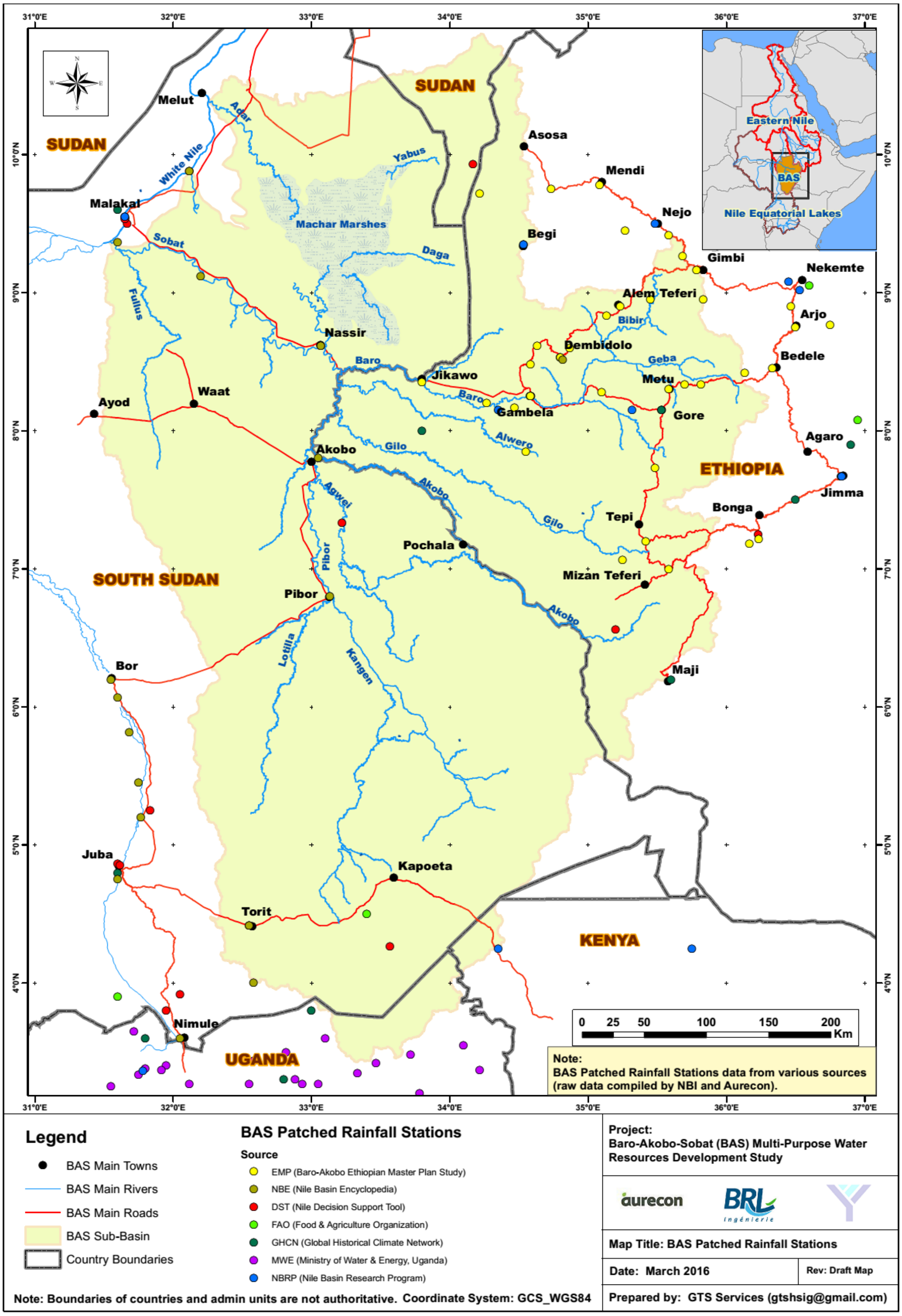
| ID | Station name | Lat | Long | Source[1] | StartDate | EndDate | Accuracy[2] |
|---|---|---|---|---|---|---|---|
| 44 | Hillet Doleib | 9.367 | 31.600 | NBE | 5/31/2003 | 5/31/1945 | 3 |
| 45 | Hurumu | 8.333 | 35.700 | EMP | 1/31/1952 | 12/31/1992 | 1 |
| 46 | Itang | 8.200 | 34.267 | EMP | 1/31/1956 | 12/31/1989 | 2 |
| 47 | Jarso | 9.450 | 35.267 | EMP | 1/31/1952 | 12/31/1992 | 2 |
| 48 | Jikawo | 8.350 | 33.800 | EMP | 1/31/1973 | 12/31/1989 | 2 |
| 49 | JIMMA | 7.670 | 36.830 | FAO | 6/30/1952 | 12/31/1998 | 2 |
| 50 | JIMMA | 7.670 | 36.830 | GHCN | 6/30/1952 | 10/31/2011 | 1 |
| 51 | JUBA | 4.800 | 31.600 | GHCN | 1/31/2001 | 12/31/2004 | 2 |
| 52 | KAJO-KAJI | 3.900 | 31.600 | FAO | 1/31/2016 | 12/31/1982 | 1 |
| 53 | KAPOETA | 4.500 | 33.400 | FAO | 1/31/1938 | 8/31/1985 | 2 |
| 54 | Kiltukara | 9.717 | 34.217 | EMP | 1/31/1955 | 12/31/1992 | 3 |
| 55 | KITGUM V.T.C | 3.300 | 32.800 | GHCN | 1/31/2014 | 12/31/1995 | 1 |
| 56 | Kodok | 9.883 | 32.117 | NBE | 8/31/2000 | 2/29/1980 | 3 |
| 57 | LEKEMTI | 9.050 | 36.600 | FAO | 1/31/1971 | 12/31/1998 | 2 |
| 58 | Lerua Mission (Palataka) | 4.000 | 32.583 | NBE | 2/28/2027 | 3/31/1938 | 4 |
| 59 | LIMUGENET | 8.080 | 36.950 | FAO | 1/31/1969 | 12/31/1991 | 3 |
| 60 | MAJI | 6.200 | 35.600 | GHCN | 4/30/1954 | 9/30/1975 | 3 |
| 61 | MALAKAL (AERO) | 9.600 | 31.600 | GHCN | 1/31/2009 | 5/31/2004 | 2 |
| 62 | Malek | 6.067 | 31.600 | NBE | 12/31/2019 | 2/29/1940 | 3 |
| 63 | Masha | 7.733 | 35.483 | EMP | 1/31/1952 | 12/31/1992 | 2 |
| 64 | Mendi | 9.783 | 35.083 | EMP | 1/31/1955 | 12/31/2000 | 2 |
| 65 | Metu Hospital | 8.300 | 35.583 | EMP | 1/31/1952 | 12/31/1992 | 1 |
| 66 | Mizan Teferi School | 7.000 | 35.583 | EMP | 1/31/1953 | 12/31/1992 | 2 |
| 67 | Mongalla | 5.200 | 31.767 | NBE | 4/30/2003 | 8/31/1939 | 2 |
| 68 | MOYO | 3.600 | 31.800 | GHCN | 1/31/1939 | 7/31/1980 | 3 |
| 69 | Mugi | 8.617 | 34.633 | EMP | 1/31/1973 | 12/31/1992 | 3 |
| 70 | Nasser | 8.617 | 33.067 | NBE | 6/30/2022 | 3/31/1981 | 2 |
| 71 | Nimule | 3.600 | 32.050 | NBE | 1/31/2004 | 12/31/1965 | 2 |
| 72 | Nolekaba | 8.950 | 35.833 | EMP | 1/31/1952 | 12/31/1992 | 2 |
| 73 | Pakwo | 8.167 | 34.467 | EMP | 1/31/1956 | 12/31/1989 | 2 |
| 74 | PAKWO | 8.000 | 33.800 | GHCN | 6/30/1956 | 5/31/1984 | 3 |
| 75 | Pibor Post | 6.800 | 33.133 | NBE | 9/30/2013 | 11/30/1976 | 1 |
| 76 | Rejaf | 4.750 | 31.600 | NBE | 1/31/2014 | 8/31/1939 | 2 |
| 77 | Rob Gebeya | 8.600 | 34.867 | EMP | 1/31/1973 | 12/31/1992 | 3 |
| 78 | Saiyo | 8.517 | 34.817 | NBE | 10/31/2009 | 8/31/1937 | 2 |
| 79 | SHEBE | 7.500 | 36.500 | GHCN | 3/31/1965 | 12/31/1984 | 3 |
| 80 | Shebele | 8.483 | 34.583 | EMP | 1/31/1973 | 12/31/1992 | 3 |
| 81 | Tepi | 7.200 | 35.417 | EMP | 1/31/1953 | 12/31/1992 | 2 |
| 82 | Terakeka | 5.450 | 31.750 | NBE | 1/31/2025 | 12/31/1972 | 3 |
| 83 | Tombe | 5.817 | 31.683 | NBE | 1/31/2013 | 11/30/2024 | 3 |
| 84 | Torit | 4.417 | 32.550 | NBE | 11/30/2022 | 12/31/1992 | 2 |
| 85 | Wama | 8.767 | 36.750 | EMP | 1/31/1975 | 12/31/1987 | 2 |
| 86 | Wush-Wush | 7.183 | 36.167 | EMP | 1/31/1953 | 12/31/1992 | 1 |
| 87 | Yayu | 8.333 | 35.817 | EMP | 1/31/1952 | 12/31/1992 | 1 |
| 88 | Yeki | 7.067 | 35.250 | EMP | 1/31/1953 | 12/31/1992 | 2 |

