ENTRO
EASTERN NILE TECHNICAL REGIONAL OFFICE

BARO AKOBO SOBAT MULTIPURPOSE WATER RESOURCES DEVELOPMENT PROJECT STUDY

SCOPING REPORT

V.3 March 2016

BRL Ingénierie

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Date document created	**22 September 2015**
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Title of document	**Baro Akobo Sobat multipurpose water resources development study**
Document Reference	**800838**
Reference No.	**V3.0**

Date of publication	Ref. No :	Observations	Compiled by	Verified and validated by
6 November 2015	V1.1	Scoping Report - Draft	Jean-Michel Citeau, Steve Crerar and Team	J.M Citeau
15 November 2015	V1.2	Scoping report – Revised Draft	Jean-Michel Citeau, Steve Crerar and Team	J.M Citeau
30 December 2015	V2.0	Scoping Report - Final	Jean-Michel Citeau, Steve Crerar and Team	J.M Citeau
04 March 2016	V3.0	Scoping Report – Updated final	Jean-Michel Citeau, Steve Crerar and Team	J.M Citeau

BARO-AKOBO-SOBAT MULTIPURPOSE WATER RESOURCES DEVELOPMENT STUDY

Scoping Report

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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
EPA	Environmental Protection Authority
ESA	Environmental and Social Assessment
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	Metres 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

EXECUTIVE SUMMARY

SIGNIFICANCE OF THE SCOPING EXERCISE WITHIN THE OVERALL STUDY

The Overall Study

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 sub-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. The plan will include short, medium and long-term projects and enabling interventions; with selected short-term projects prepared to the level of feasibility study. It will also include the development of a priority sequence of multipurpose water resources development projects" as part of the IWRDMPlan
- 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.

Objectives of the Scoping Exercise

The scooping exercise represents an essential preparatory step aimed at ensuring that the study delivers a useful end-product based on and understanding of the key issues, constraints, challenges and opportunities. The scoping exercise is aimed at determining the relevant information ***to be*** collected **to complete the baseline** in order to determine the "key issues and potentials related to water resource development and management in the river basin"[1] The objectives of the scoping exercise are shown in Figure ES-1.

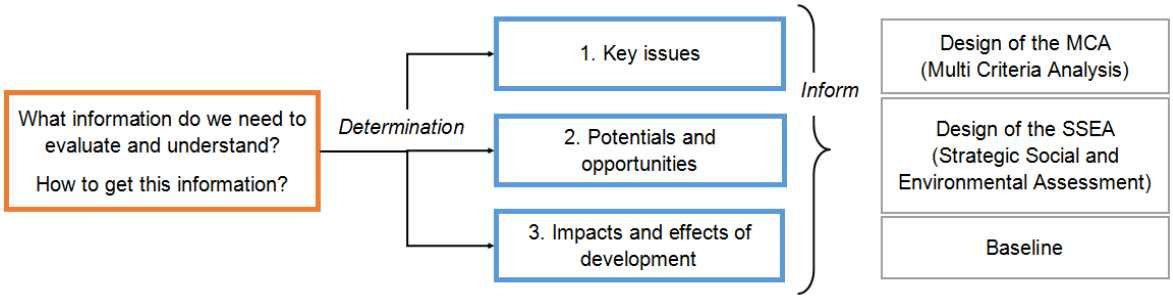


Figure ES-1: Objectives of the Scoping Exercise

[1] The baseline report comprises i) baseline, ii) key issues, iii) development potentials and iv) management/development objectives

Scoping at two levels

This study has a clear focus on the **identification and development of projects**. One of the core outputs is a "priority sequence of multipurpose water resources development projects". At the same time, this **development of projects (large and small) has to take place within a coherent and optimised strategic framework for the management and development of water resources basinwide**. For this reason the baseline (and hence the scoping exercise) has to be 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 surface water resources, the environment, biodiversity issues and a number of socio-economic aspects.
- **"Project" level.** The level of detail that is required at this level is too detailed to be assessed/collected at the basin-wide level. The scoping exercise will identify the potential development projects and areas of development potential in order to focus the baseline on these areas.

The scoping exercise is **not about the actual collection of this information but getting clarity on what information should be collected and how it will be (is being) achieved**, in particular during the baseline. Thus, the two main objectives of the scoping report are the following:

- Clear definition of the work to be carried out in the baseline and for the SSEA
- Assessment of information available, identification of gaps and implications, suggestions for mitigating critical gaps.

Scoping and the SSEA

In the baseline, certain information has to be collected in order to prepare the SSEA. To do so, it is important to evaluate **how the baseline** will inform the SSEA. The role of the scoping exercise is to answer the following questions:

- What information will be required during the baseline phase in order to feed into the SSEA framework?
- What are the limits of the SSEA?

This must be done at project level and at the basin wide level.

More specifically, for the SSEA, the scoping phase should provide 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.

SOURCES OF INFORMATION

A chapter in the report is put over to an analysis of the sources of information for the scoping exercise. This chapter provides an overview/details of the information sources that have been used to do the scoping exercise and which are seen as **key documentation/sources of information** for informing the baseline.

The various sources of information are used in two ways:

- In order **to** draft **certain parts of the scoping report**: Identification/listing of projects and identification of potential developments (by geographic area and/or need)
- Know what is in the documentation that can be used for completion of the baseline

In determining the relevant information for each sector or thematic area a two-step process has been used. The first step was to carry out a rapid examination of the available references in order to filter out the key documents. In a second step, a more in-depth analysis of the information contained in the selected key documents has been carried out to see how the they can be used to inform the baseline and SSEA. Documentation on the following areas has been examined and the key elements that may contribute to the bassline summarized:

- surface water hydrology, water quality and groundwater;
- watershed Management;
- irrigated Agriculture, livestock, fisheries and aquaculture;
- hydropower and interconnection;
- water supply and sanitation;
- navigation;
- biodiversity conservation and
- the social situation and security

Metadata are presented in the report for:

- Meteorological, hydrological, groundwater and water quality data;
- Topographic, sediment and morphological data and data on the hydrographic network
- Data on conservation areas, ecosystems, biodiversity and wildlife;
- Demographics and social data

When looking at the documentation and data the aim has been to:

- State what the purpose and potential use of the information is
- What information/data would seem to exist and what is needed for the study
- What the gaps are
- How to get round the gaps.

BASIN-WIDE APPROACH TO SCOPING (OR SCOPING BASINWIDE)

Development of projects will take place within the context of the basin as a whole. The dynamics of the basin has to be understood in order that the impacts of various development options can be properly evaluated. This will be the main role of the SSEA. The basinwide scoping has been aimed at understanding what information is available on the basinwide aspects so that the SSEA can be properly designed.

At the basinwide level, the focus has been on:

- Climate, surface water hydrology, water quality, groundwater and watershed condition/ degradation
- Consideration of the transboundary aspects of irrigation, hydropower, navigation developments
- Conservation, ecosystems and biodiversity
- Social aspects, human dynamics and security
- Enabling environment (policy, access to services etc.)

When it comes to looking at the potential cumulative impacts of development, these are the areas which have to be well understood in the baseline. In the scoping exercise the available data has been assessed and while there are many gaps, most challenges are not insurmountable. The main exception is the lack of information on the functioning of the large wetlands in the basin, most notably, the *Machar marshes*.

SCOPING FOR PLANNED AND POTENTIAL PROJECTS / INTERVENTIONS

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 work should therefore be focused on these two areas:

- For i) the already identified projects, it is clear and these projects can be inventorised at different levels of detail. This is a **clear goal** and output of the scoping exercise.
- For ii), it is necessary to identify either/both areas of need and potential (opportunity). The focus (need or opportunity) will depend on the sector or thematic area. Some development will be more related to potential (e.g. hydropower), while some will be more related to need (e.g. water supply).

CONCLUSIONS

Due its preparatory nature it is important to note that conclusions to the scoping exercise do not in themselves really inform the study. Substantive and informative conclusions should come out of the baseline work. The scoping exercise is preparatory in nature and these conclusions are more about highlighting where the focus should be for the baseline in order that the SSEA and overall Plan can be built on a solid understanding of the basin and of the various development opportunities and management needs.

Focussing efforts

The scoping exercise has allowed the Consultant to understand where efforts need to be spent in completing the baseline. While there are serious gaps, there is also an abundance of documentation covering most of the thematic areas. The depth and accuracy of the information contained in these documents and date sets varies and is often not up-to-date or sometimes simply re-presents or re-analyses data already presented in earlier studies. Nevertheless, there is sufficient information to complete the baseline with the caveat that areas of uncertainty (due to gaps) will be highlighted and suggestions on how to get round these gaps proposed. Some of the proposals will be applied during the baseline, some will effectively be for further work which could form part of the IWRDMPlan.

It is well understood that the basin provides excellent water resources development opportunities and that current levels of development are extremely low. Several large-scale hydropower projects have already been identified and studied in the highland source areas in Ethiopia. Scope for small-scale development has been identified in South Sudan.

Central questions

The scoping exercise has highlighted the fact that the **planning, design and potential implementation of the large-scale hydropower schemes** will probably lie at the heart of the IWRDMPlan since in addition to providing electricity, these schemes would/could

- regulate flows, supporting the development of irrigation schemes downstream,
- provide the irrigation schemes (and other beneficiaries) with protection from floods through flood attenuation.
- provide a source of gravity-fed water supply to settlements downstream and opportunities for other developments
- reduce the seasonality of flows and (if their construction results in large-scale abstraction for irrigation) reduce the flows further downstream, both aspects having a significant impact on the *Machar marshes* and other wetlands whose ecology depends not only on adequate inflows but also on the natural seasonality of flows with wetter and drier periods.
- Have an impact on the seasonality and overall contribution of flows to the White Nile

Accurately quantifying these last two points based on the currently available information will be a challenge and it is clear that the Plan itself will have to include measures that support better understanding and improved management in the future.

Sensitivities and Development Potential

The SSEA framework will essentially be based on a good understanding of the "sensitivities" (the existing and potential environmental and social issues) and the Development potential (ways in which the available resources can be developed and managed to improve livelihoods and support economic growth) as summarised in the Figure (see below). By developing the SSEA in parallel with the investigation of development potential (projects and potential ones), due attention can be paid to the sensitivities in order to ensure that the best choices are made.

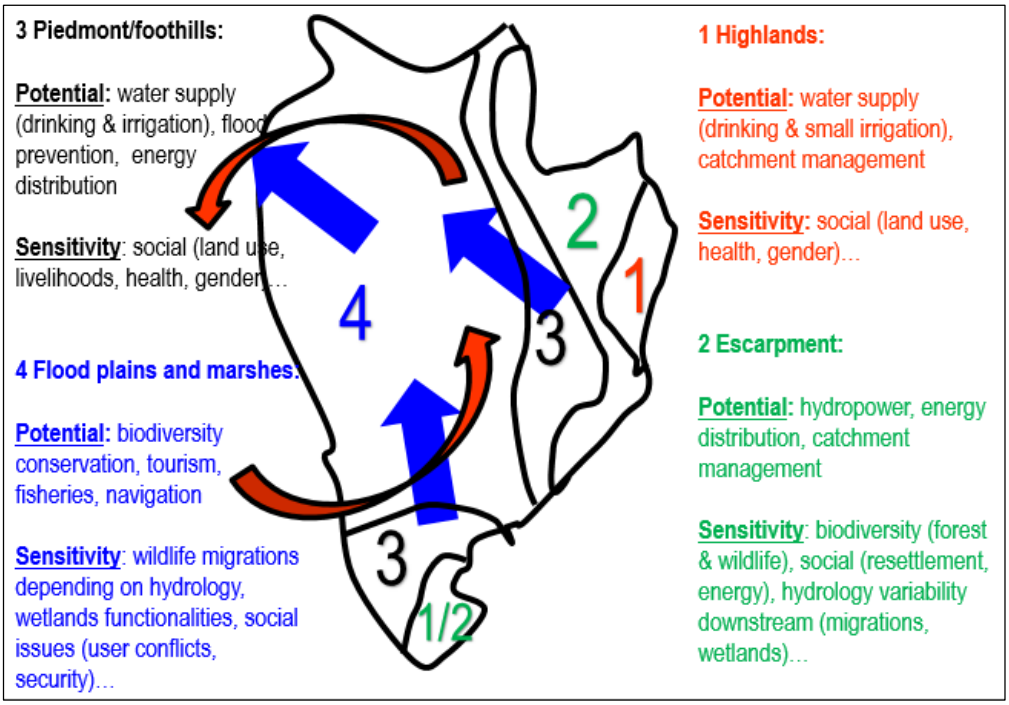


Figure ES2: Simplified representation of potentials and sensitivities in the basin

Potential for rapid change

Although development in the basin is currently at a very low level, there is a **very real prospect of rapid change**. A high rate of economic growth in Ethiopia has been sustained for several years now and there is a rapidly growing need to increase both electricity and agricultural production. The implementation of the first hydropower scheme is relatively imminent and private investors are showing real interest in the development of the floodplains downstream of Gambella for both large-scale rainfed and irrigated agriculture, but efforts are not well-coordinated or planned. In South Sudan, the current security situation is challenging when proposing development projects, but the situation could change and improve rapidly leading to rapid development. The Consolidated Agriculture Master Plan has recently been made available and the associated Irrigation Master Plan is about to be finalised. These two documents will provide a good indication of where development may move forward first.

Transboundary Perspective

From a transboundary water resources perspective there is pressure to develop the water resources of the Baro-Akobo-Sobat because the impact on flows in the White Nile of major irrigation expansion in the sub-basin is subdued by the presence of the *Machar marshes*. When less water spills over into these wetlands there is also a reduction in the total water evaporated from the system.

IDENTIFICATION OF GAPS AND TECHNIQUES PROPOSED TO BRIDGE THE GAPS

The presence of data and information gaps in this type of study is to be expected and should not be allowed to stop progress. It is important that:

- gaps should be clearly identified and stated, together with their implications on the anticipated or actual results or conclusions;
- efforts to mitigate gaps should be presented and applied with a clear statement of assumptions and limits;
- frameworks and models should be built in such a way that their outputs can be improved if the gaps in the input information are reduced or removed.

Bearing these things in mind will lead to the building of a robust plan that includes within itself the measures required for improving its accuracy and usefulness.

Data gaps identified

Details of the perceived gaps have been presented in each of the sections of this report. What follows is only a summary of some of the key areas where there are significant gaps:

At this stage of the study, the main gaps in data, information and understanding include:

- Dynamics of inundation and hydrological functioning of most wetland areas
- Status and condition of many of the basin's ecosystems, including detail on the content and outputs of ongoing and planned conservation projects
- Capacity, facilities and resources of many of the institutions in place to implement environmental and social mitigation measures
- Livelihoods and livelihood zones, employment and income in the basin
- Migration and pastoral mobility routes in the basin

These are some of the areas that have been identified during the scoping exercise for further investigation during the baseline in order to improve the team's knowledge and understanding of these critical areas.

Limitation of the field missions in some sensitive areas within the basin

Even if the SSEA, which is a strategic level assessment, relies mainly on secondary information and expert opinion, a rapid field visit to the main projects sites identified and potential impact areas could be profitable for the study if this is possible. At the same time, it is recognised that this will almost certainly not be possible for the critical potential impact areas such as the *Machar marshes* in South Sudan. This is likely to remain a gap.

Use and limits of remote sensing

As already indicated in the overview above, one of the central question of the baseline and which will be a thread running through all the development scenarios to be investigated, is the potential impact of development in the upstream areas and the impact on the environment and the availability of water for development downstream. Once the IWRDMPlan is developed it should be with an adequate understanding of the significant potential effects (adverse or positive) of upstream development on:

- the hydrological patterns of the BAS,
- the extent and size of the flood plains and wetlands,
- the availability of water and vegetation for both cattle and wildlife and other uses such as additional food for the communities at the end of the dry season,
- the risk of floods,

- Climate change uncertainty,
- High humidity downstream in the sub-basin areas,
- the location and extent of settlements.

The analysis of the available information in the scoping exercise has shown that the necessary technical questions cannot be adequately answered on the basis of the existing data. It will be necessary to conduct further analysis if remotely sensed information in order to map and assess the inundation dynamics and better understand the hydrological functioning of the wetlands.

A solid/robust approach foundation for water resources modelling

While it is clear that there is not sufficient information available to set up accurate water resources models, it is still important that models are put in place that both provide the best answers possible for the time being and which can be improved as better more complete data sets become available. It is important that the models developed do not have to be completely rebuilt to make use of new improved data sets.

Consultation with stakeholders

The consultation and engagement of a wide range of stakeholders is crucial to ensure the success of the SSEA and the eventual implementation of the IWRDMPlan.

NEXT STEPS

Work on the baseline is already well advanced.

The following steps are planned over the next six months:

- Compilation of draft Baseline Report (Deliverable 4a) by 5 March 2016
- Compilation of draft Key Issues and Objectives Report (Deliverable 4b) by 5 March 2016
- Compilation of draft Development Potential Report (Deliverable 4c) by 5 March 2016
- Compilation of first draft SSEA framework by 5 March 2016
- 3rd Stakeholder workshop by end March 2016
- Compilation of draft Concept Note of Short-term options by 5 March 2015

1. INTRODUCTION

1.1 OVERALL CONTEXT

1.1.1 The Nile Basin Initiative (NBI)

The **Nile Basin Initiative (NBI)** is a partnership between the riparian states of the Nile River: Burundi, Democratic Republic of Congo, Egypt, Ethiopia, Kenya, Rwanda, South Sudan, Sudan, Tanzania and Uganda. The NBI seeks to **develop the river in a cooperative manner, share substantial socio-economic benefits, and promote regional peace and security.** The NBI started with a participatory process of dialogue among the riparian countries that resulted in an agreement on a shared vision, namely, to "achieve sustainable socioeconomic development through the equitable utilization of, and benefit from, the common Nile Basin water resources," and a Strategic Action Program to translate this vision into concrete activities and projects.

The **Eastern Nile Subsidiary Action Program** (ENSAP) of the NBI was launched by Egypt, Ethiopia and the Sudan (with South Sudan joining in 2012) to **initiate concrete joint investments and action on the ground** in the Eastern Nile sub-basin in the areas of power generation and interconnection, irrigation and drainage, flood preparedness and early warning, watershed management, development of planning models and joint multipurpose programs. ENSAP is governed by the Eastern Nile Council of Ministers (ENCOM) and implemented by the Eastern Nile Technical Regional Office (ENTRO) in Addis Ababa, Ethiopia. Funding for ENSAP accrues from Eastern Nile countries and varied bilateral and multilateral development partners.

1.1.2 Integrated Development of the Eastern Nile (IDEN)

The Eastern Nile Technical Regional Office (ENTRO), established by the Eastern Nile Council of Ministers (ENCOM) of water affairs in the Eastern Nile countries, is responsible for managing the Eastern Nile Subsidiary Action Program (ENSAP), whose overall objective is the cooperative development of the water resources of the Eastern Nile Basin, which include the Baro-Akobo-Sobat River Basin, in a sustainable and equitable manner to ensure prosperity, security, and peace for all its peoples.

In pursuit of this objective, ENTRO has formulated the **Integrated Development of the Eastern Nile (IDEN)** as a suite of integrated development projects including hydropower, irrigation and drainage, flood control, watershed management, and water resources management. Because of its regional water and land resources potentials and the role it can play in regional peace, stability and security, the Baro-Akobo-Sobat Multipurpose Water Resources Development Study Project became one of the seven (7) projects identified in the IDEN.

The objective of the IDEN Project is to initiate a regional, integrated, multipurpose development project through a first set of investments that confer tangible, win-win gains and demonstrate joint action between the Eastern Nile countries.

1.1.3 Baro-Akobo-Sobat sub-basin

The location of the Baro-Akobo-Sobat sub-basin with respect to the Eastern Nile and the whole Nile Basin is shown in Figure 1-1.

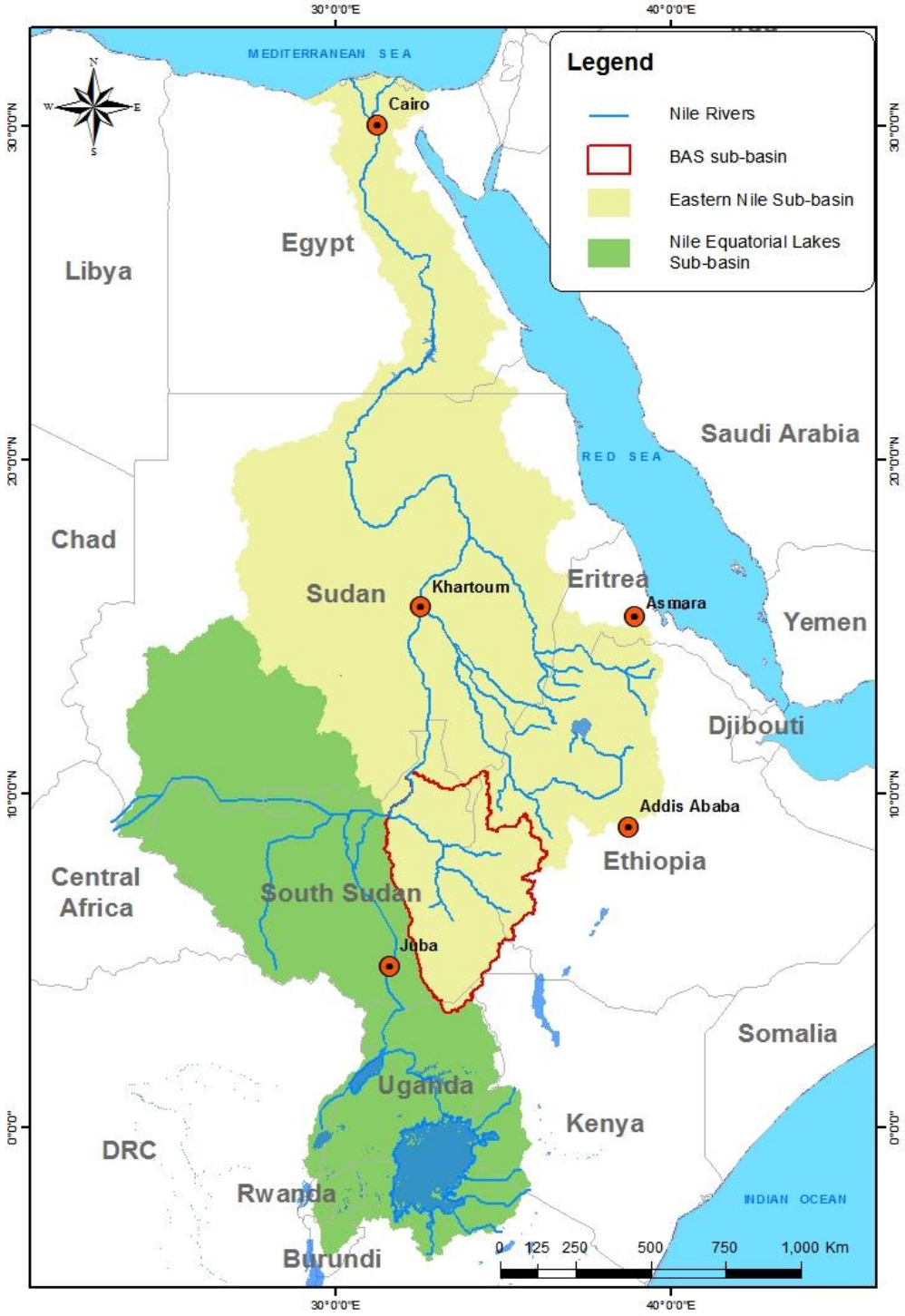


Figure 1-1: Location of the Baro-Akobo-Sobat sub-basin within the Nile Basin

The Baro-Akabo-Sobat sub-basin, with its catchment area of more than 205,000 km2, consists the Baro, the Akobo and the Pibor rivers. The Baro River originates in the highlands of Ethiopia (2,000 – 3,500 masl); from the eastern parts of BAS sub-basin, draining west wards through Gambella plain (450 masl) into the Republic of South Sudan. The Pibor River with its tributaries originates from the Imatong Mountains in Eastern Equatoria state Republic of South Sudan, draining northwest through grassy flat plain. The Pibor is joined on its way by the Akobo, Gilo and Alwero Rivers originating from the Ethiopian highlands. Pibor River continued its northwest flow direction; at the confluence of Pibor and Baro Rivers the Sobat River is formed.

The seasonal rainfall pattern and large flat areas have resulted in the formation of many wetlands that have been a defining influence on the activities of the people of the sub-basin. The *Machar marshes* are located north of the Baro River upstream of its confluence with the Pibor River. This wetland system in a depression has a hydrology primarily driven by evaporation and local rainfall. Hurst, 1950 and the Jonglei Investigation Team (1954) followed by the work of El-Hemry & Eagleson (1980) and Sutcliffe (1993) revealed that the hydrology of Sobat River after Baro is characterized by over bank spills into the *Machar marshes* and other wetlands on the western Bank. The seasonal stream of Adar at the northern end of the *Machar marshes*, flows through extended grassy flat plains and would appear to be the only channel connecting the marshes to the White Nile, although it is not gauged.

The mean annual flow of the Baro River at Gambella is around 12.4 billion m^3 (1980-2000). In its lower course, the flow spills and a large amount of spillage enters the *Machar marshes*. Annual spillage is estimated to be in excess of 3 billion m^3 (1980-2000) and the mean annual flow is recorded to be 9.53 billion m^3 (1905-1955) at the mouth of the Baro River. Once contributions from the Pibor, Akobo, Gilo and Alwero Rivers are taken into account the average annual inflow of the Sobat River at the Doleib hill located upstream of Malakal is estimated to be 13.687 billion m^3 (1905-1955). It should be noted that these figures come from the literature and are quoted in order to provide context. During the course of this study the hydrology will be investigated in detail which may result in some revisions to these estimates.

Rain fed crop cultivation is the principal livelihood activity in most of the basin where adequate rainfall is available. The economy, which is largely based on traditional cultivation methods, is subsistence oriented. Production is dominated by cultivating crops such as maize and sorghum for local consumption. The lowland population practise shifting cultivation, mainly for growing sorghum. In South Sudan more than 95% of households are categorized as subsistence-level rain-fed farmers cultivating small areas using simple manual agriculture implements.

In the semi-arid to arid areas of the sub-basin pastoral livestock becomes predominant. Livestock as a source of livelihood is more important for the South Sudan side of the basin where there is a high concentration of cattle, sheep, and goats. The main livelihood strategies in the sub-basin are therefore a combination of crop and livestock production followed by 'crop only' farming and 'livestock only' production.

Farm employment (combining crop and livestock production) constitutes the primary form of employment for the population. The communities in the sub-basin basin (both in Ethiopia and Sudan) appear to have very limited experience in accessing cash income due to the remoteness and inaccessibility of the region from regional market centres

Fishing is also an important component of the livelihood strategies of communities that live along the rivers and wetlands in the sub-basin. The Baro-Akobo-Sobat sub-basin has a high potential for flood plain **aquaculture**, but lacks efficient aquaculture technologies.

Overall, there is a dearth of infrastructure in the sub-basin, specifically in terms of road networks, water supply and sanitation facilities, health and education services, provision of credit and extension services. Research undertaken in the western part of the basin indicates that there is a wide spread poverty and high levels of vulnerability.

The high rainfall, fertile lands, and rivers of the basin offer significant potential for agricultural growth. The potential for large-scale hydropower development has already been identified in the highland areas of the basin in Ethiopia.

1.2 STUDY OVERVIEW

1.2.1 Objectives

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 Consultant has taken note of the following 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, 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.

1.2.2 Main Steps

The study is both complex and challenging. It is complex because there is clearly a need for development to support social upliftment and there are the land and water resources to support this. At the same time, most of the environmentally sensitive areas are downstream of these potential developments and could be irreversibly impacted if development is not well planned and, once implemented, well monitored. It is especially challenging because there is a dearth of the critical data that is really required to the necessary planning. There are a lack of historical hydrological data and an absence of operational surface water river gauging stations in the areas of the system where the hydrology is most complex. To complicate matters further, access to the parts of the basin where knowledge is particularly limited (*Machar marshes* and other wetlands in South Sudan) is very limited due to the unfavourable security situation. The Consultant proposes to mitigate both this complexity and the challenges through the use of remote sensing and associated modelling techniques.

A simplified flow chart presented in

Figure 1-2 provides an overview of the main steps of the study.

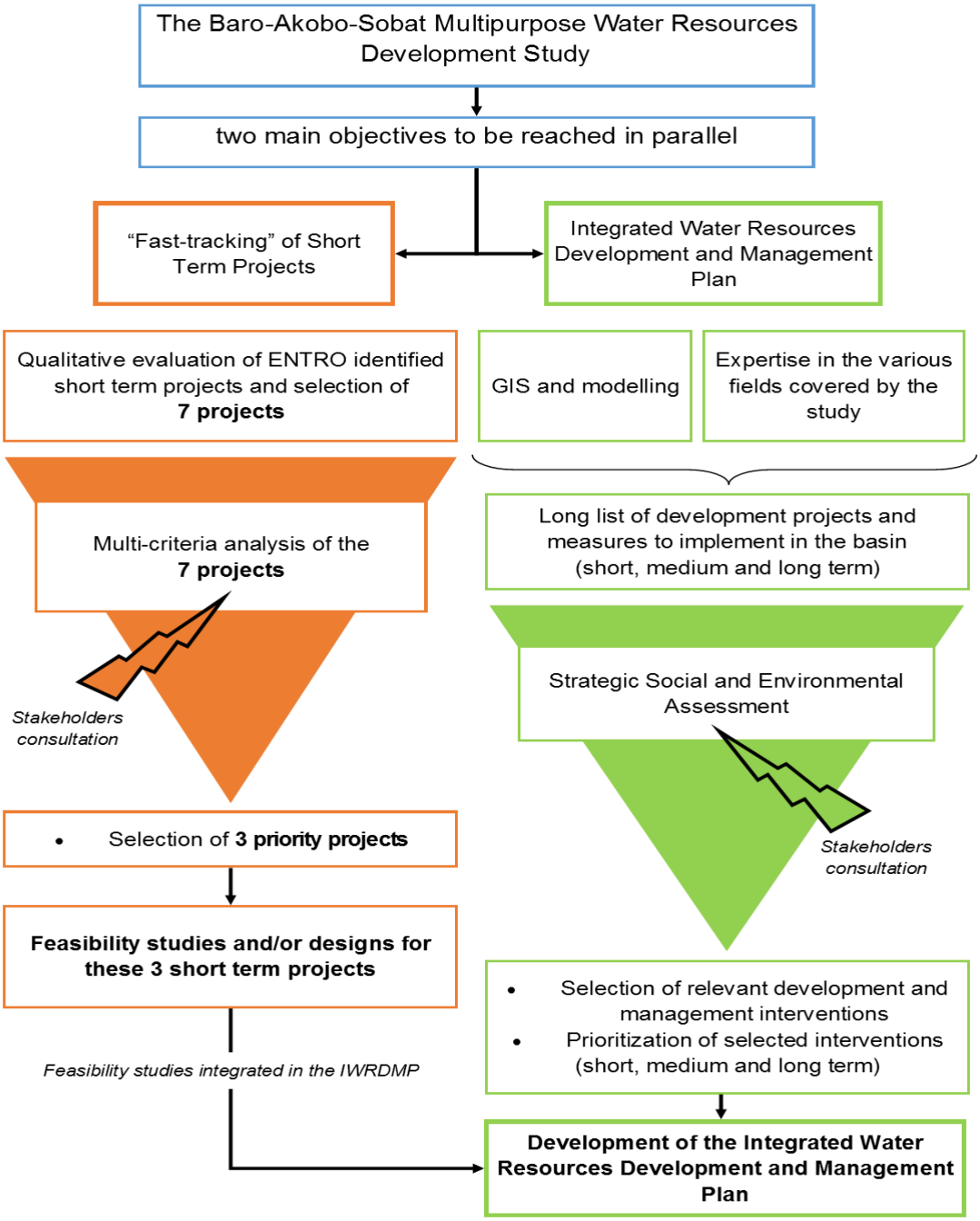


Figure 1-2: Flow chart showing key steps of the study

1.2.3 Central role of the SSEA

Since the SSEA activities were launched during the scoping phase, we provide hereafter a specific overview of the SSEA objectives and steps.

1.2.3.1 Purpose of the SSEA

The Environmental and Social Assessment Procedures for African Development Bank's Public Sector Operations (June 2001)[2] describes the objectives of the SSEA as follows:

"Strategic Social and Environmental Assessment (SSEA) is a process that promotes the inclusion of environmental and social considerations upstream in policy-making and planning. It is an instrument that assesses environmental and social influences associated with a proposed policy, strategy, plan, or program, particularly those targeting a specific region or a sector. By assessing, social, economic, environmental, and institutional impacts associated with potential development options, it facilitates screening out inappropriate or unacceptable projects at an early stage, thus, minimizing the risk that projects would have encountered due to environmental and social inappropriateness (…)

A sectoral or regional Environmental and Social Assessment (ESA) shall be carried out to evaluate the likely environmental and social consequences of a proposed sector-wide or region-wide plan or program. The plan or program may be related to a sector such as water and sanitation, energy, transport, etc. or it might be related to a geographical area or region. The main benefit of a sectoral or regional ESA is that it allows for the consideration of more far-ranging and cumulative impacts and broader types of alternatives than provided by a projects specific ESA. Sectoral or regional ESAs can facilitate the preparation of project-specific ESAs at later stages of development.

A sectoral ESA focuses on the design or strengthening of an institutional and regulatory framework for carrying out environmental or social responsibilities. It generally assesses the major impacts of concern in the sector as a whole and prescribes standard approaches to project design and mitigation. In so doing it reduces the scope of work for individual project-specific ESAs. A regional ESA on the other hand examines the cumulative effects of multiple activities in a specified region. The activities may be ongoing, planned or anticipated in the future. Regional ESAs help to define priorities and options."

For information, the content and structure of a SSEA report can be summarized as in the figure below.

[2] Latest version (2015) Environmental and Social Assessment Procedures for African Development Bank's Public Sector Operations was recently received. And is not yet fully reflected in this section.

Figure 1-3: SESA report content

Project Title:	Project Number:
Country:	Department:
Division:	Project Category:
Summary:	
Introduction:	
Scoping:	
Definition of the Proposed Program-Based Operation / Regional or Sector Loan / Program Operation:	
Alternative Options Considered:	
Situation Analysis/Baseline:	
Evaluation of the Environmental and Social Impacts of Options and Conclusions Regarding their Significance:	
Results of the Comparison of Alternatives:	
Expected Residual Effects:	
Summary of Stakeholder Engagement :	
ESMP, including Management Measures, Actions, Roles and Responsibilities, Timeframes, Monitoring and Cost of Implementation.	
Institutional Capacities and Strengthening Plan:	
Annexes:	

Source: General Guidance on Implementation of OS 1, African Development Bank, 2014

1.2.3.2 Main steps of the SSEA

The key steps[3] to be undertaken while conducting a SSEA are the following:

- Scoping;
- Stakeholder identification and engagement;
- Program-Based Operations definition;
- Baseline definition;
- Environmental and social assessment;
- Management options and institutional measures;
- Preparation of an Environmental and Social Management Plan (ESMP)

1.3 THE SCOPING EXERCISE

1.3.1 Methodology

The scoping exercise is aimed at determining the relevant information ***to be*** collected **to complete the baseline** in order to determine the "key issues and potentials related to water resource development and management in the river basin"[4]

[3] This section will be updated soon with to the latest recommendations provided by the version (2015) of the Environmental and Social Assessment Procedures for African Development Bank's Public Sector Operations.

[4] The baseline report comprises i) baseline, ii) key issues, iii) development potentials and iv) management/development objectives

The objectives of the scoping exercise are shown in Figure 1-4.

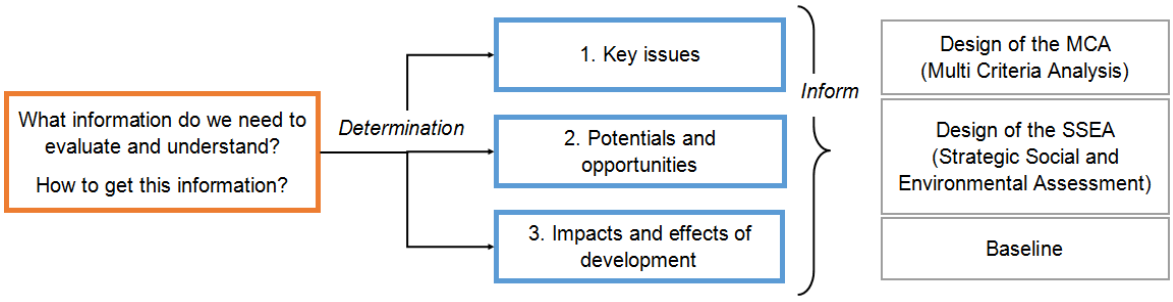


Figure 1-4: Objectives of the Scoping Exercise

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 resources basinwide. For this reason the baseline (and hence the scoping exercise) has to be 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. The challenge here is that many projects/interventions are yet to be identified so - **how to know where to do the baseline work?** Our approach to the baseline and the related scoping at the intervention/project level will be as follows:

  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 should therefore be focused on these two areas. For a), the already identified projects it is clear. It is important that all projects are inventoried. This is a **clear goal** and output of the scoping exercise. For b), we need to identify both areas of need and potential (opportunity). The focus (need or opportunity) will depend on the sector or thematic area. For example:
  - Hydropower – based on potential
  - Interconnection/transmission – need (and opportunity)
  - Water supply – based on need (for human and livestock)
  - Irrigation – large-scale is mainly on potential. Small-scale on need and/or potential
  - Fisheries – capture fisheries mainly on potential; aquaculture need and potential
  - Tourism – mainly potential
  - Etc.

The methodology for the scoping exercise at project level is shown in Figure 1-5. It is important to remember that the scoping exercise will also be realised at basin level in order to define the limits of the study and that application of the SSEA at the project level has to fit within the basin-wide context and limits.

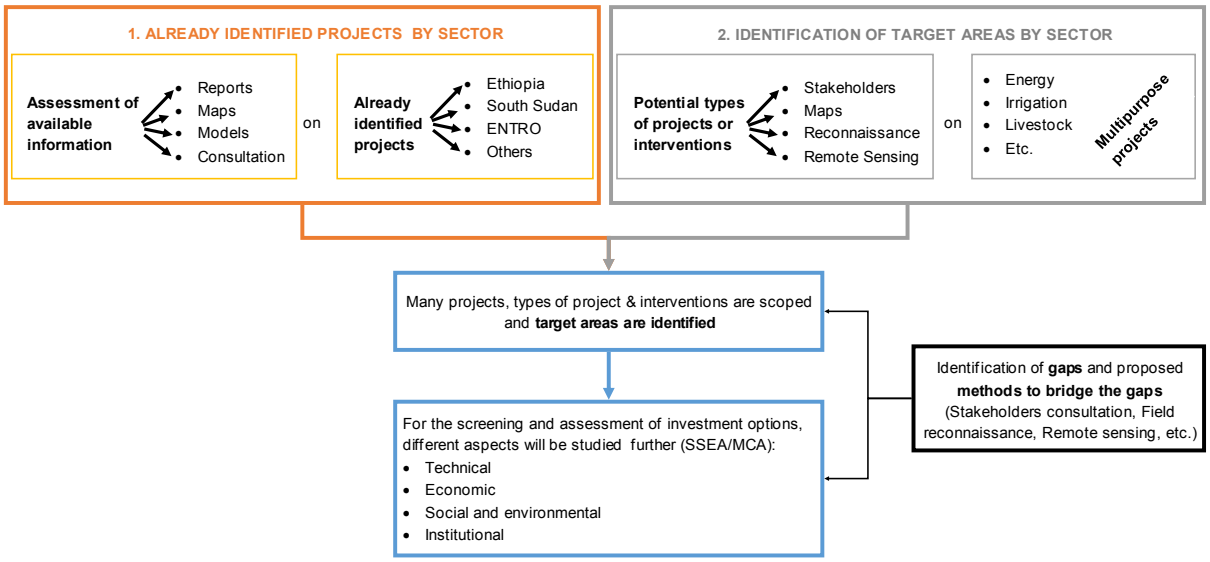


Figure 1-5: Methodology for the Scoping exercise at project level

In conclusion, it is important to stress that the scoping exercise is **not about the actual collection of this information but getting clarity on what information should be collected and how it will be (is being) achieved**. Thus, the two main objectives of the scoping report are the following:

- Clear definition of the work to be carried out in the baseline and for the SSEA
- Assessment of information available, identification of gaps and implications, suggestions for mitigating critical gaps.

1.3.2 Scoping and the SSEA

In the baseline, certain information has to be collected, especially for the SSEA. To do so, it is important to evaluate **how the baseline** will inform the SSEA. The role of the scoping exercise is to answer the following questions:

- What information will be required during the baseline phase in order to feed into the SSEA framework?
- What are the limits of the SSEA?

This must be done at project level and at the basin wide level.

More specifically, for the SSEA, the scoping phase should provide information concerning:

- Key environmental and social priorities to be integrated into the IWRDMP design and objectives (see section 3.1);
- The existing institutional mechanisms in place (see section 3.2);
- The potential linkages between the intended activities of the IWRDMP and environmental and social resources (see section 3.3);
- The potential for intended activities to cause impacts on sensitive environmental components and vulnerable social groups (see sections 3.3 and 4.4).

1.4 THIS REPORT

This Chapter, Chapter 1 of the report has provided the context to the project and the role of the Scoping Exercise within the overall study, as well as how the scoping exercise has been carried out in order to reach its objectives.

The purpose of Chapter 2 is to review the various sources of information. These sources have been, divided into two parts, although there is clearly an overlap between the two:

- **Documentation** such as previous and ongoing studies. This review has been carried out along thematic and sectoral lines and
- **Existing data**. The available data, both numeric and spatial are reviewed in this part of the chapter. In line with the general methodology that has been applied for the Scoping Report, for each thematic/sectoral area the purpose for which the data are required is first stated and then, with this in mind, the availability of the data and data gaps are assessed.

As is explained in the methodology the scoping exercise has been carried out at two levels, at the basinwide level and at the individual/sectoral level. Chapter 3 presents the results of the scoping exercise at the basinwide level.

Chapter 4 presents the results of the scoping exercise at the sectoral level and focusses on the identification of planned and potential interventions within in each sector. Although a sectoral approach has been used, the potential for multipurpose interventions is also considered.

2. SOURCES OF INFORMATION

2.1 INTRODUCTION

This chapter provides an overview/details of the information sources that have been used to do the scoping exercise and which are seen as **key documentation/sources of information** for the baseline.

The various sources of information are used in two ways:

- In order **to write the scoping report**: Identification/listing of projects and identification of potential developments (by geographic area and/or need)
- Know what is in the documentation to help us complete the baseline

2.2 DETERMINATION OF THE RELEVANT INFORMATION PER SECTOR

2.2.1 Surface water hydrology

2.2.1.1 Bibliography relevant for the study

Since the 1980s, various studies which are relevant to the surface water resources of the Baro-Akobo-Sobat Basin have been conducted, either as part of Nile Basin studies, country specific master plan studies, feasibility level studies, or other specific hydrological, transboundary and modelling studies.

The list of documents which are relevant to the surface water hydrology component of this Study include (in chronological order):

- Shahin, Hydrology of the Nile Basin, 1985
- Selkhozpromexport, Baro-Akobo basin master plan study of water and land resources of the Gambella Plain (Annex 1: Climatology and hydrology), 1990
- Ardco-Geoserv, Survey and analysis of the upper Baro-Akobo-Sobat Basin: Final report, Volume II: Water resources, 1995
- TAMS-ULG, Baro-Akobo River Basin integrated development master plan study, Annex 1: Water resources , 1997
- Sutcliffe & Parks, The hydrology of the Nile, 1999
- Norplan, Norconsult, & Lahmeyer, Baro 1 & 2 Multipurpose Projects: Feasibility Study, 2006.
- ENTRO, Multi-purpose development of the Eastern Nile, One-System Inventory Report on Water resource related data and information: Ethiopia , 2006
- ENTRO, Multi-purpose development of the Eastern Nile, One-System Inventory Report on Water resource related data and information: Sudan , 2006
- ENTRO, Multi-purpose development of the Eastern Nile, One-System Inventory: Water Atlas of the Baro-Akobo-Sobat and White Nile Sub-basin, 2007
- ENTRO, ENWMP Cooperative regional assessment (cooperative regional assessment) for watershed management: Transboundary analysis: Baro-Sobat-White Nile sub-basin, 2007
- ENTRO, Multi-purpose development of the Eastern Nile, One-System Inventory Annex 1: Baro-Akobo-Sobat and White Nile Sub-basin , 2008

- ENTRO, Baro-Akobo-Sobat and White Nile Multipurpose Water Resource Development Study Project: Project baseline information, 2009
- Mohamed, The hydrological study of the Baro-Akobo-Sobat basin, 2011
- ENTRO, Baro-Akobo-Sobat Multipurpose Water Resource Development Study: Knowledge Base Development for BAS: Hydraulics Draft Final Report by Dr KE Bashar, 2011
- ENSAP & ENTRO, Baro-Akobo-Sobat Wetlands Knowledge Base Consultancy. Draft report, 2012
- Nile Basin Initiative, Data compilation and Pilot Application of the Nile Basin Decision Support System, 2012
- SMEC, Water Resources Assessment Study, Torit, Eastern Equatoria State, Ministry of Water Resources and Irrigation, South Sudan, 2012)
- Nile Basin Initiative, Design Report: Needs Assessment and Design of a Regional Nile Basin Hydromet Services and a National Water Resources Monitoring System for South Sudan, 2014
- Nile Basin Initiative, Compiling, processing and quality assuring hydro-meteorological data for the Nile Basin Initiative, 2014
- Thoan, BAS Compiled Report, Thoan, 2014
- ENSAP, Eastern Nile Multi-Sectoral Investment Opportunity Analysis, 2014

2.2.1.2 Assessment of the information currently available in reports

A brief review of each document, emphasizing its importance for this Study is presented as follows:

Shahin, Hydrology of the Nile Basin, 1985

This report is a comprehensive source of information on the hydrology of the Nile Basin. It describes and quantifies the key components of the hydrological cycle in the Nile Basin and analyses the water balance based on recorded data and by means of analytical methods. Information is provided on a sub-basin basis. Key aspects which are addressed include the physiography of the basin, the climate, precipitation, evaporation and evapotranspiration, geology, geohydrology, surface water runoff, water storage and conservation, control works and environmental impacts.

Selkhozpromexport, Baro-Akobo basin master plan study of water and land resources of the Gambella Plain (Annex 1: Climatology and hydrology), 1990

This master plan study covered the lower area of the Baro-Akobo-Sobat Basin in Ethiopia up to the 500 m contour level. It entailed reconnaissance surveys, field studies on soils, and hydrological, geological and hydro-geological field surveys. The report assessed the condition in the basin in terms of climate, hydrology, geohydrology, geology, soils, fish and fauna. The potential for irrigation, rainfed agriculture, forestry as well as hydropower schemes were identified and economic analyses were undertaken. The hydrological analysis addressed the spatial and temporal distribution of runoff based on observed records and correlations between flow records, as well as the probability of flooding and sedimentation.

Ardco-Geoserv, Survey and analysis of the upper Baro-Akobo-Sobat Basin: Final report, Volume II: Water resources, 1995

This study investigated the part of the Baro-Akobo-Sobat Basin which was not covered by the Selkhozpromexport (1990) study. However, this study was not as comprehensive as the Selkhozpromexport study in terms of data collection and interpretation. Errors and data anomalies have also been uncovered.

TAMS-ULG, Baro-Akobo River Basin integrated development master plan study, Annex 1: Water resources, 1997

This comprehensive study covered the Ethiopian part of the Baro-Akobo-Sobat Basin and involved an assessment of the development potential related to water, natural and social resources. The study built on available data and previous studies and provides a detailed overview of the water resources in the basin. Specific aspects which are covered include climatology, surface water hydrology and monitoring, floods, groundwater, dam operation and sedimentation. The study investigated specific development options (irrigation and hydropower) within the basin as well as water supply schemes at pre-feasibility level.

Sutcliffe and parks, the Hydrology of the Nile, 1999

This report provides an overview of the Nile Basin surface water hydrology in terms of the drainage network, early studies, the hydrometric network, water balance calculations, land use and climate and the operation of existing dams. It includes a chapter on the Baro-Akobo-Sobat Basin and provides a detailed analysis of the water balance of the *Machar marshes*, while the links and spills between different rivers and channels on the Gambella Plains are also described.

Norplan, Norconsult, & Lahmeyer, Baro 1 & 2 Multipurpose Projects: Feasibility Study, 2006

The objective of this study was to produce a bankable document based on the analysis of all the important aspects required for the formal approval of the Baro 1 and 2 hydropower projects, including the Genji hydropower scheme. It addressed all relevant baseline investigations, including hydrological and climatological assessments, and provides plans, drawings and cost estimates regarding technical, economic/ financial, environmental, and socio-economic aspects.

ENTRO, Multi-purpose development of the Eastern Nile, One-System Inventory Report on Water resource related data and information: Ethiopia, 2006

This report compiled information on water resources and focused on the Ethiopian part of the Eastern Nile sub-basins. The report discussed proposed projects, including hydropower and irrigation projects. The data collected in this report will be used to support the identification and analysis of multipurpose development opportunities under the Eastern Nile Multipurpose Development Program. The report provides limited rainfall, sedimentation and runoff data within the Baro-Akobo-Sobat sub-basin.

ENTRO, Multi-purpose development of the Eastern Nile, One-System Inventory Report on Water resource related data and information: Ethiopia, 2006

This report compiled information on water resources and focused on the Sudan part of the Eastern Nile sub-basins. The report discussed proposed projects within the Sudanese sub-basins, including hydropower and irrigation projects. The data collected in this report will be used to support the identification and analysis of multipurpose development opportunities under the Eastern Nile Multipurpose Development Program. The report provides limited rainfall, evaporation, sedimentation and discharge data for Sudan.

ENTRO, ENWMP Cooperative Regional Assessment (CRA) For Watershed Management: Transboundary Analysis: Baro-Sobat-White Nile Sub-Basin, 2007

This report comprised an integrated, cross border analysis of the watershed system in the Baro-Sobat-White Nile sub-basin in order to identify the main characteristics and challenges in the basin and the opportunities and benefits of cooperation in watershed management. The report describes the bio-physical as well as socio-economical, agricultural forestry, biodiversity and transport characteristics of the basin. It highlights specific watershed management issues and provides a synthesis of opportunities and potential for development.

ENTRO, Multi-purpose development of the Eastern Nile, One-System Inventory: Water Atlas of the Baro-Akobo-Sobat and White Nile Sub-basin, 2007

To support its multipurpose development objectives, ENTRO began an exercise in 2006 to create a One System Inventory (OSI) to support the planning of the Joint Multipurpose Program (JMP). The OSI was to be a regional knowledge base across the three EN countries, initially focused on three themes: water resources, socio-economic and environmental issues. This information was expected to be useful for decision-makers and senior program and project coordinators at ENTRO to write terms of reference for new studies in the Inception Phase of the JMP and to aid the literature survey of these studies. The atlas provides maps, charts and tables related to land surface features, climate, land use, soils, geology, vegetation, hydrology, infrastructure, utilities and the environment.

ENTRO, Multi-purpose development of the Eastern Nile, One-System Inventory Annex 1: Baro-Akobo-Sobat and White Nile Sub-basin, 2008

This report contains information on the Baro-Akobo-Sobat-White Nile basin, including socio-economic characteristics, hydrological and water infrastructure, environmental issues and water management opportunities. The hydrological study includes rivers and marshes, runoff, dams and reservoirs, hydropower and water balance. The report provides useful information on the Baro-Akobo and Pibor-Sobat systems, as well as the *Machar marshes*.

ENTRO, Baro-Akobo-Sobat and White Nile Multipurpose Water Resource Development Study Project: Project baseline information, 2009

This report summarises available baseline information on the Baro-Akobo-Sobat and White Nile sub-basins, including relevant maps and tables. Specific categories which are addressed include hydrology, climate, drainage patterns, ground water, flooding, irrigation, hydropower potential, navigation, livelihoods and natural resources, environmental and social issues and institutional arrangements.

ENTRO, Baro-Akobo-Sobat Multipurpose Water Resource Development Study: Knowledge Base Development for BAS: Hydraulics Draft Final Report by Dr KE Bashar, 2011

The report included a desktop review of available data with regard to the hydrometric network, subcatchments and the drainage network within the basin. Field work was also conducted to identify water resources management and development issues and challenges and to assess the environmental and physiographical status of the basin, which are described in the report.

Mohamed, the Hydrological Study of the Baro-Akobo-Sobat Basin, 2011

This study investigated the hydrology and gauging system of the Baro-Akobo-Sobat Basin. A SWAT model was developed for rainfall runoff computation using public domain datasets. The main objectives were to assess the availability of remotely sensed and global data, to build and calibrate a hydrological SWAT model for the BAS basin and to derive hydrological conclusions from the model. The report provides useful information on the BAS river network as well as the available meteorological and hydrological stations and associated datasets.

ENSAP & ENTRO, Baro-Akobo-Sobat Wetlands Knowledge Base Consultancy. Draft report, 2012

The main objective of this study was to consolidate the knowledge and available information on the Baro-Akobo-Sobat wetlands. A gap analysis was also undertaken to develop a proposal for future work to fill knowledge and information gaps. The report describes the main river network in the basin and provides estimates of runoff volumes and monthly rainfall depths at key locations. It provides an ecological assessment, a wetlands inventory, maps and descriptive information on wetlands in the basin and summarises proposed developments.

Nile Basin Initiative, Data compilation and Pilot Application of the Nile Basin Decision Support System, 2012

The purpose of this report was to document and assess datasets collected for hydrological modelling of the Nile Basin as well as for quantifying environmental, socio-economic and macro-economic indicators that were selected for Pilot Case scenario evaluation. The data included water infrastructure, land use and cover, topography, meteorological data, hydrological data, groundwater, demographics, vegetation, economics and malaria endemicity. This baseline data was used to derive drainage networks, sub-catchments, dam footprints and irrigation scheme footprints. Temporal datasets were also derived for catchment rainfall, evaporation, climate change and runoff sequences. The report provides useful information on the availability, source and quality of the aforementioned data within the Baro-Akobo-Sobat basin.

SMEC, Water Resources Assessment Study, Torit, Eastern Equatoria State, Ministry of Water Resources and Irrigation, South Sudan, 2012)

The objective of this project was to assess technically viable, economically feasible and environmentally sound interventions for rehabilitating or providing new water supply and sanitation services in Bentiu, Bor and Torit. The study included the collection of hydrogeological data, aquifer pump-out tests, water sample analysis, surface water resource assessment using catchment modelling as well as groundwater resource assessment. Torit, located on the northern bank of the Keneti River, is included in the Baro-Akobo-Sobat project boundary. This report provides useful information on rainfall, evapotranspiration, and runoff and water quality at Torit.

Thoan, BAS Compiled Report, Thoan, 2014

The main objective of this study was to assess flood inundation extents and vulnerabilities in the Baro-Akobo-Sobat Basin and to develop a flood forecasting tool using a combination of GFT, hydrologic (HEC-HMS) and hydrodynamic (HEC-RAS) models and global datasets. The report also provides useful information on historically flood prone areas in the Gambella plains and South Sudan.

ENSAP, Eastern Nile Multi-Sectoral Investment Opportunity Analysis, 2014

The EN-MSIOA study was one of several specific studies undertaken to achieve the general objective of the NCORE from the Eastern Nile perspective. The overall objective was to develop a regional water investment strategy for the EN region that broadly supports socio-economic development, poverty reduction, and the reversal of environmental degradation. The study was divided into four main tasks: Inventory and Situation Analysis; Strategic Scoping of EN Multi-Sectoral Investments; Multi-Sectoral Analysis of Investment Opportunities; and MSIOA Final Products. Key deliverables included a Situation Analysis Report; a Strategic Investment Scoping Report; a Multi-Sectoral Investment Scenario Analysis Report; and a final MSIOA Report with Investment Profiles for selected projects, an Implementation Strategy and an Action Plan. The set of reports provide useful information on catchment characteristics and water resources, existing and planned water resources development projects, and the results of scenario evaluations using water balance (MIKE Basin) and economic assessment tools which have been developed as part of the project.

Nile Basin Initiative, Design Report: Needs Assessment and Design of a Regional Nile Basin Hydromet Services and a National Water Resources Monitoring System for South Sudan, 2014

This recent project aimed to develop design specifications and an implementation plan for the Nile Basin Regional hydro-meteorological monitoring system, including a national water resources monitoring system for South Sudan. Its objective was to enhance Nile River Basin monitoring by addressing coverage, equipment, techniques, data acquisition and dissemination, sampling and testing, standard procedures, capacity development, cost estimates, and implementation planning. The report addressed the design of a Nile Basin regional hydro-meteorological monitoring network based on needs and requirements for the sustainable management and development of the shared Nile Basin water resources and provided an implementation plan for a systematic and expedited implementation of the monitoring network. Specific attention was given to the design of a hydro-meteorological network for South Sudan.

Nile Basin Initiative, Compiling, processing and quality assuring hydro-meteorological data for the Nile Basin Initiative, 2014

This project entailed a review of the available rainfall and flow data in the Nile Basin, quality control and the improvement of the data by means of gap filling. This entailed preparing and compiling available data, undertaking data quality assurance, gap filling, preparing meta-data and delivering quality assured datasets at key rainfall and flow gauging stations in the Basin.

2.2.2 Water Quality

2.2.2.1 Bibliography relevant for the study

The list of documents which are relevant to the water quality (including sediment) component of this Study include (in chronological order):

- Selkhozpromexport, Baro-Akobo basin master plan study of water and land resources of the Gambella Plain (Annex 1: Climatology and hydrology), 1990
- TAMS-ULG, Baro-Akobo River Basin integrated development master plan study, Annex 1: Water resources , 1997
- Merid, National Nile Basin Water Quality Monitoring Baseline Report for Ethiopia. Nile Basin Initiative (NBI), Transboundary Environmental Action Project, 2005
- NBI, National Nile Basin Water Quality Monitoring Baseline Report for Sudan. Transboundary Environmental Action Project, 2005
- Norplan, Norconsult, & Lahmeyer, Baro 1 & 2 Multipurpose Projects: Feasibility Study, 2006
- ENTRO, The Baro-Akobo-Sobat and While Nile sub-basin: Annexe to the One System Inventory prepared by ENTRO, 2007
- UNESCO, Sediment in the Nile River System by Dr AA Ahmed, 2008
- ENTRO, Baro-Akobo-Sobat and White Nile Multipurpose Water Resource Development Study Project: Project Baseline Information, 2009

2.2.2.2 Assessment of the information currently available in reports

A brief review of each document, emphasizing its importance for this Study is presented as follows:

Selkhozpromexport, Baro-Akobo Basin Master Plan Study of Water and Land Resources of the Gambella Plain, 1990

Water quality of some 95 water samples were collected during the BAS Master Plan Study from 1986 to 1988. The samples were collected mainly at gauging stations depending on the availability of flow at the sites. This report analysed the water samples for 18 constituents and the raw data are tabulated in Appendix III of the Master Plan Report. As part of the study, sediment sampling was also conducted at five gauging station locations in the Baro, Alwero, Chiru and Gilo rivers within the basin between 1986 and 1988, measuring suspended sediment concentrations and grain size composition of suspended and bed load sediments.

TAMS-ULG, Baro-Akobo River Basin Integrated Development Master Plan Study, 1997

This comprehensive study covered the Ethiopian part of the Baro-Akobo-Sobat Basin and involved an assessment of the development potential related to water, natural and social resources. The reports provide sediment transport data at eleven gauging stations in the Baro-Akobo-Sobat basin, collected between 1982 and 1990. The methodology for sample collection has not been reported. 101 measurements of suspended sediment loads are on record. Based on concurrent flow measurements, data at stations with sufficient data were used to derive sediment rating curves.

Merid, National Nile Basin Water Quality Monitoring Baseline Report for Ethiopia. Nile Basin Initiative (NBI), 2005

This report presented the surface and ground water quality status of the Nile Basin within Ethiopia. However, it was based on very limited data from previous master plan studies and data obtained from the MoWR database. Its main objectives were to asses water quality information, identify water quality data gaps, recommend water quality monitoring networks and identify potential pollution sources. The report expressed concern that the functions of water quality control and monitoring fell under different institutions and that some of the institutional problems included low attention being given to water quality management programs in the sector; inadequate or lack of qualified water quality management staff; insufficient allocation of financial resources to water quality monitoring interventions; inadequate water laboratory facilities for monitoring and surveillance activities; and very low or inadequate logistical support for water quality management activities. Specific locations for future water quality monitoring in the Baro-Akobo-Sobat Basin are identified in the report.

NBI, National Nile Basin Water Quality Monitoring Baseline Report for Sudan, 2005

This study reported on the status of water quality in the Sudan part of the Nile Basin. The report also dealt with water resources management, institutional and legal frameworks, water quality monitoring institutions and pollution risks. The water quality results (physical and chemical analyses results) of three regular sampling stations (Dongola, Soba and Malakal) were summarized and assessed in this report. The report concluded that "both the Nile water quality and the technical capacities of laboratories have deteriorated" but that highly qualified and experienced staff were available to implement a national plan for water quality monitoring. The report listed a number of institutions involved in monitoring, including the Ministry of Irrigation and Water Resources Ground Water and Wadis Directorate (GWWD).

Norplan, Norconsult & Lahmeyer, Baro 1 & 2 Multipurpose Projects: Feasibility Study, 2006

This report provides useful information on the water quality (both physical and chemical parameters) of the Baro River, Water quality was sampled at four locations during February 2005, namely in the Genji River, at the proposed Baro-1 and Baro-2 dam sites and in a nearby wetland area. The results were compared to water quality data from the neighbouring Geba catchment and previous measurements of the White Nile waters (Sinada and Karim, 1984). These datasets were analysed and compared to WHO standards.

ENTRO, the Baro-Akobo-Sobat and While Nile Sub-Basin: Annex to the One System Inventory, 2007

This report commented on water quality and water-related diseases in the Baro-Akobo-Sobat-White Nile Basin. The issues of oil extraction and water hyacinth infestation were discussed in terms of their environmental impact on the basin.

UNESCO, Sediment in the Nile River System by Dr A Ahmed, 2008

This report provides an overview of sediment in the Nile Basin at regional level. It was aimed at assessing and understanding the sedimentation processes within the Nile Basin, and the potential impacts on socio-economic development and the environment. It also provides practical guidelines for dealing with sedimentation from a water resources perspective. It does note, however, provide specific information for the Baro-Akobo-Sobat Basin.

ENTRO, Baro-Akobo-Sobat and White Nile Multipurpose Water Resource Development Study Project, Project Baseline Information, 2009

This report highlighted two main sources of water pollution in the Baro-Akobo-Sobat basin, namely river basin settlements and household dumping. The report also commented on groundwater sources, and the types and quality of the aquifers in the Baro-Akobo-Sobat basin.

2.2.3 Groundwater

2.2.3.1 Bibliography relevant for the study

In general, there are not many detailed and relevant studies that have been conducted in the study area and the availability of groundwater data is very limited. Regional context study documents containing groundwater information are those from the Ethiopian side of the project area. The master plan studies conducted between 1990 and 1996 are the main documents available for the Baro Akobo part of the project area. Regarding the Sobat portion of the study area no comprehensive study documents have been obtained thus far (besides brief literature retrieved from various sources). The main source of data/information is found to be the Ethiopian Ministry of Water, Irrigation and Energy (MoWIE) and the regional Water Bureaus and the South Sudan Ministry of Water Resources and Irrigation.

A list of the reports that contain information and data that will be of use is presented in Section 2.3.6 (Groundwater Data); the following four reports were found to contain key information and are briefly summarised in the next section:

- Baro Akobo Basin Master Plan Study of Water & Land Resources of the Gambella Plain, Final Report, Vol IV, Annex 2: Geomorphology, Geology and Hydrogeology, Selkhozpromexport, USSR, 1990.
- Preliminary Water Resources Development Master plan for Ethiopia, Vol. III, Annex A: Hydrology & Hydrogeology, WAPCOS, India, 1990
- Survey and analysis of The Upper Baro-Akobo Basin, Final Report, Volume II: Water resources. ARDCO-GEOSERVE, 1995
- Baro-Akobo River Basin Integrated Development Mast plan Project, Final report, Water Resources, Annex D: Groundwater, TAMS, ULG Consultants Ltd, Oct 1996
- Feasibility Studies, Detailed Designs And Technical Specifications For The Urban Water And Sanitation Facilities In The Three State Capitals Of Bentiu, Bor And Torit,

2.2.3.2 Assessment of the information currently available in reports

Baro Akobo Basin Master Plan Study of Water & Land Resources of the Gambela Plain, Final Report, Vol IV, Annex 2: Geomorphology, Geology and Hydrogeology, SELKHOZPROMEXPORT, USSR, 1990.

This report presents fairly detailed work on the geology and hydrogeology of the Baro Akobo portion of the study area and is based both on remote sensing and field data. It defines three unconfined aquifers and a confined aquifer. An attempt was made to quantify the groundwater resources using a water balance approach and a value of 1284 Mm^3/year was obtained although this is considered to be an over-estimate. Some key findings are summarised below:

- The aquifers are very extensive and can be used for water supply.
- Potential yields from high-yielding boreholes range from 3 to 20 l/s.
- Good prospects for water supply are within Gog basalts with anticipated operational yields of 1.5 to 7 l/s.
- The water bearing formations east (of the Precambrian deposits) seem least favourable with yields usually less than 0.2 l/s.
- Certain areas bear practically no water (e.g. the Oligocene-Miocene deposits east of Itang village and the Paleogene deposits of the Gilo Formation).
- Localised aquifers in recent alluvial deposit (e.g. extensive areas in the western part of the Gambella plain and narrow strips along the rivers), are low-yielding but can be used in places for local water supply through shallow, ~10 - 20m deep wells, which may be suitable for manual water lifting. These aquifers are vulnerable to pollution.
- There appears to be a general increase in yield from North to South.

- The optimum depth of operation wells are between 50 and 80m.
- The most reliable source of water supply is Alwero Formation composed of Pliocene deposits.
- In specific areas where artesian conditions prevail, there is potential for ~200m deep boreholes that may be able to supply ~20 l/s. These deeper waters are however likely to to be more mineralised (with high concentrations of certain elements like iron and manganese).

Preliminary Water Resources Development Master plan for Ethiopia, Vol. III, Annex A: Hydrology & Hydrogeology, WAPCOS, India, 1990

The then Ethiopian Valleys Development Authority (WRDA) undertook a study with the aim of developing a master plan for water resource development at a national level. The emphasis was on surface water resources. Due primarily to the limitations on the availability of adequate data, very little information was provided on groundwater resources. The groundwater resources of the Baro Akobo basin were however briefly described in the two physiographic divisions: 1) The Western highlands which consist predominantly of volcanic and igneous rocks with limited groundwater potential; 2) The outer lowlands which lie to the west of the western highlands (forming the Gambella plain), where aquifers are mostly weathered and fractured crystalline rocks.

Survey and analysis of The Upper Baro-Akobo Basin, Final Report, Volume II: Water resources. ARDCO-GEOSERV, 1995

This study was conducted by the then Water Resources Development Authority (WRDA) with the objective of assessing the groundwater resources of the Upper Baro-Akobo Basin. It included desk and field studies and limited exploratory drilling. The study concluded that there is high potential for large scale groundwater production in basaltic and granitic rocks, and that groundwater use is limited. From these observations, it is evident that there is good potential for groundwater development in this area.

The area was divided into five groundwater areas based primarily on geomorphologic, geological and structural factors, and the groundwater potential and possible drilling targets in these areas were described. The study also described the groundwater characteristics of individual hydrolithological units. Some pertinent points on these are summarised below:

- Precambrian rocks: Variable yield potential, but caution on potential for over-pumping.
- Aboko basalts: No significant groundwater potential.
- The Pre-Rift Volcanics: Variable potential; most promising are the Maji Flood Basalts.
- Mekonen Basalt: Potential for deep groundwater.
- Surma Basalt: Low potential.
- Denbi Dolo Trachytes and Basalts Flows: Very low potential.
- Hypabyssal Intrusive Rocks: Generally poor, but good potential where intruded by dykes.
- Tepi Basalt: High potential.
- Quaternary Deposits: High potential associated with alluvial fans and intermountain deposits.

Baro-Akobo River Basin Integrated Development Mastrplan Project, Final report, Water Resources, Annex D: Groundwater, TAMS, ULG Consultants Ltd, Oct 1996

Following the study by ARDCO-GEOSERVE (1995), the then Ministry of Water Resources launched an integrated master plan study for which groundwater was one of the components. The objective was to review and analyze existing groundwater information and if appropriate, formulate an implementation program for groundwater development.

The geology of the area was simplified and grouped into three units and a schematic geological section along the Ethiopian highlands towards South Sudan depicts the subsurface distribution of the geological units and the regional geomorphological profile. The geological units, from oldest to youngest, are:

i. Precambrian, meta igneous and metasedimentary rocks (Pi)
ii. Tertiary igneous rocks (Ti)
iii. Undifferentiated quaternary rocks (Q)

Possibly the most useful information is captured in the aquifer classification. Here four categories were developed with accompanying notes on groundwater potential (Table 2-1)

Table 2-1: Aquifer systems within the BAS basin

Aquifer system	Brief description
The Basement Complex Aquifer	Borehole and spring production ranges from less than 1 l/s to > 18 l/s, SWL ranges from 2 to 40m b.g.l., most of the springs yield <1 l/s.
The Holocene Alluvial Aquifer	Alluvium deposited along the alignment of river courses, generally perched, direct hydraulic continuity with the rivers, low permeability, well yields 01. to 1 l/s.
The Quaternary Lacu-Alluvial Aquifer	Ranges in depth to about 30m, low permeability (0.01 to 2.0 m/d), low productivity (0.01 to 0.5 l/s), phreatic water levels, range from surface to about 7m.
The Regional Aquifer	Include Plio-Quaternary sedimentary deposits continuing beneath the Gambella Plain and beyond the Ethio Sudan border, Transmissivity in sedimentary formation (120m2/d), test yield (0.01 to 2.5 l/s), water levels about 13.8 to 30.1m b.g.l.

The simplification of the geological and hydrogeological environments seems to have overlooked the role and importance of mapping the volcanic rocks as separate and independent unit. Instead it the volcanic were merged with the Basement complex. These two units have distinct characteristics both in terms of geology and hence hydrogeology, and ideally should be grouped separately.

Feasibility Studies, Detailed Designs And Technical Specifications For The Urban Water And Sanitation Facilities In The Three State Capitals Of Bentiu, Bor And Torit, Final Water Resources Assessment Study Report: Bor Town - Jonglei State, SMEC,2013

This is a document from the South Sudan Ministry of Water Resources and Irrigation. As the title implies it was conducted for urban water supply purposes. Though this volume is prepared particularly for Bor town, the information contained in the report has relevance in providing geological and hydrogeological information for southern Sudan. Therefore, it also gives good information on the Sobat part of the study area (Jonglei state). Since the work dealt with the three regional capital towns and beyond, the study covered several relevant topics: A review and assessment of relevant baseline water resources at a wider scale; the delineation of geological and hydrogeologial boundaries; a description of aquifer systems and hard rock boundaries; the updating of water balances; and estimates of aquifer systems' sustainable yields. The study combined both desk and field studies (including geophysical surveys). The findings and conclusions of the study from the review of the two reports (Bor and Torit Towns) have been briefly outlined below.

Hydrogeology

The main hydrogeological units described for the Sudd basin which covers about two third of the country are:

- **Nubian Formation:** The Nubian Formation forms an important hydrogeological unit in Sudan. Within South Sudan it is found in the west and north-west part of the Sudd Basin. The water bearing layers consist of coarse-grained sandstones which have relatively high transmissivities. It is dominated by arenaceous beds although siltstone, mudstone and limestone are also present. In the central western part of the Sudd Basin the Nubian Formation is overlain by Umm Ruwaba Formation aquifers. Permeability and transmissivity ranges from 0.5 to 30 m/day and 100 to 3 000 m^2/day respectively and water quality is generally considered fit for human consumption.
- **Umm Ruwaba Formation:** The Umm Ruwaba Formation which is dominant in the Bor area contains both vertically and horizontally variable permeability aquifers. The aquifers usually consist of confined sand and gravel layers (alluvial sediments) of substantial thickness and low to moderate permeability. The depth to water is around 10 metres and water salinity varies from 100 to over 5 000 mg/L TDS. Generally, groundwater quality is considered suitable for raw water supply. However there is variable hardness, and together with elevated iron and manganese concentrations, may pose a risk of scale formation and pipeline blockage in some areas such as Bor locality.
- **Recent alluvial deposits:** The alluvial deposits although of limited aerial extent are considered an important water source for villages. They generally have good water quality, high permeability, are unconfined, have a shallow water table of <10 metres, and are recharged each wet season.
- **Basement Complex rocks (lesser importance):** The Basement Complex rocks form an extensive hydrogeological unit in South Sudan covering approximately 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. Overlying the Basement Complex rocks is a mantle of clay and weathered basement with extensive laterite deposits. Groundwater supplies may be found within the laterites, although they are not considered reliable in the dry season.

The groundwater gradient within the Sudd Basin is towards the centre, and the basin, with respect to groundwater flow, may be closed. Artesian pressures are reported from within the basin centre where the Sudd Wetland, the largest wetland in Africa, is located.

Groundwater use

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 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 Bor, 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. 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.

2.2.4 Watershed Management

2.2.4.1 Bibliography relevant for the study

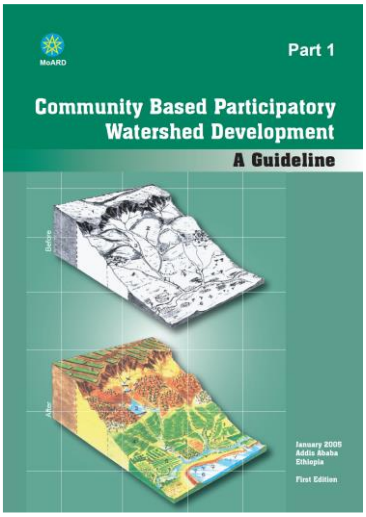
A list of bibliography relevant to the study is given below:

- Halcrow/ENTRO (2007) ENSAP. Watershed Management Project. Project Implementation Plan. Vol 1. Main Report.
- Halcrow/MoWR (2007), Awash River Basin Flood Control and Watershed Management Study Project, Baseline Report 3, Watershed Management.
- Halcrow-GIRD/MoWR (2008), Rift Valley Lakes Basin Integrated Resources Development Master Plan Study Project, Phase 1 Final Report, Part II Sector Assessments, Volume 7 – Environment, Annex B: Soil and Water Conservation and Watershed Management,
- Lakew Desta et al (2005) Community Based Participatory Watershed Development: Part 1. A Guideline, Part 2 Annex. Ministry of Agriculture and Rural Development. Addis Ababa, Ethiopia.
- http://www.slmethiopia.info.et/index.php/slm-knowledge/slm-publications and http://www.slmethiopia.info.et/index.php/download-center/viewcategory/18-gis-maps
- Tecsult/ENTRO (2006) Cooperative Regional Assessment (CRA) for Watershed Management. Transboundary Analysis, Final Country Report, Ethiopia.
- WFP - MERET (2002) Managing Environmental Resources to Enable Transitions to more Sustainable Livelihoods. Report of the WFP Appraisal Mission.
- WFP - MERET (2005) Report on the cost-benefit analysis and impact evaluation of soil and water conservation and forestry measures (draft).

Of these the Tecsult/ENTRO (2006) report and Lakew Desta et al (2005) are the most important and relevant, with the other documents providing background information and procedural guidance.

2.2.4.2 Assessment of the information currently available in reports

Lakew Desta et al (2005) Community Based Participatory Watershed Development: Part 1. A Guideline & Part 2 Annex.



The MoARD Guidelines are the basis for most soil and water conservation interventions and watershed management in Ethiopia and provide detailed information on the process of community engagement as well as technical information regarding a wide range of potential interventions. As well as a rationale and policies and strategies related to watershed management the guidelines outline the concepts and principles of Participatory Watershed development planning (PWDP) and guide a user through the planning procedures and steps. Part B provides information concerning watershed management interventions divided into:

- Physical Soil and Water Conservation
- Flood control and improved drainage
- Water Harvesting
- Soil F
- Fertility management and Biological Soil Conservation
- Agro-foresty, Forage Development and Forestry
- Gully Control
- Feeder Roads

For each intervention information is given regarding suitability by agro-ecological zone and land use, design and technical standards, work norms and planning and implementation arrangements. The

Annex describes survey methods, assesses intervention suitability and provides lists of useful plant species.

Tecsult/ENTRO (2006) Cooperative Regional Assessment (CRA) for Watershed Management. Transboundary Analysis, Final Country Report, Ethiopia.

The cooperative regional assessment is a comprehensive document and describes the bio-physical and socio-economic landscape of the Ethiopian part of the Nile Basin comprising the Abbay, Tekeze and Baro Akobo sub-basins. The document initially discusses the background to and definition of Watershed Management in the Ethiopian context and sets Watershed Management within the legal and policy framework and discusses the role of agriculture and forestry within the Eastern Nile Basin. For each sub-basin the biophysical (Climate, Geology, Soils, Land Cover / Land Use) characteristics, water resources and socio-economic characteristics (population, farming systems, social infrastructure, transport and markets) are discussed.

Following on from this the document introduces a wide ranging analysis of resource degradation and identifies suitable Watershed Management interventions. It finally looks at long-term capacity issues and monitoring needs. The report includes a large number of text maps, many of which have been used for illustration in the watershed management section of the scoping report.

Halcrow/MoWR (2007), Awash River Basin Flood Control And Watershed Management Study Project, Baseline Report 3, Watershed Management. & Halcrow-GIRD/MoWR (2008), Rift Valley Lakes Basin Integrated Resources Development Master Plan Study Project, Phase 1 Final Report, Part II Sector Assessments, Volume 7 – Environment, Annex B: Soil and Water Conservation and Watershed Management.

These two reports have been consulted in identifying approaches to the determination of soil erosion hazard assessment and in determining suitable criteria for use in targeting priority areas for watershed management interventions.

WFP - MERET (2002) Managing Environmental Resources to Enable Transitions to more Sustainable Livelihoods. Report of the WFP Appraisal Mission. & WFP - MERET (2005) Report on the cost-benefit analysis and impact evaluation of soil and water conservation and forestry measures (draft).

These two reports concern past watershed management approaches in Ethiopia with the 2005 report offering one of the very few economic analyses of soil and water conservation within wider watershed management.

http://www.slmethiopia.info.et/index.php/slm-knowledge/slm-publications and http://www.slmethiopia.info.et/index.php/download-center/viewcategory/18-gis-maps

These web pages inform concerning the current approach to Watershed Management in Ethiopia with the maps indicating the location of projects by regional state and woreda. This will help in identifying areas of intervention under the current project and in avoiding overlaps.

Halcrow/ENTRO (2007) ENSAP. Watershed Management Project. Project Implementation Plan. Vol 1. Main Report.

This report is a Project Implementation Plan for Watershed Management around Lake Tana. While not having direct relevance to BAS it shows the process of sub-basin to micro-watershed selection, potential soil and water conservation and watershed management interventions and the process of livelihood based project implementation.

2.2.1 Rainfed agriculture

2.2.1.1 Bibliography relevant for the study

- MoWR. (1997). Baro Akobo River Basin Integrated Development Master Plan Study, Vol. I, Vol. II, Annex 2A Land evaluation and Annex 1I Agricultural development. Addis Ababa, Ethiopia
- MAFCRD, Agriculture Sector Policy Framework 2012 – 2017
- MAFCRD, (2013) South Sudan Agricultural Sector Investment Plan
- MAFCRD, MLFI, MEDIWR, JICA. (2015) Comprehensive Agricultural Development Master Plan, Final draft
- MAFCRD, MLFI, MEDIWR, JICA (2015), Annex 1 of CAMP: CAMP Investment Plan
- MAFCRD, Situation Analysis Report 2013-2015 with the annexes and appendices
- National Bureau of Statistics (2009), *Baseline Household Survey*

2.2.1.2 Assessment of the information currently available in reports

TAMS-ULG. (1997). Baro Akobo River Basin Integrated Development Master Plan Study, Vol. I, Vol. II, Annex 2A, Annex 2B.

Annex 1I: Agricultural development

In a first step this report analysis data on climate, soils, cropping patterns, crops and irrigation. In a second step the government strategy concerning small holders, state farms and commercial farms is developed. This allowed to recommend “low-key” rural development, emphasizing (i) fertility improvement, (ii) protection of environment, (iii) scientific interaction between cropping and livestock, (iv) soil conservation practices and (v) small and medium scale irrigation

Annex 2A: Land evaluation

The land evaluation undertaken follows the method outline in the Framework for Land evaluation (FAO 1976 and 1983). In a first step it defines the intended land use and its level of management. Three management levels have been identified: (i) rain-fed, smallholder subsistence agriculture, (ii) rain-fed estate production and (iii) irrigated cropping.

Land use cover has been identified and classified based on the 1995 WBISPP data collection, which found 42% of the land cover being open woodland, 8% dense woodland and less than 1 % perennial cultivation. This information is of special interest as it enables, after updating the land cover, identifying the trends

Comprehensive Agricultural Development Master Plan, inclusive of Annex 1: Investment Plan (MAFCRD, MLFI, MEDIWR 2015)

This report contains the findings, recommendations and the investment plan of the Comprehensive Agricultural Development Master Plan (CAMP) project, which was developed between 2012 and 2015. It has been based on (i) intensive stakeholder consultations, (ii) situation analysis of the Agricultural sector, (iii) formulation of a framework for agricultural development and identification of priority areas, (iv) formulation of investment plans, including project profile sheets and enabled the proposal of the implementation framework to materialise the Master Plan.

In the states, focal points were appointed to facilitate the work of the Task Team and act as links between CAMP and state administrations.

The investment plan is the final output of CAMP activities and is based on the latest and most accurate data on the agriculture sector in South Sudan, obtained from the situation analysis and the other baseline reports produced by CAMP.

It has also produced over 110 indicative subsector project profiles to guide decision makers in identifying how to address the various impediments to development.

Situation Analysis Report 2013-2015, with annexes and appendices (MAFCRD, 2013)

The SAR is the most up to date and detailed body of information on the agriculture sector in South Sudan. It presents the physical and agricultural characteristics of the 10 states based on more than 50 trips (covering more than 50 counties).

2.2.2 Irrigated Agriculture

2.2.2.1 Bibliography relevant for the study

This list of bibliography provides an overview of the sources of irrigation and drainage data for the Baro-Akobo sub-basin of the Eastern Nile. It includes some of the most recent references on the Ethiopian side of the sub basin. The list is not exhaustive and there is no doubt that there could exist sources that have not been included. Reference materials on the South Sudanese portion of the sub-basin were not available so far. Additional relevant documents from the ongoing studies will be collected during the subsequent phase of the study.

- ENTRO. (2015). Eastern Nile Multi-Sectorial Investment Opportunity Analysis: Strategic Scoping of EN Multi Sectorial Investments. Addis Ababa, Ethiopia: ENTRO.
- ENTRO. (2014). Eastern Nile Multi-Sectoral Investment Opportunity Analysis, Country Consultation Report. Addis Ababa, Ethiopia: ENTRO.
- ENTRO. (2009). One System Inventory, Annex: Baro-Akobo-Sobat-White Nile Basin. Addis Ababa, Ethiopia.
- EVDSA. (1990). Baro Akobo Master Plan Study of Water and Land Resources of the Gambella plain. Moscow, USSR.
- EVDSA. (1995). Survey and Analysis of the Upper Baro-Akobo Basin. Vol. I. Addis Ababa, Ethiopia: EVDSA.
- MAFCRD. (2012). Comprehensive Agriculture Development Master Plan (CAMP), Situation Analysis. Juba, South Sudan.
- TAMS-ULG. (1997). Baro Akobo River Basin Integrated Development Master Plan Study, Vol. I, Vol. II, Annex 1H, Annex 1B, and Annex 1E. Addis Ababa, Ethiopia.

2.2.2.2 Assessment of the information currently available in reports

ENTRO. (2015). Eastern Nile Multi-Sectorial Investment Opportunity Analysis Study: Strategic Scoping of EN Multi Sectorial Investments

The study report focused on the provision of coordinated water infrastructure investment strategy for the EN that comprised prioritized water related investment. The report described the overview of irrigation sub sector including information on the ongoing and potential interventions on irrigated agriculture. The study also provided a brief overview and list of prioritized interventions related to irrigation sub sector to be taken forward to the next steps of the study on a sub-basin basis.

ENTRO (2014) Eastern Nile Multi-Sectoral _ Investment Opportunity Analysis Study, Country Consultation Report, Addis Ababa, Ethiopia

The report summarized data and documents as well as identified key priorities regarding water resources planning and investment for three of the four Eastern Nile Basin countries, namely Ethiopia, South Sudan and the Sudan. The report also presented summary of key Issues and challenges regarding small and large scale irrigation schemes with potential investment opportunities in the EN Basin.

MAFCRD. (2012), Comprehensive Agriculture Development Master Plan (CAMP), Situation Analysis. Juba, South Sudan

The report describes agricultural potentials and practices including brief overview of irrigation development in the South Sudan. It also outlines key issues and challenges identified during the study.

ENTRO (2009) One System Inventory, Annex: Baro-Akobo-Sobat-White Nile Basin

The study focused on three themes: hydrology and water infrastructure, socio-economic characteristics and environmental issues. The report showed in brief the collection and analysis of the data available on irrigation in the basin. The report also provided an overview of traditional small-scale rainfed agriculture systems and existing highland valley bottoms small-scale irrigated cropping in the most upper part of the basin.

EVDSA. (1990). Baro Akobo Master Plan Study of Water and Land Resources of the Gambella plain

The study was a master plan study in the eastern (lower) part of the Gambella plain. It presented details on soil, hydrological, geological and hydro geological survey. Based on the analysis of data from the survey results, the study identified lists of medium and large scale irrigation projects. The study also prepared a River Basin Master Plan for the lower part of Gambella plan

EVDSA. (1995). Survey and Analysis of the Upper Baro-Akobo Basin

The study made an evaluation of the needs and possibilities of irrigation schemes. It identified and provided a number of medium and small scale irrigation schemes in the upper reach of Baro-Akobo River Basin.

TAMS-ULG. (1997). Baro Akobo River Basin Integrated Development Master Plan Study

The study was commissioned to assess the development potential of water, natural, and social resources of the entire Baro-Akobo River Basin. The report presented available potential suitable land and water resources for irrigation, identified high priority irrigation projects, conducted pre-feasibility studies for the identified priority projects and prepared master plan development for the basin. The master plan was developed from a review of the previous master plan studies by EVDSA (1990, 1995)

2.2.3 Livestock

2.2.3.1 Bibliography relevant for the study

- ENTRO, Project Baseline Information, 2008-2009
- World Bank, Rapid Water Sector Needs Assessment And Way Forward, August 2012
- Ministry of Agriculture, Forestry, Cooperatives and Rural Development, Ministry of Livestock and Fisheries Industries Consolidated Agriculture (Development) Master Plan, May 2015 (final Draft)[5]

2.2.3.2 Assessment of the information currently available in reports

ENTRO, Project Baseline Information, 2008-2009

This report discusses how much the social, cultural and economic nature of the people residing within Baro-Akobo-Sobat basin is linked with livestock plus the difference in the type and kind of cattle they keep depending on their ethnicity group.

World Bank, Rapid Water Sector Needs Assessment and Way Forward, August 2012

The report gives an overview of the water resources and discusses the water use, Government's strategy and priorities, the existing policy and the sector in general.

Reading of these reports and field visits, both in Ethiopia and South Sudan have led to the following observations:

- **Ethiopia** - Amongst the Baro Akobo basin communities in Ethiopia and particularly in the Gambella region the possession of large numbers of livestock is considered to be prestigious. The requirement of girls' families that typically 20 head of cattle must be provided as dowry for marriage makes it difficult to reduce the number of the cattle holdings per household.

  Although the Ethiopian policy prioritizes the first utilization of water for human consumption and animal drinking, not all water supply schemes constructed in the past particularly in the Baro Akobo basin area make provision for or have sufficient capacity sufficient capacity to also meet the watering demands of livestock. Livestock watering is an issue particularly during the dry seasons. The Nuere Zone and Jor Woredas in Gambella are known to have the highest livestock populations however there are huge challenges in both Woredas: the Nuere Zone Woreda has the lowest water supply coverage zone in the region and the Jor Woreda is inaccessible.
- **South Sudan** - About 80 to 90% of the population in South Sudan live in agro-pastoralist communities. In 2012 the livestock population of the agro-pastoralist communities of about 36 million consists of 11.7 million cattle, 12.4 million goats and 12 million sheep. The annual growth of the livestock population was estimated to be between 2 and 3%. The patterns and use of grazing areas for livestock are dependent on the availability of water particularly during the dry season from December to May. During the dry season pastoralists travel long distances from their homestead in search of water for their livestock following the pattern of water availability. One of the main causes of conflict between pastoralist communities arises on account of livestock movement across tribal boundaries in search of water. Therefore it is essential that communities are consulted when new sources of supply are provided so that provision can also be made for livestock watering at locations that are suitably remote from the points of potable water supply.

[5] This report was only received recently and has not been fully analysed or utilised in this draft scoping report

2.2.4 Fisheries and aquaculture

2.2.4.1 Bibliography relevant for the study

- Abebe Getahun 2007. An overview of the diversity and conservation status of the Ethiopian freshwater fish fauna. Journal of Afrotropical Zoology, Special issue: 87-96.
- Abebe Getahun and Stiassny 2008. The Freshwater biodiversity crisis: The case of the Ethiopian Fish fauna. SINET: Ethiopian Journal of Science, 21 (2): 207-230.
- Bureau of Finance and Economic Development (2008). Socio-economic survey report; Gambella, Ethiopia.
- Ministry of Agriculture, Forestry, Cooperatives and Rural Development, Ministry of Livestock and Fisheries Industries Consolidated Agriculture (Development) Master Plan, May 2015 (final Draft)[6]
- Eastern Nile Technical Regional Office (ENTRO). 2008 – 2009. Baro-Akobo-Sobat and White Nile Multi-purpose water resource development study project; Project baseline information; Nile Basin Initiative-NBI, Addis Ababa, Ethiopia.
- Eastern Nile Multi-sectoral investment opportunity analysis 2014. Multi-sectoral analysis of investment opportunities report.
- Eastern Nile Multi-sectoral investment opportunity analysis 2015. Strategic scoping of EN Multi-sectoral investments.
- Eastern Nile Technical Regional Office (ENTRO), 2008-2009. Baro-Akobo-Sobat and White Nile Multipurpose water resource development study project: Project Baseline information. ENSAP-IDEN-ENTRO, Addis Ababa, Ethiopia.
- Gambella Peoples regional State Bureau of Agriculture. 2004. Gambella National Park Management Plan (Phase 2). Skape Consult.
- Gambella Reconnaissance 2009 & Census 2010. Trans-Frontier Conservation Initiative (TFCI) Task force aerial survey report. Gambella Peoples' Regional State. Agricultural Extension Directorate, Ministry of Agriculture.
- Golubtsov, A. S. and Darkov, A. A. (2008). A review of fish diversity in the main drainage systems of Ethiopia based on the data obtained by 2008, pp 69-102. In: Pavlov, D.S., Dgebuadze, Yu.Yu., Darkove, A.A., Golubtsov, A A.S. and Mina, M.V., (eds), 2008. Ecological and faunastic studies in Ethiopia. Proceedings of Jubilee meeting 'Joint Ethio-Russian Biological Expedition: 20 years of scientific cooperation', Addis Ababa, xvi +173 p.
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- Golubtsov, A. S. and Mina, M. V. (2003). Fish species diversity in the main drainage systems of Ethiopia: current state of knowledge and research perspectives. Ethiop. J. Natural Resources 5: 281–318.
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[6] This report was only received recently and has not been fully analysed or utilised in this draft scoping report

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- Ssebuliba H. B. 2012. Baro-Akobo-Sobat Wetlands knowledge base consultancy. Nile Basin Initiative (NBI); Eastern Nile Susidiary Action Program (ENSAP); Eastern Nile RTechnical Regional Office (ENTRO).
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- The Republic of South Sudan Ministry of Agriculture, Forestry, Cooperatives and Rural Development. 2015. A report on the different sectors of Agriculture in South Sudan.
- USAID 2011. Transition Strategies for South Sudan (2011-2013).

2.2.4.2 Assessment of the information currently available in reports

Golubtsov, A.S. and Darkov, A.A. 2008. A review of fish diversity in the main drainage systems of Ethiopia based on the data obtained by 2008. In Pavlov, et al. (Editors); Ecological and Faunistic Studies in Ethiopia. Proceedings of Jubilee Meeting of the Joint Ethio-Russian Biological Expedition, 20 years of scientific cooperation. Xvi + 173 pages.

The whole proceeding consists of about five articles related to fish studies in Ethiopia. The most relevant article is the review of the fish diversity of the drainage systems in Ethiopia. In this article the Baro-Akobo drainage basin is described and the fishes collected from the basin identified. Accordingly, it has been mentioned that there are 113 species belonging to 60 genera. Most of these species are Nilo-Sudanic fishes shared among waters of the sub-basins of the Nile including waters in the South Sudan, Sudan and Egypt.

Hussien Abegaz, Gashaw Tesfaye and Abebe Cheffo. 2010. Riverine fishery assessment in Gambella Peoples' Regional State. Agricultural Extension Directorate, Ministry of Agriculture, Addis Ababa, Ethiopia.

This document is produced as a result of a study on the fish and fisheries of the region in 2010. It attempts to estimate the potential fish production from the water bodies, describes the methods of fish catch, processing and marketing in the different zones of the Gambella Region with limited depth.

Abebe Getahun 2007. An overview of the diversity and conservation status of the Ethiopian freshwater fish fauna. Journal of Afrotropical Zoology, Special issue: 87-96.

This publication is generally about the fish fauna of Ethiopia, with considerable emphasis on the diversity and distribution of the fishes of the Baro-Akobo Basin in the limits of Ethiopia. It also highlights the conservation problems the fish fauna is currently facing in the freshwater systems of Ethiopia.

Ssebuliba H. B. 2012. Baro-Akobo-Sobat Wetlands knowledge base consultancy. Nile Basin Initiative (NBI); Eastern Nile Susidiary Action Program (ENSAP); Eastern Nile Technical Regional Office (ENTRO).

This document mentions the presence of over 3 million ha of wetlands in the basin many of which have not been delineated and categorized. The wetlands are riverine and lacustrine and represented as marshes the sizes of which vary with flooding time.

The paper identified three major gaps that need to be filled; to make an ecological/biodiversity assessment of the ecosystems of the BAS; to study the socio-economics of the BAS for ecosystem and livelihood support and to carry out detailed wetlands inventory survey that integrate the hydrological and environmental flow into ecosystem maintenance and livelihood support.

The Ecological Assessment shall require studies of selected biological interactions of fishes, among other vertebrates, together with their migration patterns and habitat preferences in relation to physical environments.

The Republic of South Sudan Ministry of Agriculture, Forestry, Cooperatives and Rural Development. 2015 Comprehensive Agricultural Development Master Plan

The report discusses the status of the different sectors of agriculture including fisheries and aquaculture in South Sudan. Capture fisheries in South Sudan is enormously important in nutrition and food security. Fish is the country's most widely consumed animal protein source. The total catch is calculated as being 143,000 tonnes/year.

The potential yield of the fisheries in South Sudan is not known with accuracy, but probably exceeds 200,000 tonnes/year Maximum Sustainable Yield. Most of this resource is located in the Sud, 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 wild fishery in South Sudan is an open access one, with no controls on numbers of fishers or entry. Open access is an undesirable management regime, and inevitably leads eventually to overfishing and the collapse of fish stocks. There is no active fisheries management carried out by the national or state governments. There are already signs of overfishing near the larger towns on the Nile and Sobat rivers, and in some lakes.

The main fishing gear is the gill net, with cast nets, long lines spears and cover pots common, depending on the area being fished. A variety of boats and canoes are used, with non-motorised planked and dugout canoes common. 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 220,000 individuals. More than 1.7 million individuals in South Sudan are living in households where someone fishes, and are thus directly dependent in some way (livelihood, income or food security) on the country's wild fisheries. Most of the population uses fish for nutrition and food security.

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. There are considerable imports of smoked fish as well as fresh fish on ice from Uganda. In peaceful times exports by boat of fresh fish on ice to Khartoum, amounting to about 16,000 tonnes/year, occur from the Nile and Sobat. Dried fish is also exported to Sudan and Ethiopia.

2.2.5 Hydropower and Interconnection

2.2.5.1 Bibliography relevant for the study

- TAMS hydropower projects feasibility study, 2015
- ENTRO, Eastern Nile Multi-Sectoral Investment Opportunity Analysis (2015)
- Ethiopia Council of Ministers, Regulation No ……/2015 - Council Of Ministers Regulation To Provide For The Regulation Of Energy Operations (draft), 2015
- EPP, Draft Sample PPA of Large Hydro Facility Developed as a JV between IPP and EEP, May, 2015
- COMESA, Ethiopia South Sudan Power Interconnector, undated
- COMESA, South Sudan Uganda Interconnector, undated
- Republic of South Sudan, Ministry Of Electricity, Dams. Irrigation. and Water Resources Directorate of Renewable Energy, Expression of Interest Scaling Up Renewable Energy Program in Low Income Countries, Strategic Climate Fund - Climate Investment Funds Initiative, 2014
- Energynet.dk and EA Energy Analysis EAPP- Update Regional Master Plan- Eastern Africa Power Pool (EAPP), 2014
- EEP, Power Sector Development - Powering Africa, 2014
- Parsons Brinckerhoff, Ethiopian Power System Expansion Master Plan Study Final Report , 2014
- Gurtong, Juba, Beijing Sign Loan Agreement To Construct Kinyeti Hydro-Power, 2013
- Tsegaye Sahle G., Knowledge-Base Development: Meta-Documents /Annotated Bibliography for Eastern Nile Watershed Management (ENWM) & Eastern Nile Planning Model (ENPM) Project Resources, Eastern Nile Irrigation Management Information System (Initial Development), EN Watershed Management: Spatial Land Degradation & Soil Erosion Assessment Methods & Tools, Metadata for Geodatabase Resources, ENSAP Projects Documentations for ENTRO Web-Portal, Eastern Nile Spatial Hydropower Tool , 2013
- UNIDO and ICSHP, World Small Hydropower Development Report 2013 – Section 1.1.2 Ethiopia & Section 1.1.10 South Sudan, 2013
- Tsegaye Sahle G., Knowledge-Base Development: Joint Multipurpose Program (JMP), Eastern Nile Power Trade (ENPT), and Ethiopia-Sudan Power System Interconnection (ESPSI) Projects, 2012
- NBI, State of the River Nile Basin, 2012
- Elfatih A B Eltahir, Power Market Integration Activity Contribution to Climate Mitigation Final Report, 2012
- SNC-Lavalin et al., Eastern Africa Power Pool (EAPP) and East Africa Community (EAC) Regional Power System Master Plan and Grid Code Study, 2011
- AECOM, Fichtner & PB, Comprehensive Basin-Wide Study Of Power Development Options And Trade Opportunities, 2011
- ECA, The Potential of Regional Power Sector Integration. Nile Basin Initiative (NBI) Transmission & Trading Case Study, 2009
- SWECO, NBI RPTP - Review of Hydropower Multipurpose Project Coordination Regimes, Best Practice Compendium, 2008
- Tecsult, NBI RPTP Environmental Assessment Framework for Regional Power Projects in Nile Basin Countries, 2008
- Mercados et al., Consultancy to Develop an Institutional, Regulatory and Cooperative Framework Model for The Nile Basin Power Trade, 2007
- EDF & Scott Wilson, Eastern Nile Technical Power Trade Investment Program Study, 2007
- Norplan & Norconsult, Geba Hydropower Project Feasibility Study Report, 2005

- Water Works design and Supervision Enterprise, Birbir A & Birbir R medium Hydropower Projects Reconnaissance Study, 2001
- TAMS & UGL, Baro-Akobo River Basin Integrated Development Master Plan Study, 1997

2.2.5.2 Assessment of the information currently available in reports

ENTRO (2015) Eastern Nile Multi-Sectoral Investment Opportunity Analysis

This report describes the development of a regional water investment strategy for the EN region that broadly supports socio-economic development, poverty reduction, and the reversal of environmental degradation. With respect to hydropower development of the BAS sub-basin and interconnection either at the national or regional level, the interest of this reference to the project is indirect, insofar as the study assesses available information and contribute to the identification, scoping and development of hydropower potential and related investment options, analysis and prioritization of these projects and preparation of project profiles in the Abbay/Blue Nile/Main Nile, Baro-Akobo-Sobat and Tekeze/Atbara sub-basins of the Eastern Nile. However, none of the priority projects lies in the basin of interest.

Council of Ministers, 2015 - Council Of Ministers Regulation to Provide for the Regulation of Energy Operations (draft), 2015

This regulation defines:

- Procedures for electricity generation, transmission, distribution and sale, import or export license and certificate of competency;
- Duration, renewal, amendment, replacement, transfer and termination of license and certificate of competency;
- Electricity tariff and trade guidelines;
- Transmission, distribution, energy efficiency guidelines.

EPP, Draft Sample PPA of Large Hydro Facility Developed as a JV between IPP and EEP, May, 2015

This is a template Power Purchase agreement of Large Hydro Facility Developed as a Joint Venture between Independent Power Producer and Ethiopian Electric Power (EEP).

COMESA, Ethiopia South Sudan Power Interconnector, undated

This project profile sheet provides some general information on the interconnection that 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 kilometres and from border to Malakal is around 230 kilometres. The total distance of phase I is 335 kilometres.
- 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 kilometres and from the South Sudan border to Juba is around 400 kilometres. The total distance of phase II is 700 kilometres.

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.

The technical feasibility and economic viability of the project in the context of COMESA, South Sudan Uganda Interconnector, undated

This project fact sheet is for an interconnector project of 360 kilometres, 220kV double circuit transmission line.

EEP, Power Sector Development - Powering Africa, 2014

This is a summary presentation of the on-going Ethiopian Power System Expansion Master Plan Study.

Republic of South Sudan, Ministry Of Electricity, Dams. Irrigation. And Water Resources Directorate of Renewable Energy, Expression of Interest Scaling Up Renewable Energy Program in Low Income Countries, Strategic Climate Fund - Climate Investment Funds Initiative, 2014

This document describes:

- The country's sector context;
- Rationale for selected sectors for SUREP financing; energy sector enabling policy and regulatory environment. currently there is no dedicated framework for sustainable energy regulation in the country expect in the electricity and rural electrification sector; drafting of an electricity bill, protocols and regulatory mechanisms, autonomy of the regulatory body,
- Institutional and technical capacity;
- Programs with development partners in hydropower development (Fula HPP) and rural energy development.

The document also presents a map showing the location of potential hydropower sites in South Sudan five of which are located around the town of Torit at the Western edge of the BAS sub-basin.

Parsons Brinckerhoff, Ethiopian Power System Expansion Master Plan Study - Final Report, 2014

This report describes:

- The generation planning carried out for the period up to 2037 as part of the Ethiopian Power System Expansion Master Plan (EPSEMPS). The generation plan adds future generating units to meet the load forecast of the country. In particular it list the characteristics of the seven hydropower projects identified for future development in the Baro-Akabo sub-basin; Baro I and 2, Genji, Birbir, Geba 1 and 2 and Tams, the characteristics of their reservoirs, project cost estimates and the timing of their introduction into the National power pool in order to meet the growing electrify demand;
- The work undertaken to produce an expansion plan for EEPCO's transmission network for the period from 2013 to 2037. The transmission expansion plan is based on the load forecast and generation expansion plan which are described in separate volumes of the EPSEMPS. With reference to the BAS sub-basin the extension of the 230 kV network to the south west is either under construction or committed along the route Gilgel Gibe-Jimma-Agaro-Bedele-Metu-Gambella to which the seven future power plants will be connected and eventually will be linked with South Sudan.

Energynet.dk and EA Energy Analysis EAPP- Update Regional Master Plan- Eastern Africa Power Pool (EAPP), 2014

The report is currently being evaluated by the EAPP member countries and hence cannot be released at this time. However EAPP accepted to release Volume II: Data Report that contains a list of existing and candidate power plants and transmission lines. All hydropower projects studied at a level or another in the BAS sub-basin are candidate projects.

Gurtong, Juba, Beijing Sign Loan Agreement to Construct Kinyeti Hydro-Power, 2013

Online article that describes the signing ceremony and mentions that the project budget is USD 29 million, 15% from Sudan and 85% from China. A feasibility study has been completed. The 2 MW project is undertaken by SINOHYDRO for a 14 months construction period.

Tsegaye Sahle G., Knowledge-Based Development, 2013

This document describes various knowledge-based development tools, in particular an Eastern Nile spatial hydropower tool (GIS).

UNIDO and ICSHP, World Small Hydropower Development Report 2013 – Section 1.1.2 Ethiopia & Section 1.1.10 South Sudan, 2013

This report provides an overview of the electricity sector and the small hydropower sector, renewable energy policy and barrier to the development of small hydropower. The report refers to the 5 MW Sor 2 hydropower projects project in Ethiopia and the 5MW Kinyeti hydropower project in South Sudan both located in the BAS sub-basin and for which a feasibility study has been completed

Tsegaye Sahle G., Knowledge-Based Development: Joint Multipurpose Program (JMP), Eastern Nile Power Trade (ENPT), and Ethiopia-Sudan Power System Interconnection (ESPSI) Projects, 2012

This document describes the main activities of a knowledge-based development which consist of:

- Organizing project knowledge resources (study documents, maps & drawings, modelling tools, workshop/study-tour presentations, and other information products);
- Developing meta-document for project resources (i.e. preparation of projects non-spatial data documentation);
- Developing project-based Geodatabase containing thematically-organized geospatial data;
- Developing metadata for GIS resources and preparation of geospatial data documentation;
- Creation of spatial knowledge products, including an interactive spatial hydropower tool and hydropower data gap filling by GIS that has been applied in particular to the Baro1 and 2 hydropower projects in the BAS sub-basin;
- Development of a simple web-interface provided with links to help users easily navigate to project resources and access information

NBI, State of the River Nile Basin, 2012

The report presents factual information and expert analyses on the Nile Basin to inform, educate and empower basin communities to exercise better stewardship of the common Nile water and environmental resources. Chapter 6 of the document is devoted to the hydropower sector, presents future power demand in the basin, development of the hydropower potential to respond to this increasing demand and cooperation to enhance regional energy security in the form of regional power interconnections and power pooling.

Elfatih A B Eltahir, Power Market Integration Activity Contribution to Climate Mitigation Final Report, 2012

The report documents how the Eastern Nile Power Trade Project and the Ethiopia-Sudan Transmission Line have integrated the energy markets in the EN countries from three different national markets into one regional market; It also analyze how the integration of the national markets offers an opportunity for a different screening criterion to be used in selection of new energy sources for the region. Finally the report Illustrates with examples how integration of national markets can be used within the Clean Development Mechanism (CDM) process to secure certified emission reductions (CERs).

SNC-Lavalin et al., Eastern Africa Power Pool (EAPP) and East Africa Community (EAC) Regional Power System Master Plan and Grid Code Study, 2011

This report identifies regional power generation and interconnection projects in the power systems of EAPP and EAC member countries in the short-to-long term. The study also aims at developing a common Grid Code (Interconnection Code) in order to facilitate the integrated development and operations of the power systems of the member countries.

The study further aims at contributing to the institutional capacity building for the EAPP and EAC through training of counterpart staff. The development of institutional capacity will enable EAPP/EAC to implement the subsequent activities, including the updating of both the Master Plan and the Interconnection Code.

This study covers the following countries: Burundi, Djibouti, Democratic Republic of Congo, Egypt, Ethiopia, Kenya, Rwanda, Sudan, Tanzania and Uganda.

AECOM, Fichtner & PB, Comprehensive Basin-Wide Study of Power Development Options and Trade Opportunities, 2011

The report describes an inclusive and participatory Comprehensive Basin-wide Study (CBWS) of power development options (including backbone transmission and interconnection corridors) in the Nile Basin countries1. The study analysed the status of power supply, interconnectivity, demand and trade opportunities in the region in the context of multipurpose water resource development and included a detailed implementation plan covering a 35 year time horizon (2010 – 2045) to translate the study into concrete actions at sub-basin and basin levels according to various development strategies.

An important element of the CBWS was to identify and assess options for development of major regional generation and transmission projects, because the implementation of major regional projects may provide the best opportunity for reducing long term future cost of electricity, and improving supply.

ECA, the Potential of Regional Power Sector Integration. Nile Basin Initiative (NBI) Transmission & Trading Case Study, 2009

This report presents the Nile Basin power sector integration, consisting of transmission & trading between member countries as a case study to facilitate and accelerate RPSI projects in developing countries around the world. The project will draw on international experience and theoretical analysis in this area to provide a framework to assess:

- The economic, financial and environmental benefits that can accrue to regional power trading;
- The institutional and regulatory arrangements needed to sustain and optimize regional projects; and
- The ways in which obstacles to integration have been successfully overcome.

This case study is part of an Energy Sector Management Assistance Program (ESMAP) project on Regional Power System Integration (RPSI).

SWECO, NBI RPTP - Review of Hydropower Multipurpose Project Coordination Regimes, Best Practice Compendium, 2008

The report describes best practice to coordinate the regimes of multipurpose projects in the NB and identifies issues related to this coordination. The review of hydropower multipurpose project coordination regimes is the result of a literature study based on documents available in NBI-RPTP's library and other literature found on the Internet and from other sources.

Tecsult, NBI RPTP Environmental Assessment Framework for Regional Power Projects in Nile Basin Countries, 2008

This report describes an EA framework that ensures that the development of regional power trade and markets among the NBI countries be implemented according to sustainable development principles, including the integration of environmental and social considerations through sound EA best practices.

The purpose of this EA framework is to guide the environmental agencies of the NBI countries, project proponents and EIA practitioners to implement the proposed harmonised EA process for all regional power projects defined as such in this document.

Finally, the scope of this EA framework focuses on hydropower, thermal and geothermal and transmission lines projects qualifying to the proposed harmonised regional EA process.

Mercados et al., Consultancy to Develop an Institutional, Regulatory and Cooperative Framework Model for the Nile Basin Power Trade, 2007

This report describes a review of institutional arrangements adopted by regional power trade organisations discussion papers to the RPTP, comparison of the different arrangements. The report also describes a data collection program to collect basic information of the countries in the region which will permit in the future the development of recommendations and the development of an informed decision making process. Then, a model is proposed for developing Regional Power Trade at the Nile sub–basin and basin levels and finally Memoranda and legal documents are drafted as required.

TAMS & UGL, Baro-Akobo River Basin Integrated Development Master Plan Study, 1997

The report assesses the development potential of water, natural and social resources of the Baro-Akobo basin in Ethiopia. With respect to hydropower potential, the report identifies potential sites and performs a ranking study.

2.2.6 Water supply and sanitation

2.2.6.1 Bibliography relevant for the study

- MoWIE, Water Growth And Transformation Plan II, Final Draft, July 6,2015
- MoWIE - One Wash National Program
- MoWIE One Wash National Program Consolidated Wash Account, 2007 Annual Report Final
- MoEDIWR, Water, Sanitation & Hygiene (Wash) Sector Strategic Framework, August 2011
- PROWAS/SSN, Programme Formulation Document For Water For Eastern Equatoria State For Water Sector Programme Between South Sudan And The Netherlands (- 2013-2016)
- MoEDIWR, Water Resource Assessment And Feasibility Studies, Detailed Designs And Technical Specifications For The Urban Water And Sanitation Facilities Of Torit And Bor Towns, March 2013

2.2.6.2 Assessment of the information currently available in reports

MoWIE, Water Growth and Transformation Plan II, Final Draft, July 6,2015

This report discusses Ethiopia's second five year Growth and Transformation Plan (GTP) for water for the period from 2016 to 2020. The plan discusses the desired target for the provision of water supply and urban wastewater management, the implementation strategies, the required finance and the capacity building plan.

MoWIE - One WASH National Program

This report discusses the Ethiopian National plan and more importantly discusses and provides implementation guidance in the integration water supply, sanitation and hygiene activities; alignment and harmonization of partners; and partnerships for implementation including defining the roles and responsibilities of all parties involved.

MoWIE One WASH National Program (OWNP) Consolidated WASH Account, 2007 Annual Report Final

This report discusses the Ethiopian government plan and accomplishment of OWNP of the consolidated wash account for the Ethiopian fiscal year 2007, and also gives the list of woredas and towns that are benefiting from this program in every region.

MWRI, Water, Sanitation & Hygiene (WASH) Sector Strategic Framework, August 2011

This report identifies the South Sudan government's priority areas for interventions and spells out a number of approaches that these will have to be used. The document spells out the current situation as well as the challenges; the goals and objectives; and the priorities based strategic approaches for urban and rural water supply, and for sanitation and hygiene.

ProWaS/SSN, Programme Formulation Document for Water for Eastern Equatoria State for Water Sector Programme between South Sudan and the Netherlands (- 2013-2016)

The report discusses the Water program component for Eastern Equatoria in South Sudan for both water supply and sanitation and for water for productive use which includes livestock watering. It also discusses the implementation arrangements and the program linkages with other programs.

MWRI, Water Resource assessment and FEASIBILITY STUDIES, DETAILED DESIGNS AND TECHNICAL SPECIFICATIONS FOR THE URBAN WATER AND SANITATION FACILITIES OF TORIT and Bor Towns, March 2013

These reports discuss the available water resources for water supply development, the existing water supply and sanitation conditions of the towns, the needs and future water demands, the design criteria and the proposed water supply schemes, their designs and costs.

Analysis of these reports and field visits, both in Ethiopia and South Sudan have led to the following observations:

Main observations for the South Sudanese part of the basin

Water supply and sanitation service coverage for both the urban and rural communities is very low in South Sudan. The inaccessibility of certain communities, tribal conflict, vandalism and financial constraints have been reported to be some of the factors contributing to the low overage. Occurrences of Cholera and of Guinea Worm are also some of the reported health risks in South Sudan. Monitoring the quality of protected sources is also not commonly practised. Although water quality laboratories have been established in every state capital, the high turnover of trained staff, lack of reagents, lack of incentives and problems with the collection of samples have made it difficult to carry out water quality test analysis

Urban Water Supply and Sanitation

Urban water supply and sanitation in South Sudan is very limited. There are towns that do not have water supply systems, and even in those towns where there are water supply schemes the systems are either very old (built in the thirties), only serve some the residents or require major rehabilitation (on account of leakage losses from mains & operational failure of pumps and treatment plants) and expansion: in terms of volumes and distribution networks. In Eastern Equatoria two of the towns have systems with small networks distributing water via public water points, three towns (Torit, Kapoeta and Magwie) have boreholes fitted with solar pumps, three are supplied from rock catchments, and two (Equatos & Ishoe) from spring sources.

Some of towns are served by point sources such as shallow wells and hand dug wells fitted with hand pumps. For example Budi and Lopa-lapan are towns served by boreholes fitted with hand pumps.

Rehabilitation and improvement of the old water systems in Juba and Torit is being undertaken with the assistance of international development partners, however the long term financial sustainability of these schemes seem unlikely as tariffs do not cover the full costs of operation, maintenance and replacement. In fact in Torit no fees are currently being collected from the user community while in Juba there is inefficient revenue collection.

In Juba, the few consumers connected to the distribution network system (with estimated losses of 50%) a flat rate is charged from regardless of volume consumed as most households do not have water meters. Most of the water distributed by tanker is charged at the set rate of 6 SSP/m3.This tariff is only sufficient to cover salaries and the basic running costs of the offices and shortfalls are met from funds allocated by the government for Water Service delivery.

Coverage for excreta removal facilities at household level is very low, and open defecation is common in most of the towns. A Cholera outbreak occurred recently in Torit where open defecation is widely practised on account of the difficulty of digging latrine pits in the hard formations. Even in Juba where there is relatively better latrine coverage and septage/sludge collection and treatment in a lagoon, there have been a number of Cholera outbreaks.

Rural Water Supply and Sanitation

There is very little or no awareness about the benefits of clean water, safe disposal of faeces, and hygiene particularly amongst the rural communities. In fact until recently, hygiene and sanitation promotion was a missing element in South Sudan, and where this has started the uptake for change in sanitation practice is reported to be difficult. Communities prefer soft but traditional water sources from rivers and ponds t0 the hard water which comes from protected sources. Though rural communities may not make extensive use of safe water particularly during the wet season, there is progress in the rural communities willingness to pay fixed monthly charges to cover operation and maintenance costs for water from community boreholes.

Main observations for the Ethiopian part of the basin

The Growth and Transformation Plan (GTP) targets 98% and 100% access to safe water supply for rural and urban areas respectively and 100% access to sanitation. Currently, the GTP II is formulated, with the focus in regard to water on its safety (water quality) and security (sustainable supply). In GTP II the service level targets for rural water supply have been changed from 20 litres per capita per day within 1.5 km radius to 25 litres per capita per day within 1 km radius to reach 85% of the population of which 20% will be served with piped supplies. Therefore, the redesign of rural water supplies will require the incorporation of the revised GTP II target. Since the fiscal year 2008 the planning of Regions other than SNNP has been based on meeting the GTP II targets, whereas SNNP has first concentrated on meeting the GTP I targets in those areas where coverage is below 98%.

The GTP II target for urban water supply is to provide 100 litres per capita per day for Grade 1 towns, 80 l/c/d for Grade 2, 60l/c/d for Grade 3, 50 l/c/d for Grade 4 and 40 l/c/d for Grade 5.

Ethiopia has designed a national one WaSH program for achieving its GTP goals and objectives. Although significant progress was made in the last decade in improving access to water supply and sanitation, Gambella town and particularly the Akobo Woreda within the basin in the Gambella Region has the lowest water supply and sanitation coverage of only 2.6% in the region,. Both the Akobo and Jor Woredas are included in the current One WaSH consolidated program and are receiving finance to improve their WaSH conditions.

Movement of pastoralist communities within the basin in search of water has been a cause of conflict. 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 numbers of livestock and to rather focus on their productivity.

Unlike South Sudan in Ethiopia there is an implementation guideline and procedure for WaSH interventions and better coordination, and joint planning and evaluation amongst the development partners and stakeholders3. Capacity limitations and high staff turnover are affecting progress in meeting planned targets.

2.2.7 Navigation

2.2.7.1 Bibliography relevant for the study

Two key reports have been identified regarding Navigation:

- WFP Sudan Logistics Unit, Barge Operation Capacity Assessment For the Republic of Sudan, 2003
- UNJLC, River Cargo Transportation Assessment White Nile River Sudan, 2009

2.2.7.2 Assessment of the information currently available in reports

WFP SUDAN LOGISTICS UNIT, BARGE OPERATION CAPACITY ASSESSMENT FOR THE REPUBLIC OF SUDAN, 2003

This report aims to show the potential of river transport service in Sudan, which was not well developed in 2003. It identifies the navigable rivers and describes the major river transport corridors, the service providers in Sudan, the existing fleets for barge operation, and the main river ports assessment. The report also takes into account the navigational limitations, which require specific attention.

- The scarcity of rail and road network in Sudan makes river transport one of the most important mode of transport in the country, mainly through the Nile.
- River transport is crucial in Sudan because of many factors: economic advantage, alternative to inadequate all-weather roads to South Sudan, offers large cargo transportation, etc.
- Barges Corridors :
  - The Juba Corridor on the White Nile (stretches from Kosti to Juba), navigable all the year round.
  - The tributaries of the White Nile in the southern region, seasonal routes : River Bahr el Ghazal (reaches from Malakal to Bentiu), the Sobat Corridor (stretches between Malakal and Nassir), River Zeraf (reaches up to Old Fanjak Canal Site, Obel and Nagdiar), and the River Jur (navigable in the past, stretches between Betiu and Wau).
  - The seasonal River route on the Blue Nile between El Suki and El Rosiers.
- The River Transport Corporation and other Private Operators provide river transport in Sudan. They both have limited available capacity and cannot be relied upon.
- Types of existing fleets: Push Tugs, Self-Propelled Oil Barge, General Cargo Barge, Flat Deck Cargo Barge, Oil Fleet Barge, and Passenger Vessels. These barges are few in number and not in good condition. In order to use efficiently river transport, the report calls for rehabilitation of the quays and jetties, as well as, development and upgrading of cargo handling equipment and facilities.
- On the other hand, according to the report, the major navigational constraints are:
  - The cataracts which block the transport between Egypt and Sudan.
  - The drops in water level during the dry season are the main impediment to the navigation on some sections of the White Nile and Blue Nile, which are free from cataracts.
  - Water hyacinth which blocks some sections of the River Jur and may cause damage to or slow down Push tugs.

UNJLC, RIVER CARGO TRANSPORTATION ASSESSMENT WHITE NILE RIVER SUDAN, 2009

This assessment report gives a succinct updated guide for utilizing river cargo transportation. It focuses on the White Nile which connects Juba in the South to Kosti in the North and reflects on the river conditions. The report identifies the most important commercial operators on the White Nile between Kosti and Juba, and describes the types of vessels and fleet size they use. It also outlines the main ports facilities of the on-shore services from Kosti to Juba (private and state–managed/owned port including the Malakal Port owned by the state), which has often both mechanized equipment and porter labour for handling. The report explains the important operational constraints to using river services along the White Nile, e.g. water hyacinth, low water levels, shifting sands and silt, security constraint etc.

2.2.8 Biodiversity conservation

2.2.8.1 Bibliography relevant for the study

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2.2.8.2 Assessment of the information currently available in reports

These documents have all been gathered and carefully analyzed during the scoping phase. Some of them address specific issues and will be of importance depending on the proposed development projects. However, some documents provide general information for the baseline and are briefly summarized here after.

Agriculture Extension Directorate, M. o. (2010). Riverine fishery Assessment in Gambella Peoples' Regional State. Addis Ababa: Ministry of Agriculture.

This report summarises the available species, family and genera of fish in the region and estimated the current and potential quantity of fish production. The report indicated that fishery of the region will help in the endeavour of poverty reduction and food security provided that the sector is managed properly. Information regarding list of fish species and fish production will be utilized in the preparation of baseline report and SSEA.

ENTRO. (2008-2009). Baro-Akobo-Sobat & White Nile Multipurpose Water Resources Development Study Project, Project Baseline Information. Addis Ababa: ENTRO.

Baseline information described in the report (Baro-Akobo-Sobat & White Nile Multipurpose Water Resources Development Study Project, 2008-2009) seems relevant to the current study. Most of the baseline information such as geology, hydrology, soil, climate, etc, will be adapted to characterise the baseline situation of the basin..

ENTRO. (2012). Baro-Akobo-Sobat Wetland Knowledge Base. Addis Ababa: ENTRO.

Description and classification of wetlands included in the report (Baro-Akobo-Sobat Wetland Knowledge Base, 2012) is useful information and bases for the further investigation. Though the report didn't address seasonal variation of wetlands in size/areal coverage, it indicated how the wetlands are formed and interrelated with the Baro-Akobo-Sobat river systems. This report will be used as a source of information for the preparation of baseline report and SSEA.

UNEP. (2006). Wildlife and Protected Area Management. Juba: UNEP.

Wildlife and protected area Management Report (UNEP 2006) indicated commonly available wildlife species found in South Sudan and identified the migratory route of white eared Kob. The report also identified anthropogenic constraints faced the Kob and other endemic and endangered wildlife species of South Sudan. Information from this report will be extracted for the preparation of baseline assessment and SSEA.

2.2.9 Social situation and security

2.2.9.1 Bibliography relevant for the study

Following is an annotated bibliography of reports, studies and other documentation relevant to the social assessment of the BAS basin and its importance for the Study.

During the inception phase, potentially relevant documents to establish baseline on social issues and challenges have been identified and reviewed. Below is a selection of documents consulted?

1. Documents on Demographics and Socio-economics

- Southern Sudan Centre for Census, Statistics and Evaluation (SSCCSE) 2008: 5th Population and Housing Census.
- Central Statistical Agency (CSA) 2014: Ethiopia Mini Demographic and Health Survey 2014.
- Department for International Development (DID), 2013: Household Economic Analysis (HEA): Livelihood Profiles of Eastern Flood Plains and Nile and Sobat Rivers, South Sudan, September
- CSA, 2013: Agricultural Sample Survey 2013/2014 (2006 E.C.), Report on Land Utilization. Volume, IV.
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- NBI, 2012: Sate of the river Nile basin (Chapter four).
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- ENTRO, 2006: One-System Inventory Report on Socio-Economic Characteristics of EN Basin: Ethiopia. Draft Report.
- ENTRO, 2006: One-System Inventory Report on Socio-Economic Characteristics of EN Basin: Sudan. Draft Report.

2. Documents on Poverty and Food Insecurity

- World Bank, 2015: Ethiopia Poverty Assessment. Poverty Global Practice Africa Region. Report No. AUS6744, January.
- Abebe Shimeles and Verdier-Chouchane, Audrey, 2102: Poverty Situation and Prospects in South Sudan, in “Africa Economic n Brief”, Volume 3 • Issue 8, August.
- FAO/WFP, 2014: Special Report by FAO/WFP Crop and Food Security Assessment Mission to South Sudan. 20 February.

3. Documents on Food Security and Nutrition

- Ververs, Mija-tesse, 2010: Situation Analysis of Nutrition in Southern Sudan: Analysis Based on June 2009 Assessment. Food and Nutrition Technical Assistance II Project (FANTA-2). USAID, Washington, DC 20009-5.
- FAO and WFP, 2015: FAO/WFP crop and food security assessment mission to south Sudan. Special Report

4. Documents on Conflict and Instability

- Blanchard, Lauren P. 2014: The Crisis South Sudan. CRS report prepared for members and committees of congress. Congressional Research Service, January.
- ENTRO, 2009: One-System Inventory, Annex: Baro-Sobat-White Nile Sub-Basin. Addis Ababa, Ethiopia.

5. Documents on Social Services (education, health, water supply and sanitation)

- Ministry of General Education and Instruction (MoGEI) 2012: Educational Statistics, National Statistical Booklet of 2011. Government of Republic of South Sudan (GRSS), Department of Data and Statistics, Education Management Information Systems Unit, Juba, South Sudan.
- Ministry of Education, 2014: Country report on policies and mechanisms for labour market oriented Technical and Vocational Education & Training (TVET) provision and employment creation. Ethiopia's report prepared by Federal TVET Agency, for the 'Ministerial Conference on Youth and Employment: Access of Africa's Youth to the World of Work' in Abidjan, Côte d'Ivoire, 21-23 July.
- World Health Organization (WHO) and UNICEF. 2010. Joint Monitoring Program for Water Supply and Sanitation. Progress on Sanitation and Drinking Water: 2010 Update. Geneva and New York

6. General

- Inception Report, Baro-Akobo-Sobat Multipurpose Water Resources Development Studies, BRLi, Yerer, and Aurecon, July 2015.
- Environmental and Social Assessment Procedures for the African Development Bank's Public Sector Operations, 2001.
- State of the River Nile Basin, NBI, 2012; chapter on Opportunities and Challenges of the Growing Nile Population.

7. Social Development

- Social Atlas–Eastern Nile Basin Countries, ENTRO, January 2005.

8. Gender

- NBI Gender Mainstreaming Policy and Strategy, NBI, July 2012.
- Social Aspects of Multipurpose Water Resources Studies and IWRM Baro-Akobo-Sobat Sub-basin: Environment and Natural Resources – Status, Challenges and Opportunities, J.P. Sutcliffe, ENTRO, 2009.
- Baro-Akobo-Sobat Multipurpose Water Resource Development Study: Desk Review Report, Ehab A. Meselhe, for ENTRO, no date.
- Distributive Analysis, Cooperative Regional Assessment for Watershed Management, NBI/ENTRO, January 2007.
- Conceptual Report of a Draft TOR for the IWRM Development Plan of the Baro-Akobo-Sobat River Basin, Yasir A. Mohamed, for ENTRO, July 2011.

9. Integrated Watershed Management

- Integrated Watershed Management in the Eastern Nile: A Field Guide, NBI/ENTRO, December 2014.
- Benefits of Watershed Management in the Context of a Joint Multi-purpose Programme, Eastern Nile Watershed Management Project, NBI and ENTRO, May 2007.

10. Climate Change

- Adaptation to Climate-change Induced Water Stress in the Nile Basin, a vulnerability Assessment Report, NBI and UNEP.
- Climate Change in the Baro-Akobo-Sobat Project Area, field work consultancy report, Andu Zakaris Wani, for ENTRO, March 2011.

Many reports and documents contain data at national or Nile Basin level, but the data is not disaggregated at BAS basin level, which limits its relevance and usefulness. A review of existing relevant documents or reports on social issues was carried out to assess their importance and identifying information gaps on key issues identified during the inception phase.

2.2.9.2 Assessment of the information currently available in reports

1. Documents on Demographics and Socio-economics

The documents on demographics and socio-economic describe the population characteristics, socio-ethnic groups, economic activities, livelihoods, etc of the basin areas. But they are high aggregated at the national/sub-national levels and need to have disaggregated at the lower administrative level within the basin. Moreover, specific information on livelihood activities at the basin level is needed for identifying livelihood zones within basin.

2. Documents on Poverty and Food Insecurity

The reports related to poverty and food insecurity describe the poverty and food security status of the basin countries (i.e. Ethiopia and South Sudan). They provided national level indicators of poverty and food insecurity. And yet more information disaggregated at the basin level is needed in the next phase.

3. Documents on Food Security and Nutrition

The reports on food security and nutrition are few describing the national level situation of food security and nutritional status of children. More data and additional sources will be sought in the next phase.

4. Documents on Conflict and Instability

A few reports on Conflict and instability are identified. The reports describe various forms of conflicts (political, inter and intra ethnic conflicts over resource uses at community levels, border conflicts, and other traditional conflicts). As conflicts and instabilities vary in time and space, it needs to seek additional and recent information, thereby updating the existing information.

5. Documents on Social Services (education, health, water supply and sanitation)

There are many reports regarding social services for both basin countries. The documents provided quantitative data including national level key indicators of social services (education, health and water supply). But it needs to update the information and also having disaggregated data at the basin areas level.

6. General

Inception Report, Baro-Akobo-Sobat Multipurpose Water Resources Development Studies, BRLi, Yerer, and Aurecon, July 2015.

Contains information on stakeholders, results of field visits, scoping and SSEA, identification and screening of potential projects and other relevant information and is important as an input for the preparation of the scoping and other reports.

Environmental and Social Assessment Procedures for the African Development Bank's Public Sector Operations, 2001.

This important document presents the objectives, procedures, process, and responsibilities of parties, public consultations and public disclosure used by the African Development Bank in their operations from country programming, through project identification to project completion. It also contains a number of guidelines and examples of instruments related to planning and implementing SSEAs:

- Strategic Environmental and Social Assessment
- Typical Environmental and Social Components to Consider in ESAs
- List of AfDB's Policies, Strategies and Guidelines Related to Crosscutting Issues
- Environmental and Social Contents of a Country Strategy Paper
- Environmental and Social Contents of a Project Brief

- Environmental and Social Screening
- Environmental and Social Scoping Memorandum
- Environmental and Social Auditing
- Generic Contents of Terms of Reference and Typical Contents of an Environmental and Social Impact Assessment Report
- Generic Contents of an Environmental and Social Management Plan
- Typical Contents of an Environmental and Social Impact Assessment
- Environmental and Social Management Plan Summary
- Presentation of Environmental and Social Findings in a Project Appraisal Report
- Environmental and Social Monitoring Guidelines
- Consultation Checklist

State of the River Nile Basin, NBI, 2012; chapter on Opportunities and Challenges of the Growing Nile Population.

This chapter contains quantitative data on population, socio-economy, employment, challenges feeding the growing urban population, measures to eradicate poverty and regional integration. This information is very useful in describing broad characteristics, providing background information and identifying issues affecting the Nile Basin as a whole.

7. Social Development

Social Atlas-Eastern Nile Basin Countries, ENTRO, January 2005.

Contains information on population, living standards, education, health and access to water supply and sanitation in Ethiopia, Sudan and Egypt. This information is useful in identifying the scope and distribution of key socio-economic variables and characteristics in the Nile Basin.

8. Gender

NBI Gender Mainstreaming Policy and Strategy, NBI, July 2012.

Describes the legal and policy contexts, gender relations in the Nile Basin, gender mainstreaming policy and strategy, the institutional framework, monitoring and evaluation and action plan. This information is very important for efforts to establish a common approach to analysing and mainstreaming gender in the Nile Basin, including the BAS basin.

Social Aspects of Multipurpose Water Resources Studies and IWRM Baro-Akobo-Sobat Sub-basin: Environment and Natural Resources – Status, Challenges and Opportunities, J.P. Sutcliffe, ENTRO, 2009.

A background paper prepared for a stakeholder workshop for preparation of a Multi-purpose Water Resources Study of the BAS Sub-basin. The paper contains information on the status challenges and development opportunities for the environment and natural resources in the sub-basin and is very useful in describing the relationship between degradation of the environment and natural resources due to social and demographic trends in the BAS basin.

Baro-Akobo-Sobat Multipurpose Water Resource Development Study: Desk Review Report, Ehab A. Meselhe, for ENTRO, no date.

The report contains a desk review of available information on the BAS basin by sector, including background, the environment and socio-economic aspects of the sub-basin. This information is useful in bringing together knowledge from various sources on a variety of issues, including socio-economic aspects.

Distributive Analysis, Cooperative Regional Assessment for Watershed Management, NBI/ENTRO, January 2007.

The report identifies potential watershed management interventions. Locations and associated effects, poverty and natural resource degradation nexus, impacts of natural resources degradation at sub-basin level, including the BAS sub-basin; costs benefits and impacts of interventions in the BAS sub-basin.

Conceptual Report of a Draft TOR for the IWRM Development Plan of the Baro-Akobo-Sobat River Basin, Yasir A. Mohamed, for ENTRO, July 2011.

This report identifies drivers, needs and constraints of IWRM in the BAS Basin. Contents include the local context for water management in the BAS basin, criteria and scope of work for IWRM planning and success indicators for IWRM.

9. Integrated Watershed Management

Integrated Watershed Management in the Eastern Nile: A Field Guide, NBI/ENTRO, December 2014.

Contains chapters on watershed degradation, rehabilitation interventions, principles of watershed management, community participation, planning steps, technologies, soil and water conservation measures, environmental and social management framework, forestry and agroforestry measures, rainwater harvesting and monitoring and evaluation. This information is very helpful identifying possible locations and interventions for watershed management.

Benefits of Watershed Management in the Context of a Joint Multi-purpose Programme, Eastern Nile Watershed Management Project, NBI and ENTRO, May 2007.

Contains a description of the Joint Multipurpose Programme (JMP), watershed considerations in developing the JMP, benefits of watershed management in a multi-purpose programme, and possible watershed management interventions and their benefits. This information is very relevant for an understanding of the benefits of integrated watershed management in the BAS basin.

10. Climate Change

Adaptation to Climate-change Induced Water Stress in the Nile Basin, a vulnerability Assessment Report, NBI and UNEP.

Contains information on land cover types, degrees of vulnerability and location of hot spots, impacts of and adaptation to climate change. This information is useful in identifying and describing the relationship between climate change and variability and socio-economic factors in the Nile Basin.

Climate Change in the Baro-Akobo-Sobat Project Area, field work consultancy report, Andu Zakaris Wani; for ENTRO, March 2011.

Contains information on climate change, adaptation and mitigation measures in Ethiopia and the Sudan. Sites studied include Gambella, Bedele, Gilo, Metu, Itang Lou and Odra. A range of possible interventions are also identified. This information is relevant to identifying possible interventions to mitigate the effects of climate change and variability, with special reference to the BAS basin.

2.3 EXISTING DATA

2.3.1 Introduction

The aim of this brief section is state very concisely:

- What data exists (according to documents and feedback from stakeholders)
- What data we have
- What data we don't have (of the data that apparently exists)

"Data" is taken to include both numerical data and spatial (GIS) data sets (raster files such as DEM and vector files such as shape files)

2.3.2 Water-related Infrastructure

Water-related infrastructure includes dams and weirs, diversion structures, pipelines and canals. It also includes non-water related infrastructure like roads. Knowledge of these data is particularly important as identification of potential sites for irrigation will depend on:

- water availability notably through water storage
- accessibility to the site

2.3.3 Meteorological data

2.3.3.1 Purpose of meteorological data

Meteorological data are required for (a) calculation of crop and irrigation water requirements, (b) inputs to deterministic rainfall-runoff modelling, (c) quantification of evaporation losses from dams, lakes and wetlands, and (d) assessment of potential climate change impacts.

2.3.3.2 Data availability

GENERAL

Observed, monthly historical climate data in the Nile Basin are available from four different sources:

- The Nile Basin Encyclopaedia. Historical rainfall (and discharge) records were captured from hardcopy encyclopaedia volumes by NBI staff, and quality controlled for data capturing accuracy (but not for measurement quality).
- Data from the Ethiopian Masterplan Studies. The data were captured by NBI staff and include monthly rainfall, maximum and minimum daily and monthly temperature, relative humidity, sunshine hours and wind speed data.
- The Global FAOClim database. The database was developed as part of the FAO's Agro ecological Zone project and includes minimum, maximum and average temperatures, computed daytime and night-time temperatures, rainfall, potential evapo-transpiration (computed), moisture expressed as dew point, vapour pressure or relative humidity, wind speed, and solar energy as sunshine hours.
- The National Oceanic and Atmospheric Administration (NOAA) Global Historical Climatology Network-Monthly database (GHCN-M) (http://www.ncdc.noaa.gov/ghcnm/http://www.ncdc.noaa.gov/ghcnm/).

RAINFALL DATA

In 2014, a study to compile and process hydro-meteorological data in the Nile Basin (NBI, 2014b), was undertaken. This involved a comprehensive evaluation of rainfall data from all of the above sources, as well as other specific sources, in terms of data availability and quality. Datasets were also patched. The outcome of the study was a database of patched monthly rainfall values across the Nile Basin for periods extending from 1900 to 2011 at some stations. From this dataset, rainfall stations located within the Baro-Akobo-Sobat Basin as well as stations directly adjacent to the basin boundary were selected for use in this study. Annex 3 provides information about the selected stations (125 in total) in tabular format (3.1) and also includes a chronogram (3.2) showing the record length and data availability for both the raw and patched datasets. Figure 2-1 displays the locations of the stations. In general, the monthly patched values provide a comprehensive dataset with some geographical parts of the basin, especially the upland areas of the main sub-catchments, having more complete coverage.

An important input to the deterministic rainfall runoff modelling to be undertaken as part of this study, entails daily rainfall depths. However, very limited daily rainfall data are available within the study area. Daily rainfall values at four stations within the Baro-Akobo-Sobat 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 study basin. In order to supplement the paucity of daily rainfall data, daily rainfall records at the stations listed in Annex 3.1 have been requested from the National Meteorology Agency (NMA) in Ethiopia and the South Sudan Meteorological Department (SSMD) in South Sudan.