| ID | Station name | Lat | Long | Source[1] | StartDate | EndDate | Accuracy[2] |
|---|---|---|---|---|---|---|---|
| 89 | Youbdo | 8.950 | 35.450 | EMP | 1/31/1970 | 12/31/1989 | 1 |
| 90 | Adjumani Dispensary | 3.383 | 31.800 | MWE | 1/31/1942 | 11/30/2002 | 4 |
| 91 | Moyo Boma | 3.650 | 31.717 | MWE | 1/31/1938 | 12/31/1998 | 3 |
| 92 | Obongi Dispensary | 3.250 | 31.550 | MWE | 6/30/1939 | 2/28/1979 | 2 |
| 93 | Zaipi Dispensary | 3.400 | 31.950 | MWE | 1/31/1942 | 6/30/1980 | 2 |
| 94 | Pakelli Dispensary | 3.367 | 31.917 | MWE | 1/31/1943 | 6/30/1980 | 3 |
| 95 | Adjumani Prisons Farm | 3.333 | 31.750 | MWE | 10/31/1968 | 2/28/1982 | 3 |
| 96 | Kitgum Centre VT | 3.300 | 32.883 | MWE | 4/30/2014 | 9/30/2003 | 1 |
| 97 | Atiak Dispensary. | 3.267 | 32.117 | MWE | 1/31/1942 | 5/31/1977 | 2 |
| 98 | Palabek Divisional Hqs | 3.433 | 32.583 | MWE | 6/30/1939 | 2/28/1981 | 1 |
| 99 | Padibe | 3.500 | 32.817 | MWE | 1/31/1942 | 12/31/1983 | 1 |
| 100 | Patiko | 3.017 | 32.317 | MWE | 1/31/1965 | 1/31/1985 | 3 |
| 101 | Aringa Valley Coffee | 3.267 | 32.933 | MWE | 7/31/1967 | 4/30/1983 | 3 |
| 102 | Acholi Ranch | 3.267 | 32.550 | MWE | 7/31/1970 | 8/31/1985 | 3 |
| 103 | Kitgum Matidi | 3.267 | 33.050 | MWE | 2/28/1943 | 12/31/1982 | 2 |
| 104 | Kalongo Hospital | 3.050 | 33.367 | MWE | 1/31/1956 | 12/31/1981 | 3 |
| 105 | Paimol | 3.067 | 33.417 | MWE | 1/31/1942 | 4/30/1980 | 2 |
| 106 | Orom | 3.417 | 33.467 | MWE | 1/31/1943 | 5/31/1983 | 1 |
| 107 | Karenga | 3.483 | 33.717 | MWE | 1/31/1952 | 11/30/1977 | 2 |
| 108 | Naam | 3.350 | 33.333 | MWE | 1/31/1942 | 9/30/1983 | 1 |
| 109 | Madi Opei | 3.600 | 33.100 | MWE | 5/31/1965 | 9/30/1998 | 3 |
| 110 | Kacheri | 3.200 | 33.783 | MWE | 3/31/1964 | 12/31/1991 | 3 |
| 111 | Kaabong | 3.550 | 34.100 | MWE | 9/30/1946 | 12/31/1966 | 3 |
| 112 | Kotido | 3.017 | 34.100 | MWE | 2/28/1947 | 10/31/2003 | 2 |
| 113 | Loyoro [County Dodoth] | 3.367 | 34.217 | MWE | 4/30/1947 | 11/30/1963 | 3 |
| 114 | JIMMA | 7.667 | 36.833 | NBRP | 6/30/1952 | 12/31/2002 | 2 |
| 115 | NEKEMTEWELEGA | 9.080 | 36.450 | NBRP | 6/30/1952 | 12/31/2002 | 1 |
| 116 | SIBUSIREWELLEGA | 9.020 | 36.530 | NBRP | 3/31/1954 | 12/31/1999 | 1 |
| 117 | LODWAR | 3.117 | 35.617 | NBRP | 1/31/1950 | 12/31/2004 | 3 |
| 118 | LOKICHOKIO | 4.250 | 34.350 | NBRP | 1/31/1959 | 12/31/1993 | 3 |
| 119 | LOKITAUNG | 4.250 | 35.750 | NBRP | 1/31/1957 | 11/30/1993 | 3 |
| 120 | MALAKAL | 9.550 | 31.650 | NBRP | 1/31/1950 | 8/31/2001 | 2 |
| 121 | ADJUMANI | 3.367 | 31.783 | NBRP | 1/31/1961 | 12/31/2000 | 3 |
| 122 | GANBELLA | 8.150 | 34.350 | NBRP | 11/30/1956 | 4/30/1999 | 4 |
| 123 | BEGIE | 9.350 | 34.533 | NBRP | 2/28/1967 | 12/31/2003 | 2 |
| 124 | GORE | 8.150 | 35.320 | NBRP | 1/31/1952 | 8/31/2002 | 2 |
| 125 | NEDJO | 9.500 | 35.483 | NBRP | 1/31/1952 | 12/31/2003 | 1 |

**(1)** **Sources:** DST: NB-DSS Work Package 2 stage 2; GHCN: Global Historical Climate Network; NBRP: Nile Basin Research Programme; MWE: Ministry of Water and Energy Uganda; NBE: Nile Basin Encyclopedia; FAO: Food and Agricultural Organisation; EMP: Ethiopian Master Plan Studies.

**(2)** **Patching correlation Accuracy** 1 – Excellent; 2 – Good; 3 – Acceptable; 4 – Non-compliant

*Locations of rainfall stations*



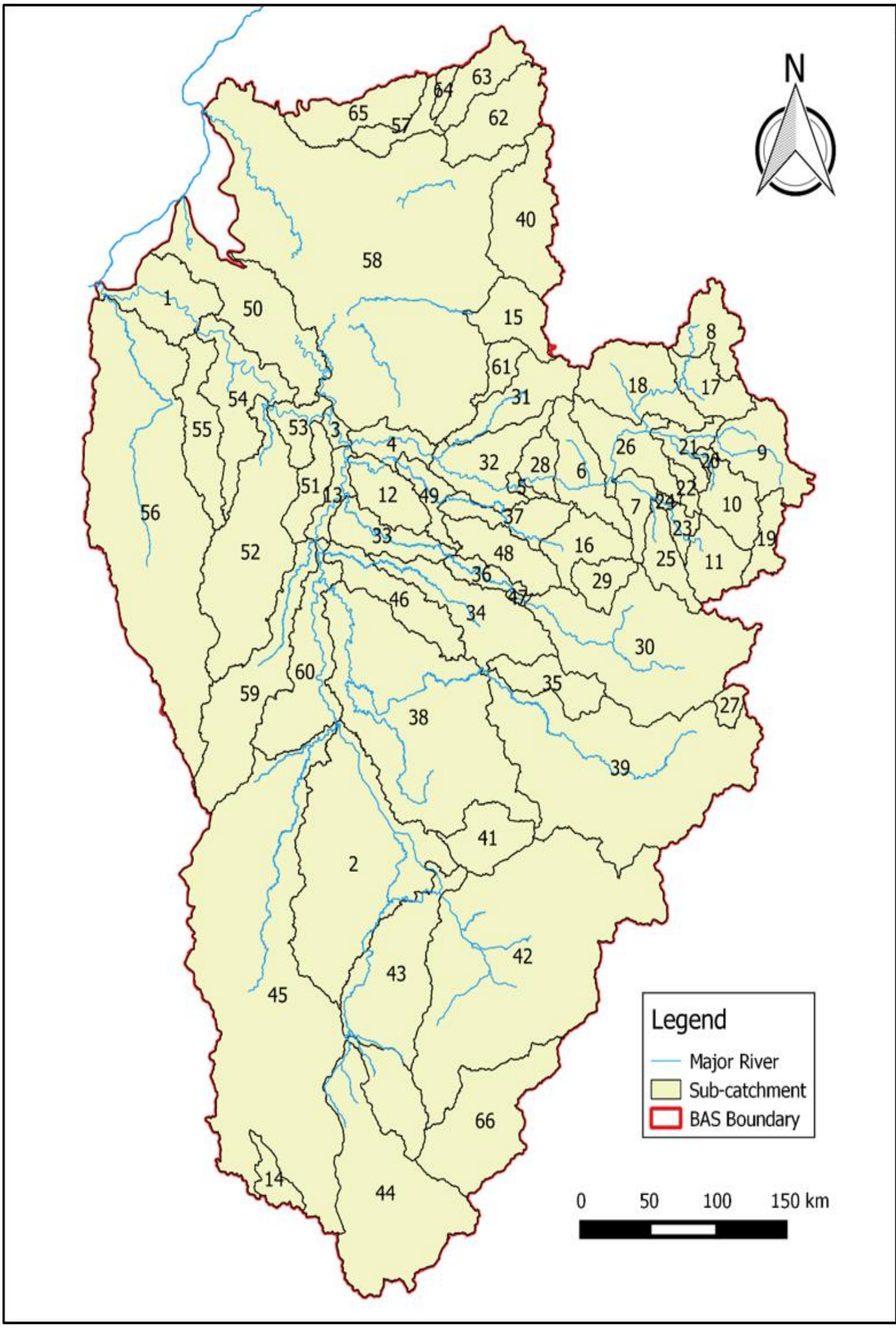
# Annex 5-c: Evaporation data

*Average monthly evaporation values at various stations in the Baro-Akobo-Sobat*

| Station Name | Source | Type | Record Period | Lat | Long | Average Monthly Evaporation (mm) | | | | | | | | | | | | MAE (mm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | |
| Abobo | EMP | Penman | 1956-1987* | 7.51 | 34.33 | 119 | 132 | 161 | 153 | 129 | 114 | 108 | 114 | 117 | 123 | 114 | 116 | 1500 |
| Bedelle | EMP | Penman | 1985-1998* | 8.27 | 36.20 | 124 | 137 | 143 | 139 | 141 | 141 | 117 | 96 | 100 | 116 | 136 | 140 | 1530 |
| Gambella | EMP | Penman | 1906-1993* | 8.15 | 34.35 | 136 | 140 | 176 | 161 | 130 | 113 | 107 | 113 | 116 | 124 | 120 | 125 | 1561 |
| Pokwo | EMP | Penman | 1956-1989* | 8.10 | 34.28 | 127 | 138 | 172 | 162 | 134 | 113 | 109 | 107 | 118 | 127 | 118 | 123 | 1548 |
| Gore | EMP | Penman | 1952-2002* | 8.09 | 35.32 | 145 | 130 | 152 | 138 | 121 | 97 | 96 | 97 | 103 | 125 | 125 | 131 | 1460 |
| Jikawo | EMP | Penman | 1973-1989* | 8.21 | 33.48 | 112 | 109 | 149 | 152 | 115 | 88 | 88 | 97 | 110 | 108 | 107 | 99 | 1334 |
| Metu | EMP | Penman | 1952-1992* | 8.20 | 35.35 | 116 | 133 | 156 | 159 | 123 | 102 | 93 | 98 | 101 | 121 | 108 | 111 | 1421 |
| Mizan | EMP | Penman | 1953-1992* | 7.00 | 35.35 | 114 | 118 | 134 | 130 | 123 | 109 | 100 | 103 | 107 | 118 | 110 | 109 | 1375 |
| Wush | EMP | Penman | 1953-1992* | 7.11 | 36.10 | 111 | 116 | 134 | 131 | 126 | 111 | 100 | 103 | 107 | 119 | 107 | 108 | 1373 |
| Anger | EMP | Penman | 1954-1992* | 9.22 | 36.22 | 110 | 121 | 143 | 150 | 127 | 109 | 100 | 103 | 103 | 116 | 104 | 105 | 1391 |
| Arjo | EMP | Penman | 1954-1992* | 8.45 | 36.30 | 106 | 114 | 138 | 131 | 119 | 100 | 89 | 94 | 100 | 112 | 105 | 105 | 1313 |
| Bambessi | EMP | Penman | 1955-1992* | 9.45 | 34.44 | 128 | 145 | 169 | 161 | 122 | 99 | 91 | 92 | 93 | 98 | 101 | 121 | 1420 |
| Dembi | EMP | Penman | 1973-1992* | 8.32 | 34.48 | 111 | 119 | 139 | 135 | 112 | 97 | 91 | 95 | 98 | 115 | 102 | 108 | 1322 |
| Gimbi | EMP | Penman | 1952-1992* | 9.10 | 35.47 | 118 | 131 | 152 | 154 | 124 | 102 | 93 | 96 | 100 | 112 | 114 | 115 | 1411 |
| Kurmuk | EMP | Penman | 1961-1988* | 10.26 | 34.28 | 163 | 181 | 205 | 199 | 151 | 125 | 114 | 118 | 116 | 127 | 130 | 152 | 1781 |
| Mendi | EMP | Penman | 1955-1992* | 9.47 | 35.05 | 116 | 131 | 144 | 144 | 125 | 104 | 99 | 92 | 95 | 109 | 99 | 107 | 1365 |
| Nedjo | EMP | Penman | 1952-2003* | 9.30 | 35.29 | 106 | 130 | 142 | 141 | 122 | 101 | 96 | 91 | 93 | 108 | 98 | 106 | 1334 |
| Dongoro | EMP | Penman | 1952-1992* | 9.16 | 35.41 | 117 | 128 | 150 | 151 | 114 | 93 | 84 | 87 | 92 | 102 | 103 | 106 | 1327 |
| Wama | EMP | Penman | 1975-1987* | 8.46 | 36.45 | 116 | 126 | 162 | 145 | 133 | 112 | 91 | 95 | 101 | 114 | 111 | 110 | 1416 |
| Bonga | EMP | Penman | 1953-1992* | 7.13 | 36.14 | 114 | 118 | 131 | 127 | 119 | 106 | 99 | 101 | 104 | 114 | 112 | 109 | 1354 |
| Gambela | FAO | Penman-Monteith | 1985-1986 | 8.25 | 34.58 | - | - | - | - | 144 | 117 | 119 | 109 | 126 | 139 | 131 | 143 | - |
| Burre | FAO | Penman-Monteith | 1989-1991 | 8.27 | 35.08 | 155 | 130 | 165 | 142 | 122 | 101 | 101 | 101 | 113 | 155 | 142 | 146 | 1570 |
| Gore | FAO | Penman-Monteith | 1982-1991 | 8.17 | 35.55 | 120 | 121 | 138 | 135 | 116 | 92 | 96 | 95 | 102 | 128 | 110 | 113 | 1365 |
| Alge | FAO | Penman-Monteith | 1990-1991 | 8.53 | 35.67 | 147 | 132 | - | 135 | 133 | 104 | 103 | - | - | 130 | 136 | 153 | - |
| Nejo | FAO | Penman-Monteith | 1989-1990 | 9.50 | 35.48 | 217 | - | - | 243 | 156 | 172 | 150 | 107 | 124 | 175 | 216 | 251 | - |
| Bedele | FAO | Penman-Monteith | 1986-1991 | 8.45 | 36.38 | - | 120 | 136 | 129 | 126 | 116 | 97 | 102 | 105 | 130 | 128 | 115 | - |
| Gambela | Shahin, 1985 | Open Water | 1950-1957 | 8.25 | 34.58 | 205 | 216 | 248 | 180 | 109 | 75 | 65 | 65 | 66 | 87 | 108 | 155 | 1578 |
| Akobo | Shahin, 1985 | Open Water | 1950-1957 | 7.78 | 33.02 | 270 | 277 | 285 | 222 | 136 | 135 | 102 | 74 | 60 | 81 | 117 | 202 | 1961 |
| Gore | Norplan, 2006 | Open Water | 1974-2003 | 8.15 | 35.53 | 112 | 116 | 134 | 128 | 111 | 88 | 81 | 85 | 91 | 102 | 100 | 103 | 1251 |
| Baro-1 | Norplan, 2006 | Open Water | 1974-2004 | 8.07 | 35.33 | 116 | 120 | 138 | 132 | 115 | 91 | 84 | 87 | 94 | 106 | 104 | 106 | 1293 |
| Baro-2 | Norplan, 2006 | Open Water | 1974-2005 | 8.15 | 8.15 | 119 | 123 | 142 | 135 | 118 | 93 | 86 | 90 | 96 | 108 | 106 | 109 | 1325 |
| Genji | Norplan, 2006 | Open Water | 1974-2006 | 8.12 | 35.22 | 120 | 125 | 144 | 137 | 120 | 95 | 87 | 91 | 98 | 110 | 108 | 110 | 1345 |
| Malakal | FAO Calculator | Penman-Monteith | 1951-2005 | 9.53 | 31.65 | 186 | 190 | 229 | 186 | 152 | 144 | 133 | 121 | 120 | 149 | 174 | 180 | 1965 |
| Torit | FAO Calculator | Penman-Monteith | 1951-2005 | 4.42 | 32.55 | 180 | 179 | 198 | 150 | 105 | 99 | 105 | 105 | 99 | 112 | 123 | 158 | 1614 |
| Pibor Post | FAO Calculator | Penman-Monteith | 1951-2005 | 6.80 | 33.13 | 195 | 193 | 220 | 168 | 127 | 120 | 124 | 121 | 111 | 124 | 144 | 180 | 1827 |