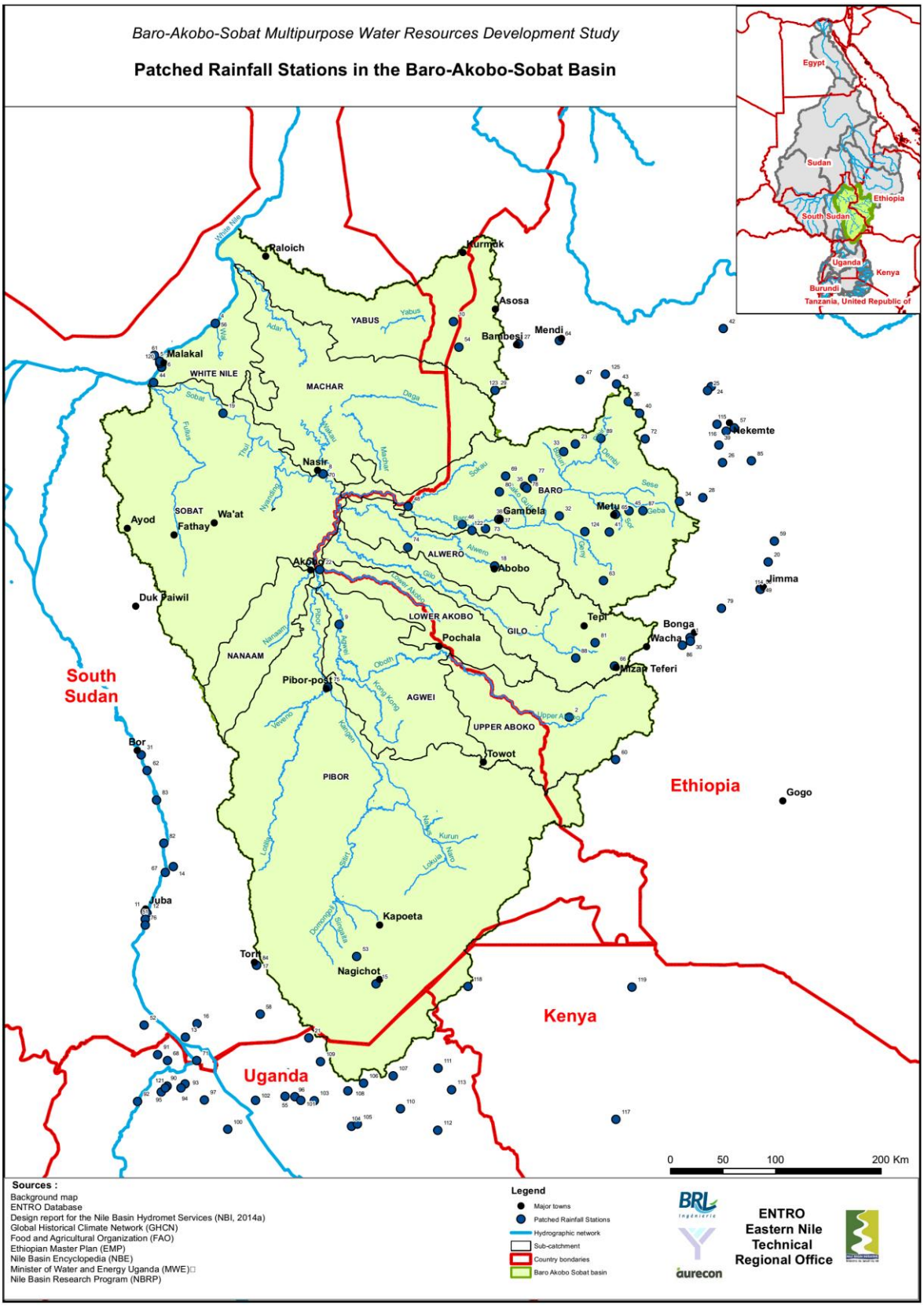


Figure 2-1: Patched rainfall stations in the vicinity of the Baro-Akobo-Sobat Basin

CLIMATE DATA

Currently, according to the design report for the Nile Basin Hydromet Services (NBI, 2014a) there are 15 active full meteorological stations in the Ethiopian part of the Baro-Akobo-Sobat Basin and one station at Malakal in the South Sudan part of the basin. These stations are typically all weather stations collecting multiple meteorological parameters at frequent intervals. The report recommended that another full meteorological station in South Sudan at Kapoeta, which is currently inactive, be rehabilitated, while two new full meteorological stations have been proposed at Pibor Post and Faddoi, also in South Sudan. The rehabilitation of the existing station at Torit should also be considered. Ethiopia is also currently investigating the installation of a weather radar in the Baro-Akobo-Sobat Basin. Table 2-2 summarises relevant details on the existing (active) and proposed full meteorological stations in the basin while Figure 2-2 displays the location of these stations. Meteorological datasets (including rainfall and temperature) for the stations listed in Table 2-2 have been requested from relevant agencies and departments in the respective countries.

Table 2-2: List of full meteorological stations in the Baro-Akobo-Sobat Basin

Country	Agency	Station name	Lat	Long	Altitude (masl)	Start date	Status	Type
Ethiopia	NMA	Abobo	7.85	34.43	530	1986	Active	CLASS 1
Ethiopia	NMA	Alge	8.53	35.67	1880	1955	Active	CLASS 1
Ethiopia	NMA	Aman	6.95	35.57	1192	1982	Active	CLASS 1
Ethiopia	NMA	Ayira	9.10	35.55	1555	1959	Active	CLASS 1
Ethiopia	NMA	Bure	8.23	35.10	1750	1975	Active	CLASS 1
Ethiopia	NMA	Dembidolo	8.52	34.80	1850	1987	Active	CLASS 1
Ethiopia	NMA	Fugnido	7.65	34.42	448	?	Active	CLASS 1
Ethiopia	NMA	Gambella	8.25	34.58	500	1976	Active	CLASS 1
Ethiopia	NMA	Gimbi	9.17	35.78	1970	1953	Active	CLASS 1
Ethiopia	NMA	Gore	8.13	35.53	2033	1952	Active	CLASS 2
Ethiopia	NMA	Hurumu	8.37	35.78	1950	1980	Active	CLASS 1
Ethiopia	NMA	Jeba	6.25	35.22	1711	2009	Active	CLASS 1
Ethiopia	NMA	Jikawo (Lare)	8.33	33.95	419	1980	Active	CLASS 1
South Sudan	SSMD	Malakal	9.55	31.65	0	1921	Active	Synoptic
Ethiopia	NMA	Masha	7.75	35.47	2282	1975	Active	CLASS 1
Ethiopia	NMA	Tepi	7.20	35.43	1205	1956	Active	CLASS 1
South Sudan	SSMD	Torit	4.42	32.55	0	-	Inactive	AWS
South Sudan	SSMD	Kapoeta	5.30	33.97	670	-	Inactive	AWS
South Sudan	SSMD	Pibor Post	6.80	33.14	0	-	New	-
South Sudan	SSMD	Faddoi	8.13	32.30	0	-	New	-

Agency: NMA: Ethiopia National Meteorology Agency; SSMD: South Sudan Meteorological Department

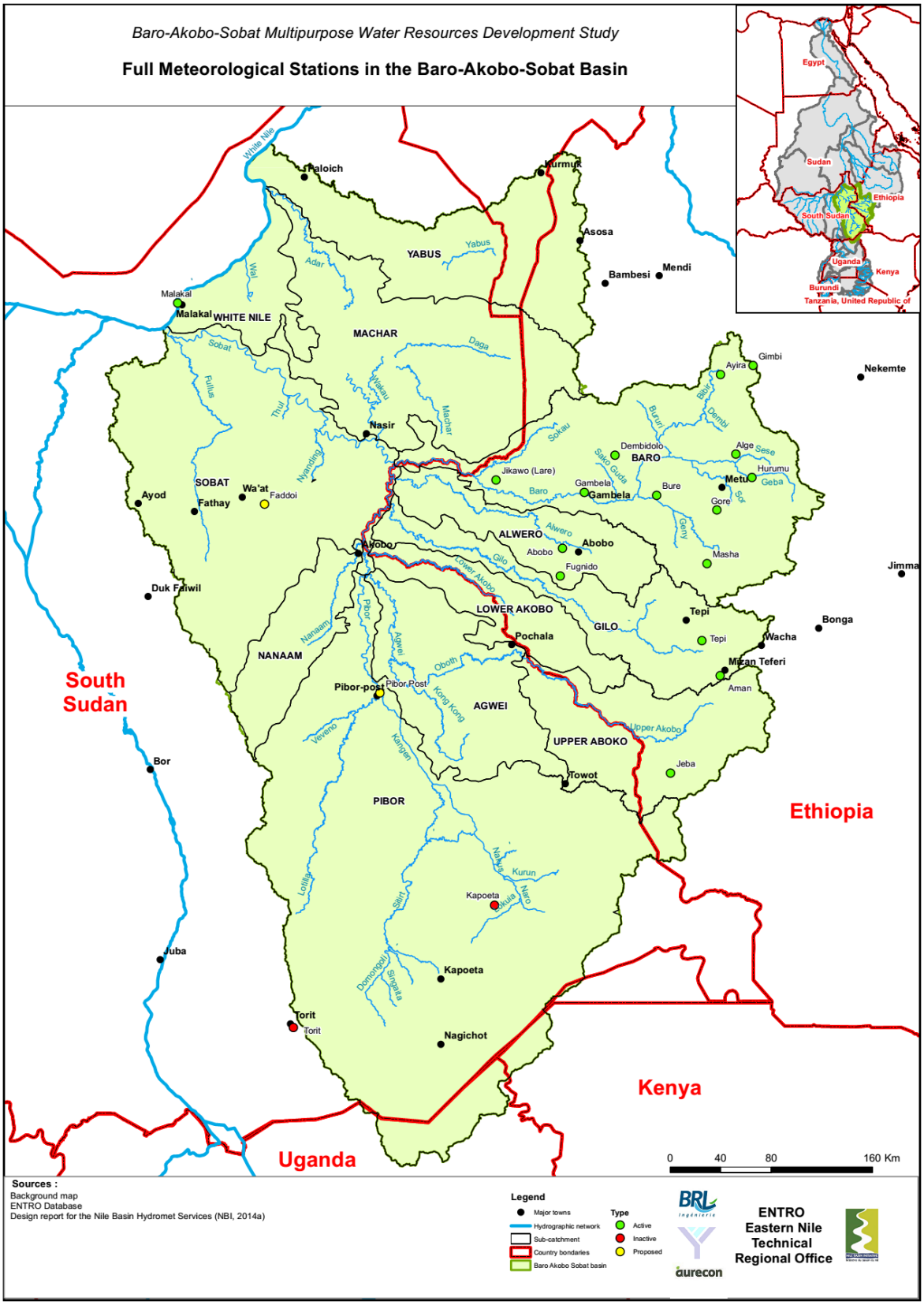


Figure 2-2: Full meteorological stations in the Baro-Akobo-Sobat Basin

EVAPORATION DATA

Average monthly evaporation values in the vicinity of the Baro-Akobo-Sobat Basin are available from the Ethiopian Master Plan studies and the Global FAOClim database. In addition, location specific observed and calculated datasets have also been sourced from previous study reports e.g. Hydrology of the Nile Basin (Shahin, 1985) and the Baro 1 and 2 Feasibility Studies undertaken for the Ethiopian Ministry of Water Resources (Norplan, Norconsult, Lahmeyer, 2006).

Table 2-3 summarises average monthly evaporation values at various stations and sites as obtained from the above sources, while the map displays the locations of the evaporation stations and sites.

Table 2-3: Average monthly evaporation values at various stations in the Baro-Akobo-Sobat Basin

Station Name	Source	Type	Record Period	Lat	Long	Average Monthly Evaporation (mm)												MAE
						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	56	159	123	102	93	98	101	121	108	111	1321
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
* Record period estimated based on corresponding rainfall station record period																		

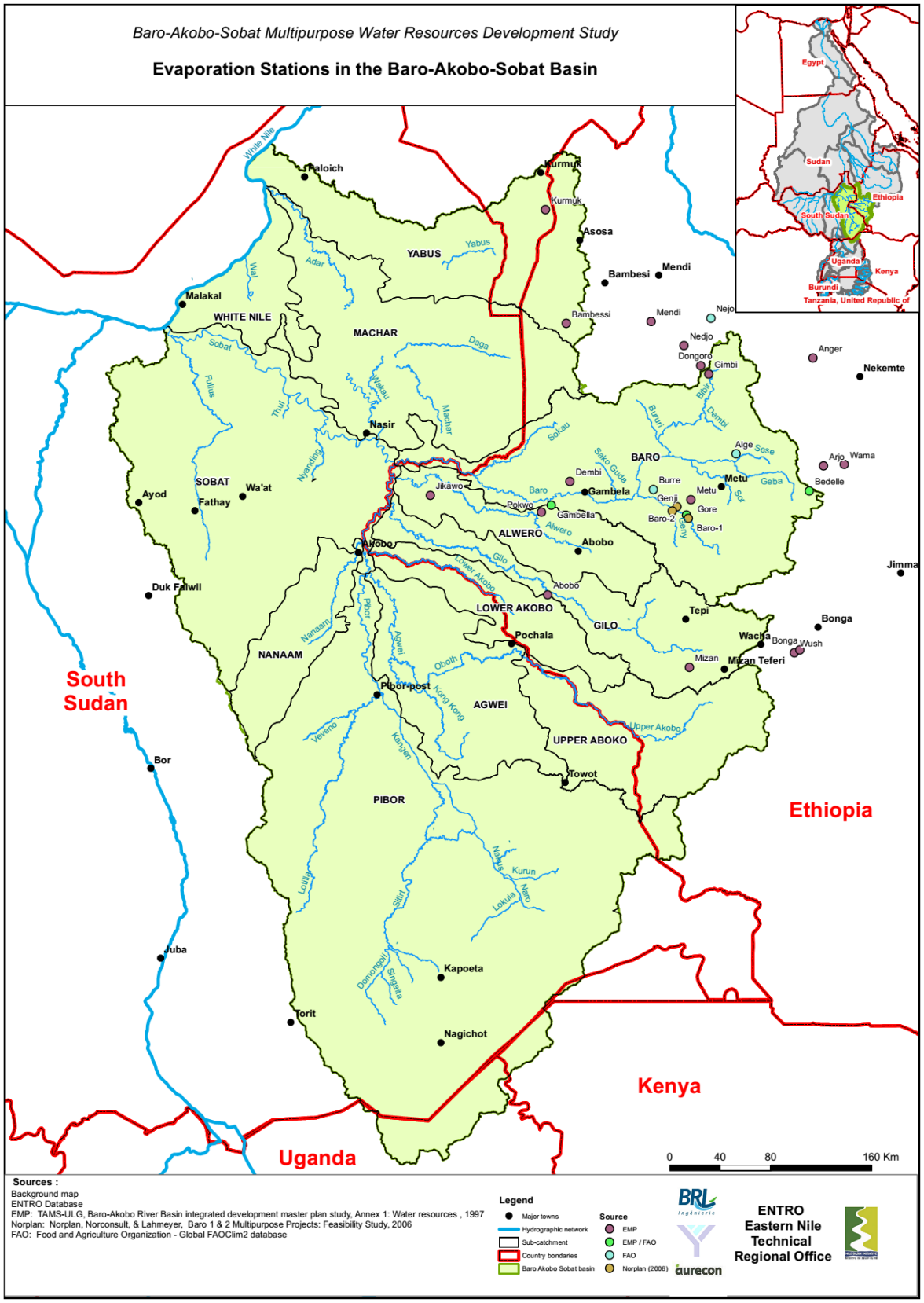


Figure 2-3: Evaporation stations in the Baro-Akobo-Sobat Basin

CLIMATE CHANGE DATA

Projections of climate change modified rainfall, temperature and evaporation data are required for assessing the consequences of regional climate change on water resources availability in the Baro-Akobo-Sobat Basin. For the purpose of this study, SimCLIM (Warrick, 2014) will be employed to determine average monthly changes in precipitation and evaporation, which will then be used, along with the rainfall-runoff model, to assess the sensitivity of water availability to climate change under two Representative Concentration Pathways based on the latest CMIP5 climate models. Monthly changes in climate will be expressed as percentage change in temperature and precipitation based on the median monthly values from up to 40 GCMs. Estimates of potential evapotranspiration will be derived from temperature based on empirical equations.

SimCLIM uses pattern downscaling to produce regional climate change patterns. Its dataset is based on data from the Global Historical Climatology Network (GHCN)-Daily. The dataset is maintained at the National Oceanic and Atmospheric Administration's National Climatic Data Centre (NCDC).

According to the Intergovernmental Panel on Climate Change, it is recommended that the most recent 20- or 30-year climate period should be adopted as the climatological baseline period in impact and adaptation assessments. SimCLIM uses a baseline period from 1986 to 2005. For the purposes of this study, a projection period of 20 years from 2045 to 2065 will be used

2.3.3.3 Data gaps

RAINFALL

The raw monthly rainfall data at stations in the vicinity of the study basin contained various gaps. However, comprehensive infilling of these gaps as part of the NBI 2014 study resulted in a much more complete dataset which, combined, spans a period from 1900 to 2011 and it is the intention to use this dataset for this study.

Spatially, Figure 2-3 shows that there is a paucity of rainfall stations in the Pibor, lower Gilo, Akobo and Sobat subcatchment and in the *Machar marshes*. In these areas, historical gridded satellite based rainfall estimates, for example:

- ARC2 (http://www.cpc.ncep.noaa.gov/products/fews/AFR_CLIM/afr_clim.shtml),
- SMHI (http://www.smhi.se/en/services/open-data/model-data-hiromb-bs01-1.33361) and
- CRU (http://www.cru.uea.ac.uk/cru/data/precip/)

will be used, in combination with observed rainfall data, to improve estimates of historic catchment rainfall in areas poorly represented by rainfall stations. These datasets typically employ advanced algorithms and blend station data and satellite information to provide rainfall estimates at either a daily or monthly time step for periods ranging from 1983 to 2012 (ARC2), 1951 to 2006 (SMHI) and 1901 to 2014 (CRU) respectively.

Although daily rainfall records have been requested from the NMA in Ethiopia and the SSMD in South Sudan, the daily rainfall satellite rainfall datasets will also be used to disaggregate the monthly rainfall to representative daily rainfall patterns in areas where daily rainfall data are lacking.

EVAPORATION

From the map it is evident that very little evaporation data are available in the lower parts of the basin and particularly in South Sudan. The Ethiopian Master Plans only provide evaporation datasets for the upper part of the basin, while the FAO station data are limited to Ethiopia. In order to supplement this data, historical global gridded climatological datasets e.g. SMHI and CRU will be used to estimate reference potential evapotranspiration in certain areas using temperature based empirical formulae. In addition, meteorological data for the stations as listed earlier have been requested from relevant agencies and departments in the respective countries.

2.3.4 Hydrological data

2.3.4.1 Purpose of hydrological data

Hydrological data are required for (a) calibration and validation of deterministic rainfall-runoff models, (b) as inputs to water balance models, and (c) for estimation of flood peaks and flood hydrographs associated with a range of recurrence intervals.

2.3.4.2 Data availability

An extensive river gauging network (83 stations in total) existed in the Baro-Akobo-Sobat Basin historically, 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.

Historical flow data within the Nile Basin are available from the following sources:

- The Nile Basin Encyclopaedia: Ten-daily observed flow data are available at various stations spread across the Nile Basin.
- Ethiopian Master Plan Reports: Monthly observed flow data at various stations across the Nile Basin.
- The Nile Basin Research programme at the University of Bergen: This programme serves as a framework for research on topics specifically relevant to the Nile Basin.
- NBI: The NBI has various datasets collected as part of previous studies.
- ENTRO BAS IMS: ENTRO maintains databases of monthly flow data at selected stations based on various sources.
- Ethiopian Ministry of Water, Irrigation and Energy (EMWIE). Flow data which were sourced from the ministry as part of the 2014 NBI (2041b) Study were made available for this study.
- Previous studies: These refer to various studies which have been undertaken over a number of years and which involved either the simulation of flow data and/or specific flow monitoring programmes.

Note: Many of the data records in the EMPs and previous study reports have been manipulated (scaled from source records to represent flows at target locations, or adjusted for reasons unknown) or simulated. It is not always possible to ascertain the approach which was used for adjustments made or for the generation of synthetic sequences. For these reasons the data quality of the master plan data records as well as flow sequences as presented in previous study reports must be viewed as questionable, and used with caution. For the current study, preference was given to the use of the Nile Encyclopaedia records.

The flow data which are available from the above sources, were evaluated and are summarised in the chronogram in Annex 4. The chronogram illustrates the length of flow record available at each station as well as the data gaps. Based on specific criteria e.g. spatial coverage, length of record, size of catchment and preliminary data quality checks, 13 stations were selected to be used for calibration and validation of the hydrological model in this study. These stations are listed in Table 2-4.

In the Baro River, it is anticipated that the gauge at Gambella will be most useful as it measures streamflow from a large catchment and also due to its long, reasonably accurate records. Additionally, gauges on upstream tributaries of the Baro River were selected to assist in quantifying the contributions to the Baro River. Preference was given to gauges which are classified as “good” in the NBI 2014 study (NBI, 2014b). There are limited gauges in the Pibor River. Consequently, stations with the most complete record upstream of the Gilo-Pibor confluence were selected. Similarly, the stations downstream of the Baro-Pibor junction at Nasir and Hillet Doleib were selected.

Table 2-4: Flow stations selected for calibration in the Baro-Akobo-Sobat Basin

Station	Source	Latitude	Longitude	Record Period (Unpatched)
Alwero at Abobo	EMP	7.84	34.55	1976-1990
Baro at Burebeiy	NBRP	8.42	33.23	1929-1932
Baro at Gambella	NBI	8.25	34.58	1904-1910, 1929-1932, 1990-2009
Baro at Gambella	NBRP	8.25	34.58	1906-1928
Baro at Gambella	EMP	8.25	34.58	1906-1989
Baro at Itang	NBI	8.183	34.27	1974-1982
Baro at Kella	NP	8.233	34.97	1987
Baro at Masha	NP	7.87	35.48	1990, 1995, 1997, 1999-2003
BirBir at Yubdo	NBI	8.95	35.48	1985-1990
Geba at Suppi	NBI	8.48	35.65	1986-1991, 1993-2005
Pibor at Pibor Post	NBE	6.80	33.13	1928-1932
Pibor upstream of Khor Gila mouth	NBE	8.13	33.19	1929-1939, 1941-1944, 1946-1963, 1973-1977
Sobat at its mouth into White Nile (at Hillet Doleib)	NBE	9.36	31.59	1905-1983
Sobat at Nasir	NBE	8.61	33.06	1929-1963, 1968-1972, 1978-1981
Sor at Metu	EMP	8.30	35.60	1967-1993
Sor at Metu	EMWE	8.30	35.60	1985-2006

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*

2.3.4.3 Data gaps

Information related to the current status of flow gauging stations as well as corresponding and more up to date flow records are being sourced from the relevant ministries in Ethiopia and South Sudan viz. the Hydrology and Water Quality Directorate under the Ministry of Water, Irrigation and Energy in Ethiopia and the Directorate of Hydrology and Survey (DHS) under the Ministry of Electricity, Dams, Irrigation and Water Resources (MEDIWR) in South Sudan.

Where there are monthly flow data missing within the datasets selected for model calibration, the gaps will be filled using simulated flow data from the hydrological model.

2.3.5 Water quality data

2.3.5.1 Purpose of water quality data

Water quality data are required in order to (a) assess the fitness for use of water resources across a range of user categories and to (b) quantify the potential impacts of catchment development and management options on water quality variables.

2.3.5.2 Data availability

Water quality appears to be poorly monitored in the Baro-Akobo-Sobat sub-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 **BAS Master Plan Study** which was conducted from 1986 to 1988 (Selkhozpromexport, 1990) reported on water quality of some 95 water samples that were collected during the study. The samples were collected at gauging stations in the Baro, Birbir, Gilo, Chiro and Alwero rivers, depending on the availability of flow at the sites. These samples were analysed for 18 constituents and the raw data were tabulated in Appendix III of the Master Plan Report.

The **National Nile Basin Water Quality Monitoring Baseline Report for Ethiopia** (Merid, 2005) refers to the data that were collected during the Selkhozpromexport Master Plan Study and in addition, lists a total of 64 surface and ground water physico-chemical and 25 bacteriological quality datasets, generated from 1972 to 2001, which were sourced from the then Ministry of Water Resources database. The actual data are not provided in the report. The author was concerned that "In Ethiopia, comprehensive and regular water quality monitoring and surveillance activities are lacking at all levels. In general, the level of emphasis provided for water quality management issues is very low when compared with the level of attention given to other aspects of water development".

The **National Nile Basin Water Quality Monitoring Baseline Report for Sudan** (NBI, 2005) found that there are no routine monitoring points in the Baro-Akobo-Sobat Basin although there is a regular (monthly) sampling point on the White Nile at Malakal. The report provides maximum and minimum values for up to 14 constituents as observed during 2001 to 2004.

2.3.5.3 Data gaps

There appears to be no form of regular water quality monitoring in the study basin. Intermittent monitoring efforts seem to focus on quality control at the location of water supply schemes only.

It is recommended that routine flow and water quality monitoring in the Baro-Akobo-Sobat Basin be implemented as recommended by the current NBI Hydromet Project (NBI, 2014a) as well as by the respective Monitoring Baseline Reports for Ethiopia and Sudan. This will, over time, improve the water quality knowledge base in the Baro-Akobo-Sobat sub-basin and provide a platform for the early identification and investigation of potential water quality problems.

The Nile Basin Hydromet report (NBI, 2014b) recommended that water quality data be collected at three priority sites, namely the Baro at Itang, Akobo at mouth, and Nasir.

The implementation of a detailed water quality monitoring programme will not be completed during this study's timeframe. For the purpose of this study, it is acknowledged that limited water quality grab samples collected at pre-identified locations during field visits will have to suffice.

2.3.6 Topographic data

2.3.6.1 Overview

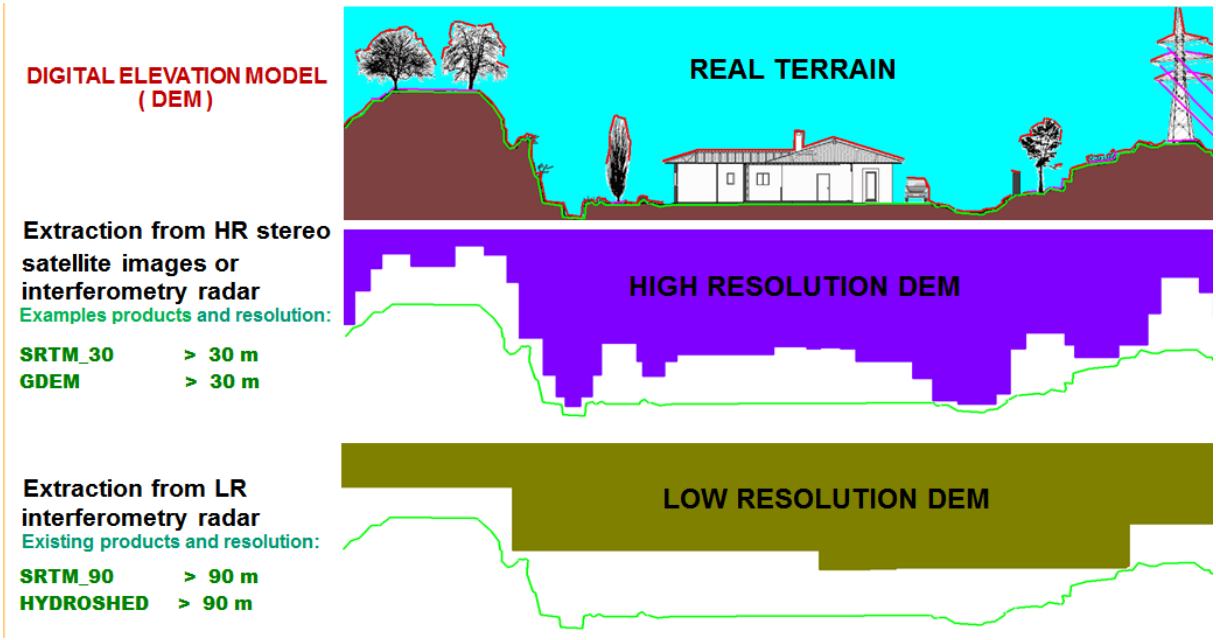
The main input to the understanding of the topography of the basin has been the digital elevation model (DEM). Considerable effort and resources have been put into producing an improved version which will be used across many of the thematic areas.

2.3.6.2 Purpose of the DEM/topograophic data

The DEM will be critical for a number of applications inlcuding analysis of the relief in the South and East of the study area, in particular for a better understanding of erosion, hydrology and geology and for application in the fields of irrigation, hydropower etc.

A 30m Digital Elevation Model (DEM) is now available having been created using world GDEM (30 metres) and SRTM (90 metres) data. These DEMs were then combined and assembled to form the global DEM. By combining several DEMs of a single place, it has been possible to eliminate the artefacts present on some but not on all of them.

As shown below, the difference between STRM90 and GDEM30 concerns the resolution with 9 pixels of GDEM30 equal to 1 pixel for SRTM90. So, all automatic products (Slopes, hydrographique network and basin) have a lower quality and accuracy with 90 meters DEM.



A separate working paper has been drafted on the application of remote sensing, and this covers the technical details with respect to the creation of the DEM.

2.3.7 Hydrographic network

A correct understanding of the hydrographic network within the Baro-Akobo-Sobat Basin is imperative in order to model the water balance in the system, to evaluate the availability of water for future development, to analyse alternative development scenarios and management interventions and to evaluate the socio-economic and environmental impacts associated with basin development.

2.3.7.1 Overview

Traditionally, for the purposes of mapping and modelling, the Baro-Akobo-Sobat Basin is delineated into six major-sub-basins, viz. the Baro, Alwero, Gilo and Akobo sub basins, almost entirely in Ethiopia, and the Pibor and Sobat-*Machar marshes* sub-basins. The Pibor and Sobat-*Machar marshes* sub-basins are characterized by various smaller tributaries and sub-catchments, many of which have not been mapped or studied in any detail.

The rivers originating from the south-western part of the Ethiopian Plateau flow westward. These include the Baro River and its main tributaries (Birbir, Geba, Sor, Gumero and Genji), the Alwero River, the Gilo River with its tributaries (Gecheb, Bitun, Beg), and the Akobo-Agwei River.

Downstream of the Ethiopian highlands, the westward draining rivers spread out over a flat marshy plain, dispersing through a multitude of small channels. These spills onto the floodplains are supplemented by significant rainfall directly on the plains. Understanding the magnitude of the contributions from both these sources is important when evaluating options for economic development and water resources management. Some of this “sheet flow” re-enters the main channels of the Baro and the Akobo west of these marshes.

Downstream of Gambella and immediately above the Jakau River junction, the Baro River bifurcates into the Baro to the north and the Adura to the south. They rejoin below the junction with the Khor Machar. The latter discharges significant water volumes to the *Machar marshes* during the high flood season. The *Machar marshes*, which has a maximum area of approximately 6 500 km2, lies north of the main channel of the Baro River and are seasonal wetlands that receive water both from rainfall, over-bank spills of the Sobat and the Baro and from local runoff via the eastern torrents (including the Yabus and Daga rivers). In the rainy season these wetlands expand to cover a large area east of Malakal and north of the Baro River. During the flood season a small amount of water from the *Machar marshes* occasionally enters the White Nile northeast of Malakal through the Khor Adar.

The Pibor River, which flows in a northerly direction, drains the Eastern Equatoria and Jonglei Regions of South Sudan. The river originates from the southern edge of the catchment and accumulates flow from three tributaries viz. the Viveno, Lotila and Kengen, 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, just below the Akobo confluence the Pibor spills westwards to the Twalor (Nyanding) a south bank tributary of the Sobat. The Pibor River becomes braided on the plains to create wide floodplains. 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. Below these streams on the foot-slopes gradients rapidly decrease and coarse sediment is deposited forming well defined valley floodplains and wetlands.

After the Pibor-Baro confluence, the river is known as the Sobat River to the 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.

Flow regimes in the Baro-Akobo-Sobat Basin are closely connected to the monsoon climate with stream flows increasing through May to September and generally peaking in September or October. When rainfall ceases, river levels decline with low flows characterising the period between January and May. The major rivers are perennial, although some of the smaller tributaries are seasonal. The majority of runoff results from the Ethiopian highlands.

2.3.7.2 Refinement of hydrographic network and subcatchments

An initial task of this study concerned a review and refinement of the hydrographic network and the associated sub-basin mapping based on the latest 30 m DEM (SRTM30). The methodology, including how remote sensing has contributed is briefly explained here after.

NETWORK MAPPING

The first step of this work was to manually draw the networks on satellite images using experience of photo-interpreters and computer processing. The automatic network generation uses elevation model (SRTM30) and calculates the theoretical direction of flow. But when the difference of height in a basin is quite low, the real stream route cannot be determined and manual mapping is required to obtain accurate results. In fact, the automatic product is used to understand the general flow direction. In the BAS study, this was very important because streams connections are not easy to understand. This is illustrated in the figure below.

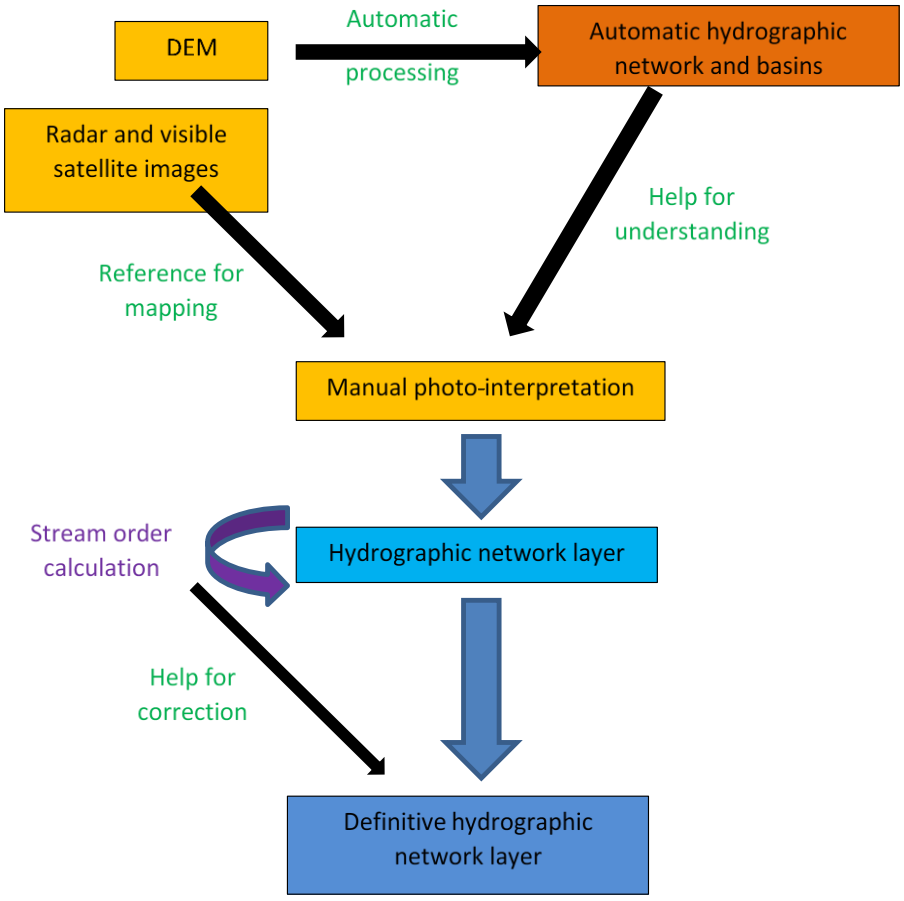


Figure 2-4: Method used to refine the hydrographic network

The remote sensing work has been used for several detailed analysis of the sub-basins and stream networks. As shown in

Figure 2-5, the river networks have been analysed down to the 8th level.

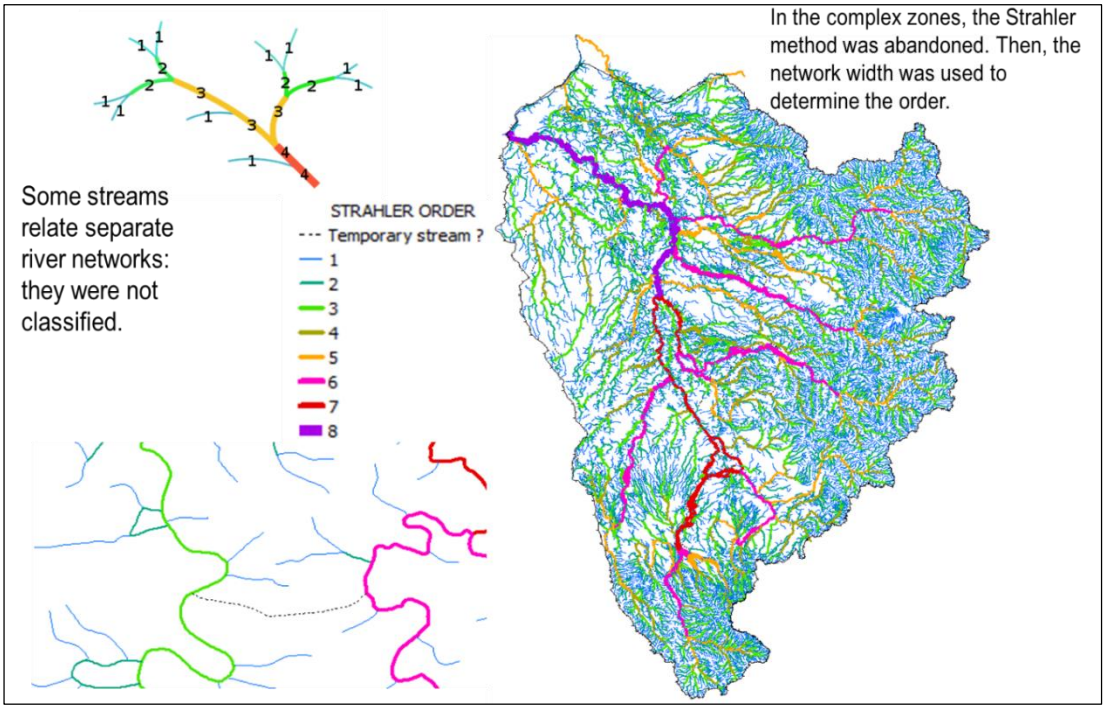


Figure 2-5: Definition of streamline order using Strahler method (application of remote sensing)

The primary streams are shown as order 8 and the smallest tributaries as 1st order. It should be noted that it was not possible to use the Strahler method (which requires that a clear order can be determined), in some highly complex and flat areas. In these areas a manual analysis using satellite imagery acquired at different times was used.

Based on the detailed definition of the network a classification of sub-basins down to the 9th order was carried out as illustrated in

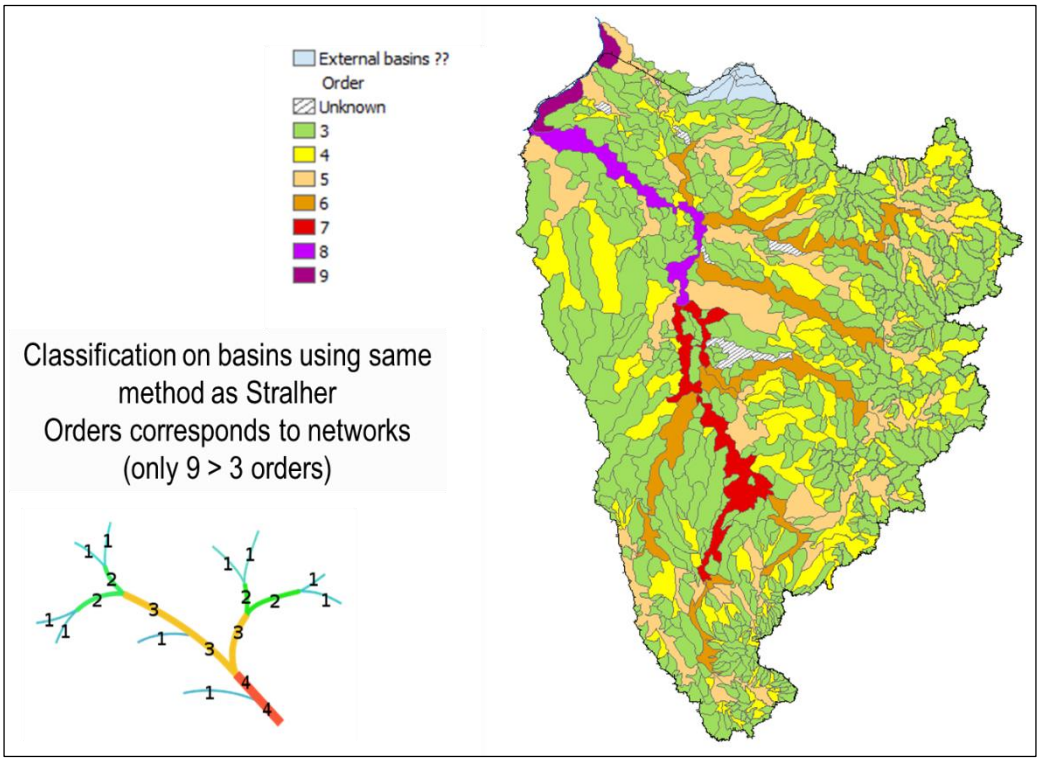


Figure 2-6.

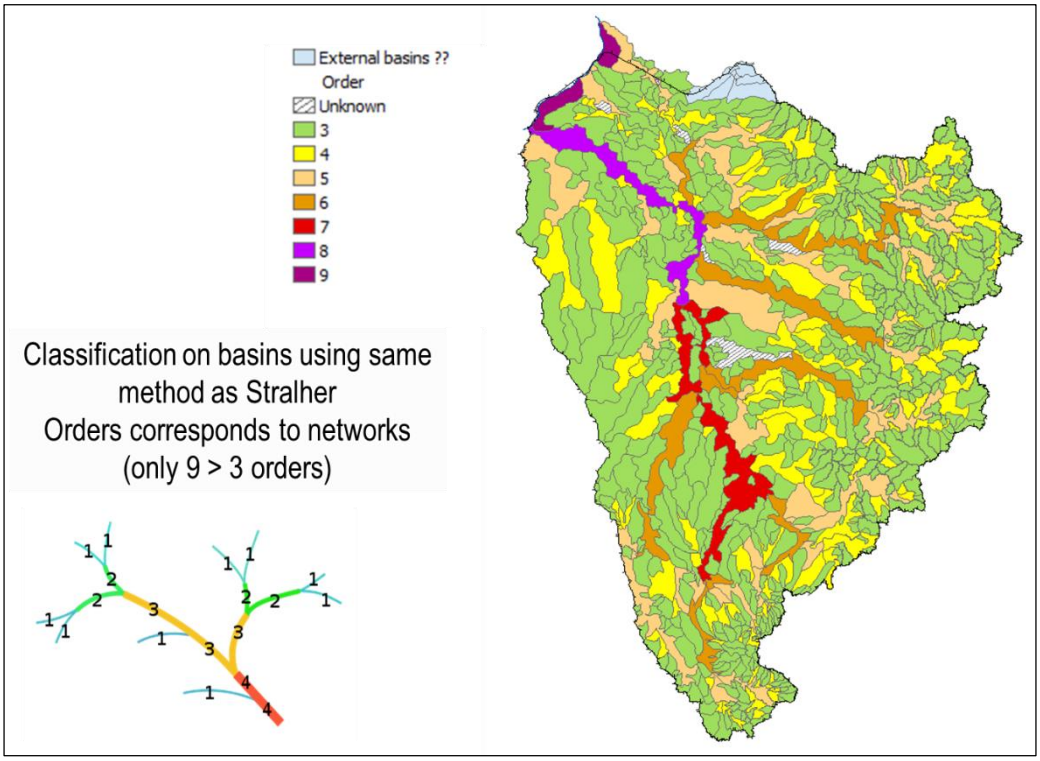


Figure 2-6: Classification of basins using Strahler order (application of remote sensing)

SUB BASIN MAPPING

The sub-basins generated in this way provide the building blocks for the accurate mapping of the main sub-basins. Basin delimitations have been made for all order > 2 stream from Strahler classification. That corresponds to 780 basins on the whole area. The scale of work could be assimilated to 1:50,000 in relief areas, and 1:200,000 in very flat areas.

The complete methodology used for remote sensing is included as Annex 2. The outcome of this task resulted in the hydrographic network and sub-basins as shown in Figure 2-7.

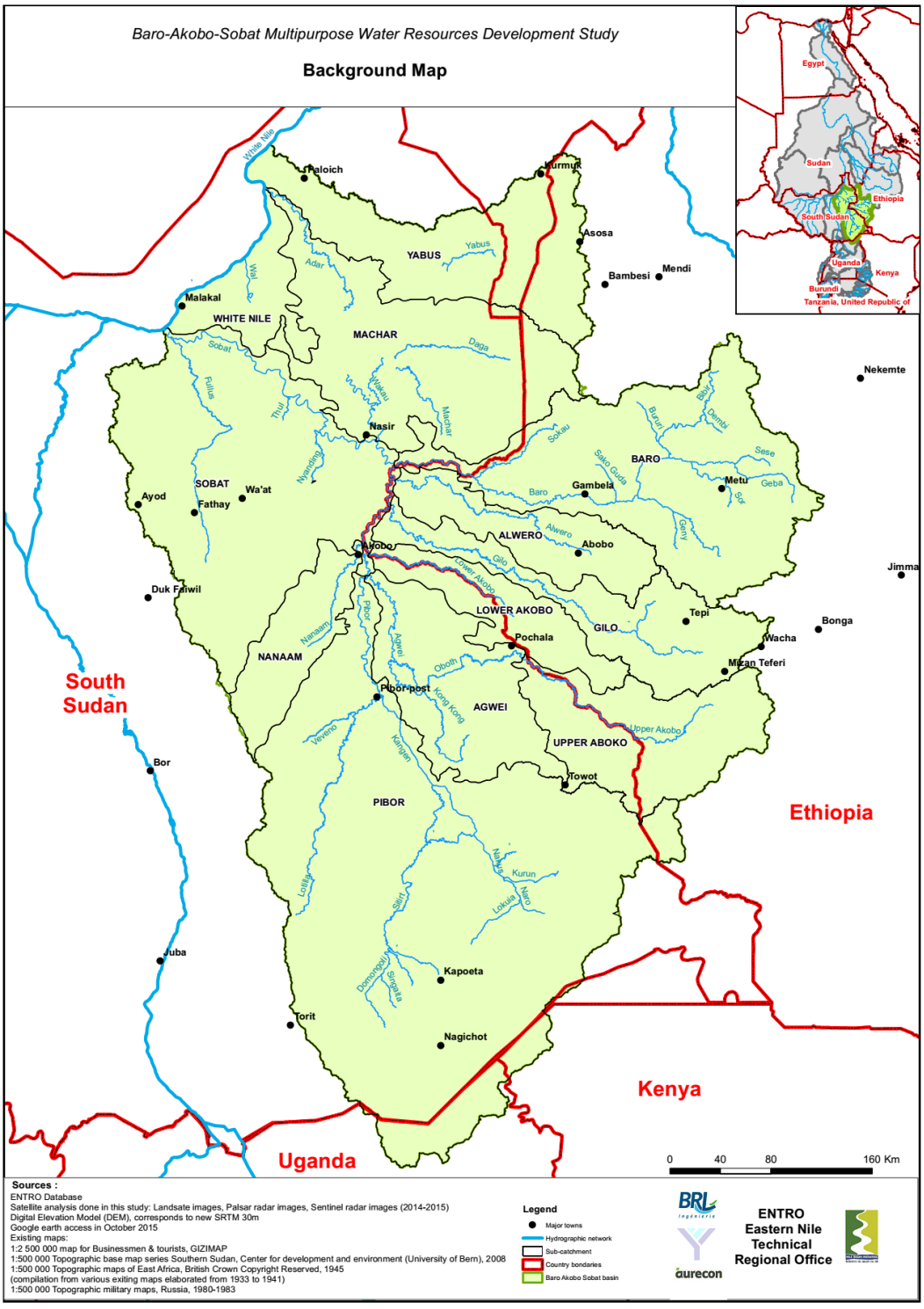


Figure 2-7: Latest hydrographic network and sub-basins

Three aspects of the hydrographic network (as shown in the figure above) are worth highlighting:

- In almost all previous studies, including topographic maps dating back to the mid-1900s, the upper Akobo River is shown to flow into the lower Akobo River. However, the drainage patterns based on the latest 30m DEM suggest that the upper Akobo River discharges into the Pibor River via the Oboth and Agwei rivers. This is confirmed by the latest satellite imagery, which distinctly shows the lower Akobo River as a separate catchment, disconnected from the upper Akobo River, and the Upper Akobo River making its way through extensive wetlands south of

the lower Akobo sub-catchment, before discharging into the Pibor River via the Oboth River and then the Agwei River.

- The upper, southern part of the Pibor sub-basin, as well as the western boundary of the Pibor sub-basin downstream of Torit, are characterised by extensive marshes and wetlands which complicate the identification of flow paths and associated subcatchments. At this stage, the Kineti River, which flows to the west of Torit in the Pibor catchment, has been included in the study area. In most existing ENTRO maps it is shown as outside.
- Although it is not shown in any detail on the figure above, we are cognisant of the spills and links between the main rivers and the extensive marshes and floodplains in the Gambella Plain and the *Machar marshes* and the importance of understanding the dynamics thereof in order to ensure accurate water balance modelling and impact analysis. Annex 2 provides the details of the detailed analysis which is being undertaken, using advanced remote sensing techniques, to improve the understanding of these links and spills. In addition, remote sensing is also being used to develop a historical time series of seasonal wetland extents to assist with the calibration and validation of the water resources models.

2.3.8 Sediment and morphological data

2.3.8.1 Purpose of data

Sediment yield and discharge data are required to (a) estimate sedimentation rates at the proposed dams to be developed as part of this study, and (b) to assess the morphological impacts of upstream developments on river and channel morphodynamics. In addition, river cross sections are required for hydrodynamic and morphodynamic modelling.

2.3.8.2 Data availability

As part of the 1990 Selkhozpromexport Master Plan Study of the Gambella Plains sediment sampling was conducted at five gauging station locations in the Baro, Alwero, Chiru and Gilo rivers within the basin between 1986 and 1988, measuring suspended sediment concentrations and grain size composition of suspended and bed load sediments. Turbidity values as high as 507 g/m3 were observed. Measurement of grain size composition entailed 45 samples, with the median sediment size approximately 0.1 mm to 1 mm. Based on this limited data along with information on long-term average discharges, semi-empirical equations were used to derive long term estimates of average sediment runoff in the catchment at the location of the monitoring sites as well as at the location of proposed dam sites. The resulting sediment discharges are tabulated in Table 2-5.

Table 2-5: Estimated long-term average sediment runoff at key locations in the Baro-Akobo-Sobat basin (Selkhozpromexport, 1990)

River-site	Catchment Area km^2	Mean annual runoff, MCM	Average turbidity, g/m^3	Mean annual sediment load, million tonnes		
				Suspended sediments	Bed load	Total sediment load
Baro-Gambella	23 400	12 685	165	2.093	0.442	2.535
Alwero-Dam (Dumbong)	1 100	184	48	0.009	0.002	0.011
Alwero-Abobo	2 790	630	64	0.04	0.003	0.043
Chiru-Ukuma Kijang	801	388	91	0.035	0.003.	0.038
Gilo-Agenga	9 850	3 980	109	0.434	0.017	0.451
Birbir-Site 2	6 840	3 472	165	0.573	0.172	0.745
Geba- site 1	6 220	44 166	65	0.687	0.206	0.893
Birbir- site 1	13 230	7 701	165	1.271	0.381	1.652
Sor site 1	1 770	688	65	0.278	0.083	0.361
Baro-Site 3 (TAMS)	20 970	11 866	165	1.958	0.413	2.371
Baro-Site 2 (Bonga)	22 290	12 182	165	2.01	0.424	2.434
Baro-Site 1 (Gambella)	22 740	12 308	165	2.031	0.429	2.46
Baro-Itang site	24 420	3 004	165	2.151	0.454	2.605
Chiru site	733	369	91	0.004	0.003	0.007
Gilo-Site 1	7 570	3 629	109	0.396	0.016	0.412
Gilo-Site 2	9 640	3 945	109	0.43	0.01	0.447
Gilo-Site 3	9 820	3 977	109	0.433	0.017	0.45

The TAMS and ULG (1997) Baro-Akobo River Basin Integrated Development Master Plan provides sediment transport data at eleven gauging stations in the Baro-Akobo-Sobat basin, collected between 1982 and 1990. The methodology for sample collection has not been reported. 101 measurements of suspended sediment loads are on record. Based on concurrent flow measurements, data at stations with sufficient data were used to derive sediment rating curves as shown in Table 2-6.

Table 2-6: Sediment rating curve and yield (TAMS-ULG, Baro-Akobo River Basin integrated development master plan study, Annex 1: Water Resources , 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	1 006	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	1 620	52.6	$Qs = 0.00130\ q^{1.189}$	124
Gecheb	79	1.90	$Os = 0.00056\ q^{1.220}$	63
Beg Wuha	125	3.33	$Qs = 0.00110\ q^{1.145}$	85

These sediment yields were noted to be relatively low. Conservative yields based on an average value of 3 mm soil loss per annum, along with typical delivery ratios were therefore adopted to estimate possible sedimentation rates for a range of catchment areas from 100 km2 to 30,000 km2, which were then used to calculate potential reservoir sedimentation rates at for a 50 year period at the proposed dam sites, assuming 100 % trap efficiency (see Table 2-7).

Table 2-7: Reservoir sediment accumulation (TAMS-ULG, Baro-Akobo River Basin integrated development master plan study, Annex 1: Water Resources , 1997)

Proposed reservoir	Catchment Area (km^2)	Sedimentation Rate (million ton/a)	Reservoir Equivalent Storage after 50 years (mcm)
Abobo	2 790	3.6	133
Chiru	733	1.32	49
Mey	353	0.76	28.3
Dumbong	1 100	1.79	66.4
Gilo-1	7 573	7.62	282
Gilo-2	9 640	9.13	338
Gilo-3	9 820	9.26	343
Birbir-R	6 840	7.06	262
Birbir-A	3 579	4.34	161
Geba-R	6 222	6.58	244
Geba-A	1 086	1.78	65.8
Itang	24 420	18.3	679
Gambella	23 461	17.8	659
Bonga	22 290	17.1	634
TAMS	20 970	16.4	606
Sese	367	0.79	29.2
Sor	1 777	2.57	95.2.
Gumero	443	0.91	33.7
Baro	1 620	2.4	88.8
Beko	1 815	2.61	96.7
Kashu	449	0.92	33.9
Saku-Guda	378	0.8	29.8

In addition to the above studies, various other sediment studies have been conducted for the African continent. Vanmaercke, Poesen, Broeckx, & Nyssen (2014) summarised and georeferenced sediment yield measurements for 682 African catchments (comprising more than 8 340 catchment years of observations) from 84 publications and reports. The data were quality controlled and a multiple regression model was constructed to develop sediment yield equations for estimating the spatial variation in sediment yields. From the results, sediment yield in the Baro-Akobo-Sobat basin is shown to vary between 100 to 1000 t/km2.a. This range is wide and thus only indicative.

Walling & Webb (1996) reviewed global sediment yield data availability, uncertainties and data reliability. Within the Baro-Akobo-Sobat basin, they estimated sediment yields of between 50 and 100 t/km2.a. Walling (1984) used the same data, but focused on the African continent. He estimated catchment yields of 0 to 100 t/km2.a in the lowland areas of the Baro-Akobo-Sobat basin and 100 to 1000 t/km2.a in the highlands.

No topographical survey data of river sections in the Baro-Akobo-Sobat Basin are readily available.

2.3.8.3 Data gaps

The following limitations with regard to sediment data in the Baro-Akobo-Sobat basin are observed:

- There is no extensive suspended sediment load database available in the basin and data collection appears to have ended in 1990 with only 100 samplings available at 11 gauging stations. These records are too limited to deduce any meaningful sediment yield-discharge relationships.
- The observed sediment yields were lower than expected, leading to the use of analytical methods for estimation of sediment yields in previous studies.
- Most of the work conducted relies heavily on the 1990 Master Plan Study by Selhozpromexport, which estimated sediment yields analytically based on very limited measured data.

It is evident that more recent sediment data should be obtained for this study. Consequently, relevant government departments in Ethiopia and South Sudan have been contacted to establish whether sediment data have been / are currently being collected in the main rivers in the basin and to obtain the associated records. These would typically include sediment loads and/or concentrations and discharge measurements close to flow gauging stations. The possibility of undertaking limited sediment sampling for this project will also be investigated. This would entail grading analyses (sieve test and hydrometer test) and possibly particle density tests of soil samples to cover the main soil type zones in the main river catchments as well as sediment samples in main rivers.

Furthermore, in light of the very limited existing information with regard to sediment data and sediment yields, the SHETRAN model will be used for modelling of sediment yields in the Baro-Akobo-Sobat Basin. The model is a physically based, spatially distributed model with an integrated surface / subsurface modelling system for water flow, sediment transport and contaminant migration in river basins.

For the purpose of hydrodynamic and morphodynamic modelling along the floodplains, remote sensing data will be used to extract general information on some basic river characteristics.

2.3.9 Groundwater data

2.3.9.1 Data availability

In general, there have not been many comprehensive studies conducted in the area and the availability of groundwater data is very limited. The master plan studies between 1990 to 1996 are the main documents available for Baro Akobo part of the project area; and few groundwater reports and databases have been found so far for the Sobat potion of the study area. The main source of data/information is found to be the Ethiopian Ministry of Water, Irrigation and Energy (MoWIE), the regional water bureaus and the South Sudan Ministry of Water Resources and Irrigation. Table 2-8 presents the data sets (and reports that contain data) that have thus far been assessed for future use.

Table 2-8: Sources of groundwater data

SN	Data Type/description	Number of Records	Source	Remarks
1 Boreholes/water points data				
1.1	Inventory data of HDWs	68	Ministry of Water, Irrigation and Energy (MoWIE) /ARDCO-GEOSERV, 1995	All with coordinate references and lithologic information
1.2	Boreholes inventory data	21	"	Except five records all with coordinate references
1.3	Baro Akobo BHs data	10	MoWIE/ESP project, 2003	Extracted
1.4	Baro Akobo HDWs data	68	"	"
2 Water Quality Data				
2.1	Water quality data of springs	175	Ministry of Water, Irrigation and Energy (MoWIE) /ARDCO-GEOSERV, 1995	All with coordinate references
2.2	Water quality data	112	MoWIE/Russian Report (1990)	To be extracted from the report appendix
2.3	Water quality data (within hydrogeology of Ethiopia and Water resources development, Tesfaye Cherinet, 1993)		Geological survey of Ethiopia (GSE)	To be extracted from the report appendix
3 Water Source and Supply data				
3.1	Indicator survey data on water supply conditions and sources by Woreda (1995)	54	Ministry of Water, Irrigation and Energy (MoWIE) /ARDCO-GEOSERV	
3.2	Water sources and supply data from Sobat area (Equatoria)	1641	South Sudan water resources office	Large dataset to be sorted and screened
3.3	Water sources and supply data from Sobat area (Jonglei)	304	" "	"
3.4	Water sources and supply data from Urban WRS database of the ESP project, 2003	64	MoWIE/ESP project	Extracts for towns
3.5	Water sources and supply data from Borehole database of the ESP project, 2003			Extracts
4 Previous studies				
4.1	Baro Akobo Basin Master Plan Study, Vol IV, Annex 2: Geomorphology, Geology and Hydrogeology, SELKHOZPROMEXPORT, USSR, 1990.		Ministry of Water, Irrigation and Energy (MoWIE)	
4.2	Survey and analysis of The Upper Baro-Akobo Basin, Volume II: Water resources. ARDCO-GEOSERVE, 1995		Ministry of Water, Irrigation and Energy (MoWIE)	
4.3	Baro-Akobo River Basin Integrated Development Mast plan Study Water Resources, Annex 1D: Groundwater, TAMS, ULG, 1996		"	
4.4	Baro-Akobo River Basin Integrated Development Mast plan Study Water Resources, Annex 2C: Geology, TAMS, ULG, 1996		"	

SN	Data Type/description	Number of Records	Source	Remarks
4.5	Preliminary Water Resources Development Master plan for Ethiopia, Vol. III, Annex A: Hydrology & Hydrogeology, WAPCOS, India, 1990.		"	
4.6	Omo River project, Preliminary report on the Geology and Geochemistry, Ministry of Mines and Power, 1975		Ministry of Mines and Energy	
4.7	Hydrogeology of Ethiopia and Water Resources Development, Tesfaye Cherinet, 1993		"	
4.8	Hydrogeological report of Gore area (NC36-16), Ministry of Mines and Energy, 2001		Ministry of Mines and Energy	
4.9	Hydrogeological and Geophysical Investigation for the Gambella Hospital,		Gambella Water Bureau	Ref Yemarshet
4.10	Hydrogeological and Geophysical Investigations Fugnido Refugee Camp Area, Gambella, AWE Consultants Plc, 2011		AWE Consultants Plc	
4.11	Feasibility Studies, Detailed Designs And Technical Specifications For The Urban Water And Sanitation Facilities In The Three State Capitals Of Bentiu, Bor And Torit, Final Water Resources Assessment Study Report: Bor Town - Jonglei State, SMEC,2013			Also report for Torit town
5 Maps				
5.1	Photo geological map of Gambella sheet, 1:100,000, Ministry of Mines and Energy/UNDP, 1969		Geological Survey of Ethiopia (GSE)	
5.2	Photo geological map of Begi sheet, 1:100,000, Ministry of Mines and Energy/UNDP, 1969		"	
5.3	Geological map of Gore sheet, 1:250,000, Ministry of Mines and Energy, 1987		"	
5.4	Hydro geological Map of Ethiopia, Ethiopian Institute of Geological survey ,1998		"	
5.5	Geological Tectonic scheme map of the Gambella plain, SELKHOZPROMEXPORT, USSR, 1990.		Ministry of Water, Irrigation and Energy (MoWIE)	Contained in the report
5.6	Groundwater Table and TDS distribution maps for upper Baro Akobo basin, ARDCO-GEOSERVE, 1995		"	Small scale thematic maps contained in the report
5.7	Simplified Geological map of Gambella plain		From Seifu Kebede's Groundwater in Ethiopia book, 2013.	Small scale map

2.3.10 Conservation areas

2.3.10.1 Purpose of conservation areas data

Data on conservation areas should help:

- Defining more precisely the environmental and social baseline on these sensitive areas;
- Assess the effects of the intended activities on these areas;
- Assess the capacity of the institutional mechanisms to implement the measures that will be recommended in the ESMP.

2.3.10.2 Data availability

The following information is available in the literature:

- Number and name of protected areas in the basin;
- Approximate and non-updated size, location and delineation of the protected areas;
- Some facts on the ecosystems of the protected areas.
- Status of some protected areas (not updated).

The following table summarizes the information available at this stage:

Name	Location	Area (ha)	Status
Gambela National Park	Ethiopia	506 100	"National Park boundaries were never ratified at a national or federal level, nor were many resources allocated for management. No management plan prepared. No visitor facilities" (TFCI, 2010).
Boma National Park	South Sudan	2 280 000	Declared as a National Park in 1977 but has not been gazetted (ENTRO, 2007)
Kidepo Game reserve	South Sudan	120 000	Was declared a Game reserve in 1975; No information is available on either the state of the Reserve or maps of its boundaries (Babiker A. Ibrahim, 2000) in (ENTRO, 2007).
Badingilo National Park	South Sudan		
Pibor catchment forest reserve	South Sudan	around 45 000	Current status of the forests is not clear. However, these forests are unique in Sudan and there is an urgent need to deter mine their status and afford them protection. With the expanding Eco-tourism industry, the Mountains could prove a significant attraction (ENTRO, 2007)
15 Ethiopian Regional protected forests			

2.3.10.3 Data gaps

Most of the available information is in the form of GIS layers and associated databases. Data will be available at a coarse level of detail at the basin-wide scale and at a higher level of detail for some of the conservation areas.

At this stage, the following information is missing:

- Exact size, delineation and location of the protected areas;
- Comprehension and updated description of ecosystems of the protected areas;
- Status of the ecosystems in place;
- Management strategy and measures planned;
- Management strategy and measures implemented;
- Capacities and facilities of the organization in charge of the management;
- Comprehensive description of the conservation projects planned and ongoing.

2.3.11 Demographics and social data

2.3.11.1 Purpose of demographic and social data

The demographic and social data required includes information on population, including migration, important social and ethnic groups and their relationships, access to basic services, water supply and sanitation; important livelihoods; poverty status, conflicts, etc.

2.3.11.2 Data availability

Currently available data includes:

- Population size, growth rate, density, rural-urban population distribution by country and basin regions. (The main sources include data and spatial GIS files, CSA pop projections for Ethiopia; the South Sudan 2009 census).
- Description of socio-ethnic groups in the basin and their livelihood activities.
- Key national level indicators of education (literacy rate, enrolment rates; pupil-teacher ratios, pupil-class ratio, etc).
- Health indicators (birth and death rates, infant mortality rates, life expectancy, maternal mortality rate, etc)
- Water supply and sanitation (% people with access to improved water source, and sanitation facility; people with access to non-improved sources, etc).
- Quantitative description of main livelihood activities (crop production, livestock rearing, fishing, forestry, agro-forestry, etc).
- Poverty status (qualitative description and quantitative data poverty status of at national level; data on poverty head count, poverty depth, poverty severity, etc).
- Food security and nutrition (qualitative description and quantitative data on food security and nutrition status).
- Conflicts (qualitative description of forms of conflicts common in the basin areas).

2.3.11.3 Data gaps

Data Gaps exist in:

- Migration data into/out of and within the basin (four types of migration: rural-urban migration; from conflict areas to safer areas; from highland to lowland, and pastoralist mobility growing migration in Ethiopian; investors offices can provide data on labourers).
- Current data on income, poverty, employment, etc ;
- Current information on forms of conflicts.
- Population distribution/density (data and spatial GIS files) Use latest CSA projections at woreda level from Inception Report
- Access to water and sanitation (Referred to the water supply and sanitation team)
- Income, poverty, employment etc. – census data, studies.

General observations regarding the availability and limitations of the data and information reviewed so far are as follows:

- More information, data and studies are available from Ethiopia than South Sudan. More information is needed from South Sudan.
- Lack of recent updated data that is disaggregated at basin and sub-basin level.
- Data is sometimes reused without updating and assessing the quality of the data.
- Information on the presence and condition of critical infrastructure

2.3.12 Ecosystems

2.3.12.1 Purpose of ecosystems data

Purpose of The purpose of data on the main ecosystems of the basin is to have an overview of the both:

- the overall ecological functioning of the basin;
- the localisation of the main ecosystem types;
- the main habitats on which both households and specific species depend;
- The linkages between water resources the availability and status of conservation of these habitats.

This should help to identify the potential linkages between the intended activities of the IWRDMP and these resources and the related potential impacts.

2.3.12.2 Data availability

The main ecosystems of the BAS are mainly described in Burgess N et al (2004) and ENTRO (2007).

Concerning the wetlands, basic and general description of the various wetlands of the BAS are provided by Hughes & Hughes (1992) and Ssebuliba (2012).

The vegetation of the BAS is well described in ENTRO (2007) which compiled information from various sources : “For Sudan these include the Jonglei Investigation Team's study (JIT, 1954), that of the Southern Development Investigation Team (SDIT, 1955), Mann (1977), Obeid Mubarak et al., (1982), Mefit-Babtie (1983), Howell et al., (1988), Howell and Lock (1993), FAO (2005), and Bussmann (2006). For Ethiopia sources included Chaffey (1979), Friis (1993), WBISPP-MARD (2002), Wood and Abbott (2001) and EWLNRS-Bird Life International (1996).” Hughes & Hughes (1992) also provide some details about vegetation to be found in wetlands.

2.3.12.3 Data gaps

Most of the available information is in the form of raster files, GIS layers and associated databases. Data will be available at a coarse level of detail at the basin-wide scale and at a higher level of detail for some sites where more detailed studies have been carried out.

Concerning the vegetation, a description has not been found neither at the BAS scale nor for specific areas such as the protected areas for instance apart from the references quoted above. Protected and endangered vegetal species are not identified neither localized.

Concerning the habitats, the main gaps are:

- Map of the BAS ecosystems;
- Accurate description and current status of the habitats of the basin (for instance, knowledge on wetlands has not been significantly improved since 1992);
- Specific measures in place to protect the habitats and level of implementation of these measures;
- Detail data on the human activities and species depending on these habitats and their degree of dependence;
- The evolution of the various habitats location and size within a year and over time;
- The linkages between water resources the availability and status of conservation of these habitats. For instance, except for the *Machar marshes*[7], information about the BAS wetlands hydrology is very scarce and sketchy[8]. Although documented, the hydrology of the *Machar marshes* remains complex and unknown to some extents.

[7] The main results of studies dealing with the Machar hydrology have been summarized by ENTRO (2007).
[8] Ssebuliba (2012)

2.3.13 Wildlife

2.3.13.1 Purpose of wildlife data

The purpose of data on wildlife is to identify the key priorities of the basin in terms of biodiversity. It should include:

- the main species present in the basin;
- The linkages between water resources and the repartition and status of these species.