*Record period estimated based on corresponding rainfall station record period

# Annex 5-d: Model subcatchment information




| ID | Sub-catchment |
|---|---|
| 1 | Hillet Doleib |
| 2 | Residual Pibor Post |
| 3 | Nasir |
| 4 | Baro at Burebeiy |
| 5 | Baro at Itang |
| 6 | Baro at Gambella |
| 7 | Baro at Kella |
| 8 | Birbir at Yubdo |
| 9 | Geba at Suppi |
| 10 | Sor at Metu |
| 11 | Baro at Masha |
| 12 | Piyor |
| 13 | Lower Pibor |
| 14 | Torit |
| 15 | Daga Post |
| 16 | Proposed Abobo Dam |
| 17 | Birbir A |
| 18 | Birbir R |
| 19 | Geba A |
| 20 | Sor |
| 21 | Geba R |
| 22 | Gumero |
| 23 | Baro 1 |
| 24 | Baro 2 |
| 25 | Genji |
| 26 | Tams |
| 27 | Kashu |
| 28 | Itang |
| 29 | Dumbong |
| 30 | Gilo 2 |
| 31 | Jakau |
| 32 | Baro Flood Dam |
| 33 | d/s Gilo Flood Dam |
| 34 | Akobo Flood Dam |
| 35 | Akobo/Aculla |
| 36 | u/s Gilo Flood Dam |
| 37 | Alwero 2 |
| 38 | Agwei Flood Dam |
| 39 | Upper Akobo |
| 40 | Yabus Bridge |
| 41 | Upper Kenamuke |
| 42 | Kobowen |
| 43 | Lower Kenamuke |
| 44 | Upper Domongo |
| 45 | Veveno/Lotilla |
| 46 | Lower Akobo |
| 47 | Pignudo |
| 48 | Alwero 1 |
| 49 | Lower Alwero |
| 50 | Wal |
| 51 | Twalor |
| 52 | Nyanding |
| 53 | Sobat u/s Nyanding |
| 54 | Sobat u/s Beguyang |
| 55 | Beguyang |
| 56 | Fullus |
| 57 | *Drains out of study area |
| 58 | Machar Marshes |
| 59 | Into Lower Pibor |
| 60 | Upper Pibor |
| 61 | Lau R at Kigille |
| 62 | Tombak R at Nela |
| 63 | Ahmar R at Kofa |
| 64 | Agab at Kofa |
| 65 | *Drains out of study area |
| 66 | *Drains out of study area |

*Delineation of model subcatchments*

## MODEL SUBCATCHMENT INFORMATION

| Sub-catchment | Catchment Area (km2) | MAP (mm) | Rainfall stations used for catchment rainfall file (monthly) | Rainfall stations used for catchment rainfall file (daily) | MAE (mm) | Evaporation stations used for catchment monthly evaporation | NAM parameters used | MAR (million m3/a) | Runoff Coefficient |
|---|---|---|---|---|---|---|---|---|---|
| Hillet Doleib | 3,015 | 769 | 1494Akobo, 1197Nasir, 1462Abwong, 1839Hillet_Doleib, 2242Nasser, 1195Malakal_MofA, 1207Shambe | Malakal | 2,048 | Malakal (FAO calculator) | Alwero | 29 | 0.013 |
| Residual Pibor Post | 10,975 | 886 | 1937Kapoeta, 3312Lokichokio, 2112Maji, 2294Pibor_Post | Pibor Post | 1,788 | Pibor Post (FAO calculator) | Alwero | 81 | 0.008 |
| Nasir | 348 | 788 | 1494Akobo, 1197Nasir, 1462Abwong, 1839Hillet_Doleib, 2242Nasser, 1195Malakal_MofA, 1207Shambe | Malakal | 2,179 | Malakal (FAO calculator) | Alwero | 3 | 0.011 |
| Baro at Burebeiy | 1,203 | 826 | 1198Pibor, 1494Akobo, 1864Itang, 1874Jikawo, 2291Pakwo, 2294Pibor_Post, 3542Ganbella | Pibor Post | 2,104 | Gambella (Observed) | Alwero | 2 | 0.002 |
| Baro at Itang | 221 | 1,011 | 2191Mugi, 2377Shebele, 1192Gambela, 1764Gambela | Gore | 1,654 | Gambella (Observed) | u/s Gambella | 9 | 0.040 |
| Baro at Gambella | 2,269 | 1,365 | 2191Mugi, 2377Shebele, 1192Gambela, 1764Gambela | Gore | 1,504 | Gambella (Observed) | u/s Gambella | 519 | 0.168 |
| Baro at Kella | 1,016 | 1,601 | 1610Bure, 3611Gore | Gore | 1,448 | Metu (Observed) | u/s Gambella | 415 | 0.255 |
| Birbir at Yubdo | 1,858 | 1,863 | 1691Dongoro, 1791Gimbi_HS, 2267Nolekaba, 2539Youbdo, 1837Henna, 3673Nedjo | Gore | 1,344 | Dongoro (Observed) | u/s Gambella | 1,421 | 0.410 |
| Geba at Suppi | 2,740 | 1,750 | 1806Gore, 1847Hurumu, 2530Yayu, 1649Chora_Kumbabe | Gore | 1,322 | Arjo (Observed) | u/s Gambella | 1,571 | 0.328 |
| Sor at Metu | 1,712 | 1,900 | 1806Gore, 2172Metu_Hospital, 2530Yayu | Gore | 1,304 | Arjo (Observed) | u/s Gambella | 1,205 | 0.371 |
| Baro at Masha | 1,729 | 1,875 | 2438Tepi, 1806Gore, 3611Gore | Gore | 1,348 | Arjo (Observed) | u/s Gambella | 1,147 | 0.354 |
| Piyor | 1,814 | 901 | 1198Pibor, 1494Akobo, 1864Itang, 1874Jikawo, 2291Pakwo, 2294Pibor_Post, 3542Ganbella | Pibor Post | 2,032 | Gambella (Observed) | Alwero | 10 | 0.006 |
| Torit | 822 | 967 | 1490Agoro, 2454Torit | Torit | 1,684 | Torit (FAO calculator) | Alwero | 23 | 0.029 |
| Upper Daga | 1,888 | 1,332 | 1562Begi_School | Gore | 1,505 | Bambessi (Observed) | Daga | 329 | 0.131 |
| Abobo Dam | 1,781 | 1,322 | 1764Gambela, 2290Pakwo, 2291Pakwo, 2141Masha | Gore | 1,565 | Metu (Observed) | Alwero | 362 | 0.154 |
| Birbir A | 1,634 | 1,733 | 1691Dongoro, 1791Gimbi_HS, 2267Nolekaba, 2539Youbdo, 1837Henna, 3673Nedjo | Gore | 1,333 | Dongoro (Observed) | u/s Gambella | 1,081 | 0.382 |
| Birbir R | 3,377 | 1,556 | 1496Alem_Teferi_School, 1610Bure, 1642Chanka, 2324Rob_Gebeya | Gore | 1,311 | Metu (Observed) | u/s Gambella | 1,511 | 0.288 |
| Geba A | 995 | 1,731 | 1806Gore, 1847Hurumu, 2530Yayu, 1649Chora_Kumbabe | Gore | 1,310 | Arjo (Observed) | u/s Gambella | 562 | 0.326 |
| Sor | 152 | 1,864 | 1806Gore, 2172Metu_Hospital, 2530Yayu | Gore | 1,321 | Arjo (Observed) | u/s Gambella | 101 | 0.356 |
| Geba R | 1,053 | 1,782 | 1806Gore, 1847Hurumu, 2530Yayu, 1649Chora_Kumbabe | Gore | 1,312 | Arjo (Observed) | u/s Gambella | 639 | 0.341 |
| Gumero | 424 | 2,039 | 1610Bure, 3611Gore | Gore | 1,317 | Metu (Observed) | u/s Gambella | 333 | 0.385 |
| Baro 1 | 492 | 2,021 | 1610Bure, 3611Gore | Gore | 1,398 | Metu (Observed) | u/s Gambella | 382 | 0.384 |
| Baro 2 | 115 | 2,076 | 1610Bure, 3611Gore | Gore | 1,433 | Metu (Observed) | u/s Gambella | 93 | 0.391 |
| Genji | 1,385 | 1,814 | 1610Bure, 3611Gore | Gore | 1,437 | Metu (Observed) | u/s Gambella | 801 | 0.319 |
| Tams | 2,590 | 1,465 | 1610Bure, 3611Gore | Gore | 1,346 | Metu (Observed) | u/s Gambella | 907 | 0.239 |
| Kashu | 456 | 2,031 | 1448Abobo, 2535Yeki, 2112Maji | Gore | 1,383 | Mizan (Observed) | u/s Gambella | 358 | 0.387 |
| Itang | 930 | 1,223 | 2191Mugi, 2377Shebele, 1192Gambela, 1764Gambela | Gore | 1,639 | Gambella (Observed) | u/s Gambella | 124 | 0.109 |
| Dumbong | 1,079 | 1,434 | 1764Gambela, 2290Pakwo, 2291Pakwo, 2141Masha | Gore | 1,530 | Metu (Observed) | Alwero | 313 | 0.202 |
| Gilo 2 | 9,364 | 1,599 | 1448Abobo, 2180Mizan_Teferi, 2438Tepi, 2535Yeki | Gore | 1,443 | Mizan (Observed) | u/s Gambella | 3,379 | 0.226 |
| Jakau | 2,337 | 1,383 | 2191Mugi, 2377Shebele, 1192Gambela, 1764Gambela | Gore | 1,653 | Gambella (Observed) | u/s Gambella | 521 | 0.161 |
| Baro Flood Dam | 2,798 | 1,024 | 1198Pibor, 1494Akobo, 1864Itang, 1874Jikawo, 2291Pakwo, 2294Pibor_Post, 3542Ganbella | Gore | 1,809 | Gambella (Observed) | Alwero | 92 | 0.032 |