2.3.13.2 Data availability

The data available on wildlife are:

- White-eared Kob habitat and migration patterns are well described in detail in Fryxell & Sinclair, 1988. Migration routes of White-eared Kob have also been depicted by: Deng (2001) who did the same as Fryxell & Sinclair, 1988. Comparing 1980 and 2001 routes at the BAS scale and CMS (2014) who presents migratory routes at the BAS scale. However they don't specify where the data comes from. Kingdon et al (2013) give also recent information about the status of White-eared Kob in the south Sudan part of the BAS.
- Nile Lechwe habitat, migration patterns and status have been described by Frost (2014) and Kingdon (2013).
- The linkages between migration patterns and status of both Nile Lechwe and White-eared Kob are highlighted.
- Elephant migration routes are depicted by Deng (2001) (founded in ENTRO, 2007). More information should be available in the literature.
- Shoebill habitat are described by Kingdon (1990)
- Bird's migration routes are described by Ssebuliba (2012) who shows the main birds migration routes between Europe and Africa. More information about specific routes within the BAS should be available in the literature.

2.3.13.3 Data gaps

- Details on other species present in the basin;
- Updated status and repartition of the existing species;
- Specific measures in place to protect them and level of implementation of these measures;
- Linkages between water resources and the repartition and status of these species.

3. BASINWIDE APPROACH: SCOPE OF WORK

3.1 ENVIRONMENT AND SOCIAL CONTEXT WITHIN THE BASIN

3.1.1 Environment and Biodiversity

3.1.1.1 Introduction

This should not be confused with the baseline study. The aim is to emphasize **what** is going to be studied at basin level in order to identify key issues, challenges and opportunities at basin level. It should highlight what may be the critical areas with respect to potential developments and what baseline (environmental/biodiversity) information will be important in these areas. This will provide the basic information for the environmental component of the SSEA.

This exercise is to get a clear picture of the environmental issues which will be addressed in the IWRDMPlan and to define the framework of the Plan. The Basin wide approach will inform strategic decisions regarding the overall approach to the development of water resources in the basin.

3.1.1.2 Key issues, challenges and opportunities

This section aims at defining what information is required to identify environment-related key issues, challenges and opportunities at basin wide level.

To assess information requirements, an indication of the main issues, challenges and opportunities that are going to be studied at basin level will be given in the scoping report (Key issues relate to different types of development - eg for irrigation, for expansion of rainfed farming, etc…). Some explanations of why this is important in the context of the study will be provided.

The BAS sub-basin hosts outstanding biological and ecological phenomena and supports livelihoods for the BAS population[9] who almost entirely relies on BAS natural resources.

Review of the previous reports, stakeholders' consultation and preliminary site visit on some of the selected areas of the basin indicated the following environmental issues/challenges within the basin:

- Habitat destruction and its impact on wildlife of the basin

  Habitat destruction and fragmentation from farming and deforestation is the root cause of most biodiversity loss in BAS. Vast areas of upland forest, savannah and dry land pasture have been replaced with agricultural land, leaving only limited shelter belts of wildlife habitat. The intensity of mechanized agricultural development has forced pastoralists to use smaller grazing areas and less suitable land, leading to the degradation of the rangelands and increased competition between livestock and wildlife.

  This destruction has been further aggravated by the impacts of conflicts in the region which have resulted in uncontrolled migration and generally unsustainable short-term livelihood coping mechanisms.

  This also includes the problem of settlements spreading into the flood plains which can be destructive to fish spawning grounds, having an impact of fisheries productivity

- Increasing poaching of wildlife

  The civil war and continuing insecurity has increased a proliferation of firearms among the communities in the region. This has facilitated illegal indiscriminate hunting, contributing to the depletion of wildlife populations. 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 even relatively abundant wildlife populations

[9] It seems that the BAS population has never been assessed.

- Over dependency of local communities on natural resources

  Lack of livelihood options for rural communities, internally displaced people (IDP) and returning refugees has resulted in an overdependence on natural resources as a source of income, causing a rapid depletion of natural resources such as wildlife, forest and wetlands.

- Evolving commercial farming in the basin

  Further threats to the basin environment could come from the revival of commercial farming in the region, including commercial rice production and tea and coffee plantations in some parts of the basin.

- Livestock & Wildlife Conflict (Grazing, Water, Disease)

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

- Water Scarcity in semi-arid Pastoralist Areas

  Shortage of water is considered one of the main reasons for conflicts and community unrest. Conflicts arise due to sharing of water of one community by the other community. Such conflicts could have been solved by providing adequate water points. The locations for water points must be identified in consultation with community members to avoid unforeseen interest of neighboring communities.

- 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.

- Deforestation in Upper catchment and Siltation of Reservoirs in Downstream

  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.

  Encroachment of natural forest areas for the expansion of farm land and expansion of investments beyond the allocated land areas in the high lands and lowlands of the basin in Ethiopian part as well as lack of proper coordination between investment and environmental protection offices.

  Conflict between neighboring tribes and cross border due to the competition for limited resources such as grazing areas and water points; as well as due to cattle raiding mainly to satisfy cultural requirement of dowry in some tribes.

- Flood Risk

  Flooding of the lower basin (low-lying areas) of Baro-Akobo experience between two and four months of flooding between June and November. Flooding mainly results from backwater upstream of major confluences on nearly level and, rainfall in excess of soil infiltration capacity, and discharge in excess of channel capacity. Currently, flood risk has increased as a result of expansion of large scale farms, investments, and other schemes in the lower basin, especially in Gambella region of Ethiopia.

  Therefore, in the future, development interventions will worse flooding and it needs monitoring, if further development schemes are in place. This would be followed with catchment protection which is in turn essential to long-term control of flood risk at the lower part of the Baro-Akobo-Sobat Basin. Some irrigated areas require flood protection and pumps will be needed for drainage.

Other environmental issues include:

- Siltation of river channels and downstream reservoirs,
- Shrinkage of wetlands due to wetland farming,
- Absence of land use plan in sensitive areas such as Imatong Mountains, etc,
- Absence of proper or validated management plan for the national parks,
- Lack of awareness about the wildlife conservation and its use,
- Incomplete legal framework (e.g. the Environmental policy of South Sudan not endorsed);
- Environmental policy and legal framework not elaborated at lower administrative levels
- Massive growth of water hyacinth,
- Lack of proper coordination between investment offices and environmental protection offices at zonal and woreda levels
- Pollution of rivers by urban waste (example Gambella town),
- Pollution generated by oil exploitation,
- Prevalence of water related and other parasitic diseases,
- Cross border and tribal conflict and associated migration of people and associated impacts on the environment, and
- Climate change.

3.1.1.3 Data gaps

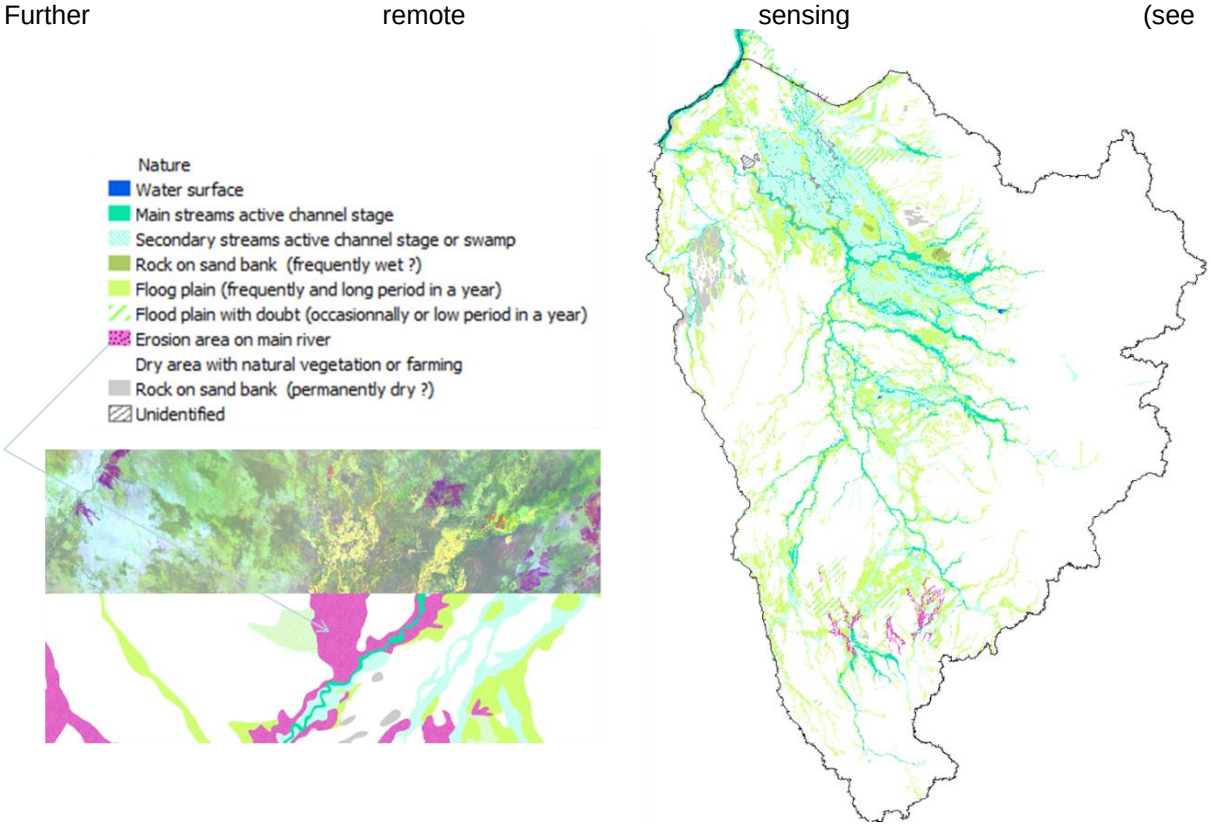
The identified subsequent data gaps to be filled in the subsequent phases of the study include:

- The size and type of wetlands. Regarding wetland size, different reports contain different figures. They are also not classified as permanent and seasonal wetlands. There are wetlands which were not mentioned in the reviewed reports. Therefore, this variation in the size and type of wetlands of the basin needs to be bridged by analysing using Remote sense data of different seasons and years. Particularly, the size of wetland in driest year and driest month will be important to evaluate sustainability of the system.
- The amount of ecological flow. There is no information as to how much water is needed to feed the *Machar marshes* from the spill over of Baro and Sobat rivers. This has to be established before proposing any water abstraction for irrigation and other projects. The same is true for Akobo and Pibor rivers and their wetlands. There is a challenge that how much water abstraction from the BAS Rivers will be acceptable for sustainable wetland management (to not cause significant impact on the wetlands as well as in Nile River). This has to be established using different scenarios and models.
- Extent of flood prone areas and flood risks. Different reports indicated that there is flooding problems in the basin, but none of them has exhaustively mapped these flood prone areas. Therefore, the current study requires mapping of flood prone areas so that flood protection works could be proposed.
- Size and management of protected areas of the basin, especially Gambella National Park. Therefore, it requires redefining and preparation of management plan for the park.
- The extent of land degradation and deforestation in the basin. Forested areas, particularly in the highland portion of the basin, are being degraded due to removal of natural forest for the expansion of crop production. Hence the extent of deforestation and associated land degradation needs to be assessed and mapped.
- Type and severity of water born and water related diseases in the basin. Assessment of water related and water-borne diseases and other endemic disease associated to water resource development in the basin needs to be conducted, and
- Institutional setup and capacity to handle the environmental issues of the basin are the major gaps need to be filled.

The proposed methodology to fill in the above quoted gaps consist of:

- Further literature collection and review,
- Stakeholder consultation to collect further data (including GIS data) and benefit from their knowledge of the area and the linkages between the environmental features of the basin and availability of water resources,

Further remote sensing (see



- Figure 3-1) analysis in order:
  - To map the flooded areas and wetlands complex and visualizing its variability over time;
  - To quantify and understand the dynamics of the inundation over time.

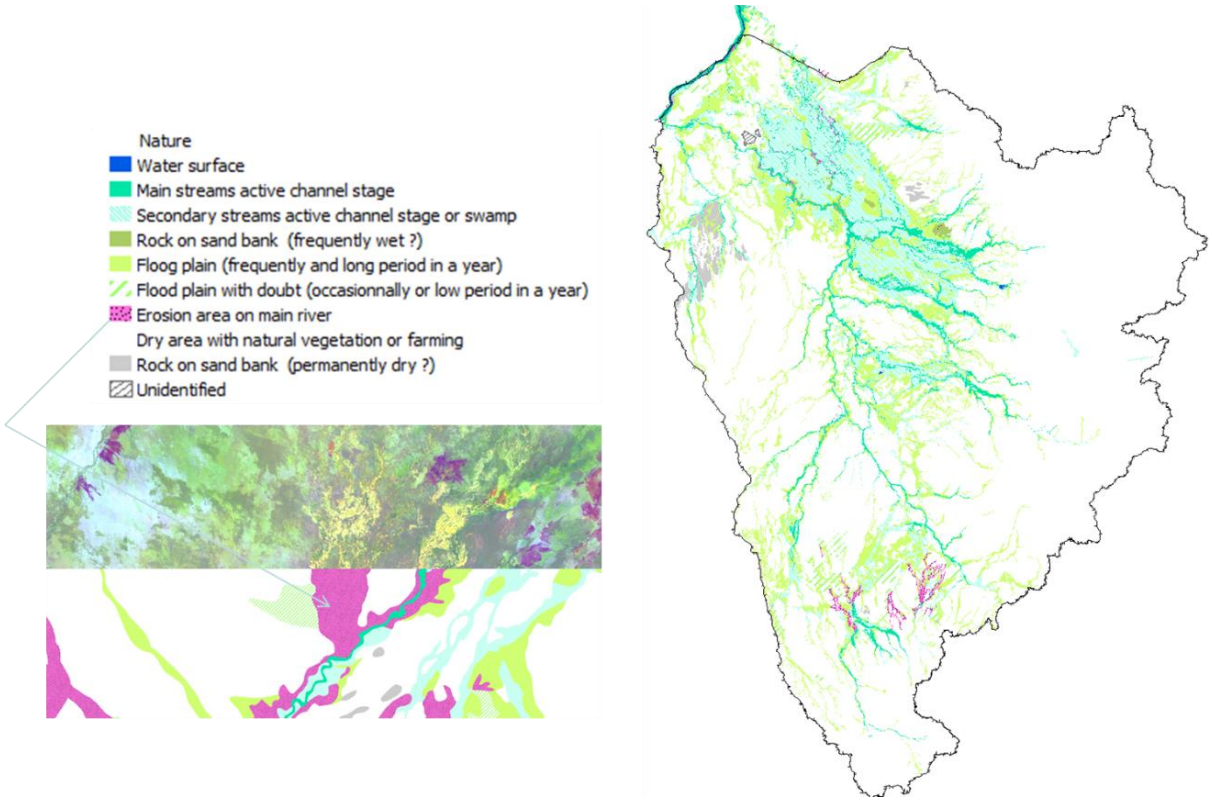


Figure 3-1: Remote sensing has been used to map and understand the wetlands of the basin

3.1.1.4 Level of detail

LEVEL OF DETAIL REQUIRED FOR THE BASELINE

Because SSEA have a broader, upstream and more long-term strategic perspective than ESIA, the baseline of the SSEA should not be as specific and detailed as the ESIA one.

According to the latest guidelines of the African Development Bank, the relevant baseline "will be in part a general situation assessment of overall environmental and social conditions relevant to the Project Based Operations' focus area (…), and in a 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."

In addition, the level of detail of the baseline will depend on the possibility to bridge the gaps identified above.

At a basin wide level the environmental and social baseline aims at comparing of alternative development scenarios in relation to the available resources (land, water, technology, skill, etc.) taking into account the identified environmentally hot spots. Therefore, general information will be sufficient at the basin level. Specific environmental issues or environmental hotspots will be detailed when necessary.

At the project level the assessment of the project characteristics should be detailed enough to identified all the potential impacts and evaluate cost and benefit of implementing the proposed project. Specific environmental information on the project sites area could also be used.

KIND OF INFORMATION WHICH WILL BE USED IN THE SSEA

In accordance with the guidelines of the African Development Bank, the baseline will be mainly based on secondary sources and expert opinion.

STAKEHOLDER CONSULTATION REQUIREMENTS

- At international and national level, governmental agencies, ministries in charge of environmental aspects and NGOs involved in the basin will be consulted. In addition, other water related sectoral governmental agencies and ministries will be consulted in order to collect the various sectoral Master Plans and project documents.
- At the regional level, decentralized governmental agencies involved in environmental and social aspects will be consulted.
- At the local level, the main protected areas management units could be consulted when possible.

For more details, please refer to the consultation plan presented in a separate report.

3.1.1.5 Study limits

The limit of the study for SSEA cannot be bounded by the limit of hydrographic boundary of the basin. It has to include downstream issues beyond the hydrographic limit and assess the impact of development on water availability, water quality and siltation of reservoirs located outside the study basin. Therefore, downstream close border/basin effects on water resources to be carefully considered, including cumulative effects with other similar projects in the Nile basin, also wildlife migration routes

3.1.2 Social assessment, human dynamics and land tenure

3.1.2.1 Introduction

This section describes what will be studied in more detail at basin level in the BAS basin in order to identify key social development issues, challenges and opportunities. Critical areas of relevance to potential developments and the critical baseline social information in these areas will also be highlighted. This section will contribute to obtaining a clear picture of the social issues to be addressed in the IWRDM Plan and to define the framework of the Plan.

The basin wide approach will inform strategic decisions regarding the overall approach to the development of water resources in the BAS basin.

3.1.2.2 Key issues, challenges and opportunities

The main social issues that will be addressed in the Plan include the following:

- **Incidence of poverty and food insecurity** is still high in the sub-basin and way of addressing poverty eradication will be one of the 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 and community levels as women have low access to productive resources, education and health services; and women have high work burden.
- Various forms, intensity, duration and impacts of **conflicts** in the basin.
- There will be a **potential for influx of people** (various forms of migration) into the 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 basin areas should be addressed the in the plan. In addition potential effects of population increase, resettlement, increasing investment (commercial farms –leaseholds) will be considered in the plan.
- Various **forms 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 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.
- **Basins' population heavy reliance on natural resource base** (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 plan.
- **Weak institutions, poor coordination and cooperation among existing institutions**. There are varying levels of capacities and resources operating in the basin countries and basin areas. Therefore the issue capacity building for coordinating and implementing development programs and plans.

These key issues are summarized in the table here after. The preliminary identified challenges and opportunities are also provided.

Table 3-1: Preliminary key issues, challenges and opportunities identified for the social assessment

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 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
Lack of diversified household sources of income	There are opportunities for households to diversify activities and generate cash income (agro-processing, crafts etc), but these require support (access to credit, markets etc)	The dependence of subsistence farming households on the natural resource base make its fragile during times of drought of natural disaster
Isolated nature and conditions in the sub-basin	Expansion of mobile phone network and data services, mobile phone banking etc	Lack of exposure to the outside world of knowledge and technology including trade activities constrains capacity development increasing dependency syndrome and poverty
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. 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. 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 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. Accommodating Varying interests.

3.1.2.3 Data gaps

After identifying the demographic and social information that is useful for the study and information that is known to be available at present, the remaining data gaps are identified. While additional data and studies are needed from Ethiopia, the gaps are larger and more information is needed from South Sudan. Among the remaining data gaps are:

- **Migration**: there are several types of migration, i.e. rural to urban, highland to lowland, insecure to more secure areas, nomadic pastoralists, and transboundary migration
- **Government-sponsored resettlement** – primarily in Gambella Region of Ethiopia
- **Agricultural Leases** (primarily in Gambella Region of Ethiopia, but also in some parts of Oromia and SNNPR
- **Conflicts and security, including food and water security** (primarily in South Sudan, but also along the border between Ethiopia and South Sudan)
- **Gender relations** – NBI has prepared a Gender Mainstreaming Policy and Strategy, but awareness and implementation of it among the Nile Basin countries is not known. Knowledge and implementation of the policy and strategy is likely to be very uneven and mainly at the upper levels of government in ministries responsible for gender and child and social development. Ethiopia has a gender strategy and tools for the water sector prepared by MOWIE.
- **Lack of recent updated data** that is disaggregated at basin and sub-basin level. Data is reused without updating and assessment of the quality of the data.
- Current information on the status and intensity of conflicts and security situation in the basin
- Information on the presence and condition of critical infrastructure
- Current information on **employment and income**
- **Government-sponsored programs** like resettlement and agricultural leases.

3.1.2.4 Level of detail

LEVEL OF DETAIL OF THE BASELINE

During the baseline, existing information on the above issues will be updated, and remaining data gaps will be addressed by extracting and compiling relevant information through collecting and reviewing additional data sources. There is sparse data, mainly disaggregated data, about the above social issues at the sub-basin level and also at local level to analyse adequately context-specific social development issues, opportunities and challenges and for identifying strategic issues to be considered in preparing the SSEA and basin development plan.

In line with social issues identified in this report; more local level/disaggregated information (both quantitative and qualitative) will be collected during the baseline.

STAKEHOLDER CONSULTATION REQUIREMENTS

The approach will be participatory, which includes key stakeholders' consultation at various levels and interactive community forum combined with Focus Group Discussions and Key Informant Interviews) for project level data as well as collating available secondary data. The main tools of data collection will include guidelines, checklists and lists of demographic and social indicators relating to key issues identified in this report.

3.1.2.5 Study limits

As large movements of population occur within the basin and into the basin, the baseline should not be limited, for this specific aspect, to the hydrographic dynamics but should include schematics showing the population movements into and out of the basin.

3.1.3 Water resources and catchment condition/status

3.1.3.1 Introduction

This section aims at getting a clear picture of the issues related to water resources which will be addressed in the IWRDMPlan. A water balance model and a hydrodynamic/morphodynamic model will be built and this will inform several expertise of the study. This will be highly important for the assessment of the catchment condition. Indeed, from the basin-wide point of view, the focus is on the interaction with water resources and the environment. This means issues of erosion, deforestation etc. However, there is a need to include also the interaction between livelihood enhancement and watershed management (improved farming practices supporting both reduced erosion AND improved livelihoods). This is further explained in Section 4.2.7 as it is more at project level.

3.1.3.2 Water resource modelling

INTRODUCTION

The approach to water resource modelling of the BAS sub-basin has been informed by a detailed evaluation of available models and hydro-meteorological data, to be supplemented with remote sensing data. Modelling will entail rainfall-runoff and water balance modelling, as well as hydrodynamic and morphodynamic modelling, all of which will provide analytical tools for the evaluation of development and management scenarios.

Note: Historical flow records in the upper Baro tributaries, as well as in the Alwero, Gilo, and Akobo and Pibor rivers are limited and intermittent, which makes it difficult to determine long-term average flow values in these rivers and to assess seasonal and monthly flow variability. In order to ensure that the proposed schemes in these tributaries are adequately evaluated, the hydrological analyses to be undertaken as part of this assignment will focus on improving the understanding of spatial and temporal flow variability in these tributaries. In addition, the spills and links between the main rivers in the Gambella Plain as well as the water balance of the Machar marshes will constitute a key component of the hydrological analysis in this study.

The various models that will be used can be summarised as follows:

- Rainfall-runoff modelling (NAM)
  - To simulate long term flows in ungauged catchments
  - To assess high-level impacts of climate change
- Water balance modelling (MIKE HYDRO Basin)
  - To evaluate development potential
  - To assess impacts of development on flow patterns and volumes
- Sediment yield modelling (SHETRAN)
  - To estimate long-term sediment yields across basin
- Hydrodynamic / Morphodynamic modelling (MIKE 21C)
  - To evaluate extent of flooding
  - To assess morphological impacts of developments
  - To improve understanding of flow dynamics on floodplains / marshes / wetlands and to predict development impacts

WATER BALANCE MODEL

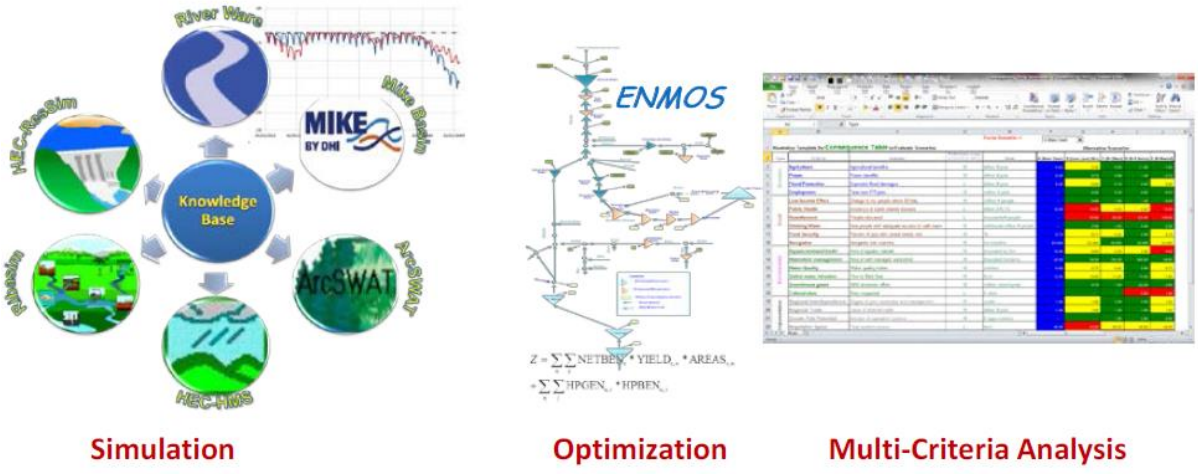
A customised water balance model of the BAS sub basin will be constructed for this project. The model resolution and configuration will be dictated by the hydrographic network, links between rivers and floodplains, spatial availability of hydro-meteorological, locations of gauging stations and proposed schemes, and vertical accuracy of the DEM. Daily time step, lumped conceptual rainfall-runoff modelling will also be undertaken. Final model parameter sets will be derived by a conventional iterative calibration procedure based on assessing the goodness-of-fit of simulated flows with observed flows via a range of objective functions. The model will simulate rainfall-runoff processes, irrigation water use, evaporation and seepage losses, hydropower generation, spills and links between the river channels, floodplains and marshes, and limited groundwater-surface water interaction.

The main purpose of the water resources modelling task will be to assess the water balance along the major rivers in the Baro-Akobo-Sobat Basin and the White Nile and Main Nile Rivers downstream, under both current (baseline) and future development scenarios / management options. Furthermore, the modelling will inform the evaluation of hydrological and related economic, social and environmental impacts resulting from water resource developments in the Baro-Akobo-Sobat Basin.

One of the most important elements in any modelling process is the selection of the most relevant and appropriate model(s). This decision should be guided by a clear understanding of the purpose of the modelling, the type, accuracy and precision of required model output, spatial and temporal requirements for model configuration, the availability of relevant and accurate input data which are required to 'build' the model and the availability and quality of observed data to be employed in model calibration and validation.

Over the last number of years, various water resources models of the Nile Basin and/or the Baro-Akobo-Sobat basin specifically have been developed and applied. These models were developed as part of the Joint Multipurpose Program (JMP), the Eastern Nile Planning Model (ENPM) Project, the Regional Power Trade Investment Program, the Eastern Nile Irrigation and Draining Study, the Eastern Nile Watershed Management Project and various other research and ad hoc studies.

Figure 3-2: Models developed under the ENPM project

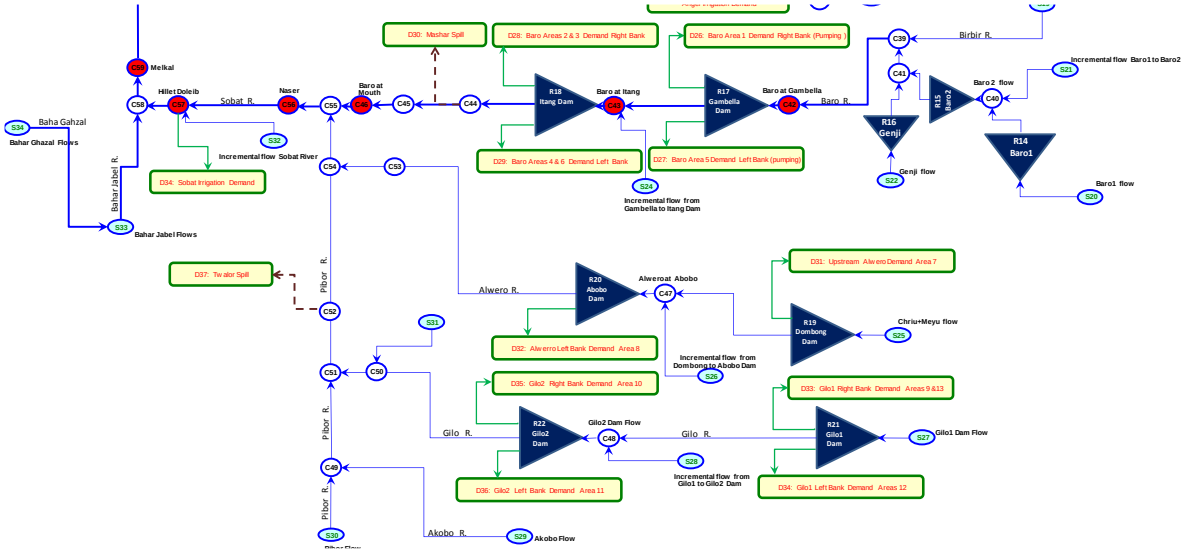


Source: World Bank, 2013

As part of the ENPM Project for example, various knowledge bases, toolkits and modelling tools were developed with the specific aim of informing integrated water resources planning within the ENTRO region by providing analytical insights into the resource management and investment options in the Eastern Nile in a multi-sectoral regional context. The models included simulation, optimization, and multi-criteria tools and are summarised as follows:

- Soil and Water Analysis Tool (SWAT): A monthly time step SWAT model was developed and calibrated using public domain datasets for the entire Nile Basin, with a focus on Eastern Nile scenarios. Data collected as inputs to the model include a digital elevation model, land use, land cover and soil maps and weather data. Simulations were performed for forty years (1960 to 2000).
- RIBASIM: A monthly time step, calibrated RIBASIM model was developed for the Eastern Nile and used to analyse future scenarios of changing water demands, water infrastructure, agriculture, climate change, land use change and management scenarios. Flows were synthesised from 1900 to 2002.
- RiverWare: A monthly time step model was configured for the Eastern Nile Region and used to analyze a number of scenarios, particularly related to Blue Nile mainstem projects and their impacts downstream under different filling and operating rules. Simulations were performed from 1956-1991.
- HEC Suite: Various HEC models were configured for the Eastern Nile region including the development of a monthly time step HEC-ResSiM model to explore the impacts of water infrastructure on system hydrology using the historical time series data from 1954 to 1980. In addition, daily time step HEC-HMS and HEC-RAS models were developed as part of the Eastern Nile Flood Season Monitoring program for the Baro-Akobo-Sobat Basin in Ethiopia and South Sudan.
- MIKE Basin: The monthly time step Mike Basin modelling system that was initially linked to the Nile DSS was used by ENTRO as part of the JMP1-ID project activities to optimise power production within the basin. The original model was calibrated based on observed flows at Gambella, Nassir and Hillet Doleib, while simulations were performed for forty years (1960 to 2000). As part of the original model configuration, long-term inflow sequences were generated upstream of proposed dam or hydropower sites and irrigation abstractions, while special attention was also given to the link between the Baro River system and the *Machar marshes* as well as to the interaction (spills) between the main river system and the large floodplains along the lower part of the basin.
- MIKE HYDRO Basin: As part of the Eastern Nile Multi-Sectoral Investment Opportunity Analysis, a monthly time step MIKE HYDRO Basin model was developed to support strategic planning decisions at the scale of the EN region, through assisting to foresee the impacts of future possible water resources management and development scenarios in the main eastern Nile basins including the Baro-Akobo-Sobat Basin. The output from the model was used as input to an Excel based economic assessment model for the economic analysis of different combinations of water management and development activities.

Figure 3-3: Eastern Nile Basin Planning Model Schematic: Baro-Akobo-Sobat sub-basin



- Eastern Nile Multi-Purpose Optimization System (ENMOS): This model entailed an optimization system that allows for selecting the optimal values for key decision variables (e.g. reservoir releases, cropping patterns, etc.) in order to maximize or minimize selected objectives (e.g. maximizing net benefits in the basin) subject to constraints (e.g. related to water, irrigated areas, budgets, physical infrastructure limitations, etc.). This model uses GAMS optimization software linked to an Excel Interface for inputs and outputs.

All of the above models have been found useful to inform this study. However, some of the models have obvious shortcomings, mainly relating to the fact that many of the models were developed at a scale which is appropriate for application to the whole of the Eastern Nile Region as opposed to a local basin. Other shortcomings of some of the above models include lack of detail with regard to spills and losses along the lower floodplains of the Baro-Akobo-Sobat system, incomplete analysis of future schemes for scenario modelling, inadequate simulation of stream flows in ungauged tributaries, and the lack of rainfall-runoff modules. As a result, many of the model networks are considered too coarse for the detailed evaluations to be conducted at sub-catchment level in the Baro-Akobo-Sobat Basin.

Based on the model review, the MIKE HYDRO Basin (MSIOA) and MIKE Basin (JMP) models will be used as base models for this study, and further refined based on specific modelling approaches and data as incorporated in the SWAT and RIBASIM models. A MIKE HYDRO Basin model will be constructed to support the Baro-Akobo-Sobat Multipurpose Water Resources Development Study, by providing an accurate and detailed water resources model of the major rivers and proposed schemes in the Baro-Akobo-Sobat basin, representing both current (baseline) and future development conditions. The model will be used to assess the water balance, to understand the spatial and temporal distribution of flow across the basin, to investigate links between the major rivers and floodplains, to assess high level climate change sensitivities and to inform the evaluation of hydrological and related economic, social and environmental impacts resulting from water resource developments in the basin under a range of scenarios. The water balance modelling task will entail the following key activities:

- Refine modelling subcatchments based on location of flow gauging stations, existing and proposed schemes, the latest 30m DEM and the updated hydrographic network.
- Prepare hydro-meteorological input data.
- Undertake rainfall-runoff (NAM model) calibration based on updated climate data and flow records.
- Improve the conceptualisation of ponding, flooding, losses, spills and links in marshes and flood plains.
- Validate the model.

- Simulate long-term synthetic flow sequences for all sub-catchments by means of rainfall-runoff modelling.
- Develop a baseline model representative of current catchment conditions
- Develop scenario models representative of development interventions and/or management options

The baseline and scenario models will be imported into the latest version of the NB-DSS to inform the screening of development and investment options as part of the scenario evaluation phase of this project.

An important consideration during the evaluation of water resources interventions relates to the quantification of environmental flows. For this study, a combination of hydrological index methods and holistic rapid assessment approaches will be used to obtain a first order estimate of the quantity and timing of environmental flows required to sustain ecosystems and livelihoods that depend on these ecosystems. The NBI-Sec will also be consulted to ensure alignment with the current basin-wide study on environmental flows.

HYDRODYNAMIC / MORPHODYNAMIC MODEL

In light of the limited existing information on sediment data and sediment yields, the SHETRAN model will be used for modelling of sediment yields from catchments.

For the fluvial morphological characterization and impact analysis, sediment transport, deposition and erosion will be evaluated for different flow (and flood) conditions, considering the bed material, river type, and channel patterns etc., based on a simple MIKE 21 C model. The improved 30m SRTM DEM in conjunction with remote sensing data (e.g. satellite imagery) will be used to configure and calibrate the model in the floodplain and wetland areas. Specific aspects to be addressed include links between river channels and wetlands, seasonal variations in the areal extent of wetlands and potential morphological changes due to development interventions. It is important to note that the resolution and accuracy of the model will be dictated by the DEM quality and will not be at the same level as a model based on LiDAR and/or manual survey information. The fluvial morphological assessment will be focused on reaches where potential investments are identified.

DATA GAPS

As already emphasized, there are significant gaps within the Baro-Akobo-Sobat Basin with regard to hydro-meteorological, water quality, morphological and sediment data, all of which constitute key inputs to the water resources modelling and subsequent evaluation of options tasks.

Climate data

A comprehensive dataset of patched monthly rainfall records, which, combined, spans a period from 1900 to 2011, is available. However, spatially, there is a paucity of rainfall stations in the Pibor, lower Gilo, Akobo and Sobat subcatchments as well as in the *Machar marshes*. In these areas, historical gridded satellite based rainfall estimates will be used, in combination with observed rainfall data, to improve estimates of historic catchment rainfall. Although daily rainfall records have been requested from the NMA in Ethiopia and the SSMD in South Sudan, daily satellite rainfall datasets will also be used to disaggregate monthly rainfall to representative daily rainfall patterns in areas where daily rainfall data are lacking. Daily rainfall time series are required for rainfall-runoff modelling.

Very little evaporation data are available in the lower parts of the basin and particularly in South Sudan. The Ethiopian Master Plans only provide evaporation datasets for the upper part of the basin, while the FAO station data are limited to Ethiopia. In order to supplement this data, historical global gridded climatological datasets will be used to estimate reference potential evapotranspiration in certain areas using temperature based empirical formulae. In addition, meteorological data at key stations have been requested from relevant agencies and departments in the respective countries.

Surface water data

Information related to the current status of flow gauging stations as well as corresponding and more up to date flow records are being sourced from the relevant ministries in Ethiopia and South Sudan. Where there are monthly flow data missing within the datasets selected for model calibration, the gaps will be filled using simulated flow data from the hydrological model.

Water quality data

There appears to be no form of regular water quality monitoring in the study basin. Intermittent monitoring efforts seem to focus on quality control at the location of water supply schemes only. The implementation of a detailed water quality monitoring programme will not be completed during this study's timeframe. For the purpose of this study, it is acknowledged that limited water quality grab samples collected at pre-identified locations during field visits will have to suffice.

River morphology, erosion and sedimentation data

There is no extensive suspended sediment load database available in the basin and data collection appears to have ended in 1990 with only 100 samplings available at 11 gauging stations. These records are too limited to deduce any meaningful sediment yield-discharge relationships. It is evident that more recent sediment data should be obtained for this study. Consequently, relevant government departments in Ethiopia and South Sudan have been contacted to establish whether sediment data have been / are currently being collected in the main rivers in the basin and to obtain the associated records. These would typically include sediment loads and/or concentrations and discharge measurements close to flow gauging stations. The possibility of undertaking limited sediment sampling for this project will also be investigated. This would entail grading analyses (sieve test and hydrometer test) and possibly particle density tests of soil samples to cover the main soil type zones in the main river catchments as well as sediment samples in main rivers. In light of the very limited existing information with regard to sediment data and sediment yields, the SHETRAN model will be used for modelling of sediment yields in the Baro-Akobo-Sobat Basin. No topographical survey data of river sections in the Baro-Akobo-Sobat Basin are readily available. For the purpose of hydrodynamic and morphodynamic modelling along the floodplains, remote sensing data will be used to extract general information on some basic river characteristics.

3.1.3.3 Watershed management: key issues, challenges and opportunities

Some key points from Ethiopian experiences in watershed management include:

- Projects need to be owned by the local communities
- Complete sub-watersheds need to be included in any project, even where this involves crossing administrative boundaries
- The optimal size for project implementation is the micro-watershed, between 200 to 2,000 ha (generally 350-500 ha is recommended)
- Projects benefit from an 'integrated' approach. However, concepts on 'integrated' vary and rarely extend beyond agricultural production
- Due to the diversity of landscape and socio-economic conditions in Ethiopia, interventions need to be adapted to local conditions rather than following standardised models
- Implementation is easiest in areas offering most immediate benefits, especially water stressed areas. By extension, water conservation offers more immediate and visible benefits than soil conservation
- Community mobilization and planning takes up to about one year; implementation typically requires 3 to 5 years
- Optimal support levels are around 3 diploma level development agents (DAs) per development centre (Kebele, about 800 ha or about 2 micro-watersheds) plus trained farmers
- A key issue is the 'scaling up' from the micro-watersheds to larger areas

- The importance of markets and marketable products to offset the cost of investment in conservation. It is difficult to sustain watershed management on increased productivity of food grains alone; diversification for cash crops adapted to local markets or other income generating activities is an essential part of the mix
- The Ethiopian experience has focused primarily on soil and water conservation (especially physical structures), water harvesting, and hillside closures. SLMP has tried to address this with SLMP 2 adopting a holistic 'landscape' approach.
- The emphasis has also been on moisture deficit and food insecure areas and, therefore, on moisture conservation. There is limited experience in areas of surplus production (how to mobilise farmers) and/or in safe disposal of excess water in high rainfall areas. This could be a major issue for the current study
- Benefits from watershed management are generally described as increased crop production, sometimes accompanied by decreased fertiliser inputs; increased forage production; income opportunities especially from livestock (increased forage) and honey (increased tree cover); and aquifer recharge leading to water harvesting opportunities.
- Key constraints are institutional capacity limitations at Regional, Woreda and Kebele or community levels; free grazing of livestock; the requirement for support (pay-for-work) to support community mobilisation; and lack of maintenance after completion of the project
- There has been almost no before and after evaluation of benefits. However, most observers agree that, within the moisture deficit and food insecure woredas, the crop and forage production benefits are real. MERET undertook an economic analysis which suggests benefits are economically viable
- Despite the previous point, there is limited evidence of community drive for watershed management; self-replication is limited. Efforts have been, and remain, primarily supply-driven by government and donor agencies, and supported by payment.

While Watershed Management has been increasing in profile in Ethiopia and many people understand the benefits, there are a number of constraints to implementation:

- A good community based watershed management programme is costly and takes a long time to implement. Costs are difficult to estimate given the rapid inflation of the Birr in recent years but US$ costs from the Rift Valley Lakes Master Plan (Halcrow-GIRD/MoWR 2010) varied from US$90-200/ha for soil and water conservation rising to 200-395/ha for full watershed management including input provision and project management. Community mobilization and planning takes up to about one year; implementation typically requires 3 to 5 years
- It can be difficult to persuade land users and farmers to invest money and labour in an intangible future benefit
- Many soil and water conservation and watershed management programmes in the past did not address land users primary concerns (health, access, water supply, education) but concentrated on soil conservation. It is essential to address real concerns as 'entry points' in a watershed management programme in exchange for labour on soil and water conservation interventions. This was a point made by Bench Maji Zone staff during the reconnaissance field trip explaining slow progress of previous interventions.
- Despite the large number of micro-watersheds which have been addressed in terms of watershed management, there are problems of sustainability once support is withdrawn and little indigenous adoption of watershed management by surrounding communities.
- There is a lack of skilled staff at zone and woreda level and the DAs at kebele level often do not have the training to implement a project.
- Watershed management projects are much easier to implement if land users have security of tenure which is why a land certification and administration component has been included in SLMP. Much of the BAS highland areas have gained 1st level certification but there has been little movement yet towards 2nd level certification (which requires mapping of individual plots) largely due to capacity issues at zonal and woreda level. Staff have indicated that since land use rights come with obligations, and the failure to protect can lead to loss of title, the implementation of soil and water conservation and land management in general will be made

easier when land users have 2nd level certification. In addition land users will have greater security so will be keener to invest in their own land.

- The scaling-up of soil and water conservation and watershed management to a wider area than micro-watersheds has been an issue in the past. While concentration on micro-watersheds for implementation yields results in the short term it is unlikely to achieve sustainable improved livelihoods or any downstream sediment reduction. It will also not provide the 'critical mass' required to measure and demonstrate the physical, social and economic impact of improved watershed management. Recent watershed management approaches (ENWMP's Ribb, Gumera and Jema catchments (Halcrow/ENTRO 2007) and Hawassa and Ziway catchments in the Rift Valley (Halcrow-GIRD/MoWR 2010)) focused on sub-watersheds, within which actions would be implemented both at the micro-watershed (community action plans) level and sub-watershed (socio-economic and infrastructure entry points) level.

Opportunities from Positive Experiences:

- Significant opportunities for watershed management interventions, based on positive experiences elsewhere, were mentioned throughout the reconnaissance field trip usually in relation to Mass Mobilisation and the experiences in Tigray. It would appear (at least in conversation with zone and woreda staff) that land users would welcome watershed management interventions, and particularly a project, in their area.

3.1.3.4 Methodology to identify vulnerable areas: from basin wide to local level

A new assessment of erosion hazard to assist in the identification of vulnerable and degraded areas will be undertaken. This will use the Revised Universal Soil Loss Equation (RUSLE) which is derived from the Universal Soil Loss Equation (See Text Box) adapted to Ethiopian conditions by Hurni (1985) from research and data collected in SCRP stations with factors subsequently updated and/or reassessed by the Abbay Master Plan (BCEOM-MoWR 1998), the Woody Biomass Project (Tecsult 2004) and Nyssen et al 2004.

METHODOLOGY

Since the aim of the erosion hazard assessment is to assess *relative* erosion hazard for use in catchment selection for watershed management intervention the actual rate of soil loss is not as important as indicating relative rates of soil loss. For this it is considered that the RUSLE will be suitable.

Information for use in the RUSLE will come from the following sources:

Rainfall - Mean annual rainfall data available from NMA Ethiopia, unknown source South Sudan

Soil - Ethiopia Soil Information System (SIS), Ethiopia National Soil Map (2000), FAO/JRC Soil Map of Africa for South Sudan

Slope length and gradient – 30m DEM

Land Cover – WBISPP or more recent data if available for Ethiopia, Project derived mapping for South Sudan

Management – Hurni (1985) updated by Tekeze Basin Study

Information from other sources will be used to define other criteria that may be used in a screening process in addition to the Erosion Hazard Assessment to identify areas of particular concern (see Table 3-2).

Table 3-2: Information to be used to define criteria for the screening process in addition to the Erosion Hazard Assessment

No	Criterion	Measure	Information Source
1	Erosion Hazard	Soil loss in tons/ha/year from Erosion Hazard Assessment	Derived from project EHA incorporating rainfall, slope, soil, land cover and management data
2	Accessibility	Distance to road	Computed in GIS from ERA data
3	Urban Market Access	Distance to market	Computed in GIS
4	Downstream Impacts	Presence/absence of MoWR investments	Information from ENTRO
5	Groundwater Recharge Potential	Permeability of Geological Strata	Derived from Recharge Potential Map
6	Fragile Ecosystems (Forests/Wetlands)	Presence of forests and wetlands	Derived from WBISPP land cover data, corroborated by EWDA
7	Intervention Suitability	AEZ variability, number of suitable SWC interventions per area	Derived by project incorporating AEZ, soil, slope and land cover data and MoARD SWC guidelines
8	Land Fragmentation/ Labour Availability	Population density	Derived from Kebele population density data
9	Current Land Use	% cultivated area	Derived from WBISPP land cover data
10	Livelihood Impact	Presence/absence of food security by woreda	Data from MoARD

The draft methodology refers to the identification of priority areas for watershed management interventions. This will be based on an Erosion Hazard Assessment and other criteria which can be discussed with ENTRO in the next phase. Possible steps are:

i. GIS to identify sub-catchments using 30m DEM
ii. Undertake EHA as outlined above
iii. Overlay sub-catchments onto EHA
iv. Convert to a single Erosion Index for each sub-catchment
v. Assess current activity using kebele population data to map population density
vi. Overlay administrative boundaries to identify target woredas
vii. Overlay existing SLMP 1 & 2 woredas
viii. Undertake selection analysis

LEVEL OF DETAIL

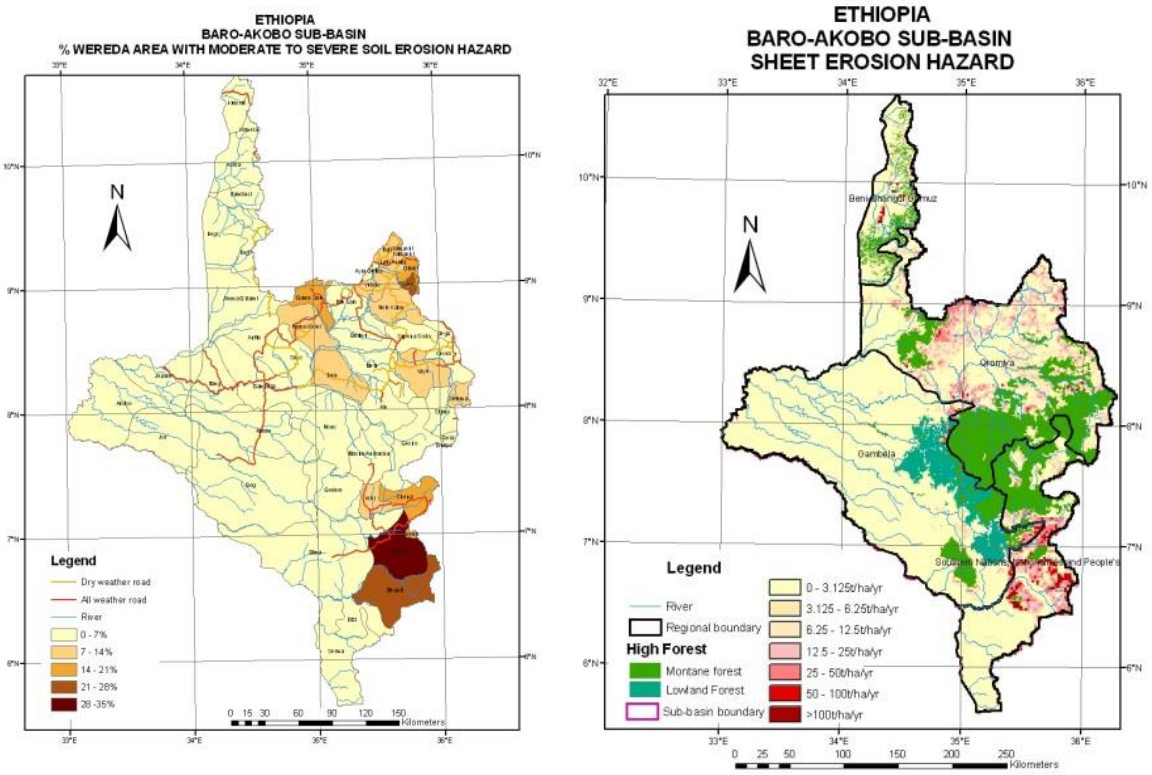
To determine the baseline situation a broad level of detail will be sufficient. The cooperative regional assessment contains maps of the Ethiopian part of BAS that are produced at scales of about 1:3,500,000 although they are derived from data mapped at 1:500,000 to 1:2m as shown here:

The EHA and subsequent determination of target areas will be undertaken initially at the catchment level and subsequently at the sub-catchment level in areas that are most vulnerable. These are likely to be the hilly sloping lands of Ethiopia in the east and bordering Kenya and Uganda in South Sudan in the south. Experience from Awash shows that mapping at the catchment level (c. 1,200-6,000km^2) is too broad for targeting suitable areas and the sub-catchment level (c. 200-600km^2, 20,000-60,000ha) provides more reliable data.

Data for undertaking the EHA and MCA are known to be available for Ethiopia from a number of sources and at different scales. The situation for South Sudan is not known at present and will need to be assessed during the baseline.

Informal stakeholder consultations were held during the reconnaissance fieldtrip at national, zonal and woreda level in Ethiopia. Similar consultations are envisaged during the baseline phase to fine tune priority intervention areas.

Figure 3-4: Erosion hazard maps for the Ethiopian part of the BAS



Source: Cooperative Regional Assessment (Tecsult/ENTRO, 2006)

3.2 ENABLING ENVIRONMENT IN THE BASIN

3.2.1 Introduction

The central aim of this study is the formulation of the Integrated Water Resources Development and Management Plan (IWRDMP). It is different from national and regional development plans in that the focus is **water resources.**

However, even if the focus is the development (and management) of water resources, it is clear that **useful/efficient development requires the appropriate enabling environment**. It is important to understand how it can have an impact on water resources developments.

The Scoping exercise is particularly relevant for the enabling environment since it will be important to know what to look at in some detail and what to deal with in a more cursory manner.

There are different possible ways of categorising the enabling environment: We have chosen the following categories:

- Access to services
- Institutional framework
- Legal and Policy framework
- Availability of funds
- Peace and security

3.2.2 Access to basic services

This includes the following areas:

- Transport - Land transport infrastructure: important enabler for developments such as irrigation etc. Also the opportunities for navigation to link with land networks
- Communications, especially mobile phone and internet access coverage
- Electricity
- Healthcare

It is important to understand the policies and strategies associated with access to basic services.

3.2.3 Institutional framework

3.2.3.1 Institutional and Administrative Framework of Ethiopia

FEDERAL AND REGIONAL ADMINISTRATION

The Federal Democratic Republic of Ethiopia (FDRE) was formally established on August 21, 1995. The FDRE comprises of the Federal States with nine Regional State members. The government structure takes power from the centre to regions and localities. The relative roles of government at the different levels (Federal, Regional and Local) in terms of power and duties, including on fiscal matters, have been defined by the Constitution, Proclamations Nos. 33 of 1992, 41 of 1993, and 4 of 1995. Under these proclamations, duties and responsibilities of Regional States include planning, directing and developing social and economic programs, as well as the administration, development and protection of natural resources of their respective regions.

The duties and responsibilities of the Regional States include planning, directing and developing social and economic programs as well as the administration, development and protection of natural resources of their respective regions. The basic administrative units in each Regional Government are the Woredas, which sub-units are the kebeles. Further, based on their authority and responsibilities the regional governments have established Sectoral Bureaus, Commissions and Authorities.

ETHIOPIAN MINISTRY OF ENVIRONMENTAL PROTECTION AND FORESTRY

Recently, as part of the effort to realize the government's Climate Resilient Green Economy strategy, the former Environment Protection Authority of Ethiopia has been upgraded into Ministry of Environmental Protection and Forestry. The new Ministry is responsible among other undertakings for spearheading the reforestation, and other wide-ranging tasks. It is expected to take measures aimed at preventing deforestation and environmental degradation which are common in many parts of the country. Participatory process of making the country's economy green and climate change resilient was initially planned to be undertaken under the ownership of the then Environment Protection Authority (EPA). However, such effort did not receive the necessary attention either at the federal or regional level thereby necessitating the establishment of the new Ministry. It is also understood that the rights and obligations of the EPA, stated under the proclamation No. 295/2002, is transferred to the newly established Ministry of Environment Protection and Forestry. The general role of the ministry is to provide for the protection and conservation of the broad environment, through formulation of policies, strategies, laws and standards, which foster social and economic development in a manner that enhance the welfare of humans and the safety of the environment sustainable.

REGIONAL ENVIRONMENTAL AGENCIES

In accordance with the principles of government decentralization and the Proclamation no. 295/2002, each national regional states of Ethiopia has established an independent Regional Environmental Agency or designated an existing agency based on the Ethiopian Environmental Policy and Conservation Strategy. The regional environmental agencies are responsible to coordinate the formulation, implementation, review and revision of regional conservation strategies; and Environmental monitoring, protection and regulation.

The Proclamation also states that regional environmental agencies shall ensure the implementation of federal environmental standards or, as may be appropriate, issue and implement their own no less stringent standards. Finally, the Proclamation states that regional environmental agencies shall prepare reports on the respective state of the environment and sustainable development of their respective states and submit them to the EPA.

3.2.3.2 Institutional and Administrative Framework of South Sudan

Gap: institutional/administrative framework of South Sudan has to be collected and mapped.

FIRST FINDINGS REGARDING SOUTH SUDAN

Concerning the institutional setup, MoE has only been established recently - after the separation from Sudan - and it is not yet fully taking off due to lack of resources; many administrational and financial challenges are faced by MoE affecting noticeably its roles and responsibilities. MoE is mainly working on; environmental management, pollution & Control, environmental education, biodiversity & wetlands, climate change and sustainable development planning. Since its formation in July 2011, South Sudan has ratified number of international environmental treaties; Biodiversity, RAMSAR, IPCCC, etc. The environmental Policy draft is under review by the cabinet.

Many international and regional NGOs are working in collaboration with the MoE i.e. UNEP is funding the Environmental Information Centre Project that will avail all relevant environmental databases in one centre, IGAD is also supporting the Drought Resilience project. JICA has funded the rehabilitation of Juba Landfill. MoE has proposed the environmental management plan for Sudd Marches as one of the strategic projects to be considered by EN-MSIOA.

3.2.4 Legal and Policy framework

3.2.4.1 Ethiopia

THE CONSTITUTION OF FDRE

The Constitution of Ethiopia (Procl. No. 1/1995), adopted in August 1995, contains a number of articles, which are relevant to environmental matters in connection with development projects, as well as to the environment in general, and forms the fundamental basis for the development of specific environmental legislative instruments. In the section, which deals with democratic rights, Article 43 gives the right to people to improved living standards and to sustainable development. Article 92 of Chapter 10 (which sets out national policy principles and objectives), includes the following significant environmental objectives:

- Government shall endeavour to ensure that all Ethiopians live in a clean and healthy environment (Article 44 states that all persons have the right to a clean and healthy environment)
- Development projects shall not damage or destroy the environment
- People have the right to full consultation and the expression of views in the planning and implementation of environmental policies and projects that affect them directly
- Government and citizens shall have the duty to protect the environment

Article 40 states that ownership of both urban and rural land is vested in the State and the people, and is common property, which is not subject to sale or other means of exchange. Peasants have the right to obtain land without payment, and are protected against eviction from land in their possession. Full right to immovable property and permanent improvements to land is vested in individuals who have built the property or made the improvements, but government may expropriate such property for public purposes, subject to the payment in advance of compensation commensurate to the value of the property or alternative means of compensation, including relocation with adequate State assistance.

ENVIRONMENTAL POLICY OF ETHIOPIA

The Environmental Policy of Ethiopia (EPE) of the Federal Democratic Republic of Ethiopia (FDRE) was approved by the Council of Ministers in April 1997 (EPA/MEDAC 1997). It is based on the Conservation Strategy of Ethiopia (CSE), which was developed through a consultative process over the period 1989-1995. The policy has the broad aim of rectifying previous policy failures and deficiencies, which in the past, have led to serious environmental degradation. It is fully integrated and compatible with the overall long-term economic development strategy of the country, known as Agricultural Development-Led Industrialization (ADLI), and other key national policies.

The EPE's overall policy goal may be summarised in terms of the improvement and enhancement of the health and quality of life of all Ethiopians, and the promotion of sustainable social and economic development through the adoption of sound environmental management principles. Specific policy objectives and key guiding principles are set out clearly in the EPE, and expand on various aspects of the overall goal. The policy contains sectoral and cross-sectoral policies and also has provisions required for the appropriate implementation of the policy itself.

The section of the EPE concerning EIA sets out a number of policies, key elements of which may be summarized as follows:

- Recognition of the need for EIA to address social, socio-economic, political and cultural impacts, in addition to physical and biological impacts, and for public consultation to be integrated within EIA procedures
- Incorporation of impact containment measures within the design process for both public and private sector development projects, and for mitigation measures and accident contingency plans to be incorporated within Environmental Impact Statements (EISs)
- Creation of a legal framework for the EIA process, together with a suitable and coordinated institutional framework for the execution and approval of EIAs and environmental audits

- Development of detailed technical sectoral guidelines for EIA and environmental auditing
- Development of EIA and environmental auditing capacity and capabilities within the Environmental Protection Authority, sectoral ministries and agencies, as well as in the regions.

The thorough and holistic approach taken to development of the policy and, in particular, recognition of the importance of addressing cross-sectoral environmental issues, has led to a national approach to environmental management, which is not only comprehensive, but also provides a sound and rational basis for addressing the environmental problems faced by the country now and those which are anticipated over the next decade.

ETHIOPIA'S CLIMATE-RESILIENT GREEN ECONOMY STRATEGY

Ethiopia is experiencing the effects of climate change. Besides the direct effects such as an increase in average temperature or a change in rainfall patterns, climate change also presents the necessity and opportunity to switch to a new, sustainable development model. The Government of the Federal Democratic Republic of Ethiopia has therefore issued the Climate-Resilient Green Economy strategy in 2011 to protect the country from the adverse effects of climate change and to build a green economy that will help to realize its ambition of reaching middle income status before 2025.

The Climate-Resilient Green Economy (CRGE) initiative follows a sectoral approach and has identified and prioritized several initiatives, which could help the country achieve its development goals while limiting today's 150 Mt CO2e emissions to around 250 Mt CO2e in 2030, which is by far less than the estimated emission under a conventional development path.

The green economy plan is based on four pillars:

- Improving crop and livestock production practices for higher food security and farmer income while reducing emissions,
- Protecting and re-establishing forests for their economic and ecosystem services, including as carbon stocks,
- Expanding electricity generation from renewable sources of energy for domestic and regional markets, and
- Leapfrogging to modern and energy-efficient technologies in transport, industrial sectors, and buildings.

As part of the strategy, the government has selected four initiatives for fast-track implementation: exploiting the vast hydropower potential; large-scale promotion of advanced rural cooking technologies; efficiency improvements to the livestock value chain; and Reducing Emissions from Deforestation and Forest Degradation (REDD). These initiatives have the best chances of promoting growth immediately, capturing large abatement potentials, and attracting climate finance for their implementation.

WATER RESOURCE POLICY OF ETHIOPIA

The Ministry of Water Resources formulated the Federal Water Resource Policy in 1998 for comprehensive and integrated water resource management. The overall goal of the water resources policy is to enhance and promote all national efforts towards the efficient and optimum utilisation of the available water resources for socio-economic development on sustainable bases. The document includes policies to establish and institutionalise environment conservation and protection requirements as integral parts of water resources planning and project development.

WILDLIFE POLICY OF ETHIOPIA

The Wildlife Policy was developed in 2006 by the Ministry of Agriculture and Rural Development. The prime objective of the policy is to create conducive environment for the preservation, development and sustainable utilisation of Ethiopia's wildlife resources for social and economic development and for the integrity of the biosphere/ biodiversity. It covers a wide range of policies and strategies relating, amongst others, to wildlife conservation and protected areas with four categories from the highest protection ranking 'National Park', followed by 'Game Reserve' and 'Sanctuary' to 'Controlled Hunting Area'.

NATIONAL POLICY ON BIODIVERSITY CONSERVATION, RESEARCH AND DEVELOPMENT OF ETHIOPIA

The policy contains policy directives with regard to the need to explore, collect, characterize, evaluate, conserve and utilize biodiversity. The need to regulate access to genetic resources through various measures, including legislation and building appropriate institutional structures and mechanisms is also mentioned. Strengthening capacity for information collection and documentation, encouraging networking and generally integration of biodiversity conservation, research and development elements in education and general awareness programmes are considered important. The policy directives emphasize the importance of community participation in the conservation and sustainable utilization of biodiversity resources together with the need to provide for access and benefit sharing for communities to and from biodiversity resources

THE RURAL LAND ADMINISTRATION AND LAND USE PROCLAMATION OF ETHIOPIA

The Constitution of FDRE leaves the detailed implementation of the provisions concerning tenure rights over rural land to be determined by subsequent specific laws to be issued at both the federal and regional levels. Accordingly, the Rural Land Administration and Land Use Proclamation No. 456/2005 was issued in 2005 to further determine the land use system and land use rights in the country or at the federal level. The Proclamation provides that land administration laws to be enacted by Regions should be based on the provisions provided therein and specifies the basic principles of rural land distribution and utilization including the scope of land use rights which Regional laws should grant. Similar to the Constitution, the Proclamation provides that peasants and nomads (pastoralists) shall have the right to get rural land holding free of charge the size of which shall be determined based upon the specific local conditions.

3.2.4.2 South Sudan

In South Sudan there is no approved environmental policy. The draft environmental policy is under review by the parliament and expected to be approved shortly. As soon as it is approved, we will review and include it in the baseline report (environment, water, any sectoral guideline, etc.).

INTERNATIONAL CONVENTIONS AND PROTOCOLS

In addition to national environmental legislations, the Federal Democratic Republic of Ethiopia is also a party to a number of Regional and International Conventions and Protocols on Environment. The Government had established an Environmental Protection Authority, and this Authority was designated as focal point for the implementation of these conventions and protocols. Currently, all the mandates of the former EPA have been transferred to the Ministry of Environmental Protection and Forestry. Some of these Conventions and Protocols are as follow:

CONVENTION ON BIOLOGICAL DIVERSITY

The general objectives of the biological diversity convention are the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. The convention encourages countries to establish a system of protected areas where special measures need to be taken to conserve biological diversity. Ethiopia signed this convention on 10 June, 1992 at the Earth Summit in Rio de Janeiro, and ratified it through proclamation 98/94 on May 31, 1994.

FRAMEWORK CONVENTION ON CLIMATE CHANGE

The ultimate objective of this convention is to stabilize greenhouse gas concentration in the atmosphere at a level that would prevent dangerous anthropogenic interferences to the climate system. This convention takes into account the fact that climate change has trans-boundary impacts. The convention commits countries to adopt national policies and take corresponding measures on the mitigation of climate change by limiting its anthropogenic emission of greenhouse gases and protecting and enhancing its greenhouse sinks and reservoirs. Ethiopia has ratified the convention by Proclamation No. 97/1994on May 2/1994.

KYOTO PROTOCOL TO THE UN FRAMEWORK CONVENTION ON CLIMATE CHANGE

To further strengthen the commitments of countries to implement the Convention on Climate Change there was a need for a refined protocol that helps in implementing and elaborating polices and measures in accordance with national circumstances. The Kyoto protocol promotes sustainable development through protection and enhancement of sinks and reservoirs of greenhouse gases.

THE VIENNA CONVENTION ON THE PROTECTION OF THE OZONE LAYER

The basic objective of the Convention is to combat the negative impact on the environment and human beings resulting from ozone depleting substances by reducing the amounts released and eventually banning their commercial use through internationally agreed measures. The Montreal Protocol entered into force in 1989 to facilitate the implementation of the convention.

Ethiopia ratified and become party to the Vienna Convention and the Montreal Protocol in January 1996. The National Meteorological Services Agency has been mandated for the coordination and supervision of implementation of this convention.

THE UNITED NATIONS CONVENTIONS TO COMBAT DESERTIFICATION

The objective of the convention is to combat desertification and mitigate the effects of droughts in countries experiencing serious drought and /or desertification, particularly in Africa. Ethiopia has ratified the convention through its proclamation no. 80/1997.

THE BASEL CONVENTION

The objective of the Basel Convention is to control and regulate the trans- boundary movement of hazardous wastes. The Bamako Convention of 1991 plays a similar role at the level of the African continent. Ethiopia ratified the Basel Convention through its Proclamation No. 357/2002. Its amendment was ratified through Proclamation No. 356/2002. The country has also ratified the Bamako Convention through Proclamation No. 355/2002.

THE STOCKHOLM CONVENTION

In the year 2002, Ethiopia fully accepted and ratified the Stockholm Convention on persistent organic pollutants by Proclamation No. 279/2002 designed to ban the use of persistent organic pollutants. The Ministry of Forest and Environment Protection has the full mandate to implement the convention at the national level.

CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES OF FAUNA AND FLORA

The objectives of the convention are to control international trade in endangered species and to ensure that international trade in non-endangered species is carried out in a manner which ensures stable markets and economic benefits for the exporting countries as well as to control and regulate illegal trade in such non endangered species, fossils and/ or their derivatives.

Ethiopia ratified the convention through Proclamation 14/1970. The mandate to implement the convention at federal level is the responsibility of the Ethiopian Wildlife Protection and Development Organization.

THE AFRICAN DEVELOPMENT BANK ENVIRONMENTAL AND SOCIAL ASSESSMENT PROCEDURES (ESAP) 2001

The AfDB issued its Environmental Assessment Guidelines (EAG) in 1992. The guidelines were used by Bank's Task Managers in implementing Bank's Environmental Policy, which was approved by the Board of Directors in 1990. In addition to providing definitions of environmental categorization and associated level of environmental assessment required in Bank financed projects, the EAG laid out step-by-step the Requirements and responsibilities related to environmental assessment at the various stages in the project cycle. However, the Bank has made progress in a number of areas which have necessitated for the EAG to be updated. Most notable was the creation of the Environment and Sustainable Development Unit (ESU) in 1996, reporting to the Vice President Operations, to establish and update policies and procedures on various crosscutting themes (environment, gender, poverty reduction, participation, and population).

In order to harmonize with these organizational structure changes, the Bank prepared the updated environmental and social assessment procedures (ESAP) in June 2001.

The main purpose of the AfDB Environmental and Social Assessment Procedures (ESAP) is to improve decision-making and project results in order to ensure that Bank-financed projects, plans and programs are environmentally and socially sustainable as well as in line with Bank's policies and guidelines. The ESAP describe the various steps that shall be followed to mainstream crosscutting issues along the project cycle, from country programming to post-evaluation. Other objective of the procedures is to make Bank's borrowers or Regional member Countries aware of environmental and social requirements for assessing Bank financed projects, programs and plans, thus enhancing their capacity to achieve sustainable development.

ESAP among others states that the projects financed by the Bank shall comply with the Bank's environmental and social legislation, policies and guidelines, with local and national requirements on public consultations and disclosure, as well as with international agreements ratified by the borrowing country. In the absence of such legislative framework, projects shall consider provision for components to enhance national capacity in environmental and social management.

The ESAP states that during the project identification phase, the screening exercise should focused on the environmental and social dimensions of a project to categorize it in one out of the four categories:

- Category-1 projects are those that are likely to have the most severe environmental and social impacts and require a full ESIA.
- Category-2 projects are likely to have detrimental and site-specific environmental and social impacts that can be minimized by the application of mitigation measures included in an ESMP.
- Category-3 shall not induce any adverse environmental and social impacts and do not need further ESA action.
- Category-4 projects involve investment of Bank's funds through Financial Intermediaries (FIs) in subprojects that may result in adverse environmental or social impacts. Specific requirements for this type of project include an assessment of FI capacities to handle environmental and social considerations.

According to AfDB project classification, the Baro-Akobo-Sobat Integrated Water Resource Development project, by its nature of situating in environmentally sensitive area and its cross boundary condition classified as category 1 project.