| d/s Gilo Flood Dam | 1,867 | 954 | 1198Pibor, 1494Akobo, 1864Itang, 1874Jikawo, 2291Pakwo, 2294Pibor_Post, 3542Ganbella | Pibor Post | 1,975 | Gambella (Observed) | Alwero | 21 | 0.012 |
| Akobo Flood Dam | 3,882 | 1,097 | 1198Pibor, 1494Akobo, 1864Itang, 1874Jikawo, 2291Pakwo, 2294Pibor_Post, 3542Ganbella | Pibor Post | 1,762 | Gambella (Observed) | Alwero | 219 | 0.051 |
| Akobo/Aculla | 1,737 | 1,327 | 1448Abobo, 2535Yeki, 2112Maji | Gore | 1,584 | Mizan (Observed) | Alwero | 205 | 0.089 |
| u/s Gilo Flood Dam | 746 | 1,047 | 1198Pibor, 1494Akobo, 1864Itang, 1874Jikawo, 2291Pakwo, 2294Pibor_Post, 3542Ganbella | Pibor Post | 1,758 | Gambella (Observed) | Alwero | 34 | 0.044 |
| Alwero 2 | 1,611 | 1,046 | 1764Gambela, 2290Pakwo, 2291Pakwo, 2141Masha | Gore | 1,702 | Metu (Observed) | Alwero | 69 | 0.041 |
| Agwei Flood Dam | 13,727 | 1,043 | 1198Pibor, 1494Akobo, 1864Itang, 1874Jikawo, 2291Pakwo, 2294Pibor_Post, 3542Ganbella | Pibor Post | 1,824 | Gambella (Observed) | Alwero | 454 | 0.032 |
| Upper Akobo | 14,281 | 1,545 | 1448Abobo, 2535Yeki, 2112Maji | Gore | 1,509 | Mizan (Observed) | u/s Gambella | 3,810 | 0.173 |
| Upper Yabus | 3,758 | 1,170 | 1177J_Maiak, 1178El-Kurmuk, 1201Yabus_Bridge, 1523Asosa, 1641Chali, 2060Kurmuk, 2061Kurumuk | Gore | 1,496 | Kurmuk (Observed) | Yabus | 676 | 0.154 |
| Upper Kenamuke | 1,982 | 1,098 | 1937Kapoeta, 3312Lokichokio, 2112Maji, 2294Pibor_Post | Pibor Post | 1,629 | Pibor Post (FAO calculator) | Alwero | 126 | 0.058 |
| Kobowen | 18,758 | 1,006 | 1937Kapoeta, 3312Lokichokio, 2112Maji, 2294Pibor_Post | Pibor Post | 1,517 | Pibor Post (FAO calculator) | Alwero | 940 | 0.050 |
| Lower Kenamuke | 5,412 | 816 | 1937Kapoeta, 3312Lokichokio, 2112Maji, 2294Pibor_Post | Pibor Post | 1,631 | Pibor Post (FAO calculator) | Alwero | 34 | 0.008 |
| Upper Domongo | 8,712 | 933 | 1937Kapoeta, 3312Lokichokio, 2112Maji, 2294Pibor_Post | Torit | 1,437 | Torit (FAO calculator) | Alwero | 343 | 0.042 |
| Veveno/Lotilla | 24,765 | 896 | 1220Mongalla, 2439Terakeka, 2447Tombe, 2454Torit, 2294Pibor_Post | Pibor Post | 1,773 | Pibor Post (FAO calculator) | Alwero | 212 | 0.010 |
| Lower Akobo | 2,431 | 978 | 1198Pibor, 1494Akobo, 1864Itang, 1874Jikawo, 2291Pakwo, 2294Pibor_Post, 3542Ganbella | Pibor Post | 1,896 | Gambella (Observed) | Alwero | 40 | 0.017 |
| Pignudo | 104 | 1,167 | 1448Abobo, 2180Mizan_Teferi, 2438Tepi, 2535Yeki | Gore | 1,675 | Mizan (Observed) | Alwero | 5 | 0.041 |
| Alwero 1 | 2,076 | 1,075 | 1764Gambela, 2290Pakwo, 2291Pakwo, 2141Masha | Gore | 1,715 | Metu (Observed) | Alwero | 103 | 0.046 |
| Lower Alwero | 1,026 | 929 | 1198Pibor, 1494Akobo, 1864Itang, 1874Jikawo, 2291Pakwo, 2294Pibor_Post, 3542Ganbella | Gore | 1,961 | Gambella (Observed) | Alwero | 9 | 0.009 |
| Wal | 5,403 | 753 | 1197Nasir, 1462Abwong, 1193Kodok, 2162Melut | Malakal | 2,080 | Malakal (FAO calculator) | Alwero | 70 | 0.017 |
| Twalor | 1,346 | 848 | 1494Akobo, 1197Nasir, 1462Abwong, 1839Hillet_Doleib, 2242Nasser, 1195Malakal_MofA, 1207Shambe | Malakal | 2,100 | Malakal (FAO calculator) | Alwero | 24 | 0.021 |
| Nyanding | 7,197 | 855 | 1494Akobo, 1197Nasir, 1462Abwong, 1839Hillet_Doleib, 2242Nasser, 1195Malakal_MofA, 1207Shambe | Malakal | 2,030 | Malakal (FAO calculator) | Alwero | 168 | 0.027 |
| Sobat u/s Nyanding | 1,099 | 789 | 1494Akobo, 1197Nasir, 1462Abwong, 1839Hillet_Doleib, 2242Nasser, 1195Malakal_MofA, 1207Shambe | Malakal | 2,162 | Malakal (FAO calculator) | Alwero | 10 | 0.012 |
| Sobat u/s Beguyang | 3,576 | 783 | 1494Akobo, 1197Nasir, 1462Abwong, 1839Hillet_Doleib, 2242Nasser, 1195Malakal_MofA, 1207Shambe | Malakal | 2,104 | Malakal (FAO calculator) | Alwero | 34 | 0.012 |
| Beguyang | 2,592 | 809 | 1494Akobo, 1197Nasir, 1462Abwong, 1839Hillet_Doleib, 2242Nasser, 1195Malakal_MofA, 1207Shambe | Malakal | 2,073 | Malakal (FAO calculator) | Alwero | 34 | 0.016 |
| Fullus | 17,492 | 805 | 1494Akobo, 1197Nasir, 1462Abwong, 1839Hillet_Doleib, 2242Nasser, 1195Malakal_MofA, 1207Shambe | Malakal | 2,000 | Malakal (FAO calculator) | Alwero | 372 | 0.026 |
| Machar Marshes | 36,228 | 837 | 1197Nasir, 1462Abwong, 1193Kodok, 2162Melut | Malakal | 1,941 | Malakal (FAO calculator) | Yabus | 151 | 0.005 |
| Into Lower Pibor | 5,126 | 885 | 1198Pibor, 1494Akobo, 1864Itang, 1874Jikawo, 2291Pakwo, 2294Pibor_Post, 3542Ganbella | Pibor Post | 1,948 | Gambella (Observed) | Alwero | 33 | 0.007 |
| Upper Pibor | 4,113 | 902 | 1198Pibor, 1494Akobo, 1864Itang, 1874Jikawo, 2291Pakwo, 2294Pibor_Post, 3542Ganbella | Pibor Post | 1,964 | Gambella (Observed) | Alwero | 28 | 0.008 |
| Lower Pibor | 957 | 871 | 1198Pibor, 1494Akobo, 1864Itang, 1874Jikawo, 2291Pakwo, 2294Pibor_Post, 3542Ganbella | Pibor Post | 2,079 | Gambella (Observed) | Alwero | 1 | 0.001 |