3.3 RECOMMENDATIONS FOR SCOPE OF THE WORK FOR THE SSEA - BASIN LEVEL

3.3.1 Environmental aspects of the SSEA at basin level

For mapping (1) purposes at the scale of the Baro-Akobo-Sobat basin, we need to:

- Identify the various flooded areas and wetlands complexes;
- Visualize their inter and intra annual variability in order to :
  - Determine their type (permanent, seasonal, etc.);
  - Map their smallest and largest outlines.

Therefore, the following maps could be useful:

- Minimum flooded area (smallest extent ever recorded (among the data available));
- Maximum flooded area (largest extent ever recorded (among the data available));
- Other inundation maps/satellite images during both wet and dry season / and during both dry and wet years.

According to our understanding of the availability of the images (radar and/or optical), we assume it won't be possible to visualize the flooded area on the entire basin at numerous time periods. **A least maps showing the flooded area of the entire basin at 5 to 10 different time periods would be fine**.

When available, **more detailed map targeting a specific area** (the *Machar marshes* for instance) would be useful. The Palsar images could be used for that specific need. Associated surface area corresponding to inundation maps of the specific zone could also be calculated at different time periods.

In order to quantify and understand the dynamics of the inundation over time (2), the following should be assessed:

- The main source of the inundation (spilflow from the rivers, rainfall, underground water, combination of various factors, …) by comparing monthly flooded area and rainfall, ETP and runoff patterns;
- The scale of the phenomenon by quantifying its inter and intra annual variability and analysing its frequency.

Therefore, monthly surface area of the flooded zone for each sub-basin is needed for a **10-years period at least.**

3.3.2 Recommendations for scope of the work for the social aspects of the SSEA at basin level

The SSEA Framework at basin-level will build on work done during the baseline. In the scoping report, it is important to be clear about what information the SSEA framework will need to be useful and applicable. This information is outlined here.

It is proposed that the SSEA Framework will include the following parameters:

- Social and Environmental Objectives of Water Resources Development in the BAS basin
- Policies, strategies, guidelines and plans - gaps and implementation issues
- Population dynamics and needs
- Access to basic services (water, sanitation, education, health, transportation power and communication)
- Livelihoods/employment/income/resources
- Key drivers of change
- Major interests (political and economic)
- Cross-cutting and transboundary issues
- Conflicts and security
- Strategic options/opportunities
- Limitations/constraints
- Risks and mitigation measures

4. SCOPING FOR PLANNED AND POTENTIAL INTERVENTIONS

4.1 INTRODUCTION

A sectoral based approach is taken for the scoping of projects/interventions. However, it is important to remember that the development of multipurpose opportunities is a key aim of the study and this should always be kept in mind when scoping opportunities. Thus, while development projects are listed by sector there is a clear intention to maximise their development across a number of sectors. A brief paragraph has been included at the end of each sectoral analysis aimed at highlighting how individual sectoral developments can be integrated into multipurpose projects.

4.2 POTENTIAL INTERVENTIONS FOR THE DIFFERENT WATER RELATED SECTORS

4.2.1 Crop Sub-sector

4.2.1.1 Introduction

The Crop sub-sector is divided into rainfed and irrigated agriculture. Projects/interventions under this heading can include the following:

- New small, medium and large-scale irrigation development projects. These are central to water resources management and planning since they i) require that a reliable source of water is available and ii) will have an impact on water resources downstream
- Rehabilitation and/or modernization of small, medium and large-scale irrigation development projects.
- Medium and large-scale rainfed development projects. While these do not have a significant impact on the available water resources and will not require that a source of water is made available, it is important to take them into consideration in the overall management of water resources. They may represent viable alternatives to irrigation in the same areas and their relative potential levels of productivity and economic viability should be taken into account.
- Small-scale rainfed development. This is included only when as component of livelihood-based watershed management. It is not within the scope of this study to detail interventions related to the improvement of the rainfed sub-sector.
- A range of related and cross-cutting and enabling interventions, including especially capacity building and access to credit.

A number of projects falling under these categories have already been identified and are introduced in Section 4.2.1.2.2 and 4.2.1.3.2. These projects will be detailed in the Baseline Report. In Section 4.2.1.2.3 and 4.2.1.3.3 the areas which have been identified as having the potential for the identification of projects are presented together with an overview of the work that will be required as part of the baseline.

With respect to this study and its scope it is important to emphasize the study is not aimed at replacing agricultural master plans and strategies. The focus is rather on how the available water resources can best be utilised to support these plans in a coordinated and coherent manner, taking into account that other sectors may also have plans that compete for the same water resources

4.2.1.2 Rainfed Agriculture

4.2.1.2.1 Overview

Rainfed agriculture is practised in most parts of the basin. 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.

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.

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. Further details are provided in Section 4.2.5 of this report.

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.

4.2.1.2.2 Identified development projects

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 (>10,000 ha) has already been carried out with varying degrees of success.

During the baseline the team will aim to obtain a clear picture of all what land has already been leased and for what type of agriculture it is intended.

SOUTH SUDAN

Although it has only been obtained recently and the detailed annexes are still required, a number of projects for the 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 and includes 35 interventions under the following 5 headings:

- Reconstruction and recovery
- Food and nutrition security
- Economic growth and livelihood improvement
- Agriculture sector transformation
- Institutional development

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.

4.2.1.2.3 Identification of target areas

The main target areas for rainfed agriculture in Ethiopia are in the highlands for small-scale subsistence and semi-subsistence rainfed farming and in the flat areas around Gambella. These areas will be the focus of investigation the Ethiopian part of the basin. The development of commercial rainfed agriculture in the plains around Gambella needs to take into account the presence of floodplains and conservation areas.

Potential target areas for project interventions in South Sudan will be carefully analysed and better understood once the annexes of the CAMP have been obtained. Key areas for rainfed agriculture will certainly include the wetter mountainous areas and the “Green belt’.

4.2.1.2.4 Information requirements and data gaps

Key studies of interest which still need to be obtained concern the land-use planning of the Gambella Park and flood plains and the complete version of the CAMP.

4.2.1.2.5 Rainfed Agriculture and multipurpose water resources development

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.

4.2.1.3 Irrigated Agriculture

4.2.1.3.1 Introduction

The practice of irrigated agriculture in the Baro-Akobo-Sobat basin is restricted to the flat parts of upper (Gambella Region) basin and the experience is very limited. The ARDCO-GEOSEV report (Vol II-C, Ground water) as cited in Baro-Akobo River Basin Integrated Master Plan Study Final Report Volume I, (MoWR, 1997), noted the existence of 10 NGO supported small scale irrigation sites with a total area of 1,100 ha in the upper Basin. The construction of Alwero irrigation project started in 1987. This scheme is located in the upper course of the Baro watershed, on the Alwero River, in Ethiopia and the plan was to irrigate a land area covering 10,400 ha. However; the operation of the scheme was not active at the time of study (EVDSA, 1990). Recently the management of this dam and corresponding potential command area has been taken over by an important investor (Saudi Star), giving priority to irrigated rice cultivation.

Limited wetland edge cultivation for maize is practised in the wetland areas. In addition to the drainage based cultivation of wetlands in the northern and eastern parts of the upper Baro-Akobo sub-basin, there is also a cultivation of taro (Colocasia esculenta) established for a long period of time in wetlands in Bench Maji Zone around Mizan Teferi, and in Sheka zone around Tepi. Traditionally, this does not usually involve any water management, as this crop is tolerant of flooding. However, water management is in practice in some areas as farmers have realized that yields can be increased in this manner with flooded areas extended and water availability improved before and after the rains. Cropping based on rainfall and residual moisture is (flood retreat) practised by the Anuwak, Opo and Komo peoples, is practised along the banks and levees of the Baro, Akobo and Sobat rivers (ENTRO, 2009).

In South Sudan, the CAMP Situation Analysis (MAFCRD, 2012) revealed that there is a considerable potential for the development of medium and large-scale irrigation schemes since a sufficient volume of surface water is available from the mainstream and tributaries of the River Nile. There is also a major opportunity for small-scale irrigation development in the Greenbelt Zone by using water from small streams. Significant numbers of irrigated plots are also found in Hills and Mountains, Ironstone Plateau, and Eastern Flood Plains. Despite all these, only a few farmers have irrigation facilities.

Based on the information available, scanty as it is, the existing irrigated agriculture in the Baro-Akobo-Sobat River basin is currently insignificant. On the other hand, the studies conducted so far had shown that there is a large potential for irrigated agricultural development in the upper part of the basin in the Gambella plain. Although the report has not yet been released, insight into the Irrigation Development Master Plan for South Sudan has also indicated that large areas have been identified in South Sudan.

4.2.1.3.2 Identified development projects

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).

Several large and medium scale irrigation sites have been identified by the studies with estimated total land areas of about 1,079,526 ha of land as potentially suitable for irrigation. Finally, the Baro-Akobo Integrated Development Master Plan Study (MoWR, 1997) identified six dam sits in the Baro Akobo Sobat basin part of Ethiopia, out of which five are for irrigated agriculture development and one is for multi-purpose. A multiple reservoir analysis was carried out for all the six dams by considering potential storage in each of the major river, in order to find the total maximum area that could be ultimately irrigated under diversified rotation. As a result, the maximum irrigable areas, considering the environmental releases and excluding return flow, were found to be 483,100 ha in the three major sub-catchments with the Baro (249,800 ha), Alwero (37,400 ha) and Gillo (195,900 ha). The list of these identified potential irrigation systems is given in the table below.

Table 4-1: Identified irrigation projects in the BAS basin

#	Catchment	Dam site	Irrigable Area (ha)
1	Baro		
1.1		Ilang Dam	98,300
1.2		Gabela Dam	151,500
		Total for Baro	**249,800**
2	Alfero		
2.1		Bobo Dam	10,400
2.2		Chiro Dam	12,000
2.3		Dubon Dam	15,000
		Total for Bobo	**37,400**
3	Gillo	Gillo-1 Dam	
3.1		Gillo 1 Right Bank	62,200
3.1.1		Let Bank	60,900
3.2		Gillo-2 Right Bank	46,900
3.2.1		Let Bank	25,900
		Total for Gillo	**47049**
		Total	**483,100**

Source: (MoWR, 1997)

Finally, the study recommended the inclusion of the below selected projects (Table 4-2) in the Master Plan scenarios, with a total net irrigable land area of 123,200 ha as being the most favourable among those options identified. Of these, the Alwero project under construction at the time was indicated as the initial phase of irrigation development. It was also suggested that the Baro right bank - Itang Dam project with a net irrigable land area of about 50,900 hectares irrigation development to be considered for feasibility level studies.

Table 4-2: Priority Irrigation Projects in the Baro-Akobo Sub-basin (MoWR,, 1997)

No	Projects selected	Area (ha)		Status
		Gross	Net	
1	Baro Right Bank, Itang Dam, Gravity	66,600	50,900	Master plan
2	Alwero, Abobo Dam	13,600	10,400	Dam constructed & irrigation network under construction
3	Alwero, Dumbong Dam	23,192	15,000	Master plan
4	Gillo Right Bank, Gillo Dam -2	47,000	46,900	Master plan
	Total	150,392	`123,200	Master plan

4.2.1.3.3 Identification of target areas

ETHIOPIA

Nearly two decades have passed since the completion of the latest master plan study. Therefore, the projects should be reviewed and modified to incorporate up-to-date information on various factors affecting decision-making: the available land resources and their limitations in the basin may change with progress in the techniques (GIS software, remote sensing technology, etc.). Use can be made of tools such as the analysis of slopes produced by the remote sensing team (see

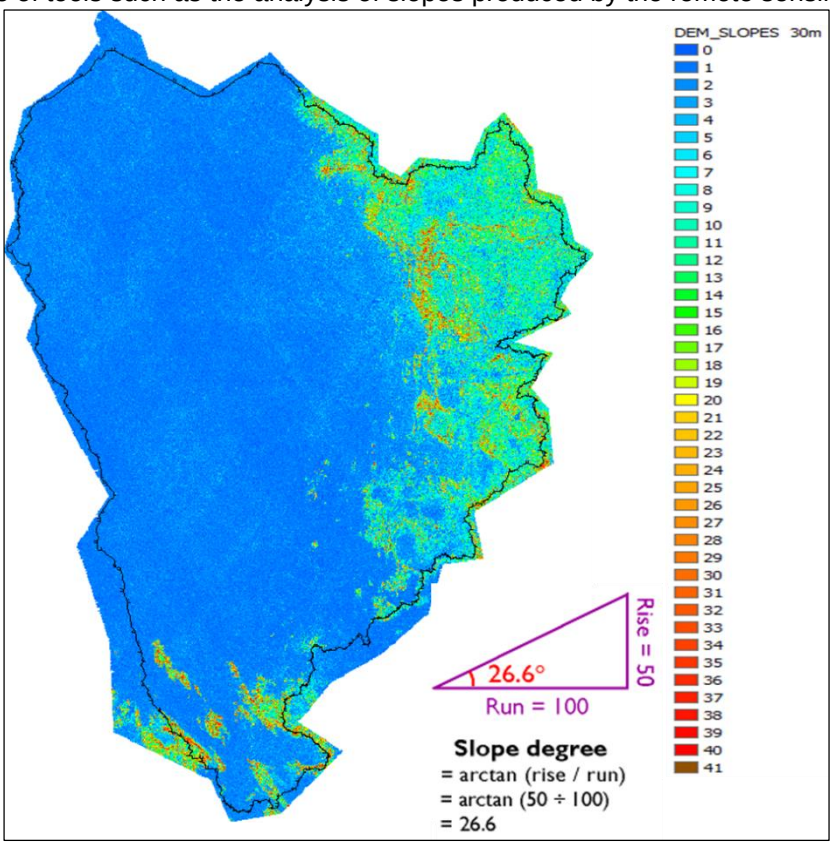


Figure 4-1).

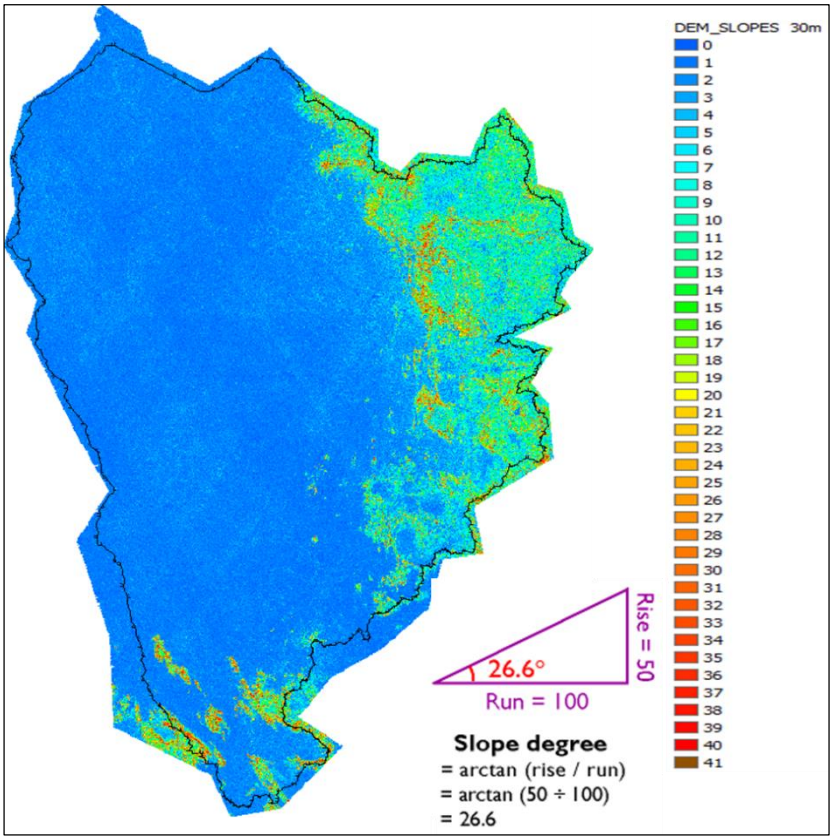


Figure 4-1: Analysis of slopes

The knowledge of the hydrology may have changed with availability of more data, the demand projections for agricultural products may change with changes in a high rate of economic growth in the country, and the cropping pattern is also likely to change with changing market conditions over time.

In general, some of the data needed for the review would be of the following category:

- Topographical data such as topographical maps 1:50,000 scale.
- Reservoir storage for irrigation.
- Meteorological data (rainfall, evaporation, temperature, etc.)
- Irrigation water requirements based on revised cropping calendar and cropping pattern, etc.
- Hydro Geological data such as, ground water elevation, etc.
- Water quality data for both surface and ground water.
- Land resources data such as land use, soil survey, land classification, etc
- Information on existing small scale irrigation schemes (practices, lessons learned).
- Information on irrigation development-related institutions, development partners, public awareness.

SOUTH SUDAN

The identification of target areas in South Sudan will be dictated by the work carried out in and the recommendations of, the Irrigation Development Master Plan. This document and the related maps will be obtained and used in development of the baseline. A preview of some elements of the report indicates that around 73,000 ha have been identified as possible candidate areas for irrigation projects in the Sobat River basin, some of which could be focussed on irrigation. These are summarised in Table 4-3 and indicated in Figure 4-2.

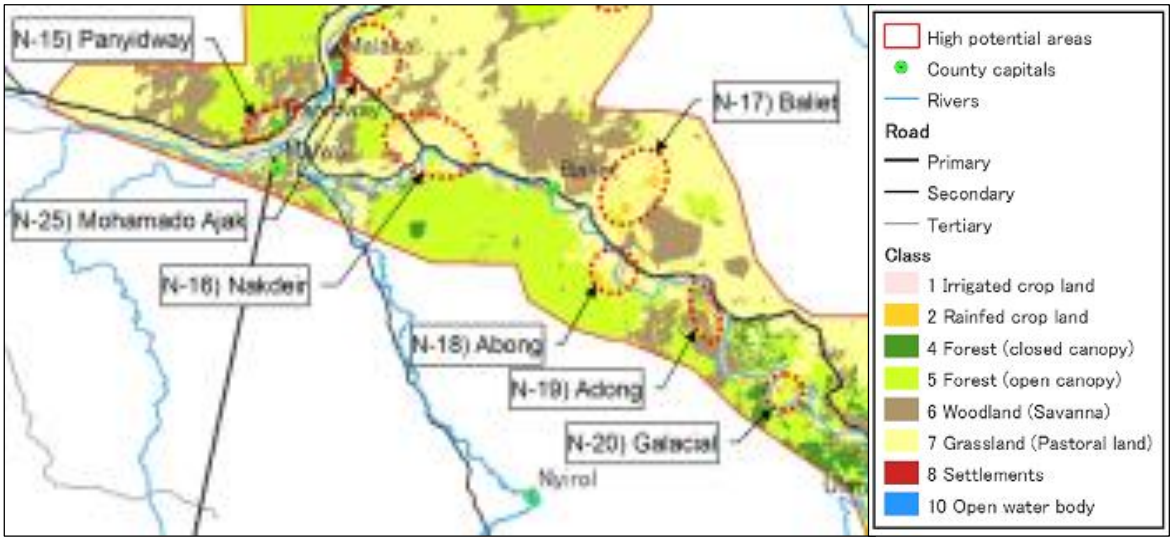


Figure 4-2: Location of some of the priority project areas on Sobat River (from IDMP, 2015)

Table 4-3: Candidates for priority project areas using water from Sobat River

Name	State	Command Area (ha)
Nakdeir	Upper Nile State	11,000
Baliet	Upper Nile State	9,000
Abong	Upper Nile State	3,000
Adong	Jonglei and Upper Nile States	4,000
Galacial	Jonglei and Upper Nile States	3,000
Doma	Upper Nile State	5,000
Ulang	Upper Nile State	10,000
Nasir-East	Upper Nile State	19,000
Nasir-West	Upper Nile State	8,000

4.2.1.3.4 Information requirements and data gaps

The study covers Southwest part of Ethiopia and Southeast including central parts of South Sudan. However, information included in this report mainly deals with Ethiopian area of the sub basin as not much work has been done on the South Sudan part of the sub basin. The exact size, location and priorities for development of specific irrigation schemes are not yet known in South Sudan. Currently, there is no baseline information to identify potentials for small, medium and large scale irrigation projects. This is one of the key areas to be filled in during the subsequent phase of the study through stakeholder consultation, collecting study document and satellite imagery interpretations and analysis. MSIOA study (ENTRO, 2014) revealed that the Ministry of Electricity, Dams, Irrigation & Water Resources in the South Sudan was preparing Irrigation and Drainage Master Plan with the assistance of JICA. The master plan is expected to identify and properly inventorIse the potential areas for small and large scale irrigation development and develop a strategic framework for irrigated agriculture in the country. It was planned to be completed by the end of June, 2015 and progress on this report shall be followed and findings will be used as input for the current study.

The followings are the two identified on-going studies in South Sudan and need to be followed and collected.

- According to the Eastern Nile Multi-Sectoral Investment Opportunity Analysis Study (ENTRO, 2014) the preparation of Irrigation and Drainage Master Plan with the assistance of JICA was underway and was planned to be completed by the end of June, 2015.

- The CAMP (Comprehensive Agriculture Development Master Plan), which is a 25 years plan for agriculture development but also fisheries, livestock, forests is being elaborated and should be compiled before the end of the BAS project. (BAS inception Report). The main report has been obtained but the annexes are also required.

Different organizations conducted studies on the Baro-Akobo river basin, but Ethiopian Valley Development Study Authority (EVDSA) and Ministry of Water (MoWR) are the two institutions which studied the basin in detail and identified Irrigation potential in the basin. The studies by both institutions had indicated a large potential for irrigated agriculture development in the lower plain of Gambella. But, some of the data in the study have been outdated due to change in the areas resulted from expansion of private farms in the lower basin area and farmers-managed small scale Irrigation schemes in the upper part of the basin. According to the information gathered from Ministry of Water, Irrigation & Energy (MoWIE) in the course of this scoping report preparation, there are several individuals and companies who are at present licensed to use about 40,000 ha of irrigable land in the Gambella plain. In addition to the intensification of rainfed agriculture, there is also a tendency that farmers-managed small scale irrigation expansion has been taking place to meet food security need for the growing population particularly in the upper most part of the basin in Ethiopia. However, current situations are not well documented and there are no data on the present condition with regard to irrigation and drainage practices in the basin. Information on the existing water use and management will enable the planner to assess the committed water uses and to arrive at net water available for further planning. It will also enable him to study the current practices and correct any deficiencies in future planning. Assessment of the existing irrigation water management system and on-going infrastructures development in the entire basin would be essential to bridge the gap. This should include a description of the existing irrigation facilities, water management practices and issues including review of the existing institutional arrangements for farmers' participation in the water management and standard of maintenance of the scheme. The assessment will also include current status of earlier identified medium and large scale priority irrigation projects.

4.2.1.3.5 Irrigated Agriculture and multipurpose water resources development

It is clear that the development of irrigated agriculture can and should fit into the overall context of multipurpose development. In particular, the following opportunities can be identified:

- The construction of reservoirs in upland areas aimed at the providing the storage and regulation for hydropower projects can also facilitate the abstraction of water for irrigation schemes downstream. An essential part of the modelling of such potential reservoirs involves optimising their operation to meet both hydropower and irrigation needs.
- Integrated aquaculture and irrigation (especially for irrigated rice). Water abstracted for irrigation can be used first for aquaculture. The nutrient enriched effluent from the aquaculture is then used for the irrigation of crops. This works particularly well for the irrigation of rice. Where rice is subsequently processed on site, some of the "waste" material can be used for the manufacture of fish feeds.

4.2.1.4 Enabling environment

The Consolidated Agriculture Master Plan would appear to cover the key areas of the enabling environment in South Sudan. It includes chapters on the sectoral development policy and implementation framework and also covers both institutional development needs and funding availability, requirements and allocation. These areas will be carefully investigated during the basline once the complete version of the CAMP and Irrigation Development Master Plan have been obtained.

INSTITUTIONAL, LEGAL AND POLICY FRAMEWORKS

At federal level in Ethiopia, the Ministry of Agriculture and Natural Resources Development (MoANRD) has the mandate of promoting the expansion of small scale irrigation schemes. While 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 Ministry of Water, Irrigation and Electricity, the implementation of Medium and Large scale irrigation projects is the responsibility of the MoWIE.

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 200 ha).

At regional level, the current and future implementation, planning, operation and maintenance of irrigation project in terms of its institutional frameworks is not well addressed. This is a gap to be filled during the subsequent phase of the study through stakeholders' consultation, collection and review of documents on the duties and responsibilities of institutions involved in the development of irrigated agriculture.

WATER SECTOR POLICY AND STRATEGIES

Water policy in Ethiopia was prepared and has been 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.

As per the water allocation and apportionment policy directives, basic human and livestock needs as well as environmental reserve have the highest priority. It also gives direction in efficient use of water and the allocation shall not be made on permanent basis, rather it shall be done on an agreed time horizon that fits best with the socio-economic development plans. It also states that water sales will be the source of finance to administer, operate and maintain large hydraulic structures.

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.

AVAILABILITY OF CAPACITY AND CAPACITY BUILDING OPPORTUNITIES

In view of the present under capacity of institutions and personnel involved in the irrigation sector, capacity building is a critical regional/national issue to enhance/improve the planning, study, design, implementation and OMM of irrigation schemes and ensure sustainable irrigation development in the EN countries. Capacity building is a continuous process and should be provided at all levels (policy makers, managers, engineers, technicians, WUAs and farmers), through a well-planned and designed short and long term training programme which included on the job training, study tours to visit best practice sites, etc. (ENTRO, 2015). However, capacity and capacity building opportunities are also one of the key areas to be filled in during the subsequent phase of the study through stakeholders' consultation at Regional, Zonal and Woreda level.

4.2.2 Hydropower and Interconnection

4.2.2.1 Identified development projects

In the Baro-Akobo sub-basin in Ethiopia, there is currently one small hydropower project (HPP) in service, **Sor** with an installed capacity of 5 MW and eight hydropower projects 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 hydropower projects are presented in the following table.

Table 4-4: Identified Hydropower Projects

Name	Status	Installed Capacity (MW)	Rated Discharge (m^3/s)	Rated Head (m)	Type
Sor	Existing	5	15	210	R-o-R
Sor 2	Project	5	15	91	Reservoir
Baro 1	Project	166	113	166	Reservoir
Baro 2	Project	479	113	479	Pondage
Genji	Project	216	31.5	380	Pondage
Birbir R	Project	467	160	351	Reservoir
Geba 1	Project	214.5	50	465	Reservoir
Geba 2	Project	157	65	263	Pondage
Tams	Project	1000	548	246	Reservoir

In South Sudan, small hydropower projects 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.

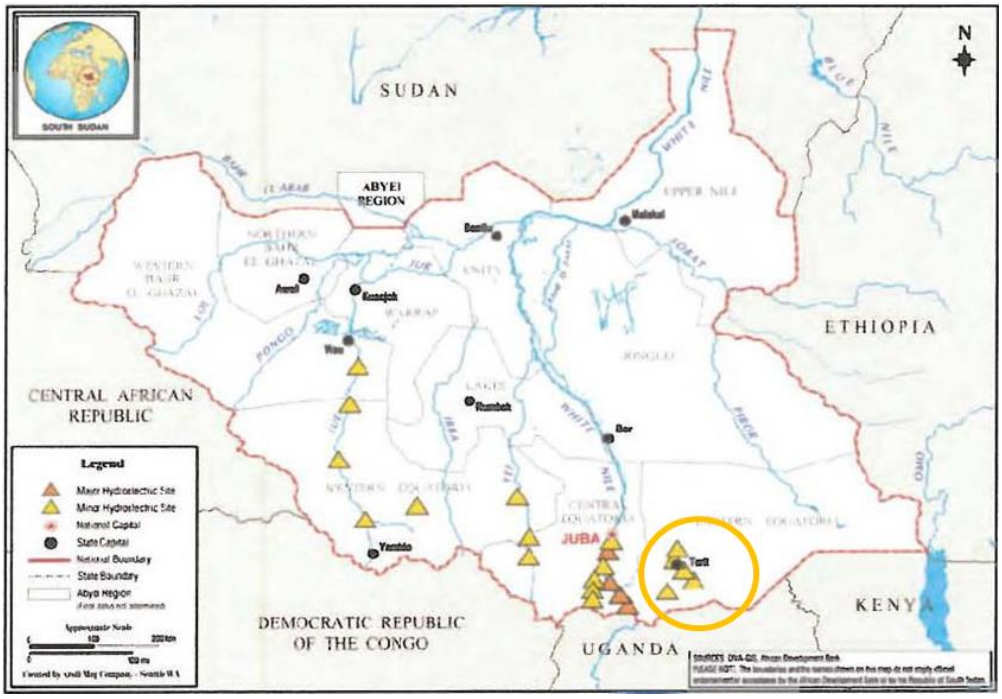


Figure 4-3: Location (orange circle) of potential hydropower sites in South Sudan

In addition, the online information site "Gurtong" published an article in 2013 to the effect that the South Sudan and Exim Bank of China had signed a loan agreement for the construction of the 2 MW Kinyeti hydropower project located in the same general area.[10]

[10] Available on: http://www.gurtong.net/ECM/Editorial/tabid/124/ctl/ArticleView/mid/519/articleId/11853/Juba-Beijing-Sign-Loan-Agreement-To-Construct-Kinyeti-Hydro-power.aspx).

4.2.2.2 Identification of target areas

The hydropower sector includes two components, power generation and its transmission. From the viewpoint of power generation, in addition to the projects that already have been identified within the BAS study area as potential candidates to meet the growing energy demand at both national and regional level, the highlands of the study area both in Ethiopia and Sudan are target areas for the identification of other potential sites. The adopted methodology has been described in the Inception Report and consists in calculating the power potential profile along a river course based on the topographic profile and the average discharge profile of the river course. With respect to transmission and interconnections, the target areas go from the local area, the near area where the generation units are located to the national grid and from then to the regional grid.

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. The eight future power plants identified in this region will be connected to this line.

At the regional level, a MOU has been signed between Ethiopia and South Sudan to connect this line from Gambella to Malakhal in South Sudan and some route surveys have been carried out. Currently because of security concerns this project is **on hold**. Nevertheless, at the regional level, all efforts concentrate on strengthening the regional transmission backbone with interconnector projects at various levels of study, design or development;

- 500 kV HVDC interconnector between Ethiopia and Kenya;
- 500 kV HVAC interconnector between Ethiopia and Sudan
- 600 kV HVDC interconnector between Egypt and Sudan
- 400 kV HVAC Kenya – Uganda interconnector;
- 400 kV HVAC Kenya-Tanzania interconnector
- 220 kV HVAC South Sudan – Uganda interconnector
- 220 kV HVAC DRC-Rwanda interconnector
- 220 kV HVAC Rwanda-Burundi interconnector

All these interconnectors will allow power exchanges throughout the region. Hence, in the future the hydropower projects identified for development in the BAS sub-basin will be components of a power pool that will stretch from Egypt to DRC and Tanzania. In addition, there are ongoing studies to connect this power pool to the Southern Africa Power Pool (SAPP) that covers all of Southern Africa South of and including both DRC and Tanzania.

4.2.2.3 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 energy 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 of Large Hydro Facility Developed as a joint venture between IPP 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. In this respect the BAS project can assist in promoting to the interested parties the GIS methodology to estimate hydropower potential.

4.2.2.4 Information requirements and data gaps

The major data gap relates to South Sudan identified hydropower potential in the area of Torit and, since several sites have been identified there probably exist some documentation on these sites. The team will make contact with the pertinent authorities (Ministry of Electricity and Dams) to assist in identifying this documentation.

Another gap, this time at the regional level is only temporary due to the non-availability of the EAPP generation and transmission planning update report until such time it has been accepted by all parties. As the project proceeds, the status of this report should be monitored as it is the main source that outlines the direction in which regional integration of the electricity sector is proceeding.

4.2.2.5 Hydropower and multipurpose water resources development

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 iof 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.

4.2.3 Potable water supply and Sanitation

4.2.3.1 Identified development projects

IDENTIFIED DEVELOPMENT PROJECTS IN ETHIOPIA

- **Gambella Region, Gambella Town** - The population of Gambella town has fairly recently mushroomed from about 30 000 to about 150 000 and reticulated water can only be supplied to residents about one day per week. Various documents have been prepared for upgrading the system from 5 000 m3/day to 10 000 m3/day or perhaps 15 000 m3/day but finance and probably also detailed design is lacking. The works would include the river intake pump station, the 3 km rising main and the treatment works.

IDENTIFIED DEVELOPMENT PROJECTS IN SOUTH SUDAN

- **Torit Water Supply and Sanitation** - The Dutch government is currently funding an investigation of water supply and sanitation in Torit and will also fund part of the implementation which includes privatization of the water supply system. There may be a need to provide assistance with this project.

  Open defecation is the main practice in Torit as well as the use of water from open surface water sources on account of the preferred taste. This and preferred open defecation led to the recent outbreak of cholera. The current Dutch funded investigation is attempting tom address these practices. The development of information and community programs for reducing these practices would be beneficial to the health of much of South Sudan's rural population. This would have to be done together with government departments and various NGOs.
- **Water Supply for Communities and Livestock** - Conceptual plans have been prepared for surface water supplies for communities and livestock in areas of Eastern Equatoria where groundwater is less favourable which is mainly limited to those areas in the South which are mainly underlain by basement rock. Consideration might be given to investigating the feasibility of the proposed surface water supply alternatives.
- **Water Supplies for Other Towns** - In 2013 detailed design reports were prepared by SMEC for the state capitals of Bentiu, Bor and Torit. The supply to Torit is being addressed as indicated above but there may be opportunity to assist the other two state capitals to commence the upgrading of their water supplies.

4.2.3.2 Identification of target areas

ISSUES, CHALLENGES AND OPPORTUNITIES FOR THE DEVELOPMENT OF WATER SUPPLY IN SOUTH SUDAN:

<u>Issues and Challenges:</u>

- Low WaSH coverage: For both urban and rural communities
- Health risks: Guinea Worm and cholera outbreaks within the basin
- Migration and conflict: Conflicts caused within the basin during movement for livestock watering
- Water quality: Poor water quality monitoring and community resistance to the use of ground water sources on account of taste
- Implementation approach: No guideline and procedure for WaSH implementation

Opportunities for the development of water supply:

- Assessment of ground water potential:
- Assessment of need and development of financial strategy
- Gap analysis of existing WaSH Policy and Strategy and development of implementation guidelines and procedures
- Supply of surface water for human consumption and livestock watering for communities residing in conflict areas: Development of surface water sources for supplying water for multi villages (communities) for both human and livestock consumption.
- Development of urban water supply schemes: Rehabilitation and expansion of water supply and waste management systems for a town like Torit where Cholera outbreaks have occurred.
- Economic tariffs: The Government's policy on water tariffs should be reviewed and should preferably cover the full operation, maintenance and replacement costs.

ISSUES, CHALLENGES AND OPPORTUNITIES FOR THE DEVELOPMENT OF WATER SUPPLY IN ETHIOPIA:

Issues and Challenges:

- Low WaSH coverage: Particularly Gambella town suffers from intermittent water supply
- Conflict and migration: Movement in search of water for livestock and the villagization policy
- O&M challenges: Lack of spare parts and lowering of ground water table due to excessive water abstraction
- Water Quality: High iron content

Opportunities for the development of water supply

- Financing the development of the Gambella town water supply
- Supply of water for human consumption and livestock watering for communities residing in conflict areas: Development of surface water sources for supplying water for multi villages (communities) for both human and livestock consumption.

With respect to the ongoing development projects and following the results of the guiding documents, it is possible to identify target areas where intervention is needed.

TARGET AREAS IN ETHIOPIA

- **Gambella Region, Akobe Woreda** - The Akobe Woreda is situated on the border with South Sudan formed by the Akabo River. During the dry season tribal conflict often arises from the migration of the local pastoralist people across the river to provide better grazing for their cattle. Aid Agencies are not working in this woreda as there is no road access during the wet season and water supply coverage is very low. There may be opportunity to reduce conflict and improve health by providing combined water supply and cattle watering facilities in Ethiopia and perhaps also the irrigation of crops for silage during the dry season so as to reduce the need for cattle migration. It should be noted that conditions are similar in the Jor Woreda and perhaps in others.
- **Gambella Region, Gambella Woreda** - WaSH coverage (for water supply and sanitation) is better in the Gambella Woreda but is still not good and requires considerable improvement. A number of NGO's and other aid organisations are already addressing this however one of the concerns that is perhaps not being addressed is that there are no formal dumping sites for septic tank pump out trucks.

TARGET AREAS IN SOUTH SUDAN

- **Water Quality Monitoring** - Laboratories for water quality monitoring have been set up in the various state capitals and have been provided with equipment. Staffing and transport have also been provided however at the time of the visit to Torit there were no chemicals available for testing. Therefore there may be a need for assistance to set up a system to ensure that the monitoring arrangements are seamless and that if necessary actions are taken to address any pollution.
- **Tariff Structure** - The government currently specifies a fixed tariff for the supply of water to urban consumers. The current tariff is inadequate for meeting operating and maintenance costs and therefore some government and other organizations are considering the possible privatization of schemes and higher tariffs in order to provide sustainable water supply systems.

  There may be opportunity to assist with the development of tariff guidelines as the Final Draft of the Water Act dated 2013 states the following: “Develop guidelines for the setting of tariffs and charges for use by Local Government Authorities and Service Providers, in accordance with RSS policies.”
- **Borehole Supplies** - The majority of water supplies for rural communities are provided by boreholes the majority of which are drilled by UNICEF which is a major developer of borehole supplies. Data on the boreholes drilled is provided to the Directorate of Rural Water Supply and Sanitation. There may be opportunity for improving the collection and monitoring of data on yields and water quality associated with various geological of formations and possible sources of pollution.

FOCUS ON THE OPPORTUNITY TO DEVELOP GROUNDWATER USE FOR POTABLE WATER SUPPLY

Studies conducted over the Ethiopian side of the project area have made the following general statements regarding potential of groundwater for supply:

- The aquifers in the area are very extensive and can be used for water supply.
- The optimum depth of operation wells are between 50 and 80 m.
- The aquifer in the 1acustine-al1uvial deposits occupying large western part of the Gambella plain may be of interest of local water supply by means of shallow (15 to 20 m) shaft wells. The yield may reach 0.5 l/s, and it is exposed to pollution.
- The aquifer in recent alluvial deposit, limited to narrow strips along the rivers is insignificant, can be utilized for local water supply through 10 to 15 m wells by manual water lifting. It is also exposed to pollution.
- During the TAMS (1996) study the following areas were identified as prospective groundwater development areas:
  - Itang vicinity (50 km west of Gambella)
  - Vicinities of Jikaro-Baro
  - Vicinities of Baro-Alwero
  - Vicinities of Alwero-Gilo
  - Vicinities of Gilo-Akobo

4.2.3.3 Enabling environment

SOUTH SUDAN INSTITUTIONAL, LEGAL AND POLICY FRAMEWORKS

Though there is no specific legislation to guide the whole sector yet there is the Local Government Act capturing water supply and management of local water resources as part of the concurrent powers shared between different levels of Government. The act provides the local Government councils with the mandate for the establishment and maintenance of water drainages and potable water facilities in their respective areas of jurisdiction.

The Government of South Sudan (GOSS) also developed a Water Policy in 2007 which provides a corner stone for the development and management of water resources and the provision of water, sanitation and hygiene (WASH) services. The policy recognizes that improved access to water and sanitation can make a significant contribution towards reducing poverty and vulnerability and in promoting livelihoods and economic growth. It recognizes the need to develop a clear strategy for providing water for livestock, which may include the construction of water harvesting structures such as haffirs and dams to trap water for the dry season. It also recognizes that low levels of access to basic water supply and sanitation services, sustainability of water infrastructure, water use conflicts and lack of a clear financing strategy are amongst its major challenges.

The basic principles of the policy include: recognition that water is owned by all riparian people, has social, economic and ecological value in all its competing uses and must be a lever for peace and not a source of conflict'; separation of institutional roles relating to water resources management from those relating to resource development and service delivery; decentralization of responsibility to the lowest appropriate administrative level; the principle of "user pays" applied with the gradual introduction of economic measures and participation of water users in decision-making processes surrounding planning, development and management of water resources, delivery of water and provision of sanitation services in an equitable and sustainable manner.

To translate the water policy into practice GOSS prepared the Water, Sanitation & Hygiene (WASH) Sector Strategic Framework and specifically the strategic approach which suggests: -

- For sanitation and hygiene there should be a community based demand responsive integrated approach aiming to minimize subsidy levels for hardware inputs with incremental capacity development of State and local governments.
- For Rural Water Supply communities to manage their water sources there should be a program based on demand responsiveness, targeting of priority areas, and combining water supply with sanitation and hygiene improvements.
- For Urban Water Supply the strategic approach contains elements of both, building infrastructure and developing an enabling environment to encourage the emergence of an efficient, effective, integrated, sustainable urban water supply services based on an equity and cost recovery.

ETHIOPIA INSTITUTIONAL, LEGAL AND POLICY FRAMEWORKS

The Ethiopian Water Resources Management (EWRM) Policy developed in the Year 2000 has an overall objective of enhancing and promoting all national efforts towards the efficient, equitable and optimum utilization of the available Water Resources of Ethiopia for significant socioeconomic development on a sustainable basis. The Water Policy promotes the utilization of water in an integrated manner but with priority to supply water for drinking purposes (for both humans and animals) whenever there is no ample resource. The Water Policy deals with three sectoral issues of which one is Water Supply and Sanitation (WSS) for the provision of water supply services that meet the livestock, industry and other water users' demands.

The WSS Policy calls for more decentralized decision-making; promotion of involvement of all stakeholders, including the private sector; increasing levels of cost recovery; as well as integrating water supply, sanitation and hygiene promotion activities. In 2002, the Ethiopian Water Sector Strategy was prepared to translate the Water Policy into Action. The strategy:

i. Acknowledges the right of every Ethiopian to have access to basic human needs;
ii. Advocates the use of appropriate technology;
iii. Enhances local communities' decision power and their full responsibility for Operation & Maintenance (O&M);
iv. Recommends the need for the establishment of safety regulations and certain safety measures; and
v. Recommends decentralization and thus in some way acknowledges user management.

In regard to sanitation Ethiopia has no separate sanitation policy of its own but a National Hygiene and Sanitation Strategy (NH&SS) that emanated from the Health Policy to enable 100% adoption of improved sanitation and hygiene practice particularly in the rural settings of Ethiopia. The NHSS emphasizes the preventive aspect of health with a focus on communicable diseases, common nutritional disorders and on environmental health and hygiene. Sanitation is also given due importance in the Environmental Policy in terms of protecting the environment and safeguarding human health, in the Water Resources Management Policy and in the Public Health Proclamation. .

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 some reforms with the aim of improving the delivery of water supply and sanitation services. An important change to the policy framework was the shift in the hygiene and sanitation strategy with the introduction of the Community Led Total Sanitation and Hygiene CLTSH approach as a national promotional tool to bring about sanitation and hygiene behaviour changes.

The Government of Ethiopia's (GoE) also designed a One WaSH National Program (OWNP) as its instrument for achieving the goals set out for WaSH in the Growth and Transformation Plan (GTP). GTP service level targets for rural water supply changed from 20 litres per capita within 1.5 km radius to 25 litres per capita within 1 km radius reaching 85% of the population of which 20% will be served with piped supply. Redesign in case of rural water supply will thus mean incorporating planning to meet the anticipated revised GTP II target.

The institutional arrangement has four major functions: Governance & Guidance, Oversight & Management, Program Implementation and Program Coordination at different levels. The schematic institutional arrangement for each functions at different levels are shown here below.

Level	Governance & Guidance	Oversight & Management	Program Implementation	Program Coordination
Federal	National WaSH Steering Committee Development partners WaSH Sector **Working Groups**(4 thematic groups)	National WaSH **Technical Team**	Ministry of Finance Economic Development and Federal Sectors' WaSH Program Management Units (WPMUs)	National WaSH Coordination Office
Regional	Regional WaSH Steering Committee	Regional WaSH **Technical Team**	Bureau of Finance and Economic Development Regional Sectors' WaSH Program Management Units (WPMUs)	Regional WaSH Coordination Office
Special Zones (or others Zones where applicable)			Zonal WaSH Program Management Units (Water, Health, Education, and ZoFED)	Zonal WaSH Coordination Office
Woreda	Woreda WaSH Steering Committee (Woreda Cabinet)		Woreda WaSH Team	
Town/City	Town/City WaSH Steering Committee (Town Cabinet)		Town/City WaSH Technical Team Municipality Health Desk Education Desk Town Water Board Town Water Utility	

Figure 4-4: Structural arrangement and functions for OWNP implementation

AVAILABILITY OF CAPACITY AND CAPACITY BUILDING OPPORTUNITIES IN SOUTH SUDAN

To be confirmed as part of baseline.

AVAILABILITY OF CAPACITY AND CAPACITY BUILDING OPPORTUNITIES IN ETHIOPIA

Besides the formal trainings for students in the universities and Ethiopian Institutes of Water Resources and short term trainings that come along with projects and programmes, there are short and long term capacity building training programs for individuals working in the WaSH sector at both Technical and Vocational Education and Training Centres (TVETCs) and at Health Science Colleges (HSCs). Many short training courses for WASH professionals given at training workshops have produced immediate results, while the capacity building of the TVETCs and HSCs aims at ensuring that a sufficient number of well-qualified WASH specialists are available. For TVETCs and HSCs graduates there are opportunities to upgrade the level of their education from Level 1 to level 5. In addition there is the Ethiopian Water Technology Centre (EWTEC) which was established in 1998 by the now Ministry of Water, Irrigation and Electricity and the Japan International Cooperation Agency (JICA) with the objective of increasing the number of skilled technicians who work in water supply maintenance, electromechanical pumps and water management in order to increase access to improved water.

4.2.3.4 Information requirements and data gaps

As highlighted in previous sub-sections.

4.2.3.5 Water supply and multipurpose water resources development

Building reservoir storage for water supply can be expensive and as a result sizing is usually carefully optimised as a function of the existing and projected demand. However, when there are other economic uses for the stored water it can be justified to build larger storage. Thus, just as reservoir storage for hydropower (which may already be large) can be managed differently in order to accomplish multipurpose functions, so also can the sizing of reservoirs for water supply be increased to allow for some or all of other multipurpose functions such as hydropower, irrigation, fisheries, recreation etc.

On rivers where flows are perennial enough to allow gravitational abstraction without significant storage, it may be sufficient to construct a diversion weir for water supply. Depending on a number of factors, including the availability of flow during the dry season, there may be an opportunity for supplying water for other economic activities such as irrigation and aquaculture. Where rivers are heavily silt-laden, the water treatment costs associated with a potable water supply schemes can be very high. This type of scheme can therefore act as a catalyst for upstream watershed management activities.

4.2.4 Livestock farming

4.2.4.1 Introduction

Livestock farming is important across most of the basin. For subsistence farmers in the highland, higher rainfed areas, they are part of a mixed farming system. In these areas best-practice activities are largely defined and included as part of integrated livelihood-based watershed management strategies. In the semi-arid to arid areas of the sub-basin pastoral livestock becomes predominant. Livestock as a source of livelihood is more important for the South Sudan side of the basin where there is a high concentration of cattle, sheep, and goats.

In the CAMP (2015) the livestock farmers in South Sudan are categorised as follows:

- Subsistence pastoralists
- Commercial pastoralists

To this list can be added the mixed subsistence farmers in the highlands (mainly in Ethiopia), who farm both crops and livestock.

The main livelihood strategies in the sub-basin are therefore a combination of crop and livestock production followed by ‘crop only’ farming and ‘livestock only’ production. Water security in rural areas is of major concern in particular in the areas characterised by semi-nomadic livestock farming where a lack of perennial water for livestock makes the establishment of settlements with assured access to water a challenge. Livestock watering during the dry season and grazing are two drivers of conflict between local communities.

4.2.4.2 Identified development projects

Few significant water resource development and management projects related to the livestock sector have been identified. In most cases the livestock sector is poorly developed in modern production terms and this discourages investment. It is clear that major investment in livestock watering infrastructure will have to be accompanied by a more commercialised approach to livestock farming and higher offtake rates.

Many of the existing and potential projects are concerned with tackling the “non-water” focussed areas of livestock farming including:

- Animal health, livestock diseases and vaccination
- Access to markets
- Grazing and land tenure

The CAMP (2015) identifies a number of interventions in South Sudan under various themes including:

- Under the theme of reconstruction and recovery
  - Development of a legal framework protecting both producers and consumers
  - Livestock and disease census
- Under the theme of Food and nutrition security
  - Measures relating to modernization and getting produce to market
  - Creation of diagnostic laboratories (disease and feed testing etc)
  - Animal health
  - Access to water
  - Marketing
- Under the theme of economic growth and livelihood improvement
  - Livestock, dairy, poultry, bee production – need for extension services, producer organizations,
  - Projects identified to promote economic growth and livelihood improvement.
- Under the theme of agriculture sector transformation
  - Improved technology (use of demonstration projects)
  - Producer associations
- Under the theme of Institutional development
  - Extension and research
  - Education

Within the Ethiopian part of the basin, considerable progress has already been made in dealing with these issue and levels of productivity have greatly improved in recent years. There are clear policies and strategies being implemented at the local level.

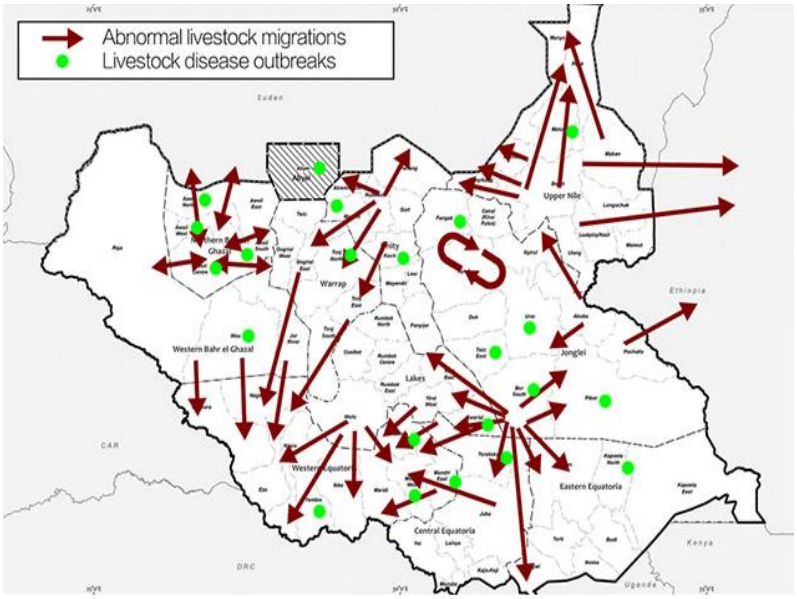
4.2.4.3 Identification of target areas

There are a number of target areas for actions in the livestock sector:

- In the upland areas in both Ethiopia and South Sudan. Water-related actions are part of the livelihood-based watershed management actions. It is beyond the scope of this study to look in detail at interventions associated with livestock health and improvement, nor access to markets etc
- In the drier lowland areas where nomadic and semi-nomadic pastoralists are the main livestock farmers. Livestock production is a key economic feature of most pastoral communities throughout the basin. The production and productivity of livestock is seriously affected by the seasonality of pastures, as influenced by availability of water supplies, widespread prevalence of endemic diseases and parasites coupled with poorly developed marketing infrastructure, veterinary services, and socio-cultural values. The consultant will examine the development potentials for livestock production, focusing in particular on the needs in terms of water supply infrastructure.

  One of the key target areas is the semi-arid area around Kapoeta. The identification of other areas that may be targeted will be informed by the annexes of the CAM once these have been obtained.

4.2.4.4 Information requirements and data gaps



It is understood that relatively reliable information on livestock numbers and location are available for the Ethiopian side. However, this is not the case for the South Sudanese side. Indeed the CAMP highlights the need for a livestock census.

The map (FAO, 2014) shown in underlines the reasons why it is so difficult to have an accurate picture of livestock numbers and distribution in South Sudan. Insecurity and disease outbreak have contributed to abnormal and unpredictable livestock movements.

Figure 4-5: Abnormal livestock migrations and livestock disease outbreaks in South Sudan (FAO, 2014)

Given the absence of reliable data in the South Sudanese portion of the basin, the aim will be to focus on a few typical areas where the situation is reasonably well understood, such as the area around Kapoeta, with the aim of developing a replicable approach to multipurpose development. This would fit in with the CAMP's stated strategy of promoting demonstration projects.

4.2.4.5 Livestock farming and multipurpose water resources development

Given the socio-economic importance of the livestock sub-sector, it is important that multipurpose water resources developments should, wherever possible, include a livestock component. Where reservoirs are built for hydropower, water supply and/or irrigation, consideration should also be given to how they can contribute to stock watering.

Policy in both countries is towards the concept of "villagisation" Discussions with stakeholders, including members of Parliament from the Kapoeta area (one of the most affected in this respect) indicated that there is a strong desire to provide more permanent watering points and in so doing gradually transform the pastoralists into sedentary farmers in recognition of the fact that this would support commercialisation of their activities and at the same time provide a better standard of living in terms of access to services (health, education etc.). Multipurpose projects can contribute to this process.

4.2.5 Fisheries and Aquaculture

4.2.5.1 Identified development projects

There are currently no development projects in the basin regarding fisheries and aquaculture. Regarding small scale farm yard aquaculture ponds, attempts were made in Central Equatoria and Western Equatoria in South Sudan (near Yei and Yambio). These areas are not located in the basin but are of interest if these projects were to be extended in the BAS basin.

4.2.5.2 Identification of target areas

The potential to develop fisheries and aquaculture in the basin is significant and diversified. The following are identified potentials for the basin:

- Development of Lake and Reservoir Fisheries
- Development of Riverine Fisheries
- Small Scale Farm yard aquaculture ponds, cage cultures
- Commercial Aquaculture Farms
- Integrated aquaculture (Rice-fish aquaculture)

The following areas for development have been identified as part of the scoping phase.

FISHERIES:

- Lakes and Reservoirs in the Gambella and South Sudan Regions. More precisely, Lake Tatta and the Alwero reservoirs would be suitable to develop fishery activities.
- Rivers in the Gambella and South Sudan Regions. As for now, the Baro, the Gillo and the Alwero rivers have been identified as potential rivers to develop fishery activities.
- Flood plains and finger ponds in Gambella and South Sudan
- Baro catchments in the Ethiopian highlands

AQUACULTURE:

Different types of aquaculture can be proposed in the basin:

- Small Scale farm yard aquaculture ponds,
- Commercial aquaculture Farms,
- Integrated aquaculture (Rice-fish aquaculture).

Aquaculture potential can be identified throughout the basin:

- Selected areas, based on set criteria for determining appropriate sites, in the Gambella and South Sudan Regions. These areas have to be determined on set criteria to select suitable sites for aquaculture. This will be defined during the baseline phase, in line with the different expertise.
- Some selected sites in Southern Nations, Nationalities and Peoples Region (SNNPR) and Oromia Region, Ethiopia. These areas have to be determined on set criteria to select suitable sites for aquaculture. This will be defined during the baseline phase, in line with the different expertise.

4.2.5.3 Enabling environment

- Institutional, legal and policy frameworks
- Availability of capacity and capacity building opportunities
  - The World Charter for Nature was adopted by the UN General Assembly in 1982. It provides the guiding principles that should govern human responsibility for biodiversity. It states that activities which might have an impact on nature shall be controlled, and the best available technologies that minimize significant risks to nature or adverse effects shall be used; in particular.
  - Similar statements are found in Convention on Biological Diversity. The Convention on the Conservation of Migratory Species of Wild Animals (CMS), also states, among its fundamental principles, that: 'the parties acknowledge the need to take actions to avoid any migratory species becoming endangered".
  - The World Bank's operational Policy on natural habitats requires that comprehensive analysis should demonstrate that overall benefits from a project outweigh the environmental costs before significant conversion of natural habitats is allowed, unless there are no feasible alternatives for the project.
  - 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 (MoA) 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 condition, 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.
  - In South Sudan, 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. The draft Fisheries Law 2012 is wholly unfit for purpose and needs to be completely rewritten before being presented to the Legislature. There are no fisheries regulations enacted.
- There are no trained fishery experts in the Agriculture offices in the regional bureau (Gambella) and the Woreda offices as well as in the regional research institution (Gambella Agricultural Research Institute--GARI)
- The fishermen are trainable and there is a possibility of providing training for the fishermen in captive fisheries, aquaculture and post-harvest technology
- In South Sudan the Fisheries Training Centre at Padak near Bor is now inoperative, having been damaged in 2014. There is no other organisation 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. No technical institutes are offering vocational qualifications in fisheries related subjects.

4.2.5.4 Information requirements and data gaps

For all the areas in Ethiopia and South Sudan more information is required as follows:

FISHERIES

- Estimation of the potential yield of the different water bodies.
  - Water Quality of the running and standing waters of the region
  - The extent of the rivers (length, width, depth) for estimation
  - According to habitat types as they may vary across the basin
- Identification of the landing sites
- Post-harvest technologies
- Market availability and accessibility
- Availability and types of fishing gears and boats
- The status and need for cooperatives

AQUACULTURE

- Site suitability analysis using GIS for selecting available and appropriate aquaculture sites
- Identification of appropriate indigenous fish species for aquaculture
- Production potential of the identified production sites

4.2.5.5 Fisheries and Aquaculture and multipurpose water resources development

As already mentioned in the preceding paragraphs the development of water resources for hydropower, water supply and irrigation will inevitably provide opportunities for the development of either/both capture fisheries and aquaculture. Both capture fisheries and aquaculture consume insignificant quantities of water and can add significant value to a water resources development.

4.2.6 Livelihood-based watershed management

4.2.6.1 Introduction

Within the context of the present study, the current thinking in Ethiopia is for 'integrated watershed management' projects with watershed management aiming to "improve the livelihood of communities/households […] through comprehensive and integrated natural resource development. It aims at productivity enhancement measures for improved income generation opportunities, enhanced livelihood support systems and high resilience to shocks." (MoARD 2005).

Based on discussions with NGOs involved in watershed management projects in the Imatong Mountains in South Sudan the same thinking lies behind the approach to watershed management in South Sudan.

Integrated Watershed Management therefore can be thought of as a holistic approach, focused on people and their livelihoods, and embracing all possible sectoral aspects which touch those livelihoods. It needs to be forward-looking, and not merely respond to symptoms of degradation.

The livelihoods focus of Watershed Management (watershed management) does not however preclude the fact that watershed management interventions will be targeted at areas of greatest soil and land degradation and that the scope of the watershed management sector in BAS will be to identify the areas of greatest degradation as potential watershed management projects with additional weight being given to catchments upstream of potential water supply and/or HEP dams. Potential intervention areas will be identified by an Erosion Hazard Assessment (EHA) using RUSLE data which can then be incorporated with other criteria in a multi criteria analysis to select the most suitable catchments.

4.2.6.2 Identified development projects

With most watershed management projects in Ethiopia targeted at highly degraded and food insecure areas there have been very few interventions in the BAS basin area. There were no MERET woredas in the area and while there were 4 SLMP 1 woredas in BAS, three were in the lowlands (Gambella, Abobo and Godere in Gambella Region) with only Geba (Metu) in Oromiya Region in the highlands. There are 3 SLMP 2 woredas proposed for 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. 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.

4.2.6.3 Identification of target areas

The only planned project interventions known about are those woredas selected for SLMP 2 as mentioned above. 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 not through any projects and is deemed to be less reliable.

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, Abdobo, 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 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.

In South Sudan, the need for watershed management in the Imatong Mountains is recognised and further information on the status of ongoing interventions will be further investigated.

4.2.6.4 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 our 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 land, 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 utilise 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).

The Local Level Participatory Planning Approach (LLPPA) developed by the project has gained national acceptance and similarly the Guidelines on Community Based Participatory Watershed Development are commonly used, directly or in some modified version. Vast areas have been 'treated' under this programme, usually supported by food-for-work. The area focus has been food insecure and (generally) moisture deficit woredas, mainly in Tigray, Amhara, Oromiya and SNNP regions (none in BAS) and activities have been largely limited to soil and water conservation measures and area closures.

The MERET/WFP project has been operating some 35 years, and offers a wealth of experience. The approach to this project has changed dramatically over the years, reflecting experience of what does and does not work. The early approach to watershed management was large scale and top down; the achievements proved not to be sustainable (mainly due to the unmanageable size of the target areas and the lack of community participation (WFP 2002) and, in some cases, were detrimental.

Over the last 20 years, in conjunction with decentralization, the project has been re-designed to be a 'bottom-up' project, owned and driven by communities. Target areas have been reduced to micro-catchments (essentially communities) with areas of 200 to 500ha. The focus has also shifted from protection – conserving the resource base – to production and improvement in rural livelihoods. This is in line with international experience and especially the Indian experience, and most organisations working in watershed management now follow similar practices.

MERET undertook a cost-benefit analysis of its interventions (WFP 2005). 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 has largely been superseded by 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 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.

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. This 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.

4.2.6.5 Information requirements and data gaps

The identification of erosion hazards will be realized first at basin level in order to identify priority areas for watershed management interventions. The methodology to realize the Erosion Hazard Assessment is presented in section 3.1.3.4.

4.2.6.6 Livelihood-based watershed management and multipurpose water resources development

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 improved livelihoods and wealthier farmers. However, experience has shown that there are usually some significant "start-up" costs ("seed financing") and efforts 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.

4.2.7 Navigation

OVERVIEW

The river corridors 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.

Ethiopia has no significant navigable waterways, and does not have any major river ports. Gambella Region has the Baro River. This river has been navigable only in the rainy season, for transporting emergency supplies to Upper Nile State of South Sudan.

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.

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 4-5: 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 (m^2)	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	-	-	

CONSTRAINTS AND OPPORTUNITIES

Based on the literature search, there are some constraints and opportunities that can be identified:

Constraints include:

- The drops in water level during the dry season are the main impediment to the navigation on some sections of the White Nile and Blue Nile, which are free from cataracts.
- The need of rehabilitation of the quays and jetties, as well as, development and upgrading of cargo handling equipment and facilities, in order to use efficiently river transport.
- The need for regular dredging of certain river reaches

Opportunities:

- River transport is crucial to transport goods or passengers between Ethiopia and Sudan because of many factors:
- Economic advantage (cheap mode of transport),
- Alternative to inadequate all-weather roads From Ethiopia to South Sudan,
- Excellent for the transport of bulky cargo.
- Economic benefits associated with the use of water hyacinth cleared from waterways.

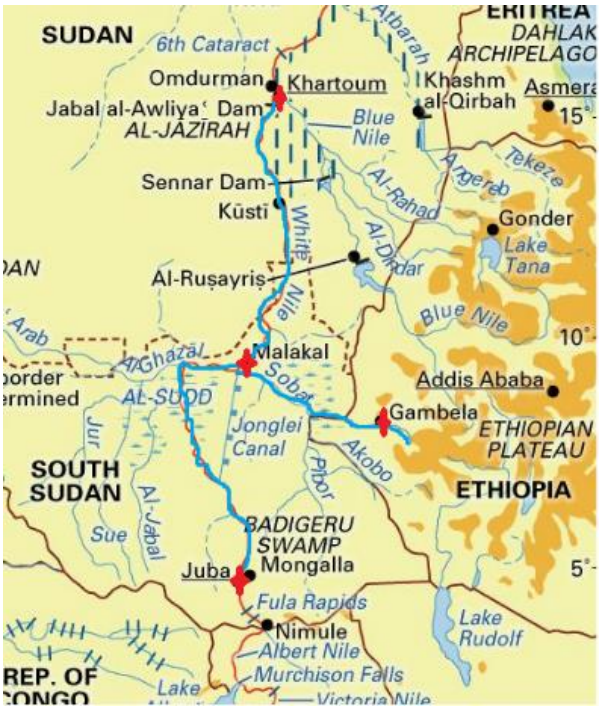
4.2.7.1 Identified development projects

The development projects of navigation are:

- The rehabilitation of the ports infrastructures 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.

4.2.7.2 Identification of target areas and development potential

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, there would clearly be a (potential) place for navigation in the transport sector once that sector has been reviewed to understand what role it may play in moving produce around the basin. A study may be required to support proposals on a regional, transboundary approach to food security. However, the potential role that navigation could represent a potential that has to be investigated in this study.

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
- The White Nile: Stretches between Malakal to Khartoum

4.2.7.3 Enabling environment

In Ethiopia, the institutional, legal and policy frameworks are regulated by:

- The Ministry of Water in Ethiopia.
- Regional Bureaus of Water Resources development.
- Water Resource Management Policy (The Ministry of Water Resources, 1999).
- National Water Sector Strategy and Water Sector Development Program (The Ministry of Water Resources, 2004).
- Water Resources Management Proclamation and Regulation (Ministry of Water Resources, 2000).
- The Ethiopian Federal Water Resources Management Policy (Ministry of Water Resources, 1999).

4.2.7.4 Information requirements and data gaps

There are still some information and data which need to be collected in order to complete the baseline study.

- The identification of the private and state companies operating on the Baro River, the types and size of existing vessels (length, width and draught), the number of available operational barges, and loading capacity utilized.
- The water level (depending on the season) of the rivers from Gambella to Khartoum and the extent of the rivers.
- The velocity vectors of the Baro and Sobat Rivers and the White Nile.
- River cross section of the Baro and Sobat Rivers and the White Nile.
- The assessment of the current conditions of the ports along the Baro River.
- The description of the current ports infrastructure.
- The estimation of the rates of river transport on the Baro River's ports.

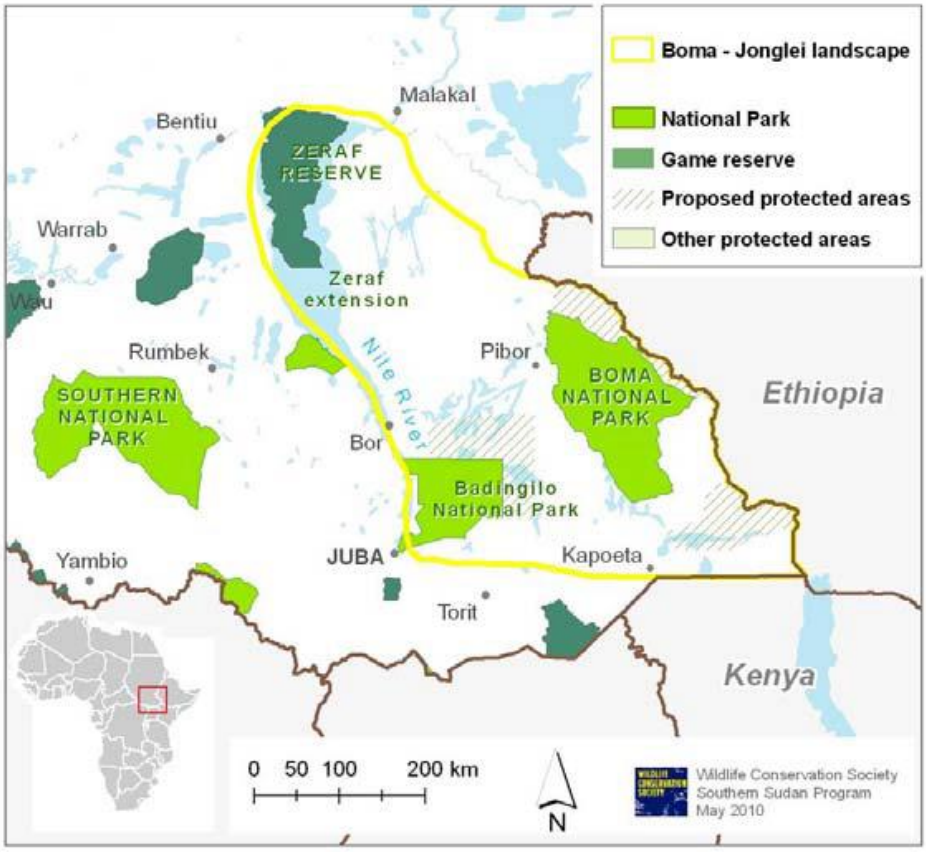
4.2.8 Biodiversity, habitats and landscape conservation

4.2.8.1 Identified development projects

At this stage, the current main identified development projects in biodiversity conservation are the following:

BOMA-JONGLEI LANDSCAPE PROJECT

"Initiated in 2009 aims to promote trans-boundary, sub-regional interventions to respond to emerging issues and the environmental challenges through a financial support from EU. Boma-Gambella Landscape has been identified as a pilot project"



Source: USAID (2010_a); Demetry (?)

Figure 4-6: Proposed extension of the protected area network in the Boma-Jonglei landscape

IGAD BIODIVERSITY MANAGEMENT PROGRAMME (BMP)

"USAID, WCS and the GOSS are working 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 Boma-Jonglei Landscape. 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 (2010)a

"The Cooperative Agreement (CA) was signed with USAID on December 1, 2008, with a completion date of September 30, 2011 (duration of 33 months). The project is located in Jonglei, Eastern Equatoria and Central Equatoria States; the project has its headquarters in Juba and a field station in Nyat, in Boma National Park.

The project's goal as stated in the CA is "to sustainably manage natural resources and conserve biodiversity across the Boma-Jonglei Landscape." Its four objectives are as follows:

- Strengthen institutional capacity for sustainable management of natural resources;
- Develop participatory land-use planning, zoning, and resource management;
- Conserve biodiversity through protected area management, monitoring, ecotourism development, and other incentives for sustainable land use and resource management; and
- Improve community livelihoods and economic enhancement." USAID (2010)b

UNDP LAUNCHING PROTECTED AREA NETWORK MANAGEMENT AND BUILDING CAPACITY IN POST-CONFLICT SOUTHERN SUDAN

"The ideal, long term solution for protected areas management in Southern Sudan would be "An ecologically representative and connected network of protected areas, subject to efficient management arrangements for the situation of Southern Sudan and adequately financed through multiple sources". This project proposes to contribute to the ideal long term solution by laying the foundations for effective protected areas management 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 Wildlife Conservation and Tourism to effectively manage and sustainably develop Southern Sudan's key protected areas. To achieve this, the project will undertake a range of activities to deliver the following three outcomes:

- Capacity for protected area management strengthened
- Management of four key protected areas improved (i.e. Southern, Bandingilo and Boma National Parks and Zeraf Reserve)
- Sustainable financing of protected areas designed and enhanced." UNDP (2009)

4.2.8.2 Information requirements and data gaps

The identification of development projects in biodiversity conservation area needs additional consultations to conduct with governmental agencies and international NGOs:

- IGAD Biodiversity Management Project
- Ecosystem Management and Conservation Partnership Program in Gambella
- IGAD Biodiversity Management Project
- Wild Crue
- CWS Wildlife protection programs in South Sudan
- EWCA
- WCS Southern Sudan Country Program
- Paul Scholte, ecological expert, specialist of links between ecology and hydrology in floodplains

4.2.8.3 Navigation and multipurpose water resources development

An obvious development that could go hand in hand with the construction of storage on the Baro River or its tributaries is the regulation of flows. This could support the year round navigability of the Baro River from Gambella to Itang and further.

4.3 POTENTIAL INTERVENTIONS FOR ASPECTS NOT DIRECTLY RELATED TO WATER RESOURCES

4.3.1 Oil exploration and extraction

Oil extraction and exploration is limited to the South Sudanese part of the basin, in the Upper Nile State. The oil industry is not directly linked to the water sector but can have direct effects on water and indirect effects on the local economy, especially on agriculture.

The document *Oil Investment and conflict in Upper Nile State, South Sudan* published by the Bonn International Centre for Conversion in 2011 has been reviewed as it emphasizes the main issues and opportunities related to the oil sector in Upper Nile State. Some complement of information have been obtained in the document *Oil Production in South Sudan: making it a benefit for all*, published by Cordaid in 2014.

4.3.1.1 Relevance of the oil sector in the BAS study

THE CRUCIAL ROLE OF OIL IN THE CURRENT SOUTH SUDANESE ECONOMY

In 2011, the oil industry provided 98% of the revenue of South Sudan, however, in 2012, the Government of South Sudan shut down the country oil production. This had a considerable impact on the economy but also on food supply as the prices increased significantly. The country is today highly dependent on oil production and, in 2011, 60% of the State budget went into security budget to face the security situation in the country.

THE IMPACT OF OIL ON WATER AND SOCIETY

The development of oil activities has had a significant impact on land appropriation. Furthermore, local people have reported water pollution in large areas around the oil fields. In the reservoirs where oil is extracted, there also water. This water is called “toxic produced water” and can be cleaned in decantation basins in the open air or is reinjected in reservoirs. The pollution can occur around the decantation basins, due to spill overs, especially during the rainy season.

The consequences of pollution can be for drinkable water but also for the cattle and agriculture because the soils can be polluted by oil residues. It is very difficult to assess the real impacts because of the current situation in the country. The areas are in a conflict zone, and hence pollution control is hampered by a number of issues including the fact that local Government has not time or resources to enforce regulations and ii) given the generally high level of risk and insecurity, pollution might not be the highest priority in the minds of the oil companies.

THE LARGEST OIL FIELDS ARE WITHIN THE BAS BASIN

The picture here after (dated 2015) is taken from Google Earth. On this picture, we can see the Paloic Oil field. Satellite images are particularly adapted to appreciate the extent of land required by the oil industry.

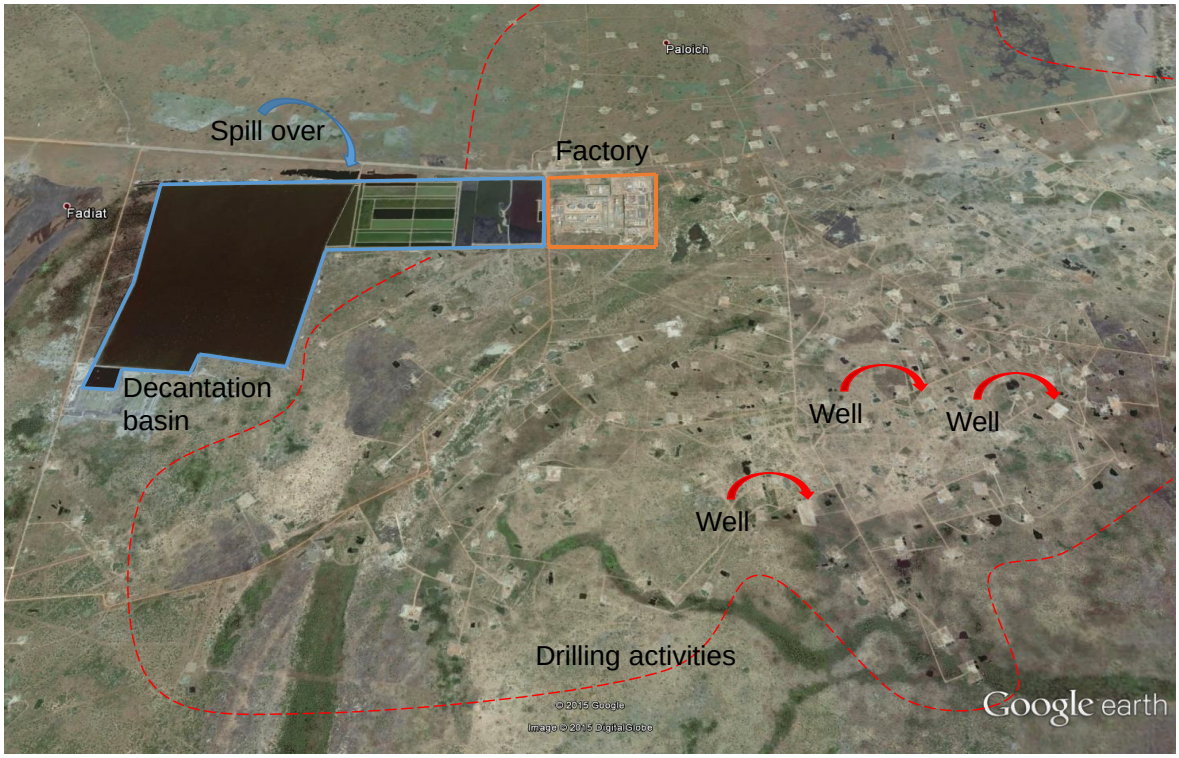


Figure 4-7: Paloic oil field – picture of 2015 (Source: Google earth satellite imagery)

There are at least 3 other oil fields within the basin, Muteeta, Gumry and Adat. The remote sensing work allowed the localization of these processing plants and the road network. These are shown in in Figure 4-8.

Figure 4-8: Oil fields in Upper-Nile State – from left to right: Muteeta, Gumry and Adat

4.3.1.2 Identification of target areas

The target areas are the areas around the different identified oil fields in Upper Nile State.

EXISTING LEGISLATION IN SOUTH SUDAN

The legislation in South Sudan regarding Oil extraction already exists and seems quite complete. The proposed measures are more about how to enforce the law.

The petroleum Act of the Republic of South Sudan was approved by the National Legislative Assembly and endorsed by the president in September 2012. Among others, the act states that the management of oil must be an "*accountable management of petroleum based on environmental, social, and economic sustainability*." The Act includes articles on "*the conduct of petroleum activities, access to land and restoration of affected land after decommissioning, duties of contractors including social and environmental impact assessments, and compensation for landowners and persons holding an interest in land. There are regulations regarding the environment, health care, safety, liability for pollution damage, non-discriminatory employment, knowledge transfer, community development, as well as dispute resolution. Moreover, the Act prescribes to make the state revenues available to the public.*" (Bonn International Center for Conversion, 2013).

PROPOSED PROJECTS

Three different types of projects can be proposed to benefit from the oil revenues and mitigate the adverse effects of this activity. These projects can be implemented in the frame of multipurpose projects.

- The oil activity generates economic growth but doesn't offer much employment. It is an emergency to secure the livelihood in these areas and to reach food safety. At least 2% of the revenues generated by the oil activity are redistributed to the State Government for development. Moreover, the oil companies have obligations to compensate for their activity. These **funds should be reallocated for agriculture development and could support irrigation in the area**. Interviews were carried out during the BICC study (Bonn International Center for Conversion, 2013) and people expressed strongly their interest for agriculture and irrigation development.
- As water can be polluted during the oil extraction process, the oil companies often compensate for this pollution by operating clean-water facilities and distributing water. The only problem with this is that it can create an over-dependence on the oil companies for the supply of clean water. The inhabitants of the area cannot continue their activities of pastoralism as they have to live next to roads where trucks of the oil companies distribute water every day. Water pollution is not a residual effect which can be compensated. **It affects potable water, water for the cattle and contaminates the soils. Mitigation measures should be preferred to compensation measures.**
- Some of the local inhabitants were not compensated when the oil companies settled because of the situation in the area (they were sometimes refugees in other areas and returned after the settlement of the oil companies). **The social audit carried out in the frame of the ESIA could allow for fair compensations.** This compensation could be financial but also support to the local population to develop agricultural activities and reduce food dependency.

The opportunity to develop these projects in the frame of multipurpose projects within the basin will be studied in more detail during the baseline study.

4.3.2 Vulnerability and disaster risk management

The International Strategy for Disaster Reduction (ISDR) defines vulnerability as the conditions determined by the physical, social, economic and environmental factors or processes which increase the susceptibility of a community to the impact of hazards. Vulnerability, then, can be seen as a function of the type, magnitude and rate of variation a given system is exposed to, its sensitivity and its adaptive capacity. Assessment of the vulnerability and disaster risk and propositions to manage these issues should be part of the sectoral approach.

Social indicators of vulnerability are shown in the following table:

Table 4-6: Social and demographic indicators of vulnerability

Parameter	Indicator
Place of residence	Flood plain, river banks, steep slopes (over 30^{o})
Population	Size, density and age distribution (age dependency ratio)
Family type	Single-parent families/families with many young children (<6 years old)
Housing type	Non-permanent materials
Ownership of assets	Owns no land or other productive assets/no clear land title or use rights
Livelihoods	Cultivating only a few crops for subsistence/reliance on hunting and gathering/herding
Preparedness	No savings or preserved/stored foodstuffs
Security and stability	Tribal, clan and/or family conflicts/social and legal protection
Migration	Recent migrants/refugees/minority groups among a majority tribe. clan or cultural system
Other	Health status of family members/disabilities
	No or low awareness of disaster or climate change risks
	No early warning system or response plan for natural disasters in place

4.3.3 Climate change – effects and mitigation

4.3.3.1 Introduction

The IWRDMP will include an identification of types, processes and impacts of climate change in the BAS basin, along with proposed adaptation and mitigation measures. Some preliminary information that will scope the work during the baseline and SEA is given in the following sections.

4.3.3.2 Degrees of Impacts

There are at least four distinct degrees of impact from climate change, which are as follows:

- **First Degree** – Increase in air temperature; increase evaporation and drying, rainfall pattern and stream flows. No or low out-migration from affected areas.
- **Second Degree** – Decrease in water supply for people and livestock, increased occurrence of both floods and droughts, negative effects on the productivity of agriculture, fisheries, grazing and forests, changes in land use. Out-migration from affected areas starts, but is still limited in scope.
- **Third Degree** – Instability of food supply and prices, streams, springs and wells dry out, climate-related illnesses begin to appear in the most vulnerable groups (e.g. young children and the elderly). Out-migration from affected areas, mainly to cities, increases and involves whole families and kin groups. Food and relief aid is required. Conflicts over access to water, productive land and grazing appear, livestock herds begin to suffer and mortality starts.
- **Fourth Degree** – Food and relief aid is required, livestock and wild game die in large numbers, crops die and are not replanted, out-migration increases and now includes whole villages and communities, and conflicts over access to water, land, grazing and other natural resources intensify and can escalate to armed confrontations. The health status of the whole population is affected, mortality among infants and the elderly increases.

4.3.3.3 Identification of hotspots

"Hotspots" can be defined as social and ecological systems or localities that are especially vulnerable to climate and other social and environmental factors.

Factors which can be used to identify hotspots include the following:

- Water shortage and stress
- Environmental degradation
- Well-being and quality of life
- Population dependency
- Health status
- Employment and migration
- Conflicts and security

Several areas in the Nile and BAS basins can be said to be hotspots, among which is the Ethiopian Plateau, where a number of dams have been constructed or are planned which affect the social and ecological systems in the immediate vicinity of the dam and reservoir as well as downstream. Social impacts include resettlement of human populations, change in agricultural practices, exposure to disease vectors, as well as inundation of sites and assets of cultural significance.

4.3.3.4 Adaptation

Adaptation can be defined as actions taken to manage or mitigate the effects of climate change. Adaptation is necessary because climate change will affect almost all types of development in terms of outcomes, impact and sustainability. High levels of poverty, high population growth and dependency rates, low education and literacy and health status and degradation of the environment all affect the ability of a social system to adapt to climate change and the effects of natural disasters.

Amongst adaptive strategies that have been identified for countries in which the BAS basin is located are:

- Drought or crop insurance for farmers
- Establish or strengthen early warning systems for floods
- Promote small-scale irrigation and water harvesting systems in dryland areas
- Improve rangeland resource management practices in pastoral areas
- Implement community-based wetlands use, management and restoration
- Plan and implement capacity building at all levels for climate change adaptation and disaster risk management
- Improve food security through multi-purpose water development projects
- Promote on-farm and homestead forestry and agro-forestry in dryland areas

4.4 SCOPE OF THE WORK FOR THE SSEA AT PROJECT LEVEL

The aim is to apply the SSEA at the level of development options, that is combinations of projects/interventions that may represent a movement towards the overall strategic development objectives

In this section, having scoped the different types and combinations of projects in Chapter 4, the information required for application of the SSEA framework will be detailed.

4.4.1 Introduction

The SSEA will include development options, the combination of projects/interventions that are a step towards defining the overall strategic development objectives in the basin. In this section, using the types of projects identified in Chapter 4, information required to apply the SSEA framework is identified.

The SSEA will support preparation of project-specific ESAs at later stages in the Study.

4.4.2 Project level data requirements

The following information is required for irrigation projects and should be gathered during the baseline phase for all the identified projects:

- Scale of the irrigation project (small, medium, and large).
- Socioeconomic situation in the target areas.
- Target population/beneficiaries (individuals, households, communities,)
- Potential outcomes of the irrigation projects
- Potential impacts on food security, local livelihoods and other resources.
- Potential impact on existing land use systems.
- Other potential impacts, risks and social conflicts.
- Potential impacts on human health and disease.
- Access by and benefits to the poor
- Relocation of communities/resettlement
- Impact on other resources (e.g. pasture and grazing area, forestry, gathering, etc)
- Potential impacts on social services and infrastructures.
- Adversely affected communities.
- Stakeholder engagement and public participation.

Information required regarding improving small scale rainfed agriculture/livelihood-based watershed management projects:

- Socioeconomic baseline of the target areas.
- Targeted areas and communities
- Currently used technologies in agricultural systems
- Potential outcomes of improved rain-fed agriculture
- Potential impacts on local food security, livelihood activities and local economy
- Potential impacts on land use systems
- Other potential impacts, risks and social conflicts
- Access of new technologies to the poor and vulnerable groups

- Stakeholders engagement and public participation
- Villagers or communities' participation

Information required regarding tourism projects:

- Tangible and intangible tourist attraction resources and areas
- Historical and cultural heritage sites
- Current use of tangible and intangible resources to support local livelihoods
- Potential social and economic impacts (both positive and negative) of tourism to local communities
- Potential impacts on social services and infrastructure
- Other potential impacts, risks and social conflicts
- Stakeholder identification, engagement and participation
- Communities' participation and their views on community-based tourism development

4.4.3 Elements of a Environmental Assessment Framework – Basinwide and for Interventions

During the preparation of Strategic Social and Environmental Assessment, all the potential environmental and social impacts of the likely water resources development projects will be assessed to prioritize projects or reduce the size of the projects or screen/reject adversely affecting projects. Major areas of impacts to be assessed include, but not limited to:

- Cumulative impacts of dams construction on size and volume of wetlands and their ecosystem,
- Cumulative impacts of water abstraction on basin hydrology and wetlands,
- Impacts of wetland reduction on socio economics and livelihood support of local community,
- Potential Impacts of water resource development on the spill of Baro River into Wetlands,
- Impact of water resources development on Wetlands of the Akobo– Pibor Spillway,
- Impact of infestation of Water Hyacinth on navigation and water loss,
- Potential environmental impacts of Oil Exploration and Extraction on *Machar marshes*,
- Impact of the potential development projects on health of the people and livestock,
- Beneficiary impacts of the development projects in improving the livelihood of the people and poverty alleviation,
- Impacts of water resources development on national parks and wildlife habitat and migratory corridors,
- Impacts of water resources development on water related and water borne diseases,
- Impact of the water resources development on climate change,
- Impact of the projects on water loss due to evaporation,
- Impact of water resource development on riverine and flood plain fishery, etc,

4.4.4 Elements of a Social Assessment Framework – Basinwide and for Interventions

Following are the elements of a social assessment framework for basinwide and project- specific interventions, presented as eligibility and readiness criteria, prioritization criteria and social safeguards. These elements will be elaborated further and applied in the baseline and SSEA reports.

ELEGIBILITY AND READINESS CRITERIA

Protected/conservation areas designated and agreed and enforcement rules and capacity built

Peace and stability and good land governance, viz:

- Area not affected by armed combat in at least the last three months
- Area not affected by refugee movements
- Area not affected by ongoing and future resettlement plans (Gambella Region - Ethiopia)
- Area not affected by/included in ongoing or planned large-scale agricultural leases
- No serious land governance issues; legal land titles and land use and tenure regimes in place

Demographic and socio-economic factors

- High population
- High population growth rates
- High age-dependency ratio
- High poverty levels
- High dependency on a few subsistence crops
- High number of nomadic pastoralists

PRIORITIZATION CRITERIA – PROJECT/INTERVENTION LEVEL

- High priority by ENTRO
- High priority by Government
- High priority by local stakeholders
- Size and description of beneficiaries
- Low access to basic services (water supply, sanitation, education, health care, energy, transportation, communication, etc.)
- Well-defined poverty targeting
- Effect/impact on women and girls
- Per capita cost
- O&M costs
- Appropriate technology
- Capacity for Operation and Maintenance/Sustainability of Interventions
- Capacity Development Plans

SOCIAL SAFEGUARDS

- Resettlement Action Plan
- Indigenous People's Plan
- Cultural Assets
- Conflict resolution

5. MAIN CONCLUSIONS OF THE SCOPING EXERCISE

5.1 OVERVIEW

Due its preparatory nature it is important to note that conclusions to the scoping exercise do not in themselves really inform the study. Substantive and informative conclusions should come out of the baseline work. The scoping exercise is preparatory in nature and these conclusions are more about highlighting where the focus should be for the baseline in order that the SSEA and overall Plan can be built on a solid understanding of the basin and of the various development opportunities and management needs.

FOCUSSING EFFORTS

The scoping exercise has allowed the Consultant to understand where efforts need to be spent in completing the baseline. While there are serious gaps, there is also an abundance of documentation covering most of the thematic areas. The depth and accuracy of the information contained in these documents and date sets varies and is often not up-to-date or sometimes simply re-presents or re-analyses data already presented in earlier studies. Nevertheless, there is sufficient information to complete the baseline with the caveat that areas of uncertainty (due to gaps) will be highlighted and suggestions on how to get round these gaps proposed. Some of the proposals will be applied during the baseline, some will effectively be for further work which could form part of the IWRDMPlan.

It is well understood that the basin provides excellent water resources development opportunities and that current levels of development are extremely low. Several large-scale hydropower projects have already been identified and studied in the highland source areas in Ethiopia. Scope for small-scale development has been identified in South Sudan.

CENTRAL QUESTIONS

The scoping exercise has highlighted the fact that the planning, design and potential implementation of the large-scale hydropower schemes will probably lie at the heart of the IWRDMPlan since in addition to providing electricity, these schemes would/could

- regulate flows, supporting the development of irrigation schemes downstream,
- provide the irrigation schemes (and other beneficiaries) with protection from floods through flood attenuation.
- provide a source of gravity-fed water supply to settlements downstream and opportunities for other developments
- reduce the seasonality of flows and (if their construction results in large-scale abstraction for irrigation) reduce the flows further downstream, both aspects having a significant impact on the *Machar marshes* and other wetlands whose ecology depends not only on adequate inflows but also on the natural seasonality of flows with wetter and drier periods.
- Have an impact on the seasonality and overall contribution of flows to the White Nile

Accurately quantifying these last two points based on the currently available information will be a challenge and it is clear that the Plan itself will have to include measures that support better understanding and improved management in the future.

SENSITIVITIES AND DEVELOPMENT POTENTIAL

The SSEA framework will essentially be based on a good understanding of the "sensitivities" (the existing and potential environmental and social issues) and the Development potential (ways in which the available resources can be developed and managed to improve livelihoods and support economic growth). By developing the SSEA in parallel with the investigation of development potential (projects and potential ones), due attention can be paid to the sensitivities in order to ensure that the best choices are made. The potentials and sensitivities of the four main zones of the basin are summarised in Figure 5-1.

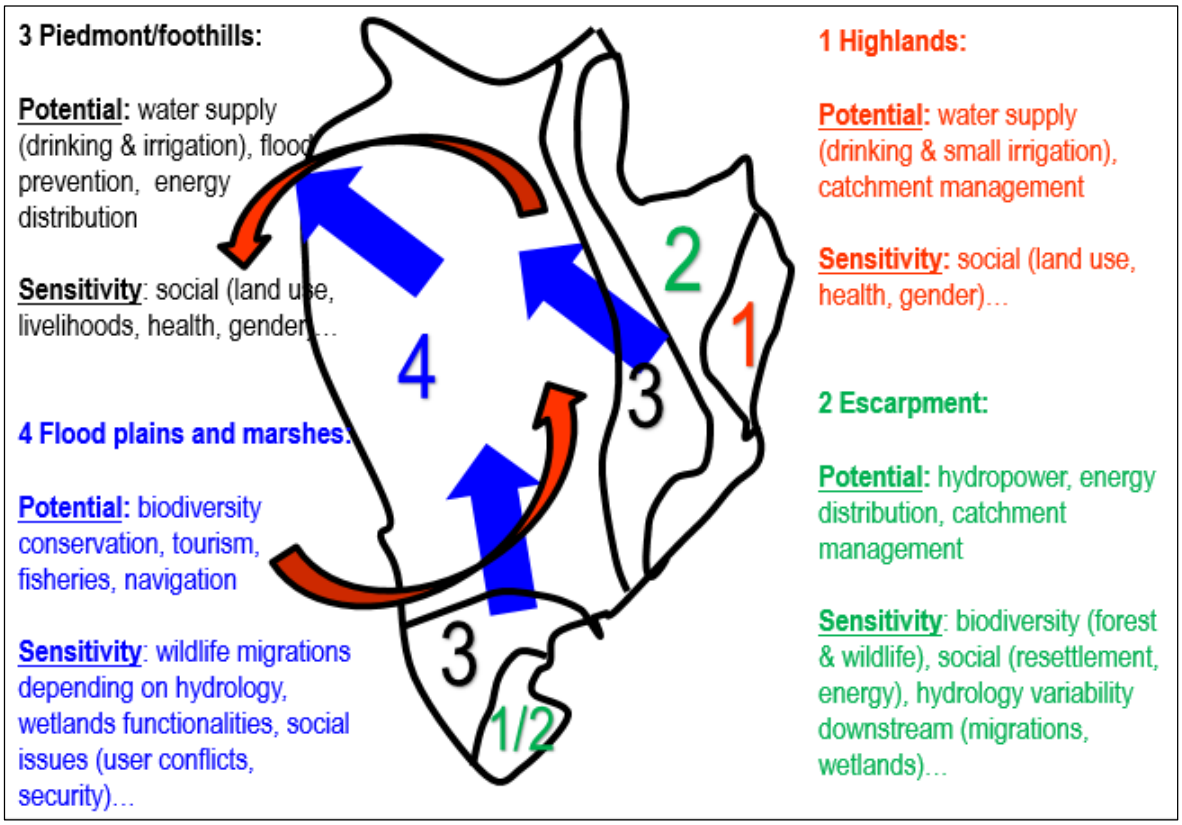


Figure 5-1: Simplified representation of potentials and sensitivities in the basin

POTENTIAL FOR RAPID CHANGE

Although development in the basin is currently at a very low level, there is a **very real prospect of rapid change.** A high rate of economic growth in Ethiopia has been sustained for several years now and there is a rapidly growing need to increase both electricity and agricultural production. The feasibility study for the largest of the hydropower schemes, Tams, has already been completed. At the same time, private investors are showing real interest in the development of the floodplains downstream of Gambella for both large-scale rainfed and irrigated agriculture, but efforts are not well-coordinated or planned. In South Sudan, the current security situation is challenging when proposing development projects, but the situation could change and improve rapidly leading to rapid development. The Consolidated Agriculture Master Plan has recently been made available and the associated Irrigation Master Plan is about to be finalised. These two documents will provide a good indication of where development may move forward first.

TRANSBOUNDARY PERSPECTIVE

From a transboundary water resources perspective there is pressure to develop the water resources of the Baro-Akobo-Sobat because the impact on flows in the White Nile of major irrigation expansion in the sub-basin is subdued by the presence of the *Machar marshes*. When less water spills over into these wetlands there is also a reduction in the total water evaporated from the system.

5.2 IDENTIFICATION OF GAPS AND TECHNIQUES PROPOSED TO BRIDGE THE GAPS

The presence of data and information gaps in this type of study is to be expected and should not be allowed to stop progress. It is important that:

- gaps should be should be clearly identified and stated, together with their implications on the anticipated or actual results or conclusions;
- efforts to mitigate gaps should be presented and applied with a clear statement of assumptions and limits;
- frameworks and models should be built in such a way that their outputs can be improved if the gaps in the input information are reduced or removed.

Bearing these things in mind will lead to the building of a robust plan that includes within itself the measures required for improving its accuracy and usefulness.

5.2.1 Data gaps identified

Details of the perceived gaps have been presented in each of the sections of this report. What follows is only a summary of some of the key areas where there are significant gaps:

At this stage of the study, the main gaps in data, information and understanding can be summarized as follows:

- Dynamics of inundation and hydrological functioning of most wetland areas
- Status and condition of many of the basin's ecosystems
- Some detail on the content and outputs of ongoing and planned conservation projects
- Capacity, facilities and resources of many of the institutions in place to implement environmental and social mitigation measures
- Details of land tenure in the basin
- Livelihoods and livelihood zones in the basin
- Employment and income in the basin
- Migration and pastoral mobility routes in the basin
- Socio-ethnic groups and relationships
- Gender, inequality and gender relations

These are some of the areas that have been identified during the scoping exercise for further investigation during the baseline in order to improve the team's knowledge and understanding of these critical areas.

5.2.2 Limitation of the field missions in some sensitive areas within the basin

Even if the SSEA, which is a strategic level assessment, relies mainly on secondary information and expert opinion, a rapid field visit to the main projects sites identified and potential impact areas could be profitable for the study if this is possible. At the same time, it is recognised that this will almost certainly not be possible for the critical potential impact areas such as the *Machar marshes* in South Sudan. This is likely to remain a gap. As already stated, it's important to understand the nature and potential significance of these gaps and to programme actions within the Plan itself to fill the gaps and to gradually fine-tune the way in which proposed projects are finally implemented.

5.2.3 Ongoing studies and documentation to be collected

While a great deal of information in the form documents, reports, data, metadata and directly from stakeholders during face to face meetings, has been collected there are still some areas where the Consultant hopes to find out more to help fill some of the gaps. In addition there are metadata that have been collected but the data itself has not been either obtained or fully analysed at this stage.

As has been stated on a number of occasions, there is a general dearth of information on the basin within South Sudan. It is anticipated that two important documents and the studies behind them will be very useful in going some way to addressing this challenge. They are the Consolidated Agriculture (Development) Master Plan (CAMP) and the Irrigation Development Master Plan (IDMP). The CAMP was released to the Consultant only recently and its contents have only been partially analysed. The IDMP has not yet been made available. Full access to these studies and the datasets on which they are based is urgently required.

5.2.4 Use and limits of remote sensing

As already indicated in the overview above, one of the central question of the baseline and which will be a thread running through all the development scenarios to be investigated, is the potential impact of development in the upstream areas and the impact on the environment and the availability of water for development downstream. Once the IWRDMPlan is developed it should be with an adequate understanding of the significant potential effects (adverse or positive) of upstream development on:

- the hydrological patterns of the BAS,
- the extent and size of the flood plains and wetlands,
- the availability of water and vegetation for both cattle and wildlife and other uses such as additional food for the communities at the end of the dry season,
- the risk of floods,
- the location and extent of settlements.

The analysis of the available information in the scoping exercise has shown that the necessary technical questions cannot be adequately answered in the basis of the existing data. It will be necessary to conduct further analysis if remotely sensed information in order to map and assess the inundation dynamics and better understand the hydrological functioning of the wetlands.

The SSEA should examine various development alternative / alternative options for elements of the IWRDMP, assess their potential impacts, improve these options in an iterative process and then compare them in respect with environmental and social criteria.

In particular, the SSEA should allow to conclusions on the characteristics (extent, duration, scale, frequency), magnitude and significance of the main potential impacts to be drawn.

It will not be possible to address the above quoted aspects (characteristic, magnitude and significance) and achieve to SSEA in a satisfactory manner without further significant remote sensing analysis on the inundation dynamics.

5.2.5 A solid/robust approach foundation for water resources modelling

While it is clear that there is not sufficient information available to set up accurate water resources models, it is still important that models are put in place that both provide the best answers possible for the time being and which can be improved as better more complete data sets become available. It is important that the models developed do not have to be completely rebuilt to make use of new improved data sets.

5.2.6 Consultation with stakeholders

The consultation and engagement of a wide range of stakeholders is crucial to ensure the success of the SSEA and the eventual implementation of the IWRDMPlan.

In accordance with the latest Guidance on implementation of OS 1 (June 2014), the type of stakeholders to be consulted can include stakeholders with knowledge of the IWRDMP focus area, the overall environmental and social conditions and the potentially affected communities. “They can be involved in identification of options, baseline analysis and in selecting management options”.

Considering these recommendations, a wide range of stakeholders to get involved in the SSEA process have been identified and partly already contacted. This is presented in more detail in the draft Consultation and Communication Plan. The main aspects which will be addressed with the stakeholders identified can be summarized as follows:

- Data collection on prevailing environmental and social conditions and specific information concerning sensitive areas and vulnerable populations,
- Identification of key environmental and social priorities to include in the IWRDMP, as well as opportunities, ongoing and planned projects,
- Identification of efficient management measures and institutional options to implement them.

The results of the gap analysis show that most of the information required to carry out the SSEA could be collected through the consultation process. The main exception is understanding the dynamics of inundation which relies on the remote sensing analysis. The participation of the stakeholders identified and their willingness to provide the necessary inputs is a critical point for the success of the SSEA. The continued support of ENTRO and that of the relevant institutions in each of the countries will remain critical to the success of the project.

5.3 NEXT STEPS

While the goals of the scoping exercise are quite distinct from those of the baseline, there is a significant overlap in the two tasks. While scoping for information, good insight into the baseline has already been achieved. When collecting metadata, progress is already made in starting to analyse the data itself. Work on the baseline is already well advanced.

The following steps are planned over the next six months:

- Compilation of draft Baseline Report (Deliverable 4a) by 15 March 2016
- Compilation of draft Key Issues and Objectives Report (Deliverable 4b) by 15 March 2016
- Compilation of draft Development Potential Report (Deliverable 4c) by 15 March 2016
- Compilation of first draft SSEA framework by 15 March 2016
- 3rd Stakeholder workshop by mid April 2016
- Compilation of draft Concept Note of Short-term options by 15 March 2016

ANNEXES

Annex 1: Bibliography

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Annex 2: Progress and methods for remote sensing

BARO-AKOBO-SOBAT MULTIPURPOSE WATER RESOURCES DEVELOPMENT STUDY

PROGRESS AND METHODS FOR REMOTE SENSING OCTOBER 2015

FIGURES

LIST OF FIGURES

1. ACCURACY OF 1:100,000 WORK FOR THIS STUDY

The creation of old or new map is based on the same principle: creation of a cartographic reference to locate the whole available data.

Old data are usually based on airborne campaign and photogrammetric restitution. Airborne black and white pictures allow an output scale between 1:500,000 and 1:50,000 but for a whole country, the mapping was done with series at 1:200,000 scale (or 1:250,000). This work has been done post-war (generally 1960 to 1975). Topographic calibration was done by field mission that did not use modern methods (GPS). In fact, this often induced wrong position for aerial photos and therefore incorrect mapping.

Recent data are based on satellite images (like Landsat 8 images) positioned by GPS coordinates. The digital mapping is therefore more reliable and allows a cartography at 1:500,000 to 1:25,000 scale

Figure1 :Landsat 8 Satellite image (15 meters resolution; acquisition 2015) at 1:100,000

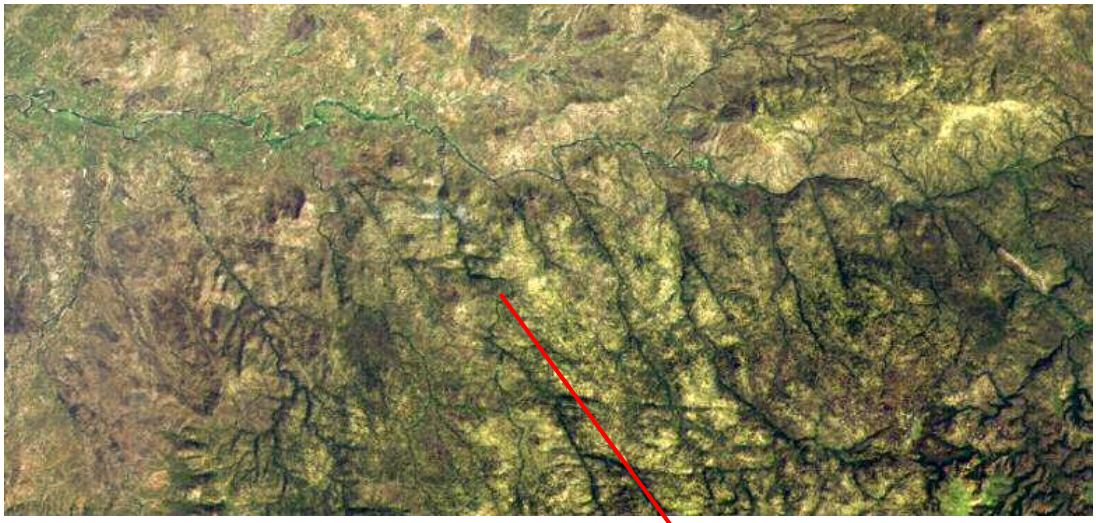
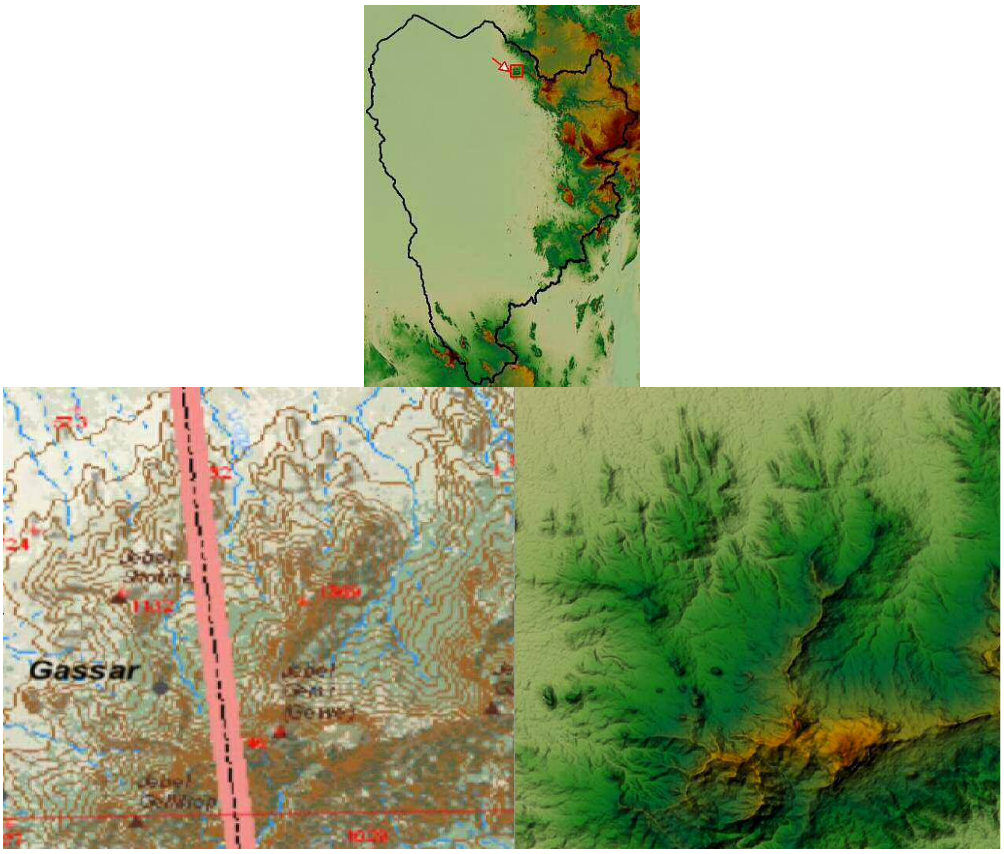


Figure2:Landsat 8 Satellite image (15 meters resolution; acquisition 2015) at 1:25,000

Similarly, old topographic maps were treated by stereo with contour lines at 50 m spacing. It is understandable that on a basin where the difference in height is less than 75 m from North to South, this is insufficient for the understanding of flows.

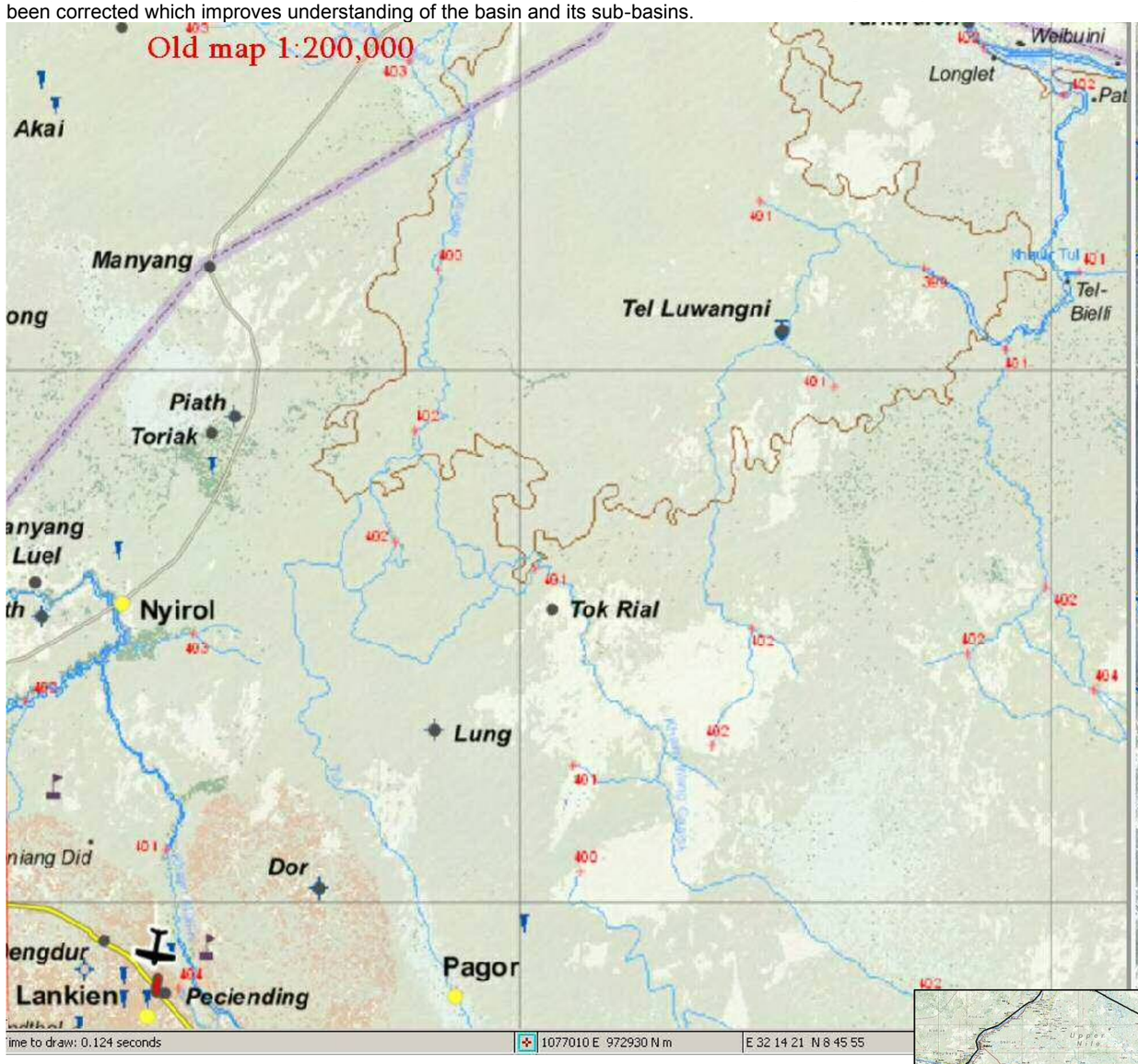
Modern technology, including satellite topographical models like GDEM or SRTM, allows to get a measured elevation point each 30 m meters with an exhaustive result, non-interpolated as with contour lines. The example below shows that the exhaustive elevation data from satellite are accurate: the elevation under the cursor corresponds to the elevation indicated on an old map (measured during a field mission).

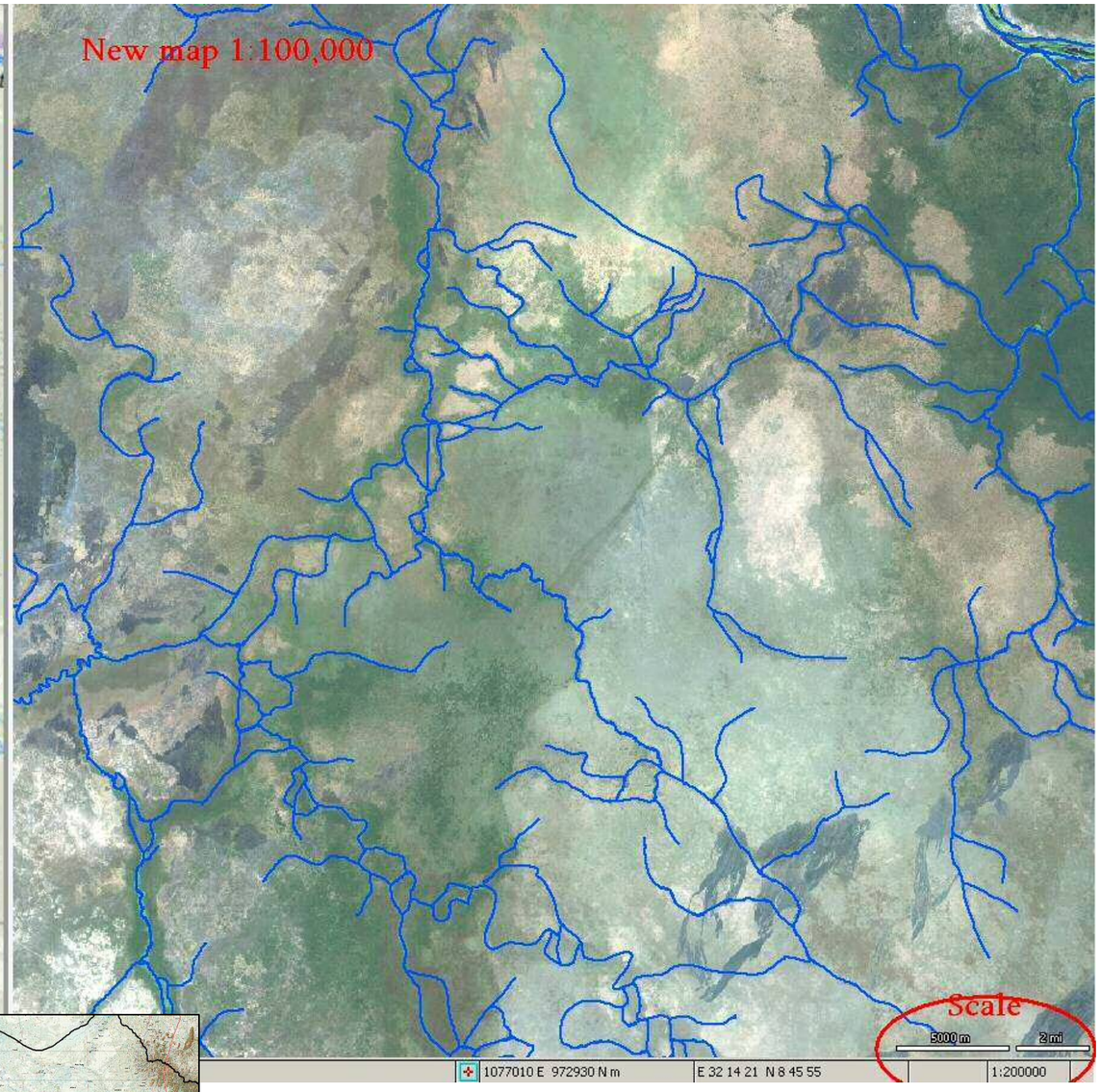
Figure 3: Sample of elevation data on old map and modern exhaustive satellite information

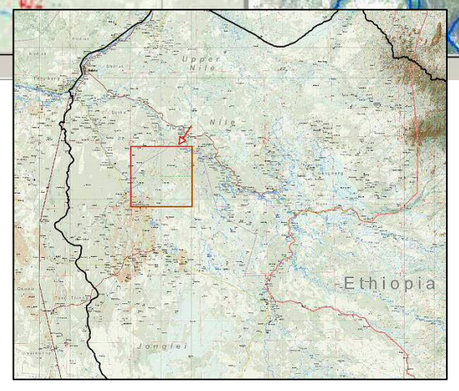


The quality of new 1:100,000 mapping is much better than old mapping works and new maps display more details (as can be seen on examples below).

Comparative example between the old map at 1: 200,000 scale (or 1: 250,000?) and the new digital map at 1: 100,000 scale: with recent data, hydrographic network is much better mapped and more reliable. The old mapping errors have been corrected which improves understanding of the basin and its sub-basins.



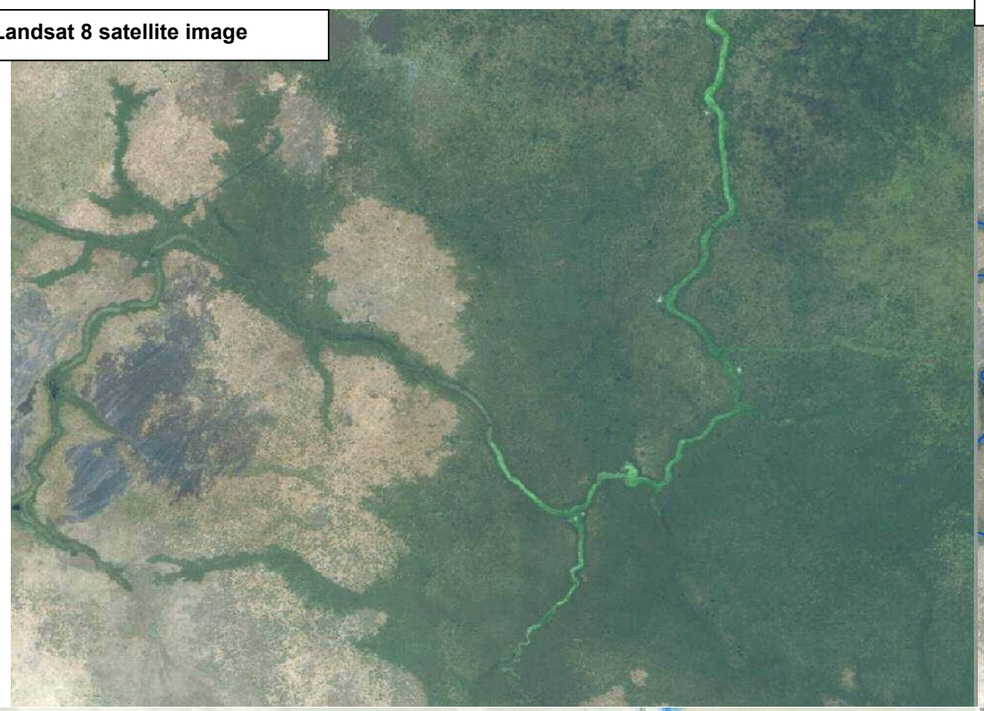




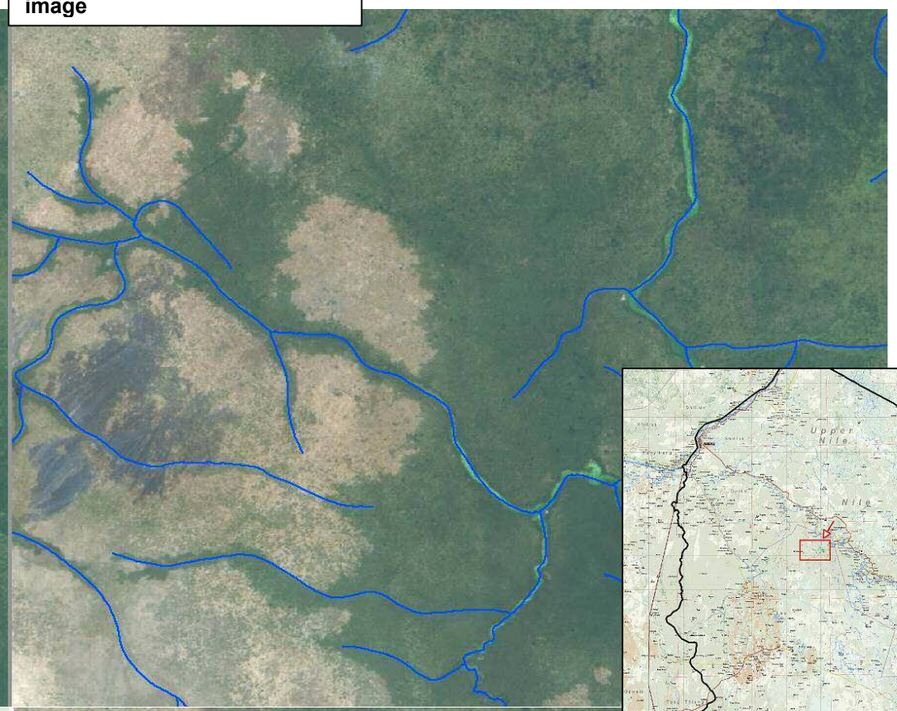
Path 172 – Row 54 Landsat 8 Satellite image (15 meters resolution, bands 432; acquisition 2015 02 18)

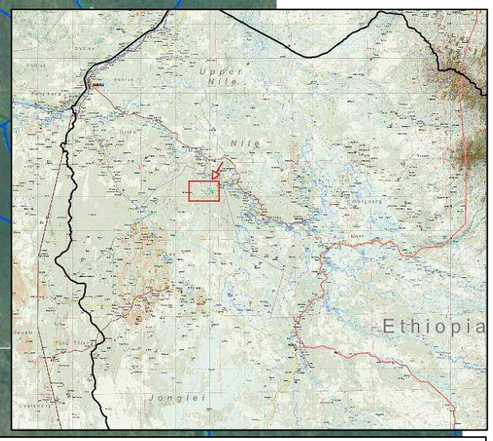
On this page, we can notice that satellite images like Landsat 8 show very well hydrographic information and the 1:100,000 mapping includes the small hydrographic network unlike old maps.

Landsat 8 satellite image

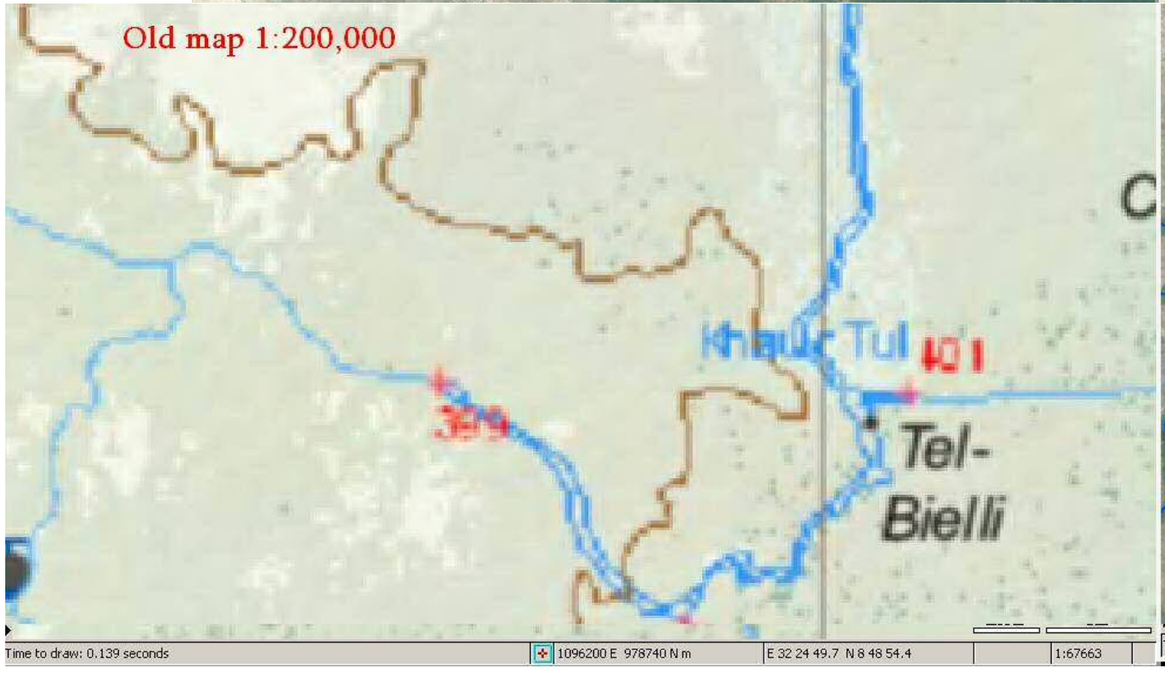


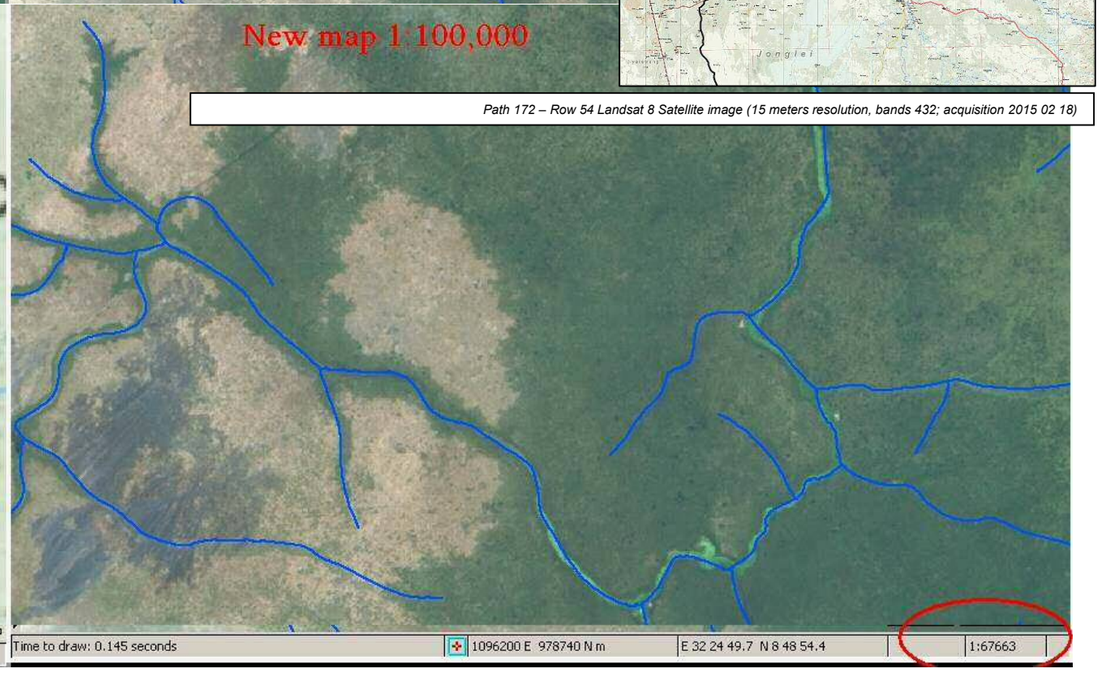
Mapping on Landsat 8 satellite image





Path 172 – Row 54 Landsat 8 Satellite image (15 meters resolution, bands 432; acquisition 2015 02 18)



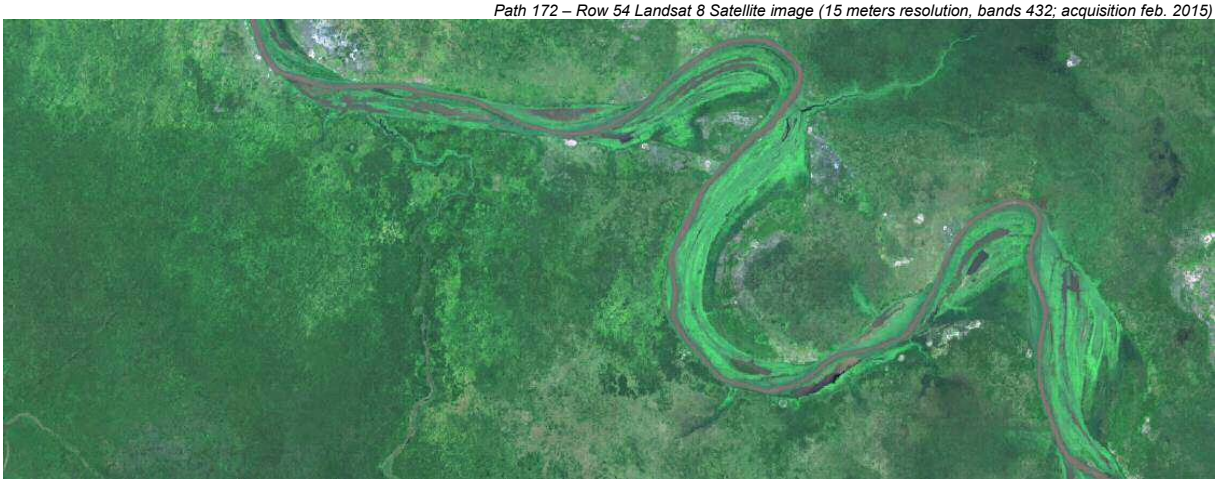


TIME SERIES

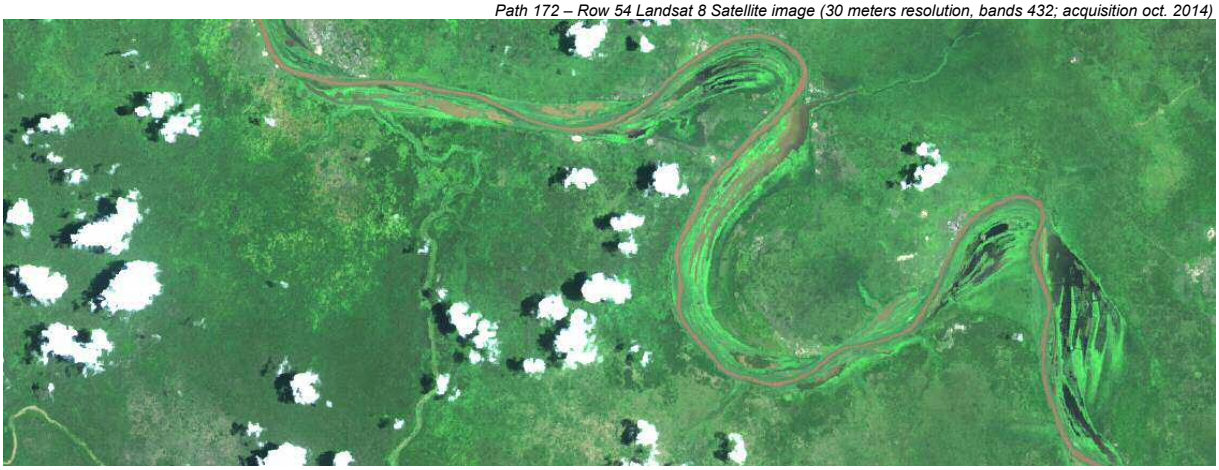
At a resolution of 1:100,000, we can see at different dates:

- Changes in the water level in the meanders of the river
- A big change in land cover/vegetation between dry and rainy season

Path 172 – Row 54 Landsat 8 Satellite image (15 meters resolution, bands 432; acquisition feb. 2015)



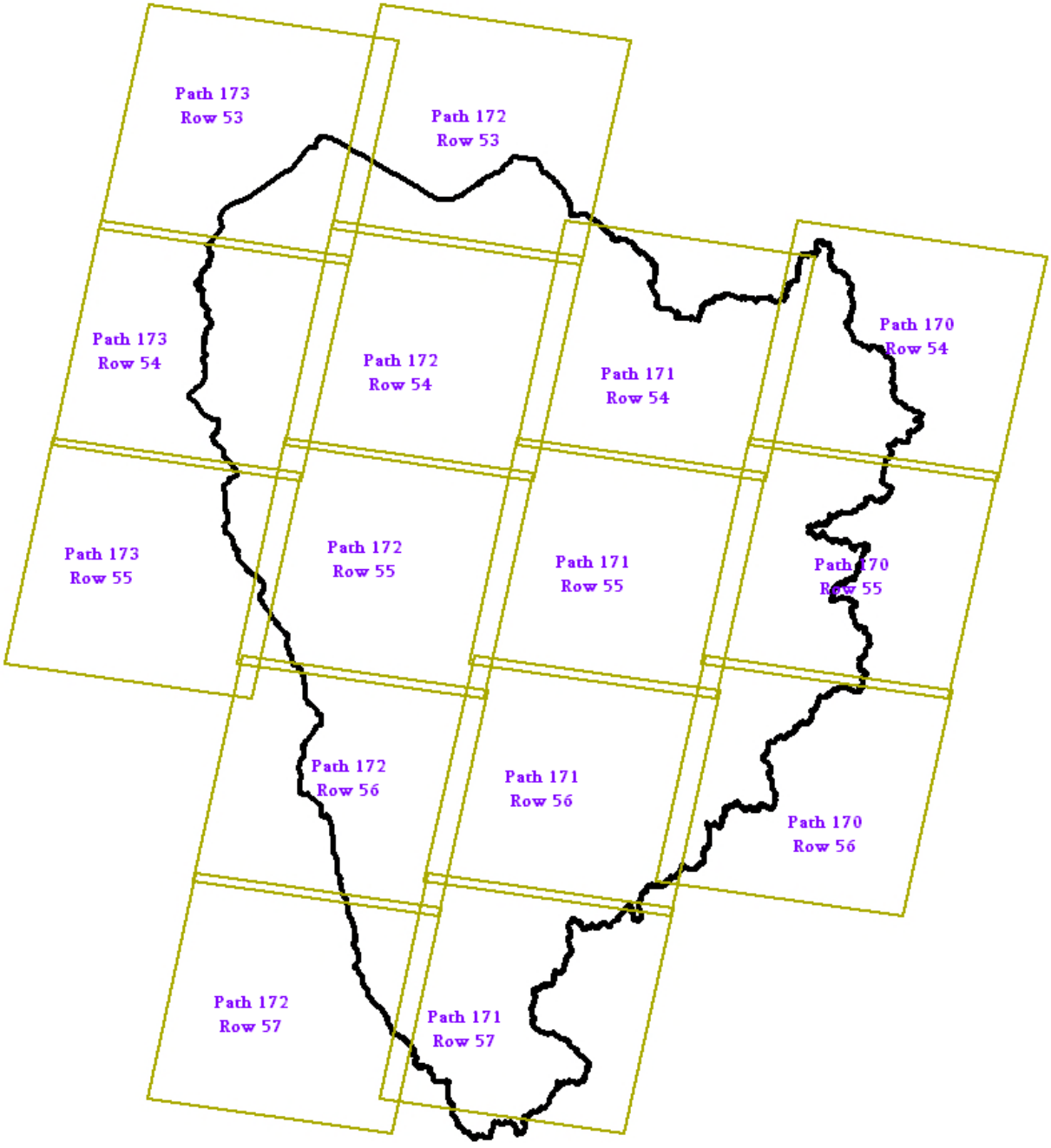
Path 172 – Row 54 Landsat 8 Satellite image (30 meters resolution, bands 432; acquisition oct. 2014)



Path 172 – Row 54 Landsat 8 Satellite image (30 meters resolution, bands 432; acquisition oct. 2013)

2. DATA USED FOR THIS STUDY

2.1 LANDSAT COVERAGE



Dates of landsat 8 images used for this study (YYYYMMDD):

date : 20150108 ROW 53 PATH 173
date : 20150108 ROW 54 PATH 173
date : 20150108 ROW 55 PATH 173
date : 20150110 ROW 54 PATH 171
date : 20150110 ROW 55 PATH 171
date : 20150110 ROW 56 PATH 171
date : 20150110 ROW 57 PATH 171
date : 20150204 ROW 54 PATH 170
date : 20150204 ROW 55 PATH 170
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date : 20150218 ROW 53 PATH 172
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date : 20150218 ROW 57 PATH 172

Dates of complementary landsat 8 images used for this study (YYYYMMDD):
date : 20140911ROW 53 PATH 172
date : 20140911ROW 53 PATH 172
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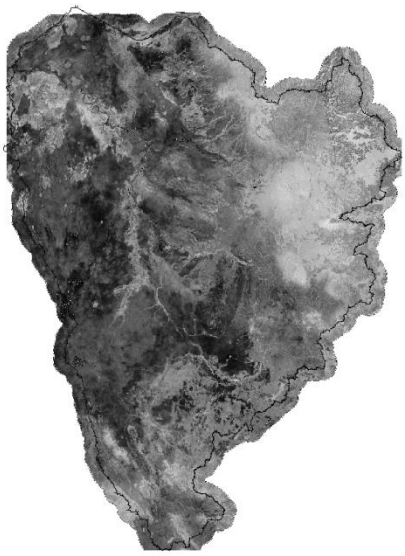
date : 20141029ROW 53 PATH 172
date : 20141029ROW 53 PATH 172
date : 20141031ROW 57 PATH 170
date : 20141031ROW 57 PATH 170

Landsat 8 images have a pixel size of 15 to 30 meters and 8 bands. We used infra red information for digital mapping because infrared is reliable to chlorophyle activity, so to water presence.