# Annex 5-e: Information sources – Floodplains, wetlands and marshes in the Baro-Akobo-Sobat basin

The following sources were used to conceptualise and model the floodplains of the BAS Basin, and are discussed in more detail below:

- GIEMS - Global Inundation Extent from Multi-satellites Dataset (Prigent et al., 2007; Fluet-Chouinard et al., 2015; Miolane et al., in print)
- GLWD - Global Lakes and Wetlands Database (Lehner and Doll, 2004).
- TTI spatial mapping of wetlands and marshes in the BAS Basin (Baro-Akobo-Sobat Multipurpose Water Resources Development Project: Scoping Report: Annex2, Dec 2015)
- The Hydrology of the Nile (Sutcliffe and Parks, 1999)
- Baro-Akobo basin master plan study of water and land resources of the Gambela Plain (Selkhozpromexport, 1990)
- 2012 Field Report on visit to Machar Marshes
- Baro-Akobo-Sobat Wetlands Knowledge Base Consultancy (Ssebuliba, 2012)
- A Directory of African Wetlands (Hughes and Hughes, 1992)

## GIEMS

The Global Inundation Extent from Multi-Satellites (GIEMS) is a monthly-mean water surface extent derived at a low spatial resolution of 0.25°equal-area grid for the period between 1993 and 2007. The derivation included combining satellite observations in the visible, near-infrared, and passive/active microwaves. It expresses the fractional inundation within each 773 km$^2$ grid box (resolution at the equator) attributed to lakes, rivers, wetlands and irrigated agriculture.

GIEMS-D15 was derived from the GIEMS data at a pixel size of 15 arc-seconds. The downscaling procedure predicted the location of surface water cover with an inundation probability map that was generated by bagged decision trees using globally available topographic and hydrographic information from the SRTM-derived HydroSHEDS database and trained on the wetland extent of the GLC2000 global land cover map. GIEMS-D15 represents three states of land surface inundation extents: mean annual minimum, mean annual maximum, and long-term maximum (the largest surface water area of any global map to date).

The GIEMS data was also downscaled to a 3 arc second (90 m) dataset (GIEMS-D3) using topographical information from the HydroSHED database and a new floodability index procedure. The resulting GIEMS-D3 database is the only long-term (1993-2007), dynamic (monthly time-scale), and high spatial resolution inundation database that is available at the global scale.

## GLWD

The Global Lakes and Wetlands Database (GLWD) represents a comprehensive dataset of global surface water area, including small and large lakes, reservoirs, smaller water bodies, rivers, and a good representation of the maximum global wetland extent. GLWD is a static database.