Landsat 7			Landsat 8		
Band	Bandwidth (µm)	Pixel Resolution (m)	Band	Bandwidth (µm)	Pixel Resolution (m)
			Band 1 Coastal	0.43 – 0.45	30
Band 1 Blue	0.45 – 0.52	30	Band 2 Blue	0.45 – 0.51	30
Band 2 Green	0.52 – 0.60	30	Band 3 Green	0.53 – 0.59	30
Band 3 Red	0.63 – 0.69	30	Band 4 Red	0.64 – 0.67	30
Band 4 NIR	0.77 – 0.90	30	Band 5 NIR	0.85 – 0.88	30
Band 5 SWIR 1	1.55 – 1.75	30	Band 6 SWIR 1	1.57 – 1.65	30
Band 7 SWIR 2	2.09 – 2.35	30	Band 7 SWIR 2	2.11 – 2.29	30
Band 8 Pan	0.52 – 0.90	15	Band 8 Pan	0.50 – 0.68	15
			Band 9 Cirrus	1.36 – 1.38	30
Band 6 TIR	10.40 – 12.50	30/60	Band 10 TIRS 1	10.6 – 11.19	100
			Band 11 TIRS 2	11.5 – 12.51	100

2.2 PALSAR RADAR IMAGE COVERAGE:



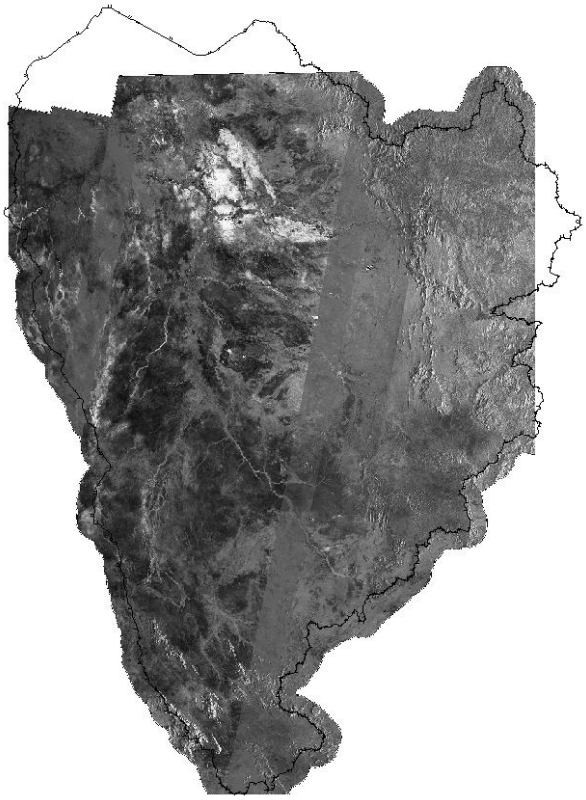
This mosaic is providing by JAXA. The Japan Aerospace Exploration Agency
At a resolution of 50 meters, this data correspond to January 2010 images acquisition. (Dry season)

Mode	Fine Scan		SAR
Center Frequency	1270 MHz(L-band)		
Chirp Bandwidth	28MHz	14MHz	14MHz,28MHz
Polarization	HH or VV	HH+HV or VV+VH	HH or VV

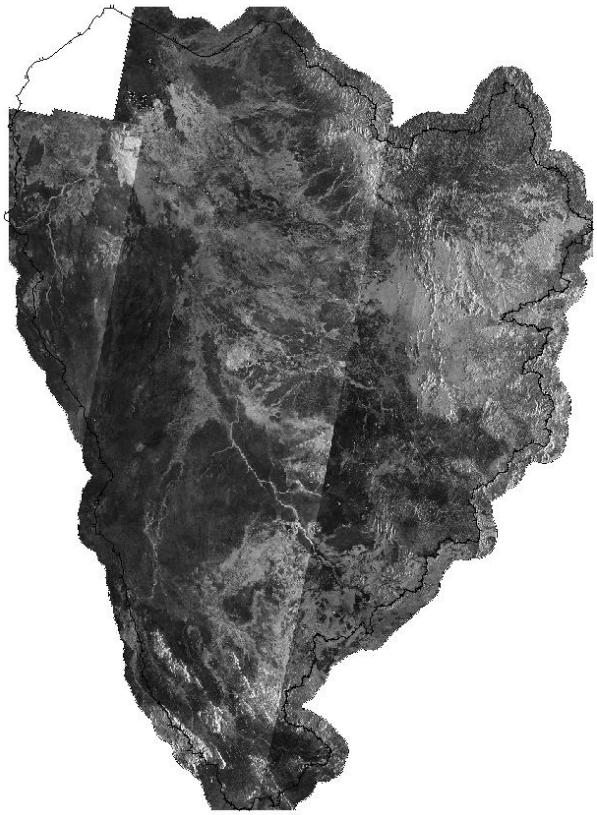
2.3 SENTINEL RADAR IMAGE COVERAGE

Sentinel-1 Satellite Characteristics

S-band TT&C data rates: 4 kbit/s telecommand; 16/128/512 kbit/s telemetry (programmable)
X-band science data rate: 600 Mbit/s



Wet season



Dry season

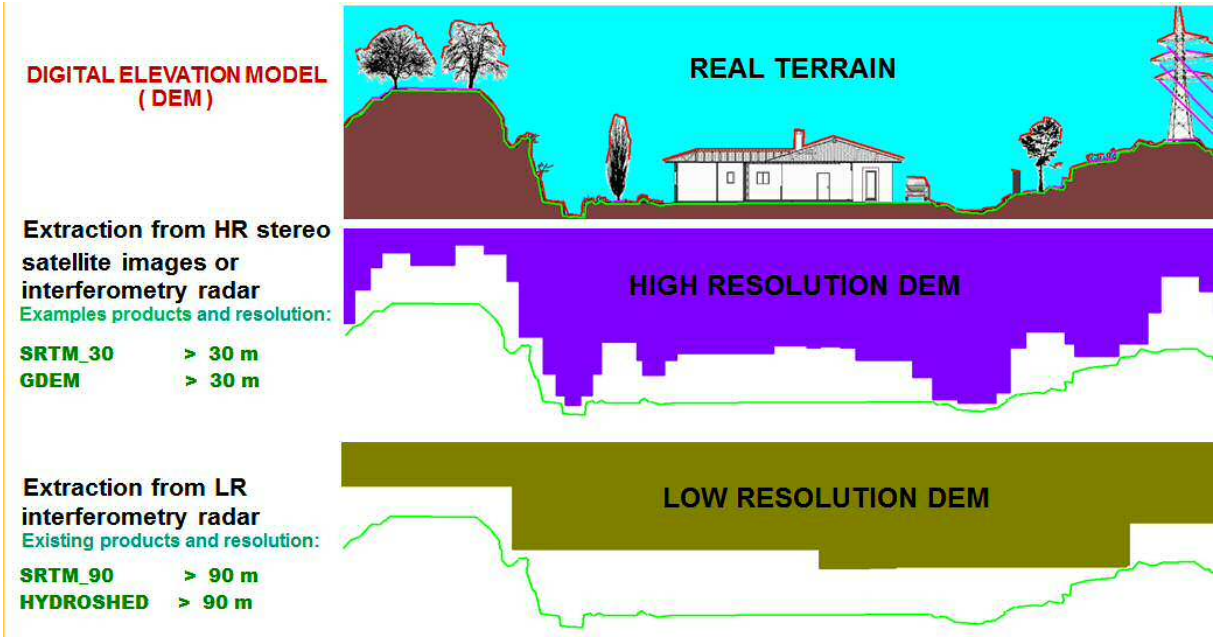
These two mosaics were assembled by at a resolution of 10 meters. The first mosaic data correspond to October 2014 images acquisition. (Wet season).The second mosaic data correspond to February 2015 images acquisition. (Dry season)

2.4 USE OR NEW DEM FOT BETTER QUALITY

In the initial methodology, the following was proposed:

"To analyse the relief in the South and East of the study area, in particular erosion, hydrology and geology, a 30m Digital Elevation Model (DEM) will be created using world GDEM (30 metres) and SRTM (90 metres) data ….. The DEMs were then combined and assembled to form the global DEM. By combining several DEMs of a single place, it is possible to eliminate the artefacts present on some but not on all of them…. it still contains quite a lot of anomalies and artefacts. Its quality is unequal from one region to another. However, the noise on the images due to the production methods used needs to be eliminated by means of statistical processing."

As shown below, the difference between STRM90 and GDEM30 concerns the resolution with 9 pixels of GDEM30 equal to 1 pixel for SRTM90. So, all automatic products (Slopes, hydrographique network and basin) have a lower quality and accuracy with 90 meters DEM.



Many Agencies made corrections on these DEM. USGS produce a SRTM 90 DEM with exaggerated hydrographic network by embeding a vector of main rivers. HydroSheed had corrected the SRTM 90 by filtering all artefacts and correcting anomalies.

The results remained of low quality because of 90 m resolution.

A second DEM was produced with other technology: the GDEM 30. This DEM has a resolution of 30 meters but presents many artefacts so its quality is not realy better than products at 90 m resolution. It's why, usually, we used a combination of these DEM to get a better resolution and lower artefacts.

Figure 4: SRTM 90 meters with exaggerated main hydrographic network

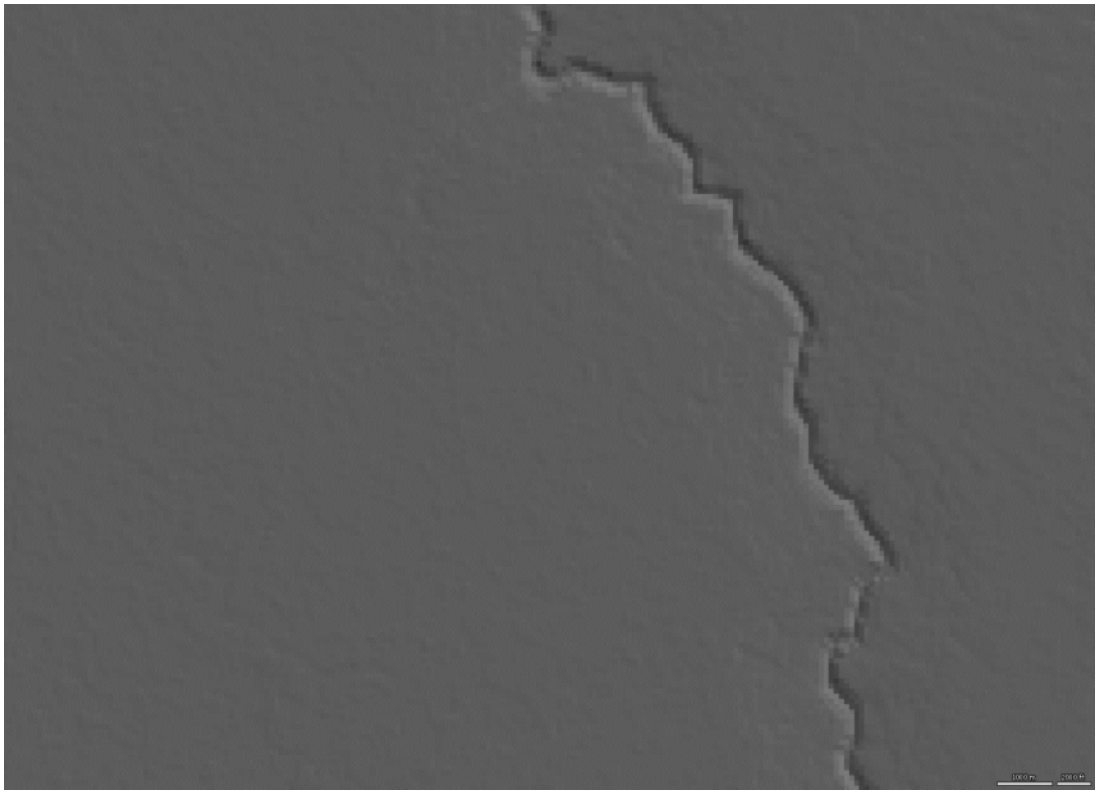


Figure 5: Hydrosheed DEM = Corrected and enhanced SRTM 90 meters

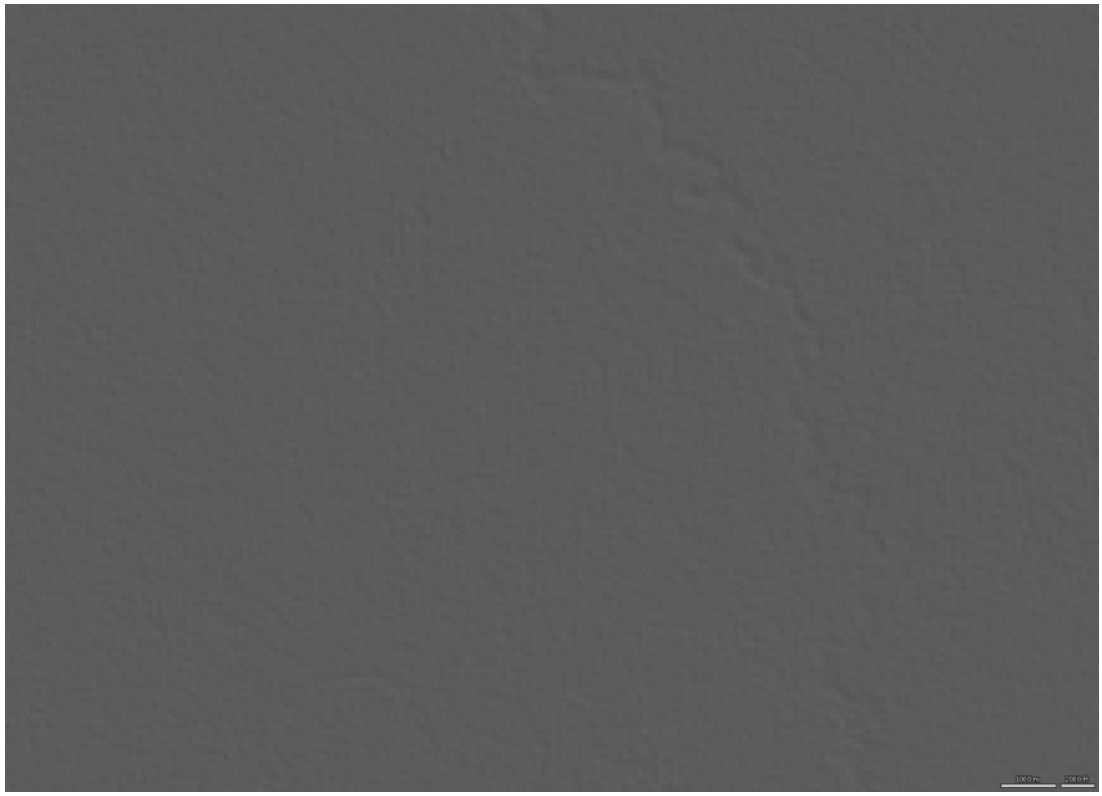
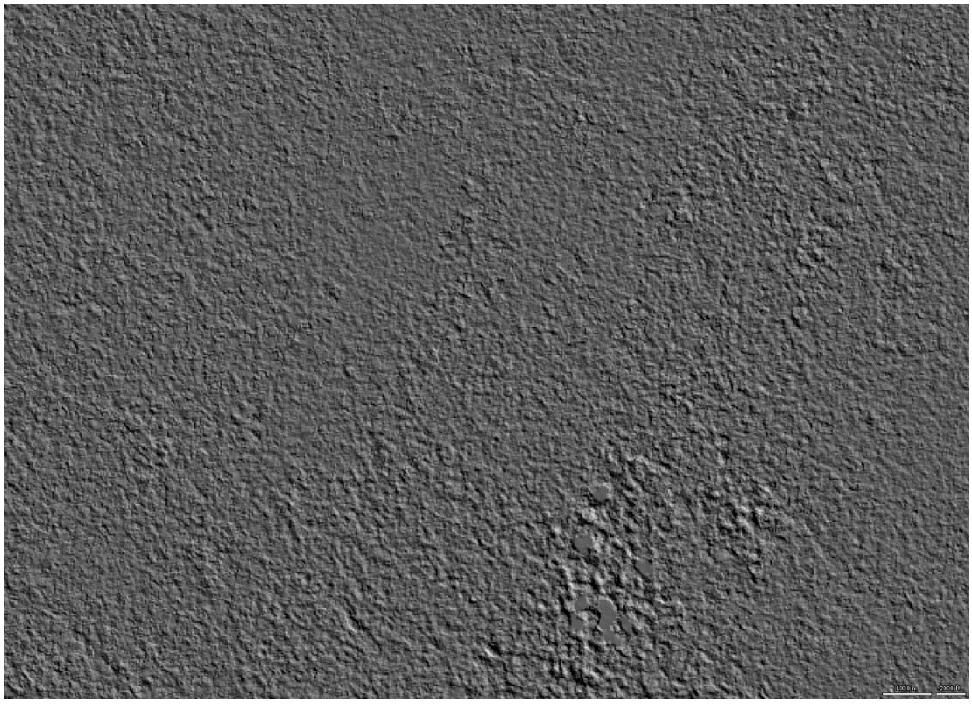
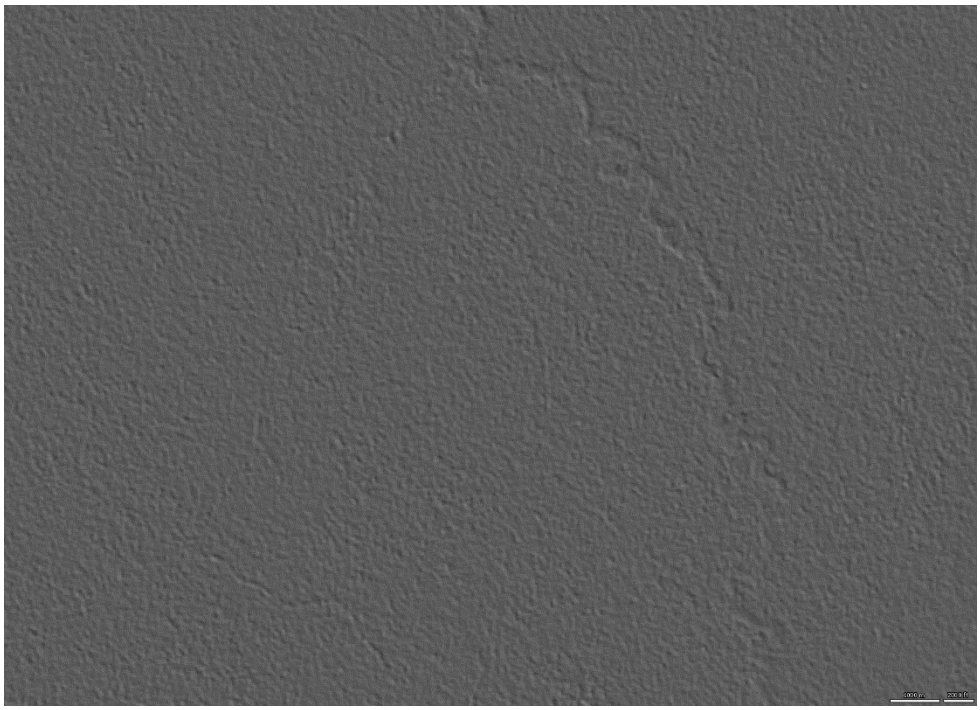


Figure 6: GDEM 30 meters DEM presents many artefacts so the quality is poor even if the resolution is higher



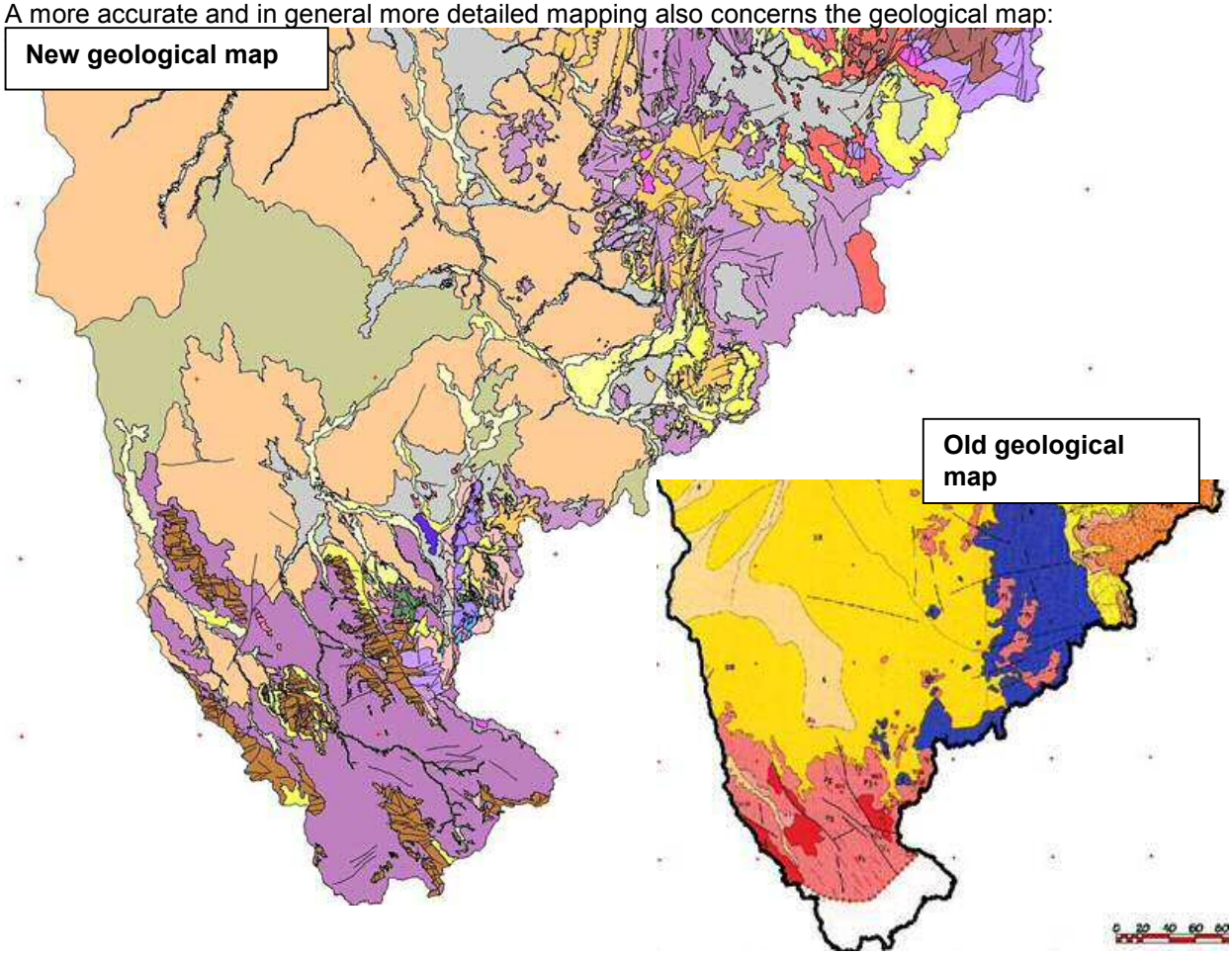
At the beginning of 2015, USGS produced a new SRTM DEM at 30 m resolution with a more efficient process. This new DEM has improved resolution and quality and was used for the BAS study. Processing is not required to improve the quality as proposed for old DEM (GDEM and SRTM90) and automated products were made possible through this new DEM.

Figure 7: New SRTM 30 meters: higher resolution and quality



3. GEOLOGY

A more accurate and in general more detailed mapping also concerns the geological map:

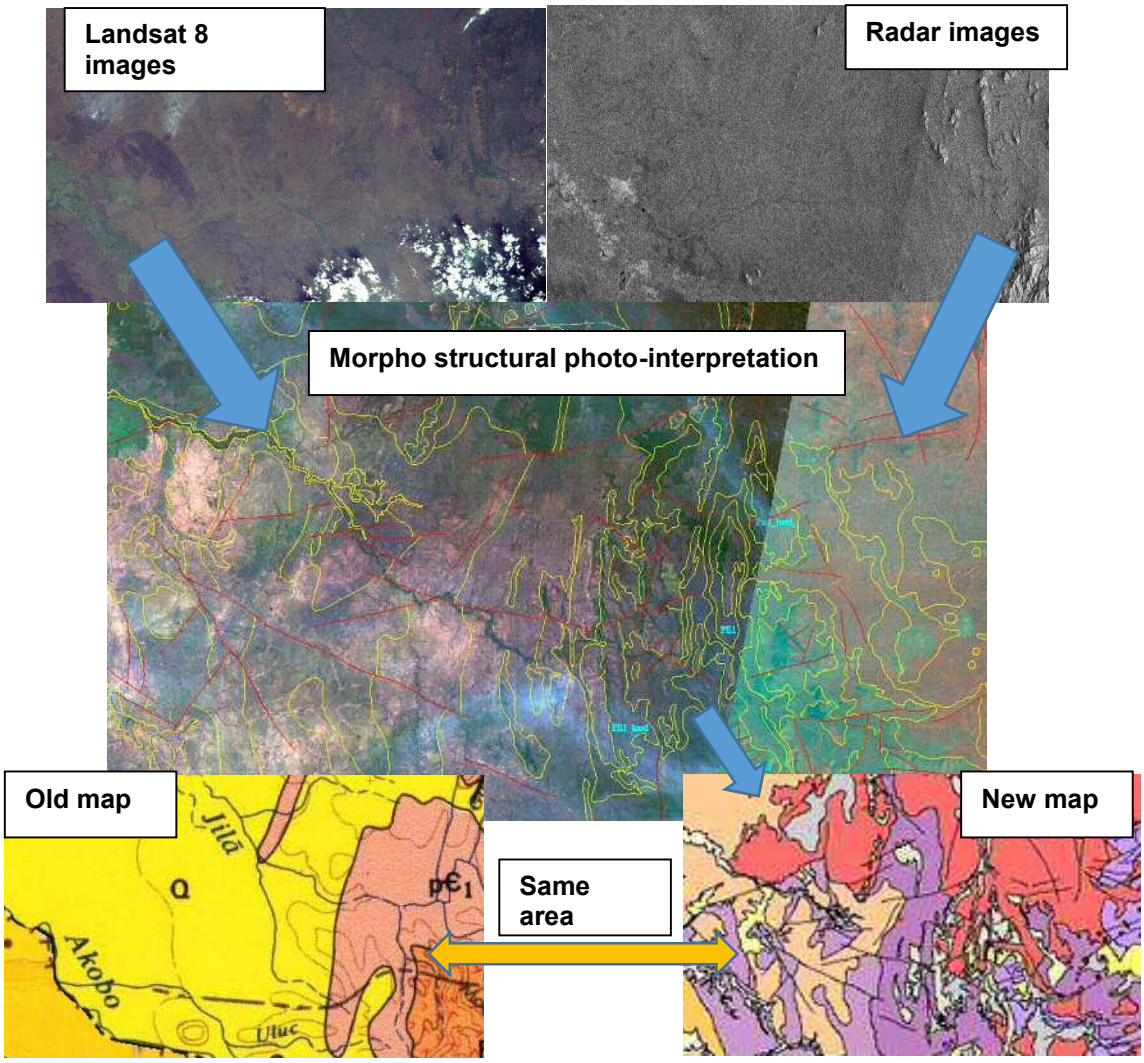


New geological map from remote sensing data was mainly based on spectral color on Landsat images (visible and NIR), combined with interpretation of geomorphology of the terrains from radar images. The morphologies are related to presence/absence of faults, folds or foliation and differential erosion processes of more or less hard rocks. When they occurred we have discriminated several morpho-tectonic signatures. Compared to the original 1:2,000,000 scale geological map, which displayed nearly 7 or 8 different lithologies (on BAS project area), we could have separated nearly 30 lithotectonic units. Beware that a same stratigraphy can include several different morphologic units.

CzUR	Cenozoic - Plio-Pleistocene	Unconsolidated sands with some gravels, silts and clays
CzVa	Cenozoic	Rhyolitic volcanic rocks
CzVb, PEpgns	Cenozoic, Lower Proterozoic	Basaltic volcanic rocks, Undifferentiated gneissic rocks
Gt1	Upper Proterozoic	Syntectonic granitoid rocks
Gt2	Upper Proterozoic	Post-tectonic intrusive granites
PE1	Lower to Middle Proterozoic	Basement lower complex - undifferentiated magmatic and metasediments
PE1_hard	Lower to Middle Proterozoic	Basement lower complex - undifferentiated magmatic and metasediments (competent facies)
PE1b	Archean?	Basement complex - Burji Gneiss (fine foliated biotite gneisses and schists)
PE3a	Up Proterozoic - Adola group	Amphibolite, chlorite, talc schists, greenstones and quartzites
PE3lb	Up Proterozoic - Tsaliet Group	Chlorite schists, quartzites and intermediate metavolcanics
PEGr	Precambrian	Granitic rocks
PE_Gabbro	Precambrian	Gabbroic rocks
PEp	Lower Proterozoic	Undifferentiated metamorphic rocks
PEps	Lower Proterozoic	Schistose supercrustal metasediments - amphibolite facies of metamorphism
PEs	Middle Proterozoic	Undifferentiated metasediments (amphibolite facies of metamorphism)
PEsa	Middle Proterozoic	Amphibolites
PEsm	Middle Proterozoic	Marbles - amphibolite facies of metamorphism
PEsq	Middle Proterozoic	Quartzites rocks
PEsy	Middle Proterozoic	Undifferentiated Syenitic rocks
PEum	Middle Proterozoic	Ultramafic rocks - Peridotites, Dunites, Harzburgites and Lherzolitic
PEx	Archean	Undifferentiated Granulite and Mylonitic facies rocks
Pga	Paleogene to Neogene	Trap basaltic series - Alkali olivine basalt and tuffs with rare rhyolites
Q_fan	Holocene to recent	Fan deltas type deposits with rapid lateral facies changes
Q_undif	Holocene to recent	Undifferentiated alluviums and unconsolidated recent deposits
Qal	Holocene to recent	Recent alluvium in active river beds and wadi undifferentiated deposits
Qal2	Pleistocene to Holocene	Older alluviums deposits - raised or incised terraces and large levees - abandoned distributary channels
Qc	Holocene to recent	Colluvium - unconsolidated screes and slope deposits - undifferentiated talus materials
UB	Upper Proterozoic	Ultrabasic rocks
Volcano	Quaternary	Small volcanoes or plugs and ring complex

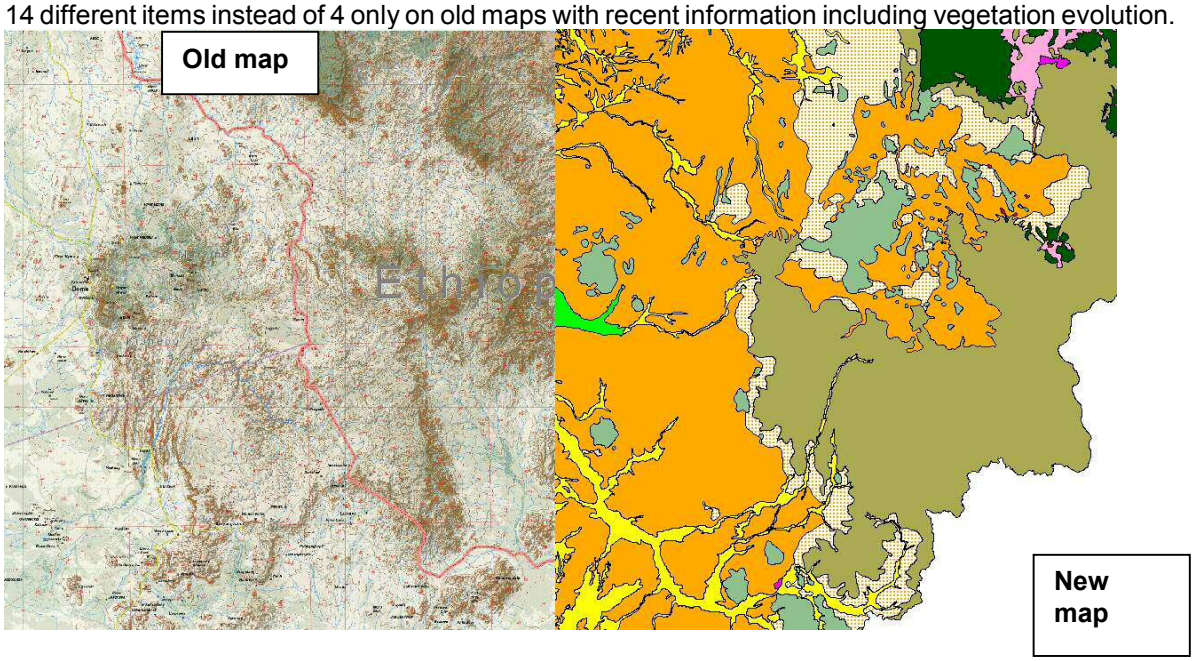
Legend of new 1:100,000 geological map.

METHODOLOGY OF GEOLOGICAL MAPPING

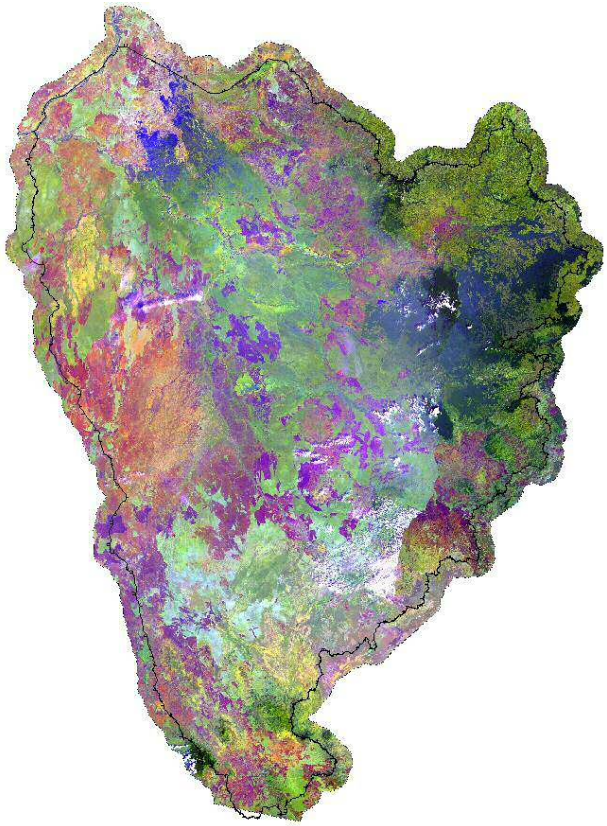


4. LAND USE

This is the same for mapping of land use: as an example below, new satellite map allows to identify 14 different items instead of 4 only on old maps with recent information including vegetation evolution.

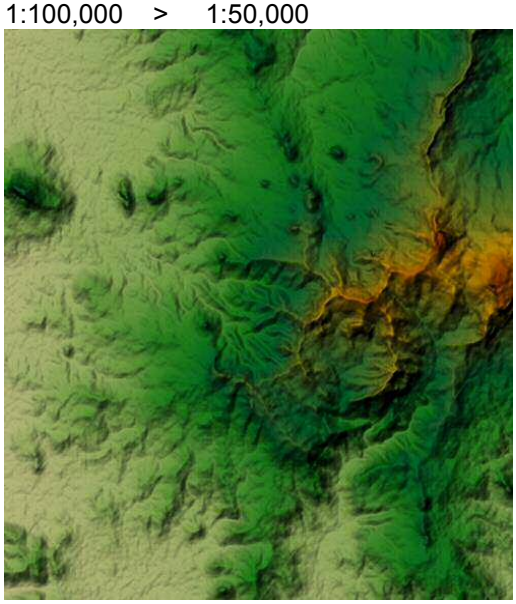


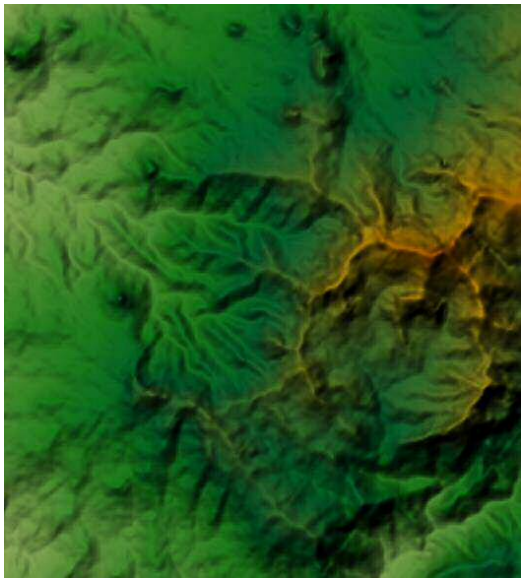
Also, the new cartography is homogeneous on the whole basin (not many scales or sources with problems of transitions between maps), and analysis the entire basin by trying to get a coherence in flow directions and connections.



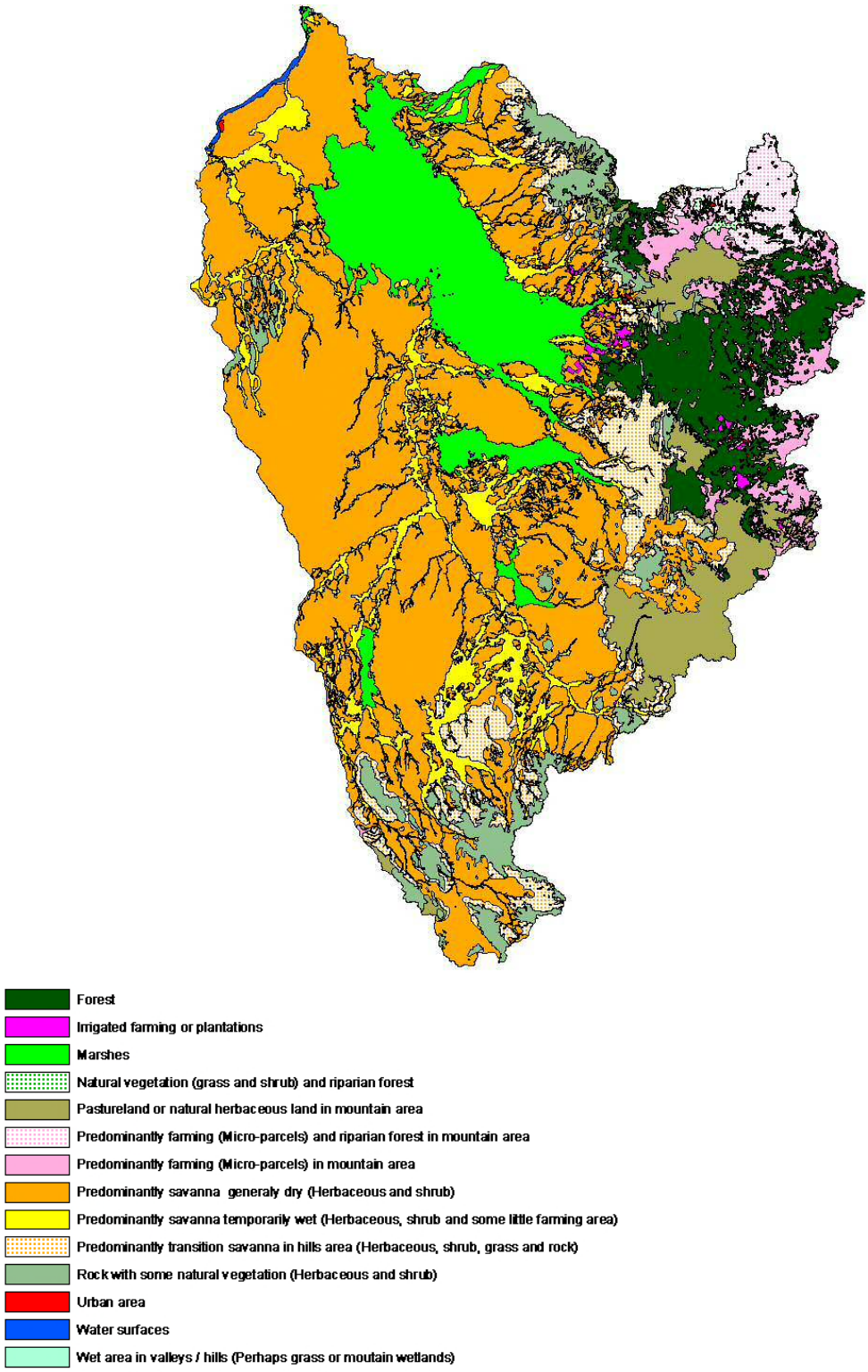
Numerical data (satellite elevation or images) offers possibility to change map scale:

1:100,000 > 1:50,000





Then, we will be able to refine information for specific detailed analysis (dam implantation for example). The 1:100,000 study will be used to select projects sites and proceed to more accurate scale studies.



The land use was directly and manually photo-interpreted on Landsat 8 images at 1:100 000 scale, so it corresponds to an inventory of 2014-2015. At this scale it is impossible to have an exhaustive land use mapping for intensive farming for example, so only big areas have been reported on map.

The main difficulty is related to the transitions of vegetation types so classes are based on dominances.

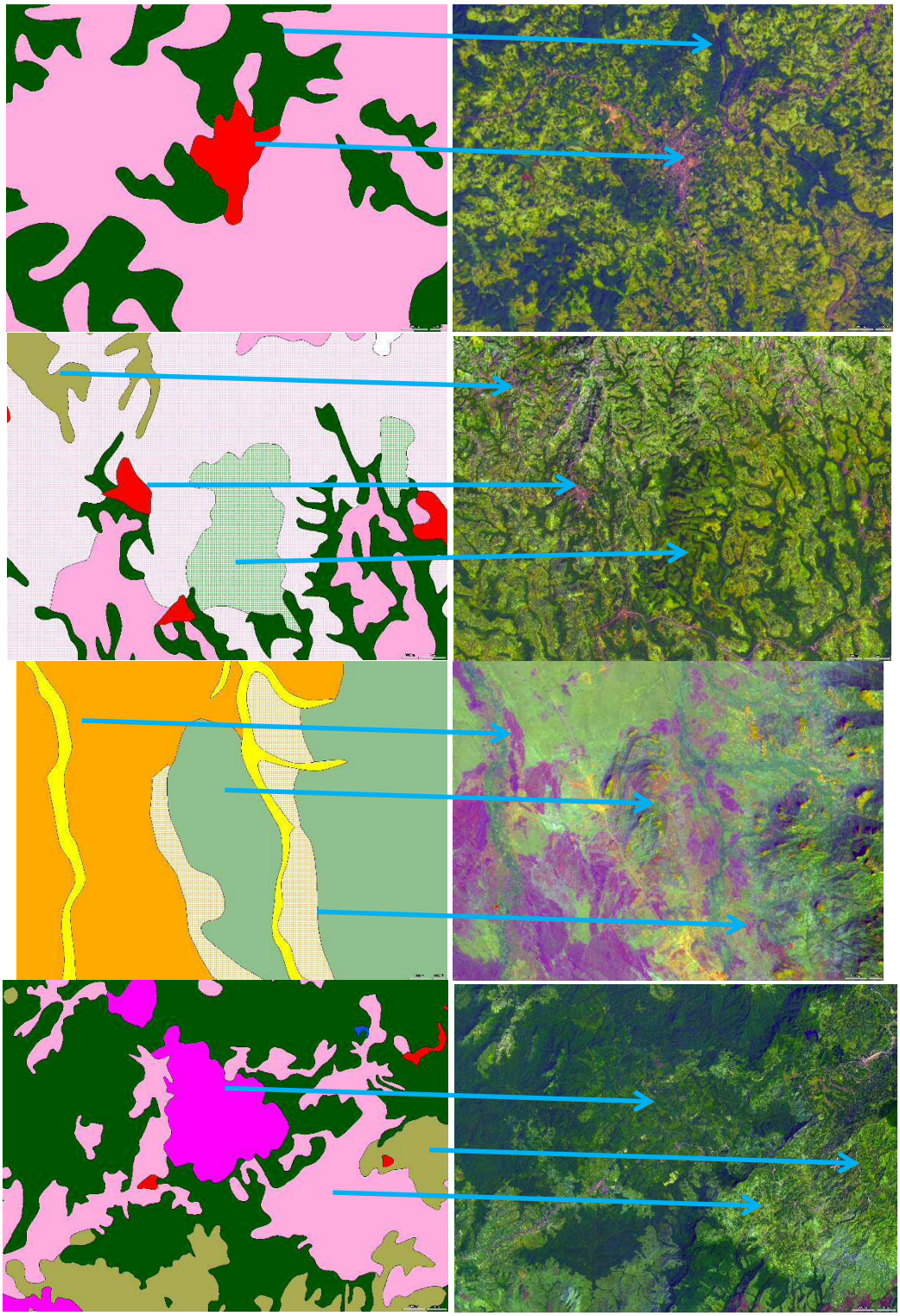
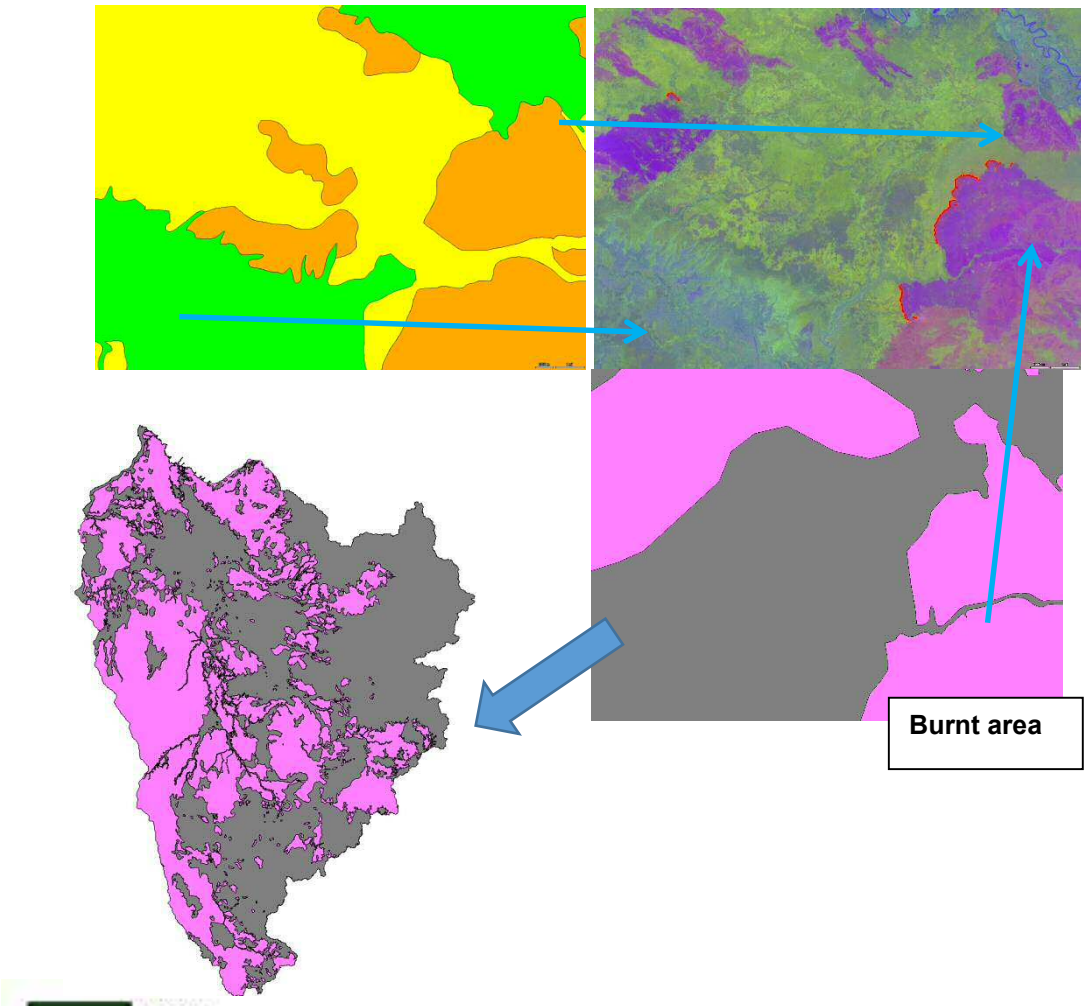


Figure 8: Correlations between images and interpretation



Regarding burnt areas, the inventory was done from 2014 to 2015 and may be undervalued because some areas are burnt every year and other only every 2, 3 or 4 years.

5. HYDROGRAPHIC NETWORK AND BASINS MAPPING

5.1 NETWORK MAPPING

The first step of this work was to manually draw the networks on satellite images using experience of photo-interpreters and computer processing. The automatic network generation uses elevation model (SRTM30) and calculates the theoretical direction of flow. But when the difference of height in a basin is quite low, the real stream route cannot be determined and manual mapping is required to obtain accurate results. In fact, the automatic product is used to understand the general flow direction. In the BAS study, this was very important because streams connections are not easy to understand.

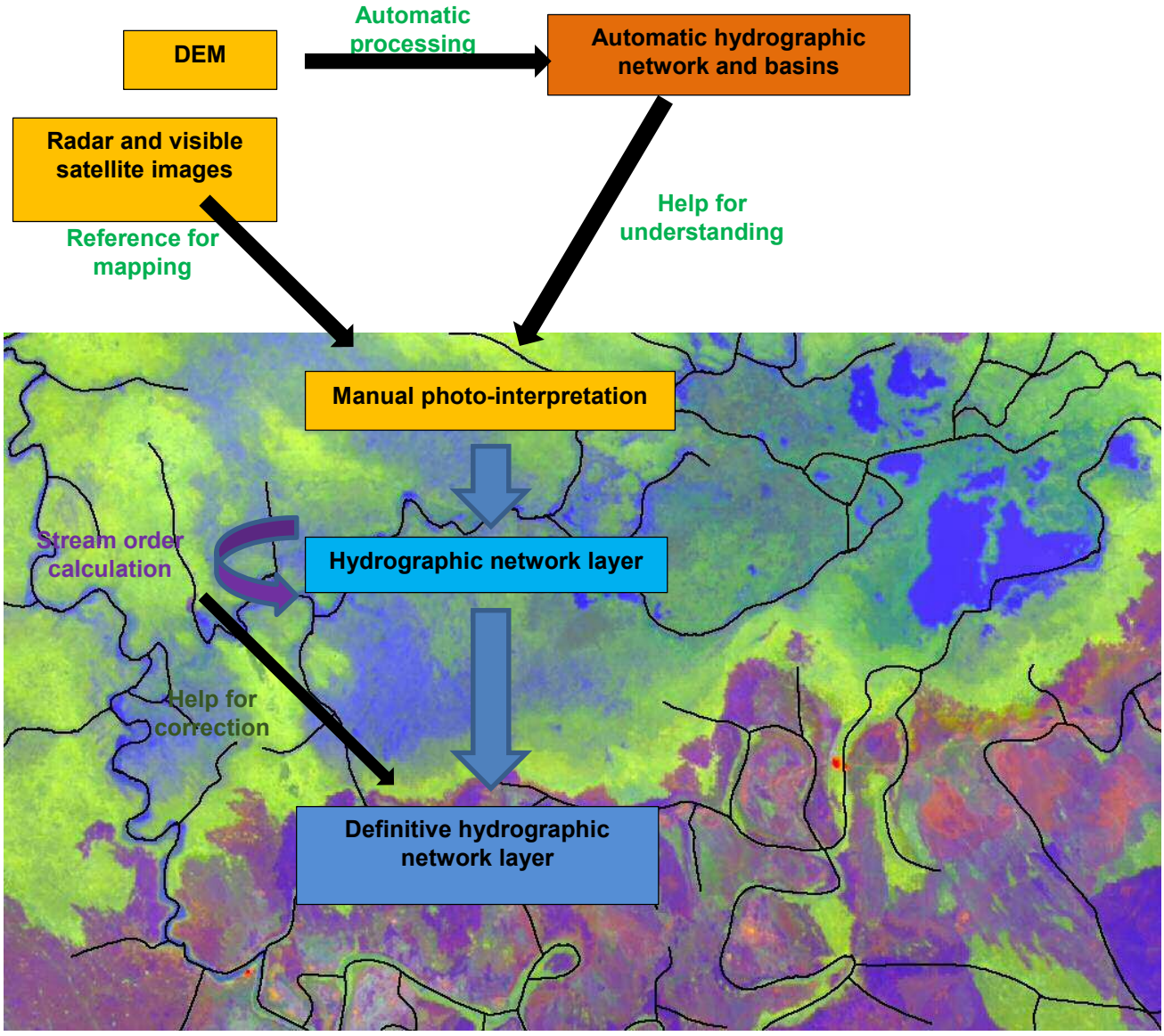


Figure 9: Sample of manual drawing on Landsat 8 satellite image at 1:75,000 scale.

In burnt areas, some streams have been extrapolated because images were difficult to interpret.

In fact, the South Sudanese part of the basin is complex because of low relief area. Frequently, many connections between rivers of neighbor basins were observed on satellite images because of water level variation during the year. These connections have to be considered and are present at different scales.

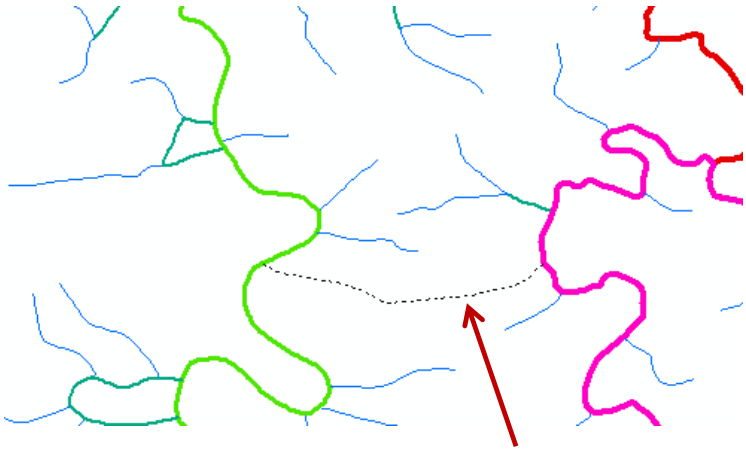


Figure 10: Observed connection between two rivers (order 1 from Strahler classification)

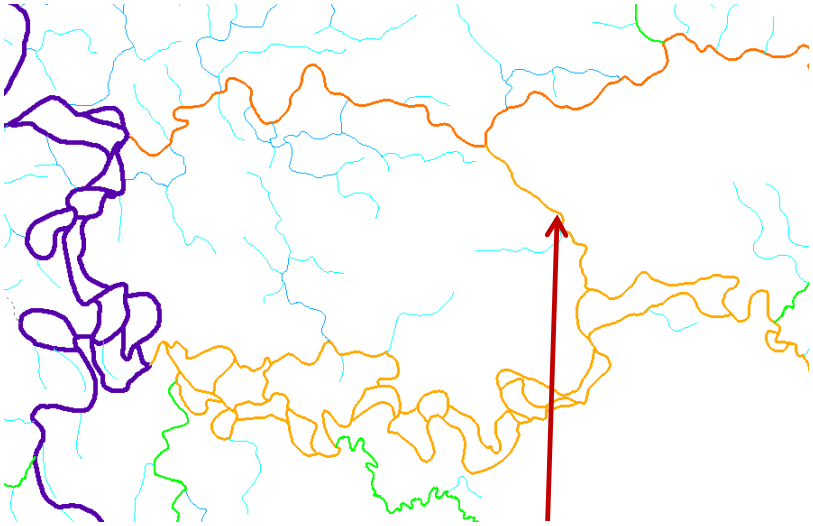
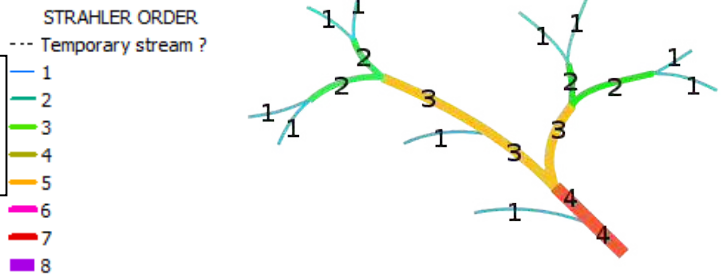


Figure 11: Observed connection between two main rivers (order > 3 from Strahler classification)

Perhaps some connections are permanent and could be explained by a topography extremely flat. The current river network we elaborated at 1:100,000 scale includes these connections[1]. River network coherence has been validated by a Strahler classification:

[1] For complex zones with main rivers connections, the Strahler classification was not feasible so, the network width was used to determine the hypothetical order.

Strahler classification methodology (hierarchy of tributaries):



For more detailed information, see:

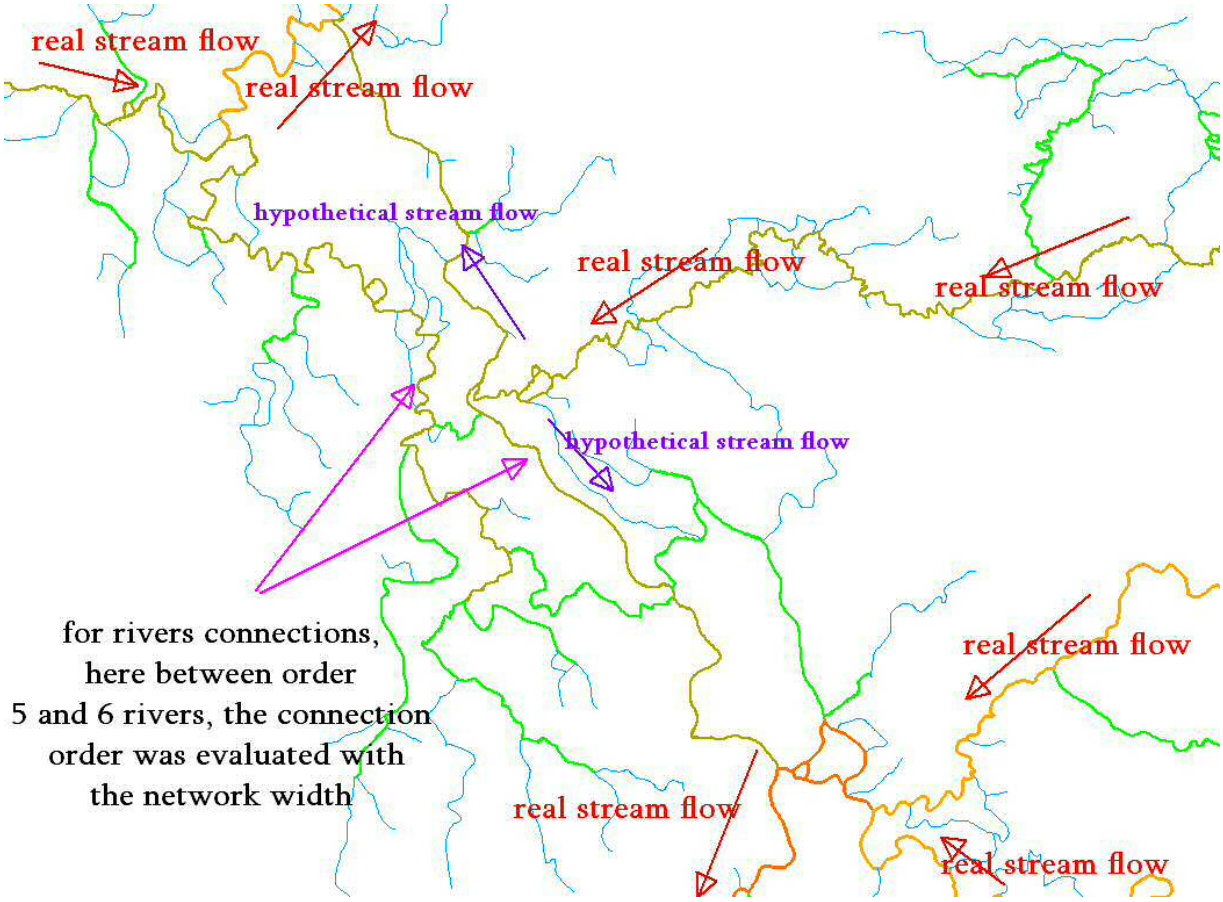
http://usgs-mrs.cr.usgs.gov/NHDHelp/WebHelp/NHD_Help/Introduction_to_the_NHD/Feature_Attribution/Stream_Order.html

and:

http://svn.osgeo.org/grass/grass-addons/grass7/raster/r.stream.order/r.stream.order.html

http://thesai.org/Downloads/Volume3No8/Paper_6-Automatic_Association_of_Strahler%E2%80%99s_Order_and_Attributes_with_the_Drainage_System.pdf

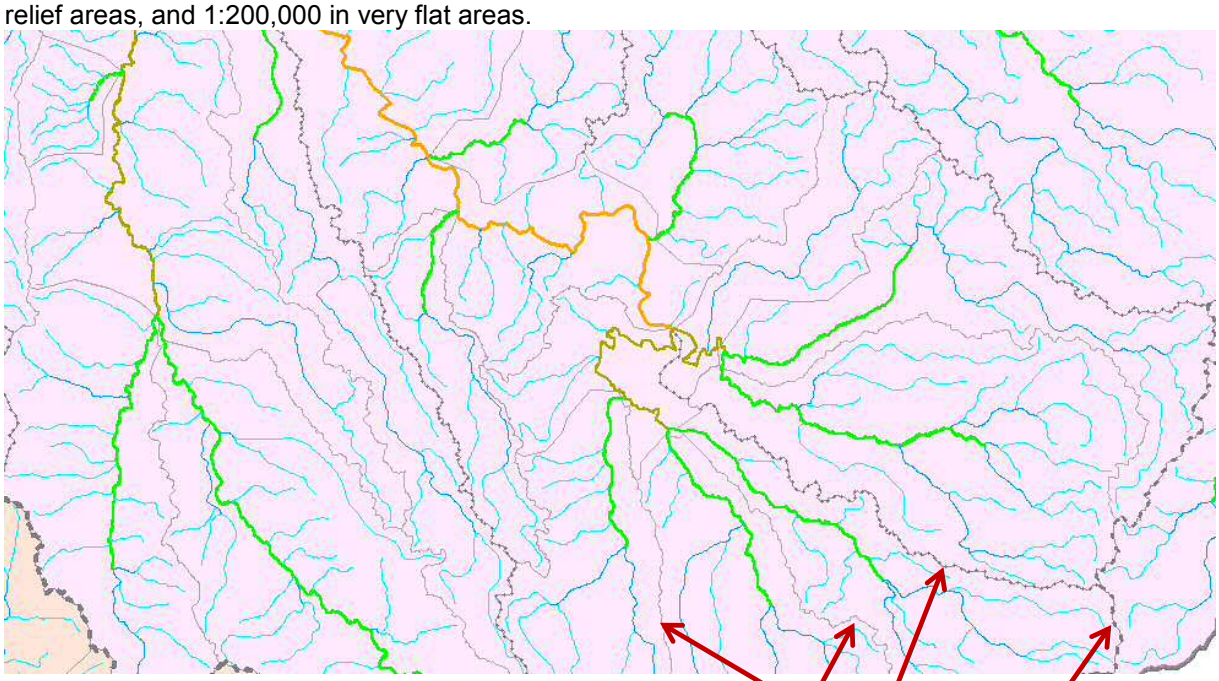
ftp://ftp.horizon-systems.com/NHDPlus/NHDPlusV21/Documentation/TechnicalDocs/SOSC_technical_paper.pdf



5.2 BASIN AND SUB BASINS MAPPING

The second step concerns sub basins. The methodology of delimitation is different between sloping areas of relief and flat areas. For sloping areas, the automatic processing on digital elevation model (SRTM 30m pixel size) gives very good results. So the photo-interpreter just gets back basins limits and controls if there are no artefacts due to dam or local false elevation. On flat areas, the automatic process gives only approximate basins limits. For internal segmentation, the photo-interpreter analyzed the detailed hydrographic network to delimit an envelope including small streams of a same main river.

Basin delimitations have been made for all order > 2 stream from Strahler classification. That corresponds to 780 basins on the whole area. The scale of work could be assimilated to 1:50,000 in relief areas, and 1:200,000 in very flat areas.



Basin limits for order 3 streams from Strahler classification

Basin limits for order 4 streams from Strahler classification

Basin limits for order 5 streams from Strahler classification

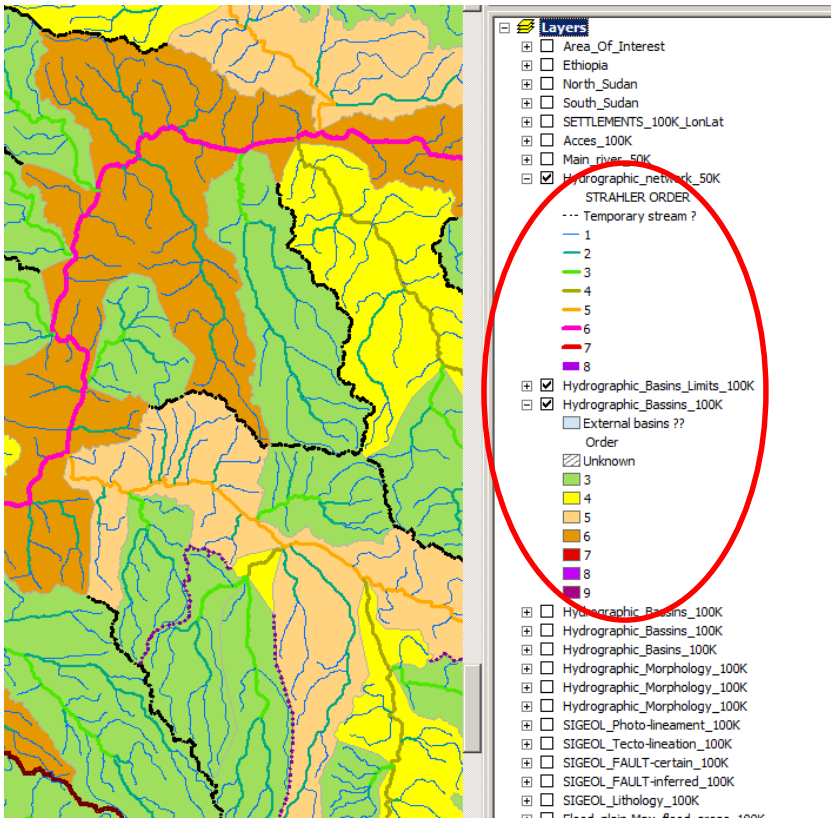
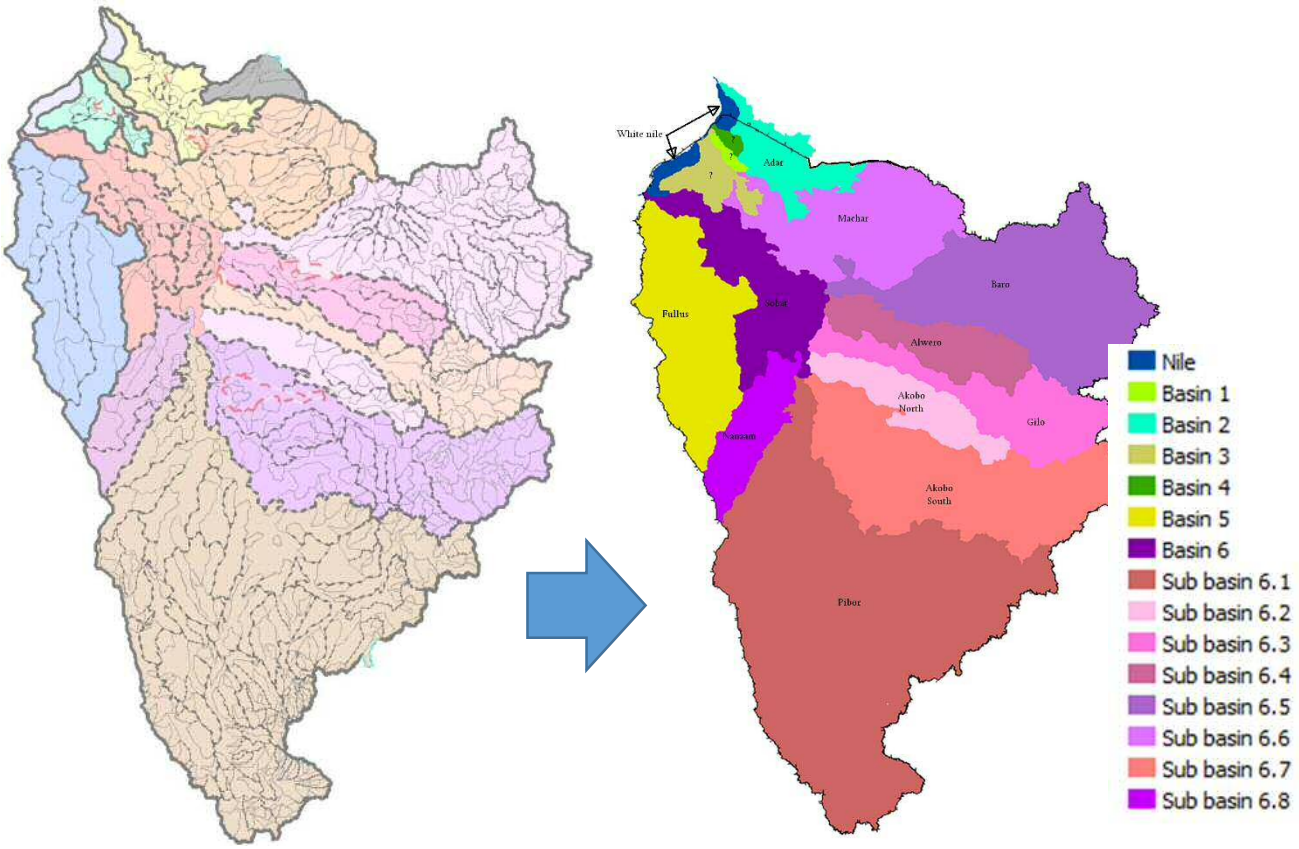


Figure 12 : Legend of Strahler classification and sub basins



From this delimitation, 12 basins have been drawn plus some other smaller directly related to the White Nile.

The slope generated on SRTM 30 shows that the sub-basin 6.5 (on previous map) is the only one not to be really concerned by very low slopes. All other basins present some interconnections with neighbor basins.