## TTI

Using landsat and radar images, TTI prepared an inundation map for the study basin. (refer

## The Hydrology of the Nile (Sutcliffe and Parks, 1999)

Sutcliffe and Parks (1999) reported that the streamflow in the Baro River below the Machar Marshes does not exceed 1.5 $km^3$ per month (560 $m^3/s$), even though the inflow upstream of the Marshes at Gambella exceeds that value. Hurst (1950) estimated that 78% of the lost water is diverted into the Machar Marshes, and the remaining 22% spills over to the left bank.

## Baro-Akobo basin master plan study of water and land resources of the Gambela Plain (Selkhozpromexport, 1990)

A study by Selkhozpromexport (1990) reported on the flooding of areas along the Baro, Alwero, Gilo and Akobo Rivers due to limited conveyance capacities as follows:

- Baro River: 860 – 1000 $m^3/s$
- Gilo River: 150 – 300 $m^3/s$
- Alwero River: 60 - 70 $m^3/s$.

These capacity ranges were used in the model in order to simulate spills when the river capacities were exceeded. Selkhozpromexport (1990) also reported on the 1988 flood at Gambella and presented maps of inundated areas for one in 10 year and one in 2 year floods – these were digitised for this project.

## 2012 Field Report on visit to Machar Marshes

This report describes a field mission to the Baro River at the locations of major spills to the Machar and provides information about the locations and elevations of spill channels

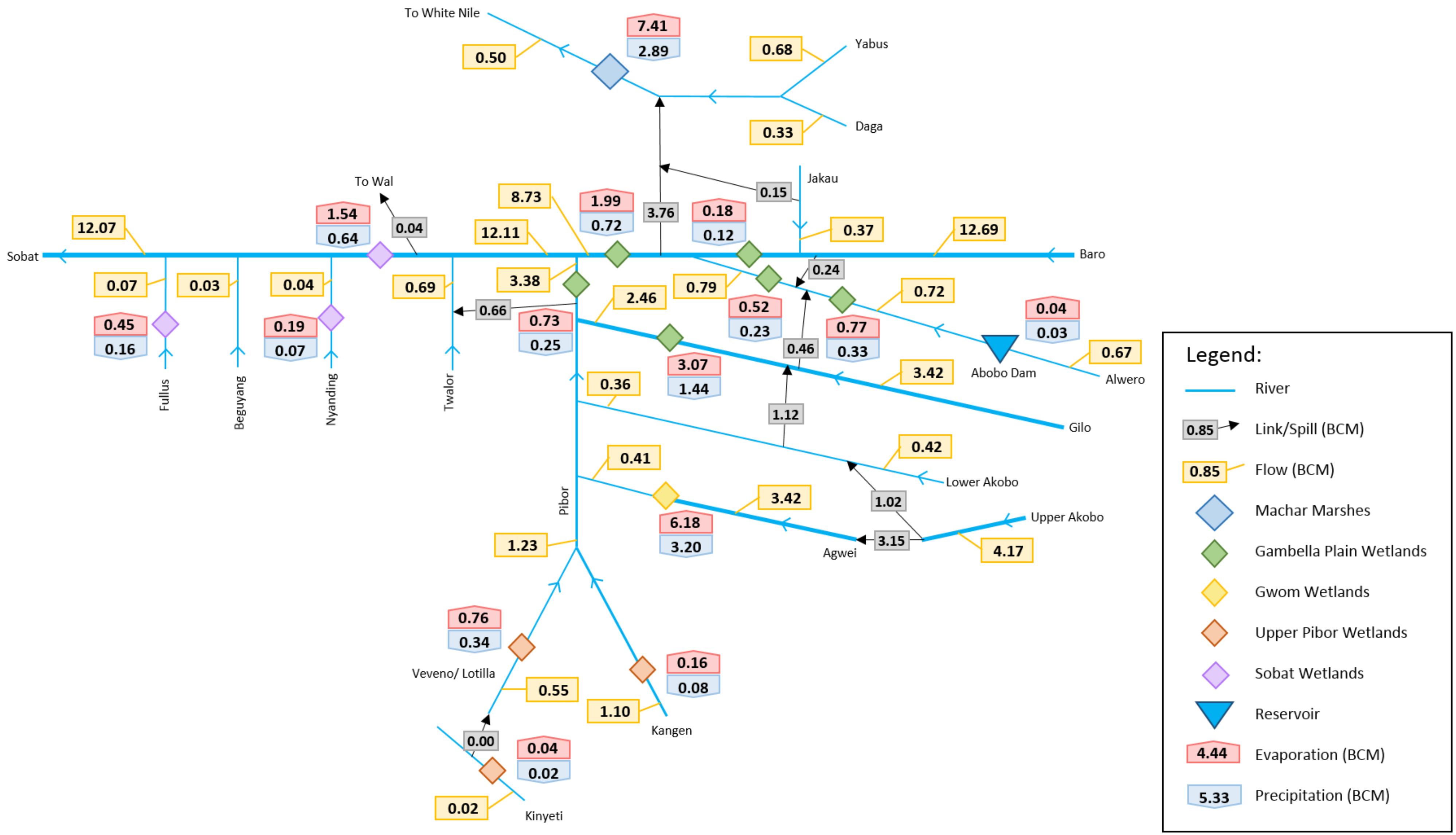
## Baro-Akobo-Sobat Wetlands Knowledge Base Consultancy (Ssebuliba, 2012)

This report provided useful information on the river system and wetlands in the basin.

## A Directory of African Wetlands (Hughes and Hughes, 1992)

This report provides very useful information regarding the location and extent of wetlands in the study area, including the Pibor catchment. It also describes the main rivers draining into and out of the wetlands.

# Annex 5-f: Long-term Water Balance of the Baro-Akobo-Sobat basin


To White Nile
0.50
7.41
2.89
0.68
Yabus
Daga
0.33
Jakau
0.15
3.76
To Wal
0.04
1.54
0.64
8.73
1.99
0.72
0.18
0.12
0.37
12.69
12.07
12.11
Sobat
Baro
0.07
0.03
0.04
0.69
3.38
0.24
0.79
0.72
0.45
0.16
0.19
0.07
0.66
0.73
0.25
2.46
0.52
0.23
0.77
0.33
0.04
0.03
0.67
Abobo Dam
Alwero
0.46
3.07
1.44
3.42
Fullus
Beguyang
Nyanding
Twalor
0.36
Gilo
1.12
0.42
Lower Akobo
0.41
Pibor
3.42
1.02
Upper Akobo
6.18
3.20
3.15
Agwei
4.17
1.23
0.76
0.34
Veveno/ Lotilla
0.55
0.16
0.08
1.10
Kangen
0.00
0.04
0.02
0.02
Kinyeti
Legend:
River
0.85
Link/Spill (BCM)
0.85
Flow (BCM)
Machar Marshes
Gambella Plain Wetlands
Gwom Wetlands
Upper Pibor Wetlands
Sobat Wetlands
Reservoir
4.44
Evaporation (BCM)
5.33
Precipitation (BCM)