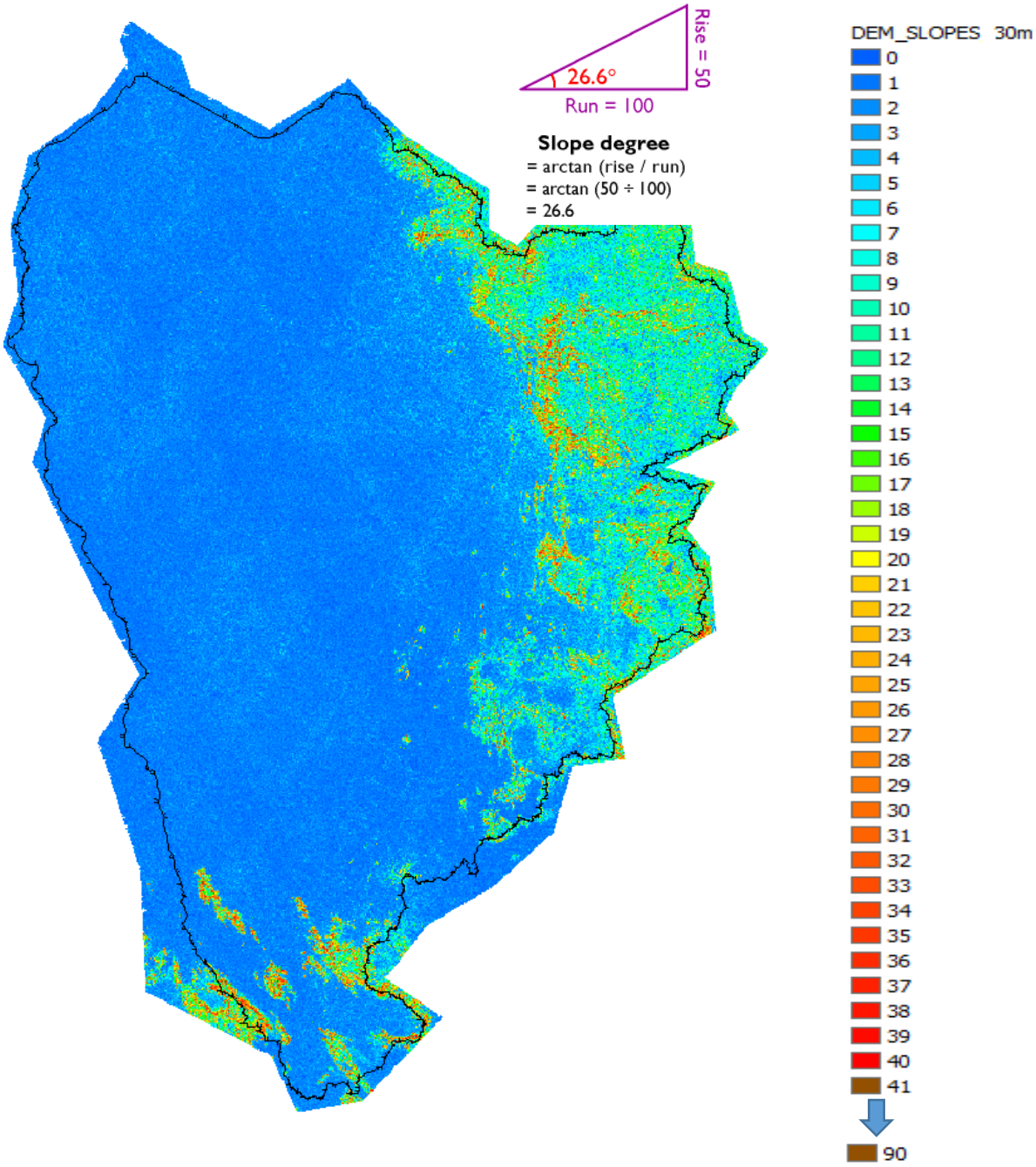
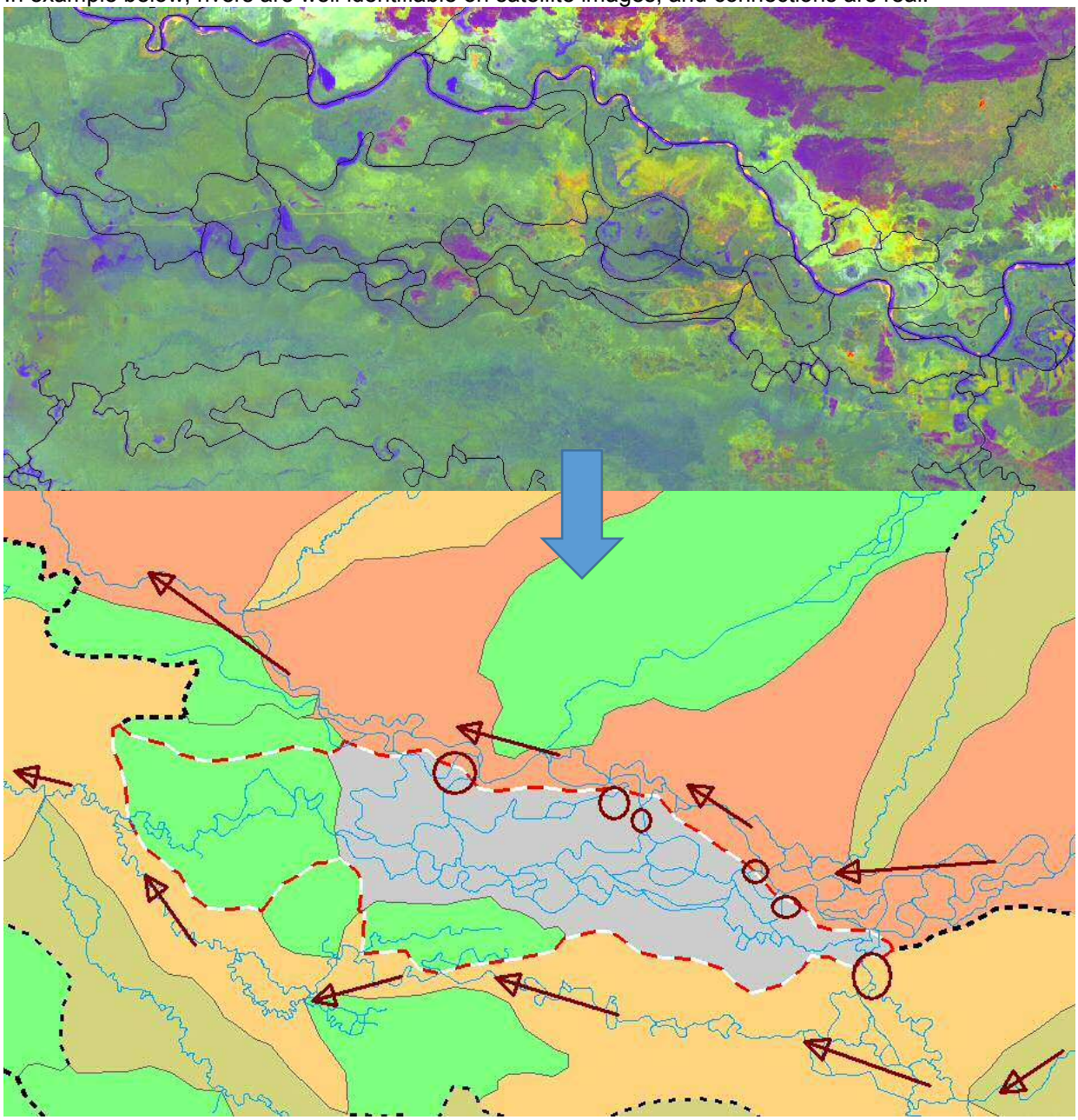


Figure 13: Slopes in Ethiopia and South Sudan Basins (BAS)

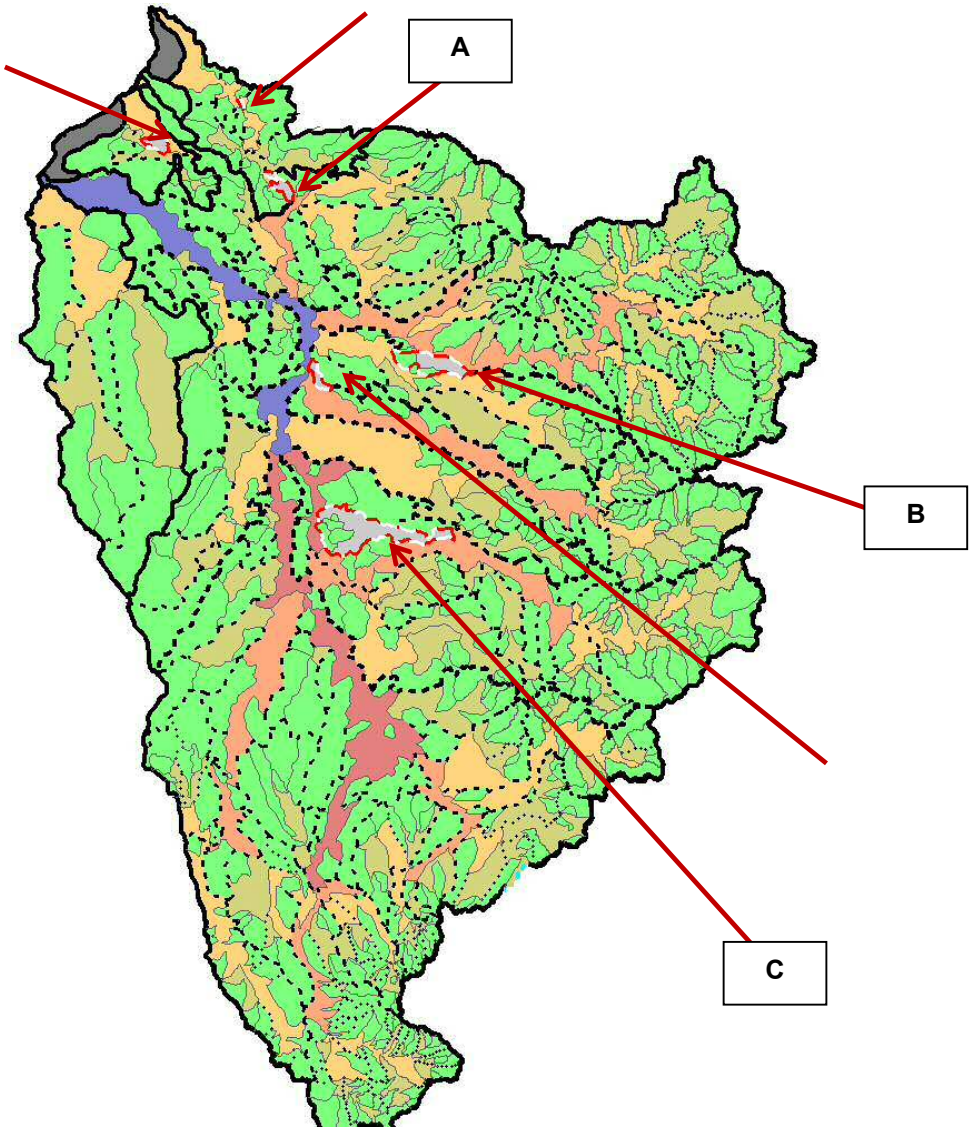
Due to these interconnections, some elementary basins could not be attached to main basins because of uncertainties. This is problematic if we consider that a basin could not end in two basins, but in this specific case, marshes presence can explain this. It is indeed common in swamps to be unable to correctly map the river network.

A complete hydro and meteorological data acquisition network with a comprehensive study of all the river network during both the rainy and the dry season is required to determine the flow direction of water. Without this expertise and regular monitoring - which is not part of this assignment - it is impossible to make a decision well informed. In fact, flow direction certainly changes in some streams during the year and from year to year, depending on the amount of water.

In example below, rivers are well identifiable on satellite images, and connections are real.

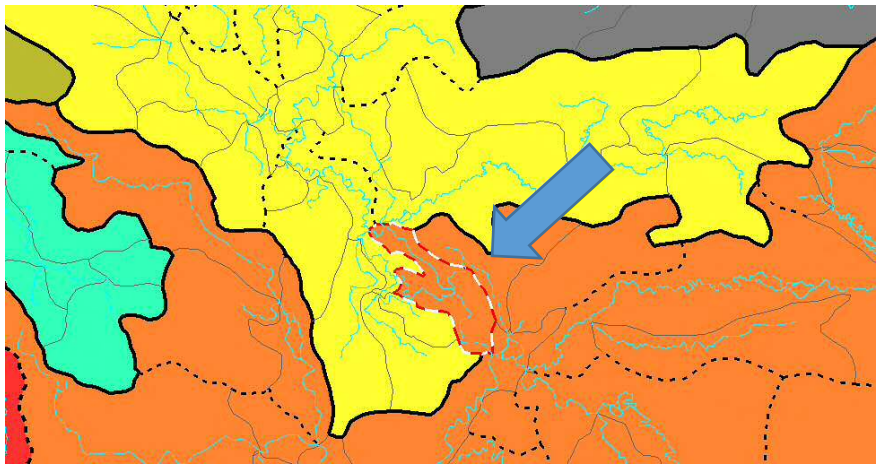


The mapping demonstrates the problem of connections. Circles identify junctions between two main rivers in a marsh area. The grey basin can't be exclusively attached to the northern or southern basin, and it induces an area of uncertainty (dashed line white & red).



This representation shows basins with uncertainties about flow direction and basins connections.

CASE A



The dry season image radar shows very well this connection between two disjointed main basins. During the wet season, this connection disappears because all the marsh is flooded.

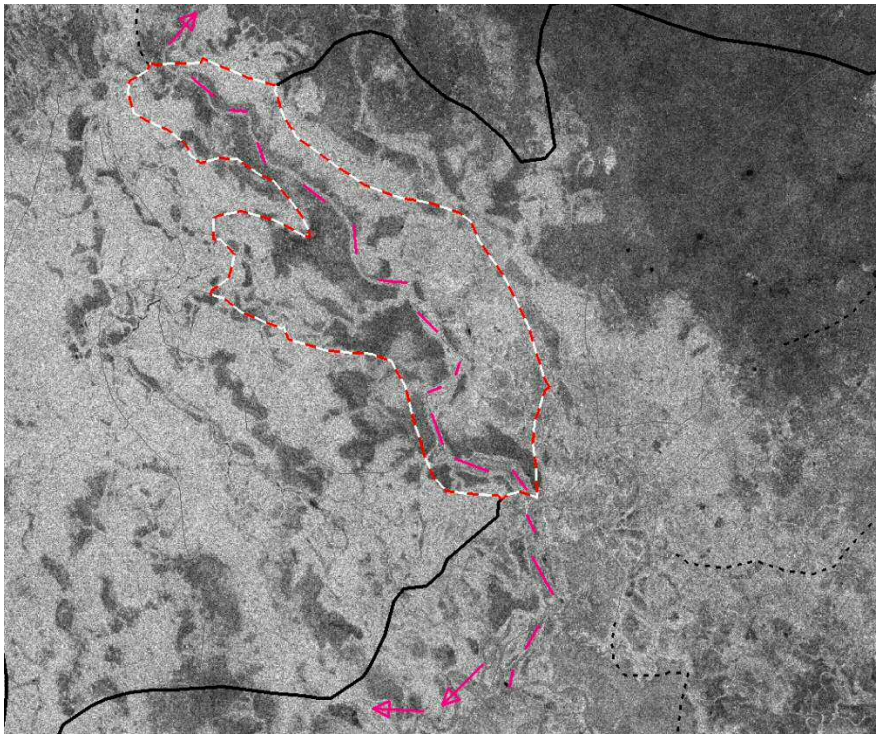


Figure 14: Sentinel radar image: dry season

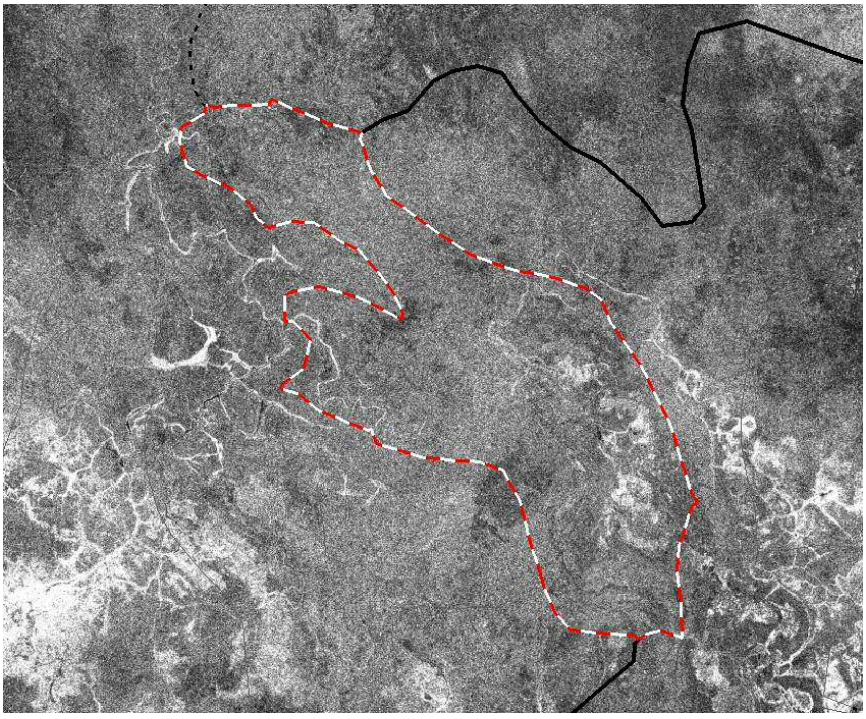


Figure 15: Sentinel radar image: wet season

CASE B

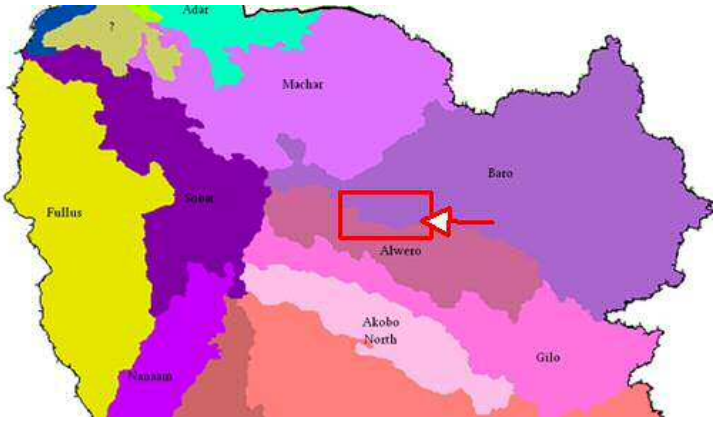
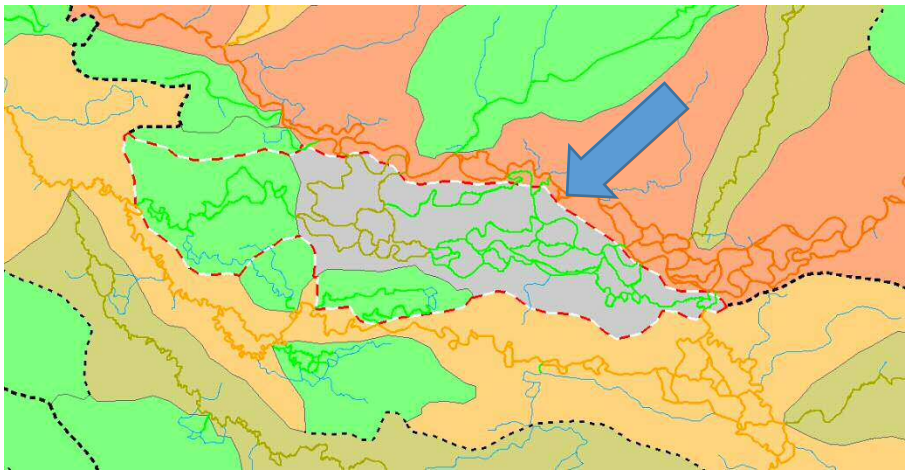


Figure 16: Location of case "B" between Baro and Alwero sub basins



As for the previous case, the dry season image radar shows very well this connection between two disjointed main basins. During the wet season, this connection disappears because all the marshes are flooded (white area on wet season image).

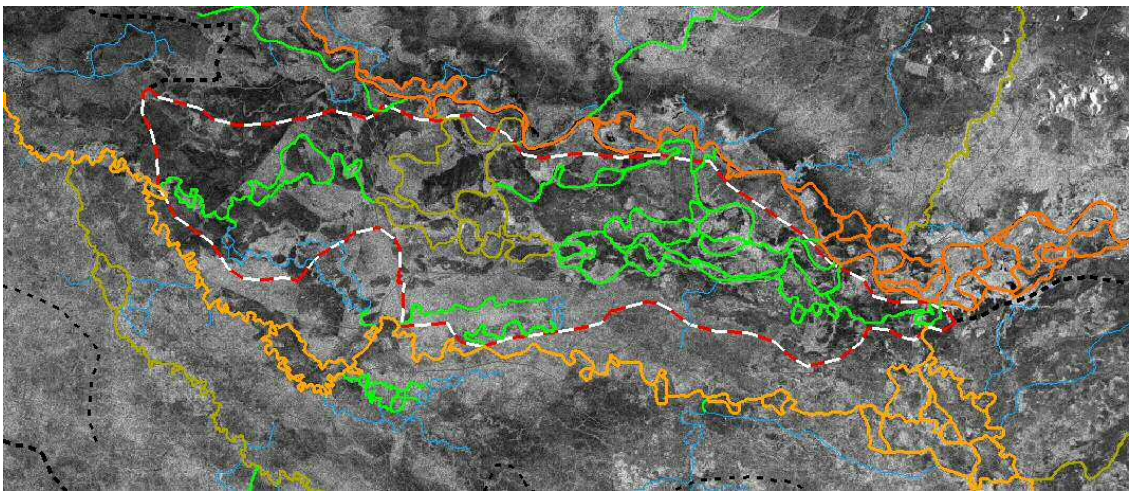


Figure 17: Sentinel radar image: dry season

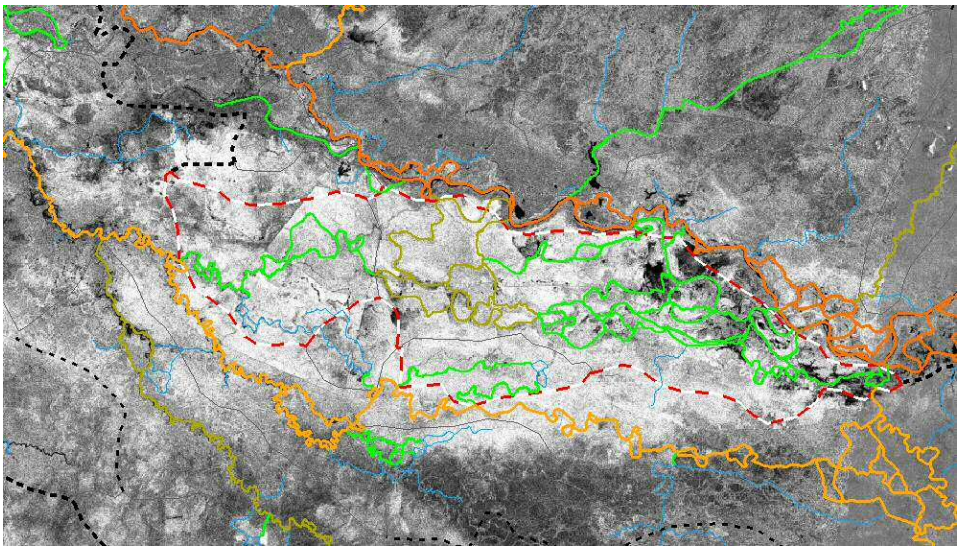
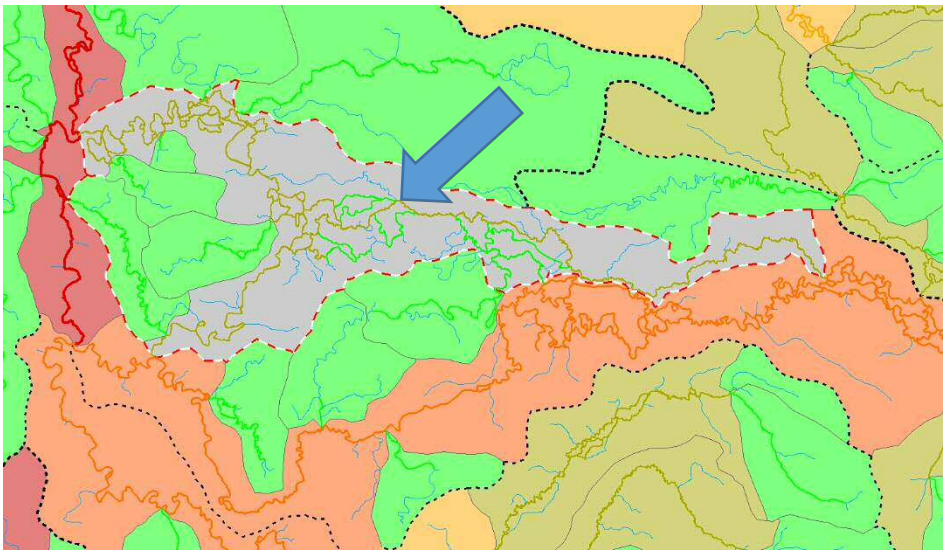


Figure 18: Sentinel radar image: wet season

CASE C



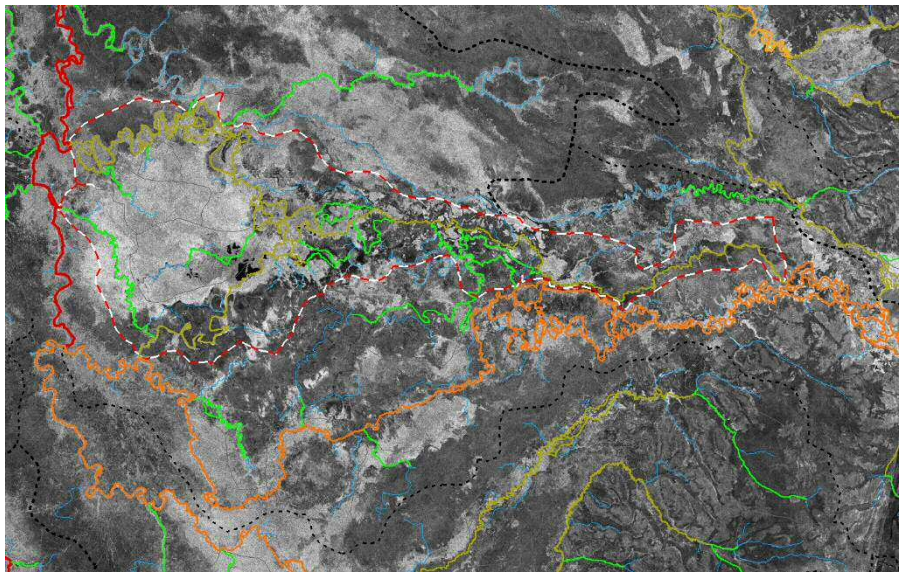


Figure 19: Sentinel radar image: dry season

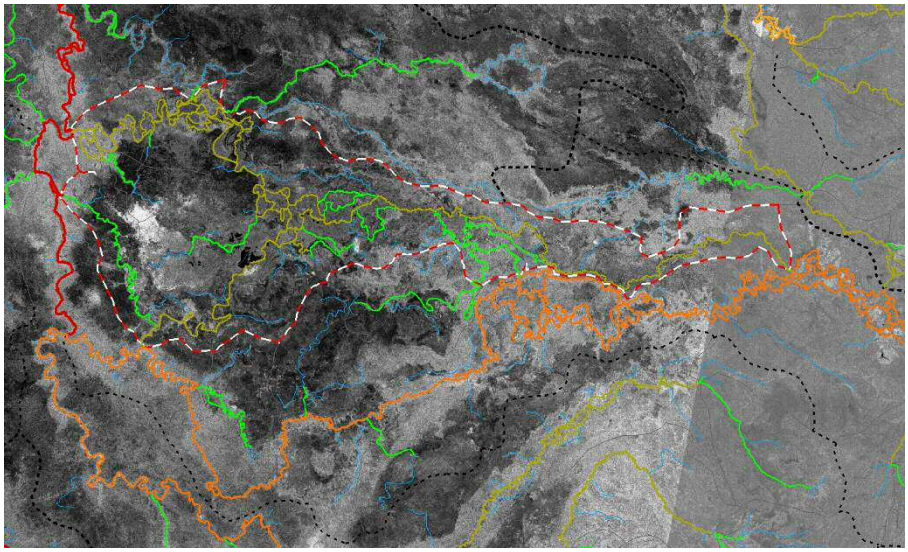
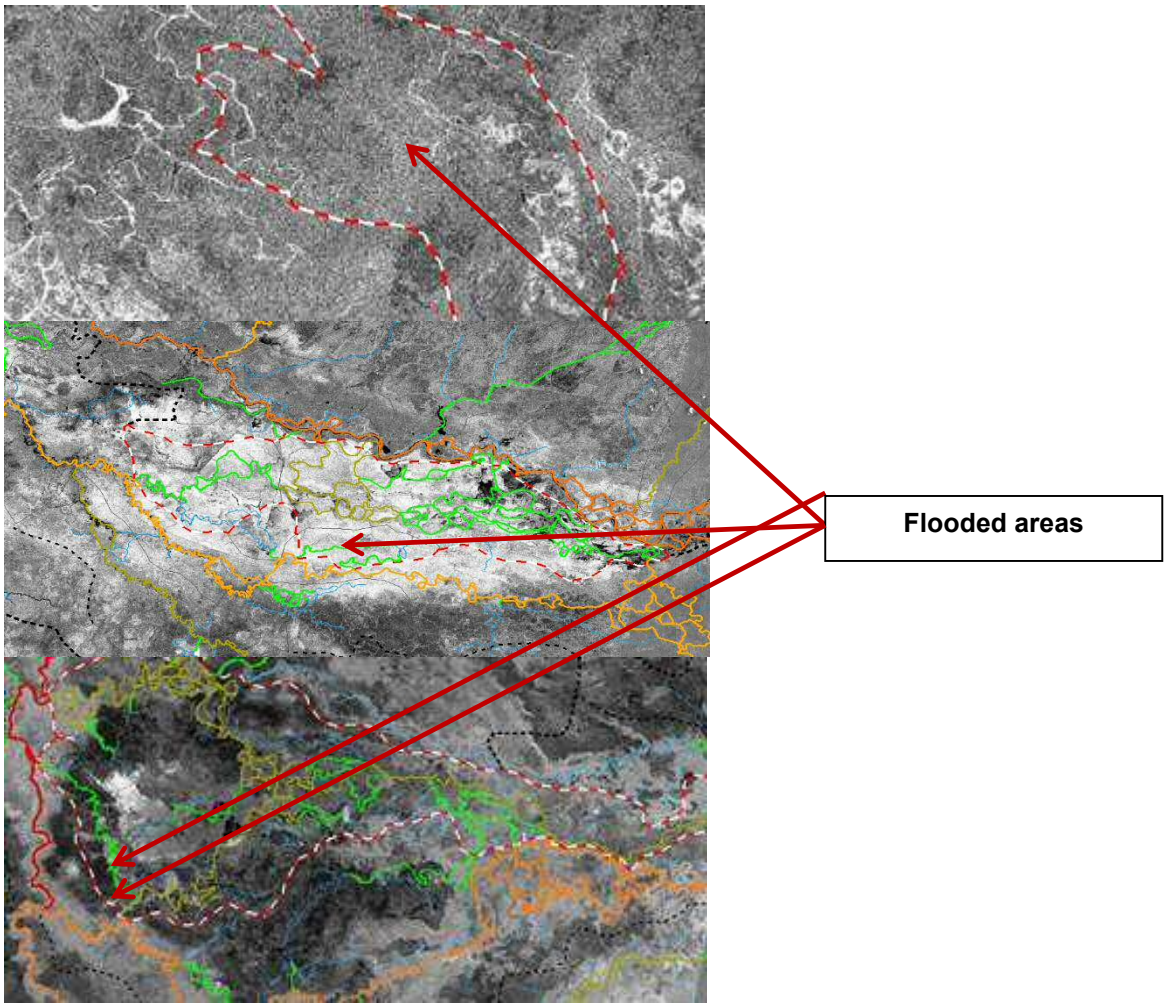


Figure 20: Sentinel radar image: wet season

As we can see on these three samples for this case, the interconnections exist and are probably active throughout the year but the directions of flow vary.

It is also an opportunity to show that the interpretation of radar images is not easy. It would be if there was no vegetation, but in the South Sudanese part of the basin, we must be very careful about interpretations.

In case A, we should notice that during the wet season, the radar image gives grey information for flooded areas. In case B, white areas indicate flooded areas, and in case C, these are the dark areas.



These differences are explained by the ratio water / vegetation. When this ratio increases, the picture is darker and vice versa. However, a large amount of vegetation usually indicates the presence of water especially when it is seasonal. A perfectly black surface indicates open water because there is no radar signal returns, but if there is floating vegetation, the response will be grey.

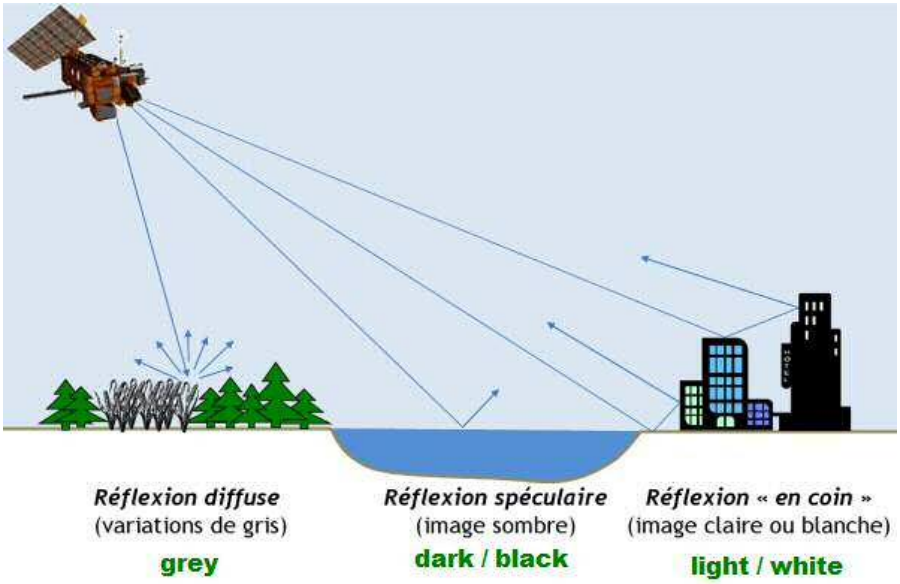


Figure 21: Radar image response versus the surface aspect.

Moreover, as shown in the following example, in burnt areas, the absence of vegetation gives a dark signal on radar images. It is logical to say that a burnt area is not wet, however the reverse is not true.

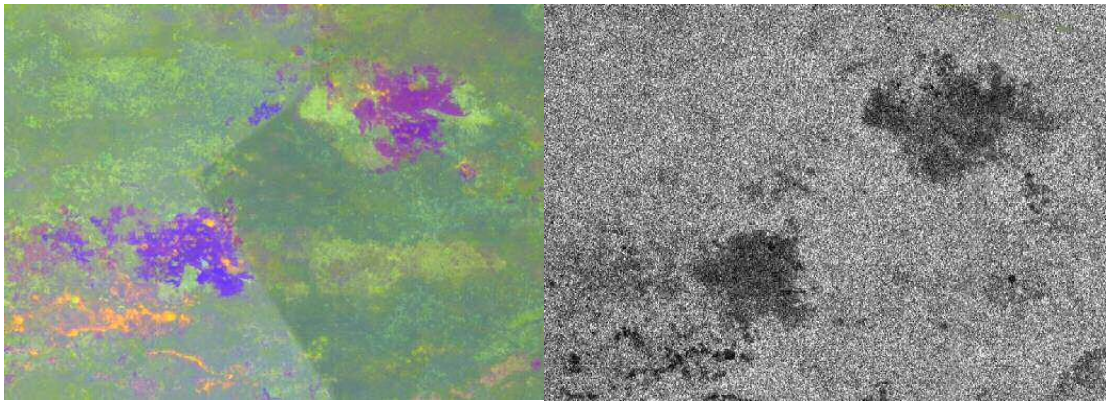
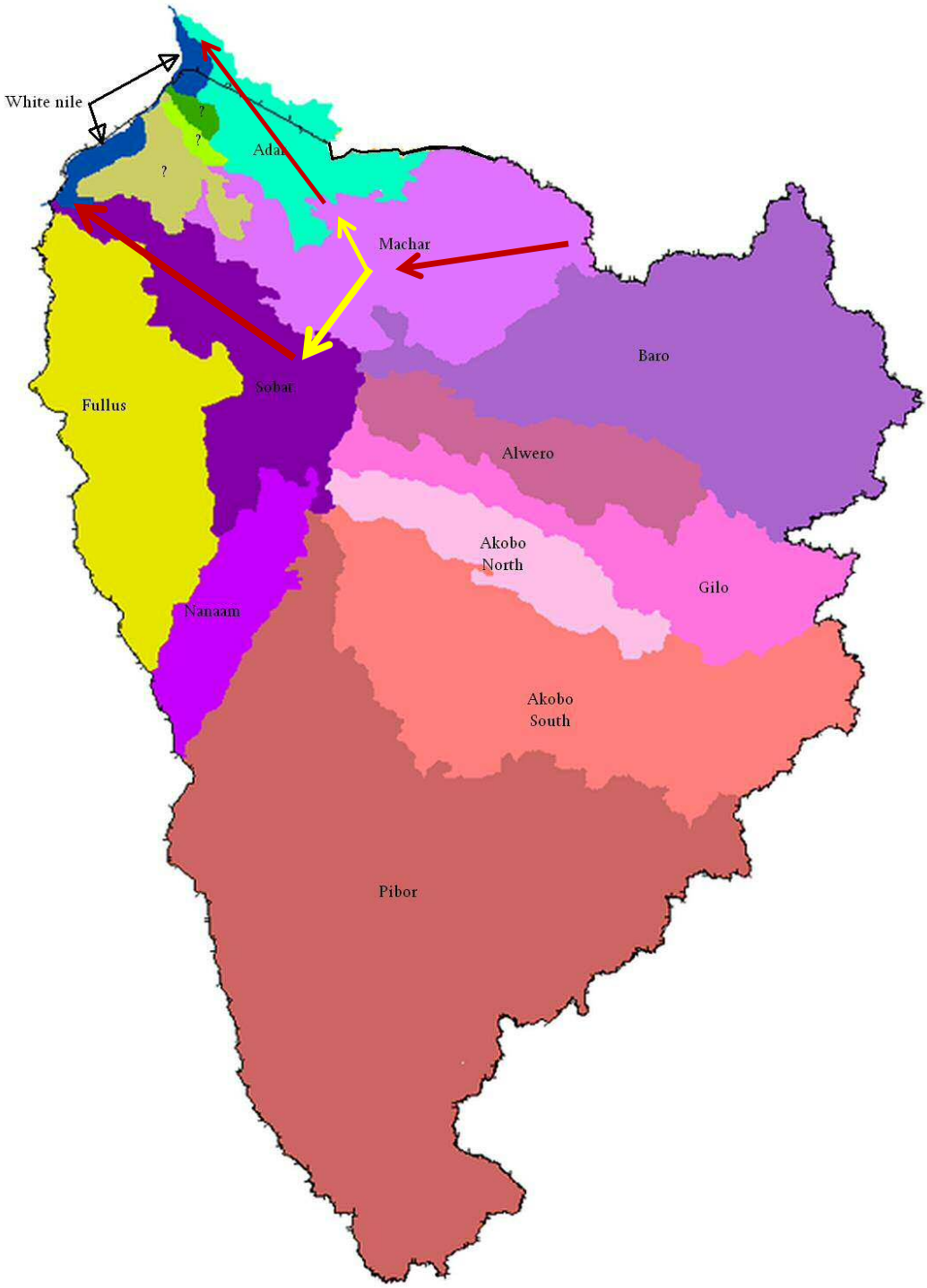


Figure 22: Burnt areas in violet on Landsat are dark on Sentinel radar image.

It is therefore important not to consider only the radar signal response, and to analyze the combination of all information: wet and dry radar images + Landsat image + network and basins. The remote sensing solution is able to indicate localization of river networks, basins delimitation and connections between basins. But this technology has its limits and sometimes require correlation of the results with field data acquisition (gauging stations, hydro meteorological stations etc.…). In the BAS study, major improvements are proposed in terms of understanding the basin river network but it remains impossible to confirm flow direction for several streams and to say when these connections are active, and if they are active throughout the year or not.

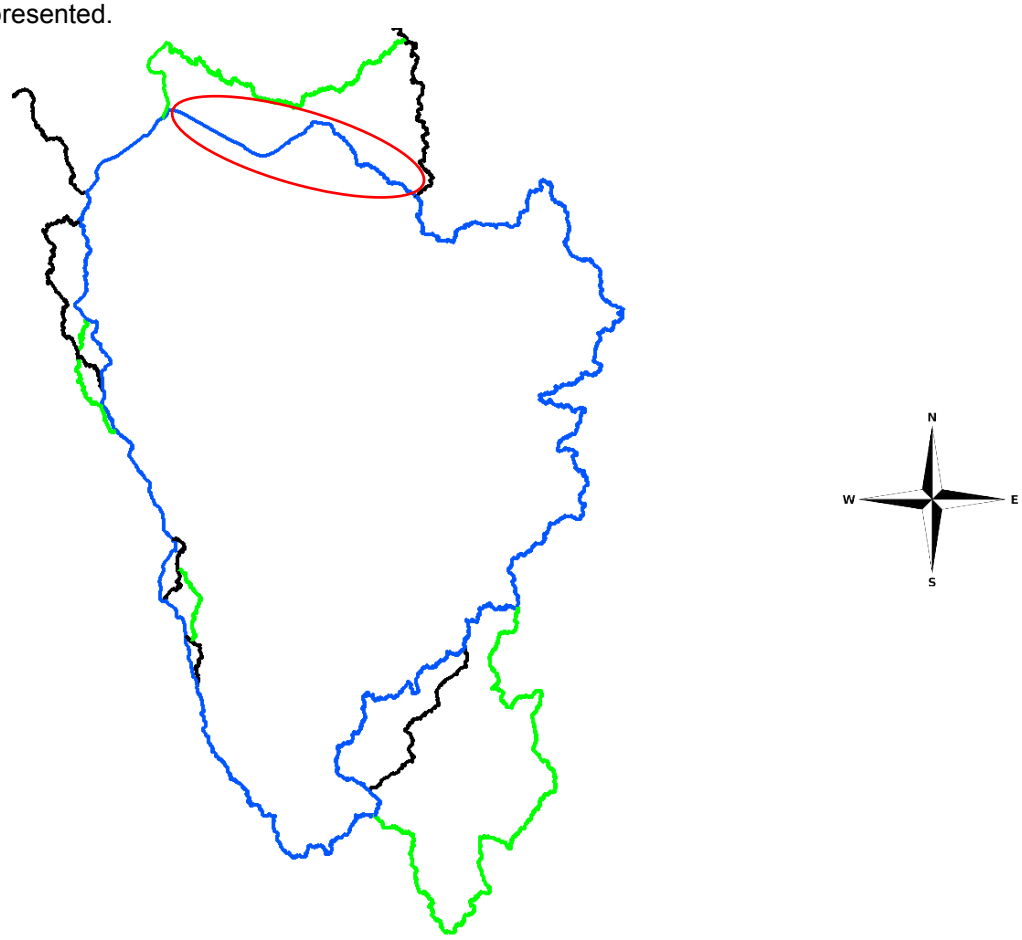


The conclusion of this analysis is that it is essential to remain cautious when assessing impacts of dams on downstream areas. The three basins (Adar – Machar – Sobat) are connected and we can formulate the hypothesis that the retention of a significant quantity of water could permanently close these interconnections and change the environment of this area.

Regarding the small basins without names beside the Nile, they can optionally be merged to the Nile basin (blue). They have been differentiated as their Strahler order was > 1.

5.3 BOUNDARIES OF THE BASIN

The boundaries vary from one source of information to another. On the illustration bellow, three versions are presented.



Black boundary is the BASWN limit used in previous studies (for example in the MSIOA);

Green boundary is based on the DEM analysis;

Blue boundary is a synthesis based on DEM and satellite observations except in the northern part where the limits correspond to the initial boundary of the project (red circle).

5.3.1 Focus on the South-west limit

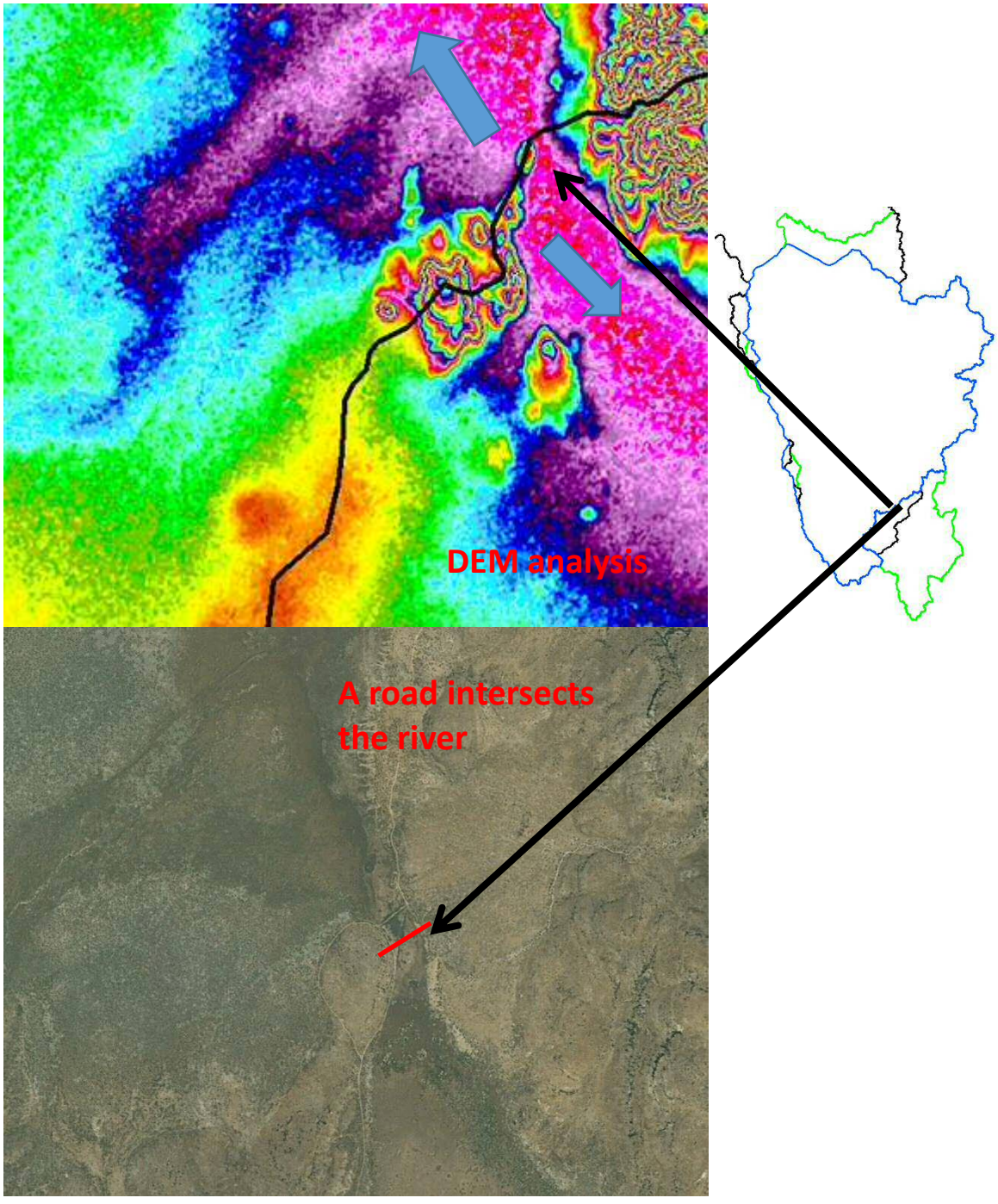
The differences in the western part are the result of low exploitable information. There is a lot of burning every year in this area which makes the analysis of images difficult and the identification of river network challenging. This difference is not really significant so the limit adopted (blue) includes the maximal area.

5.3.2 Focus on the North-west limit

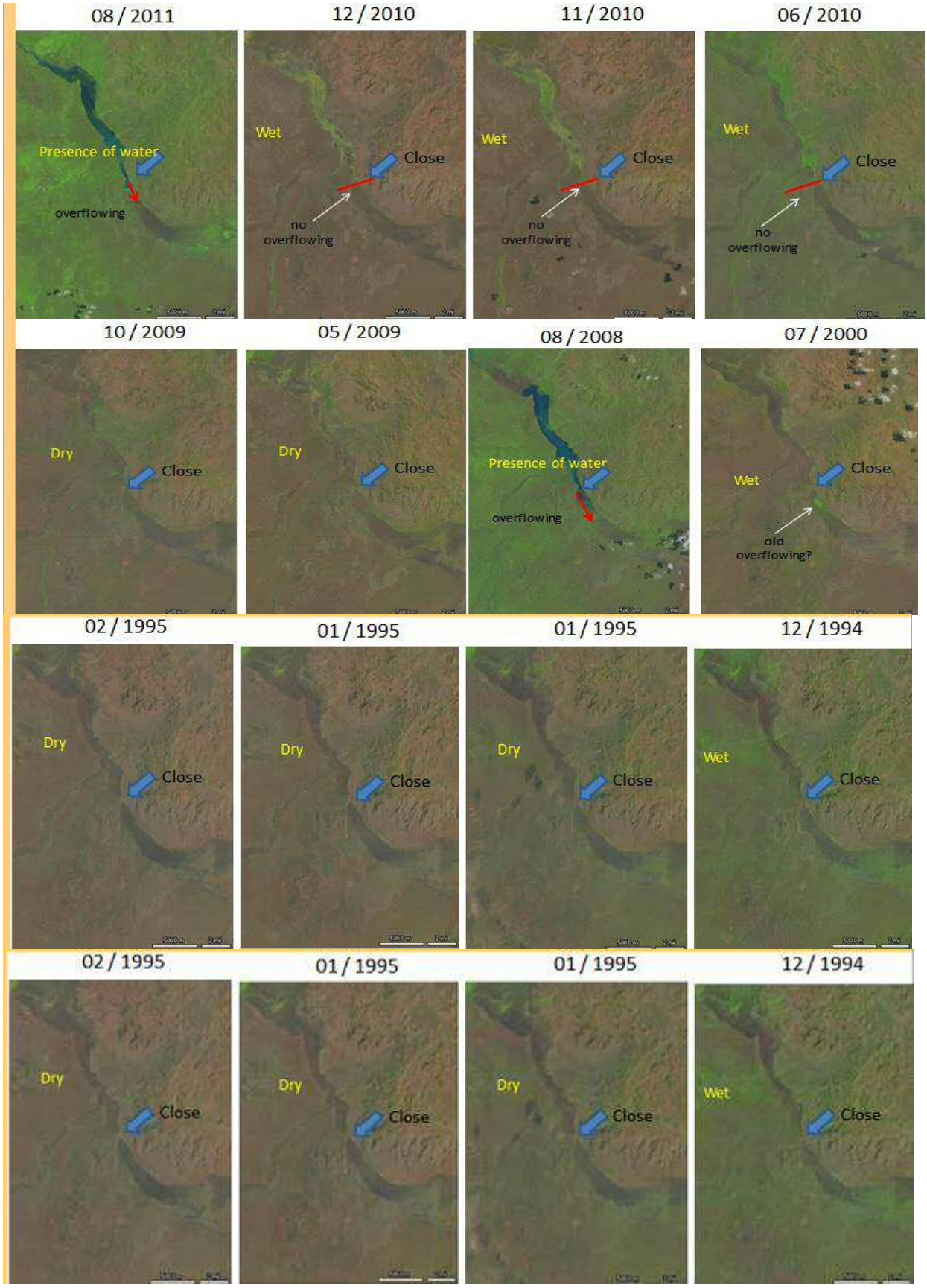
We modified this area because a clearly identifiable river, west of the blue limit, drains this zone directly to the Nile.

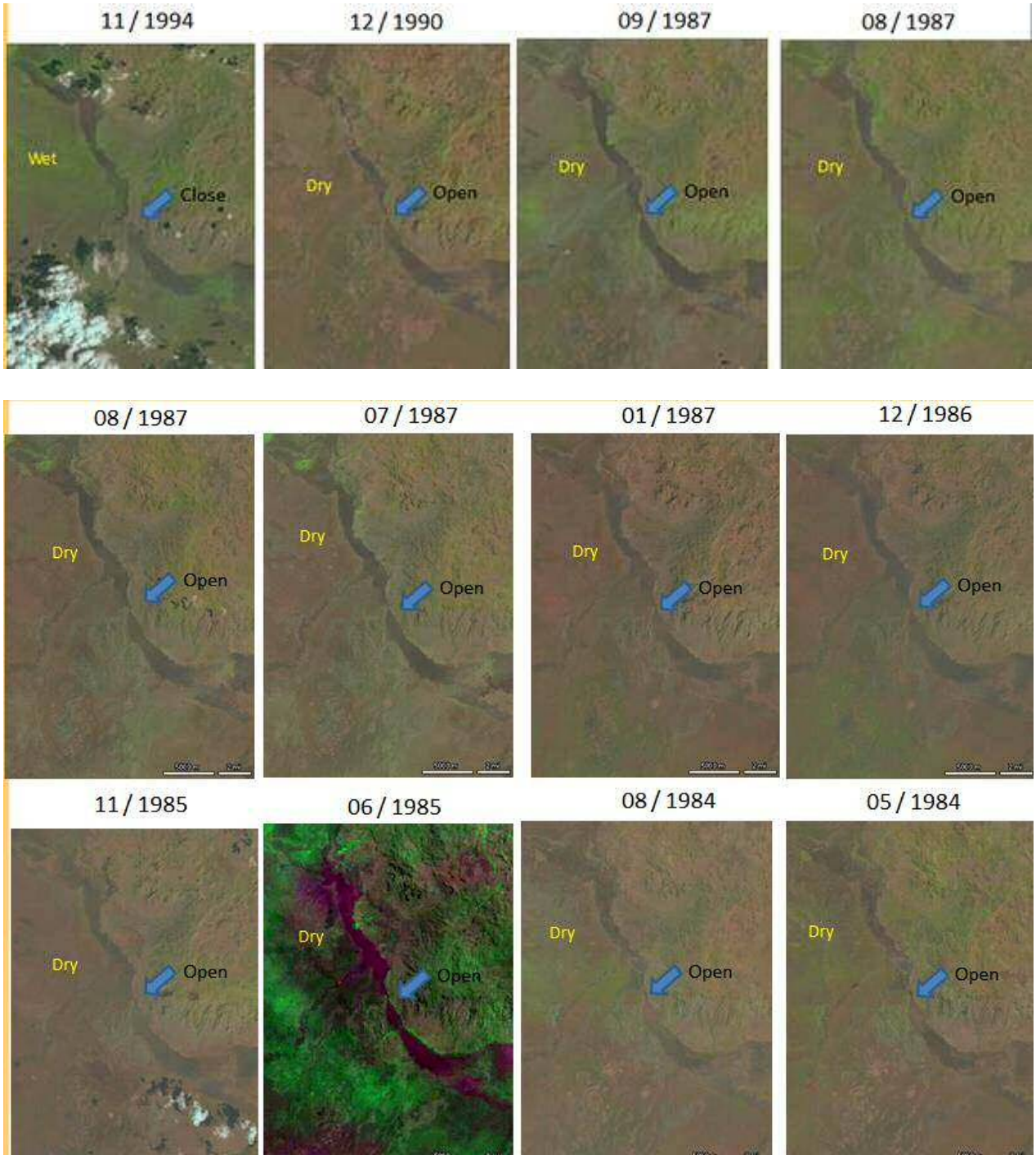
5.3.3 Focus on the South-east limit

The DEM analysis shows that the flow of the main river goes to north but that it can also flow to the south when the water level is high.



An historical analysis shows that the constricted area clearly visible with the DEM analysis was closed by a road between 1990 and 1994. Now, the flow can no longer go to the south except when the water height is very significant which means that there is an overflowing.


08 / 2011
Presence of water
overflowing
12 / 2010
Wet
Close
no overflowing
11 / 2010
Wet
Close
no overflowing
06 / 2010
Wet
Close
no overflowing
10 / 2009
Dry
Close
05 / 2009
Dry
Close
08 / 2008
Presence of water
overflowing
07 / 2000
Wet
Close
old overflowing?
02 / 1995
Dry
Close
01 / 1995
Dry
Close
01 / 1995
Dry
Close
12 / 1994
Wet
Close
02 / 1995
Dry
Close
01 / 1995
Dry
Close
01 / 1995
Dry
Close
12 / 1994
Wet
Close



This fact clearly explains why the boundary was the black boundary (on the map above) in the past, before construction of the road. We need to update this boundary (with the blue limit) in order to consider the modification of the flow due to the new infrastructure. Indeed, water flows southwards only in very rare exceptions, notably to unload excess water during heavy floods.

5.3.4 Focus on the Northern limit

GENERAL USE OF THE "MODULO" FUNCTION

A pallet of colors used to illustrate the DEM does not allow to see all details, for three different reasons:

- The human eye can hardly distinguish only 50 different colors,
- The total difference of levels from South-East to North-West is over 3000 meters; if we would use a 255 colors, palette, this would mean one color each 12 meters
- The total difference of level between South and North of the flat zones of the basin is only around 55 meters

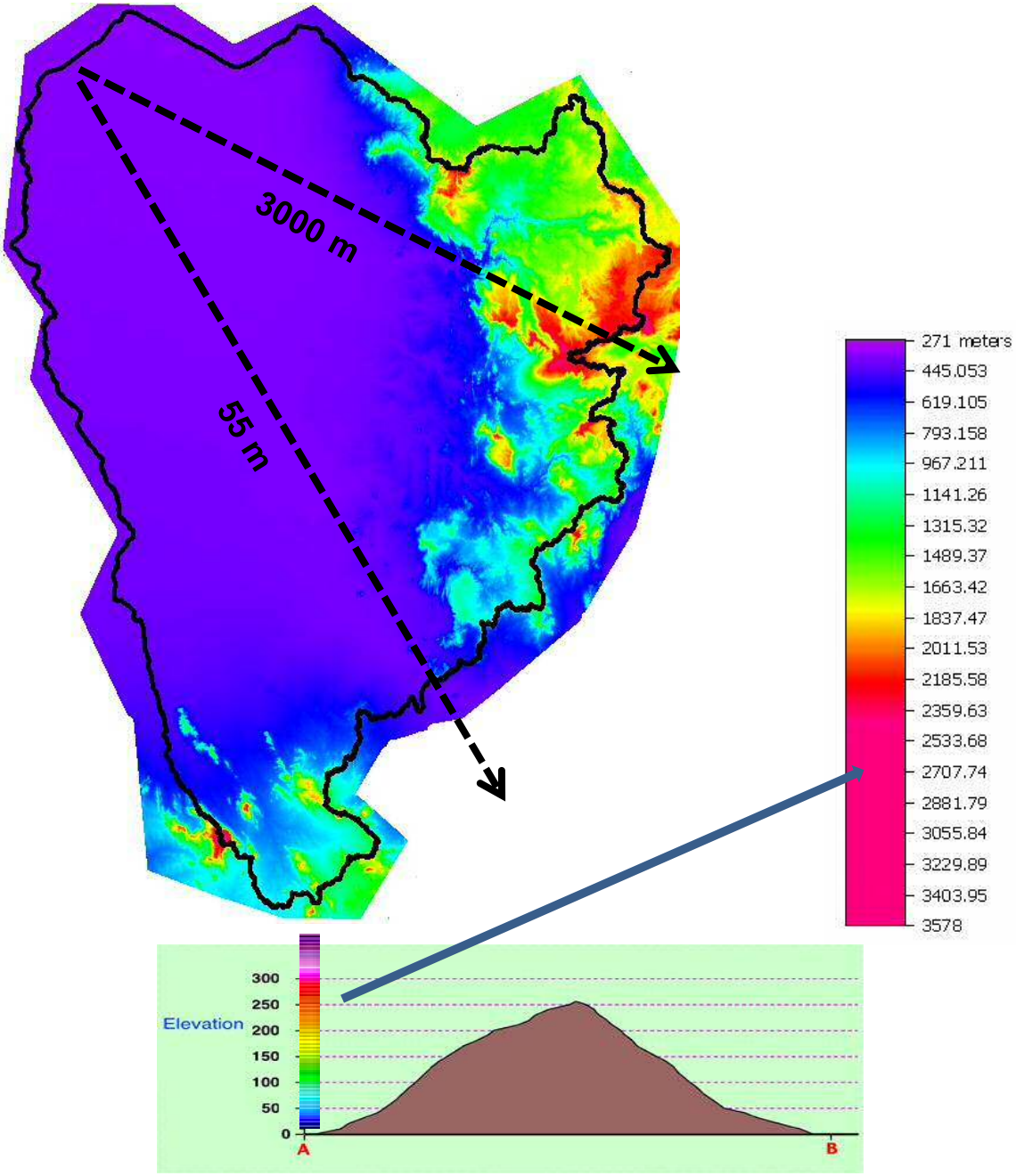


Figure 23: Example of a of 255 colors palette used on a DEM with 3300 meters difference of levels

The “modulo” function allows to transform the DEM from real altitudes to increments (variations) of altitude (here 50 meters). This allows to observe the detail of the DEM in flat zones, but is out of interest in highlands (high slopes).

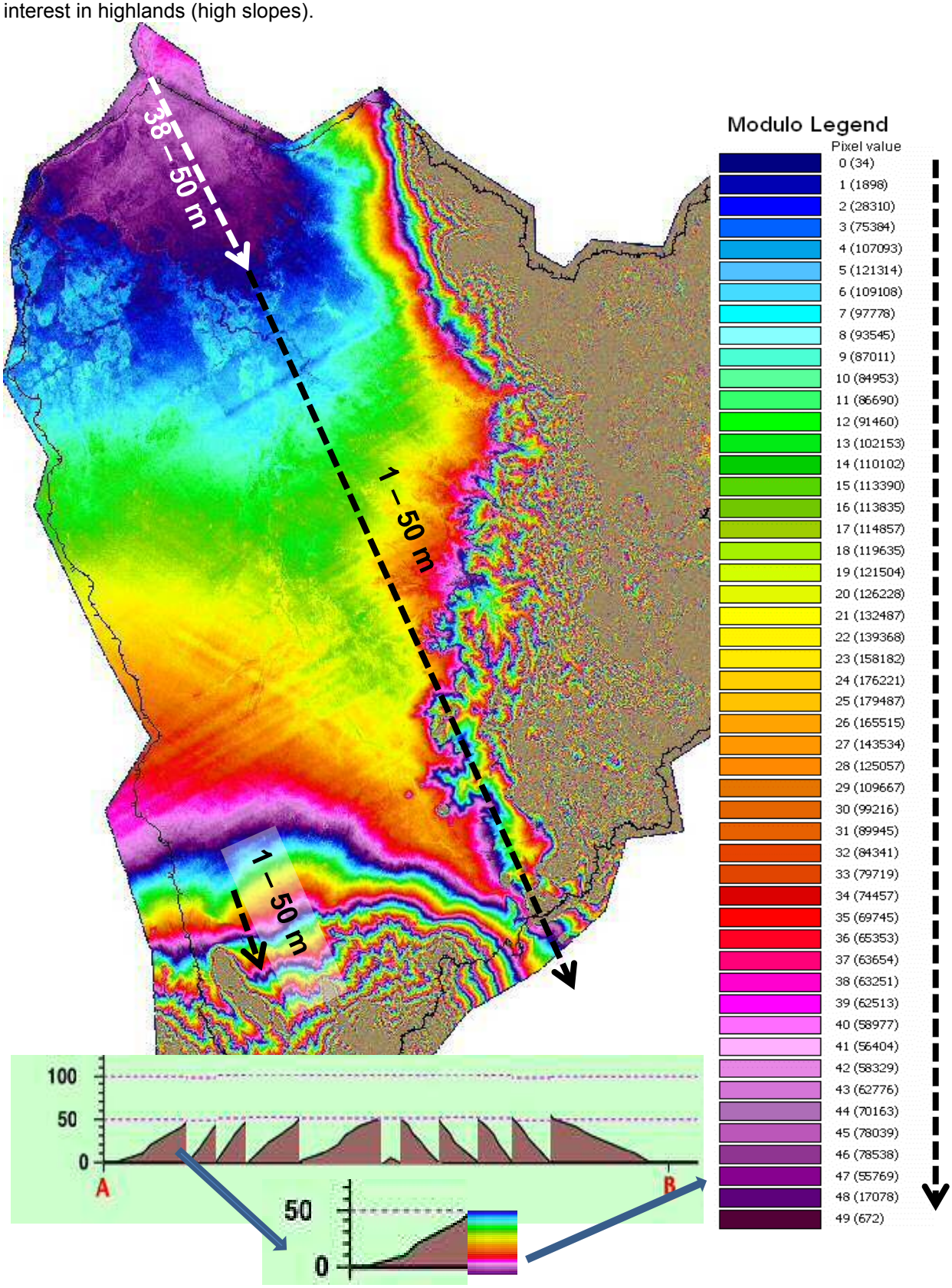


Figure 24: Example of a 50 colors palette used on the DEM as modified by the Modulo function

Processing like this, an artefact has been identified in the NASA DEM production; this is linked to crossed orbits of the shuttle during data acquisition. This artefact is visible under the form of long waves of very large extent, inhomogeneous, but with low difference of levels as can be seen on the following figure.

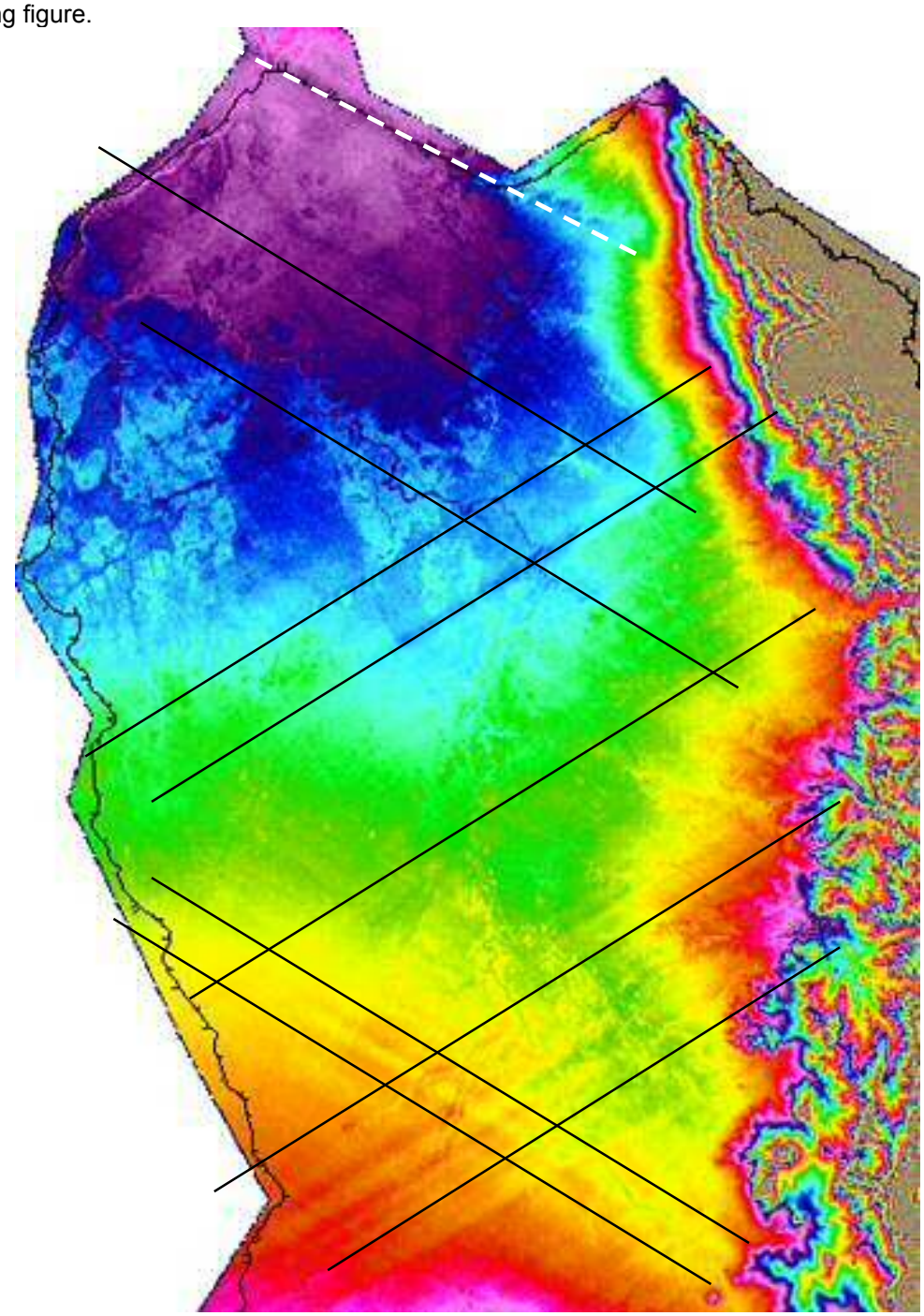


Figure 25: Artefacts on the DEM. One of them (white dot line) is remarkable because it is on the Northern boundary of the basin

Analyzing DEMs through automatic generation of hydrographic networks and watersheds for instance, are misled by this kind of artefact, because this consist in tracking the highest slopes from one pixel to the other, without taking into account this bias.

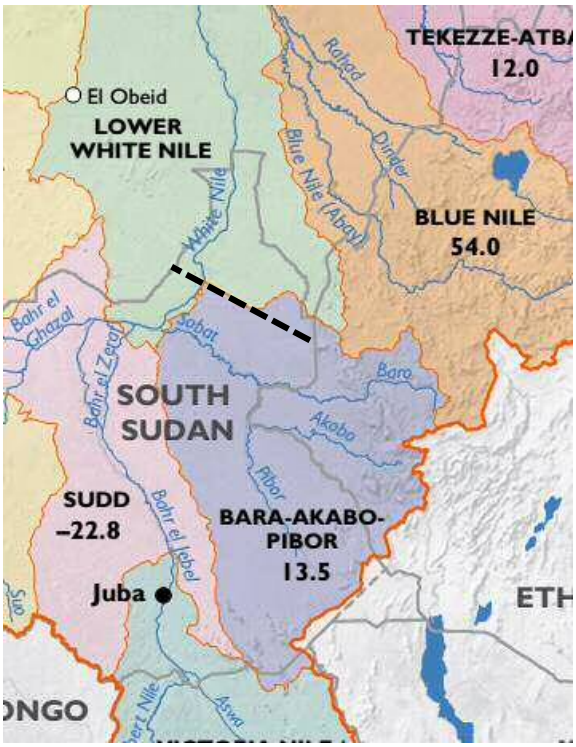


Figure 26: Example of Map of water catchment as found in the literature (State of the river Nile Basin - NBI, 2012)

We can notice immediately that the Northern limit of BAS basin comes directly from this artefact (doted black line), as it is a straight line. Therefore, during the remote sensing study, it appeared that this version is wrong and one part of the BAS basin was missing in the North.

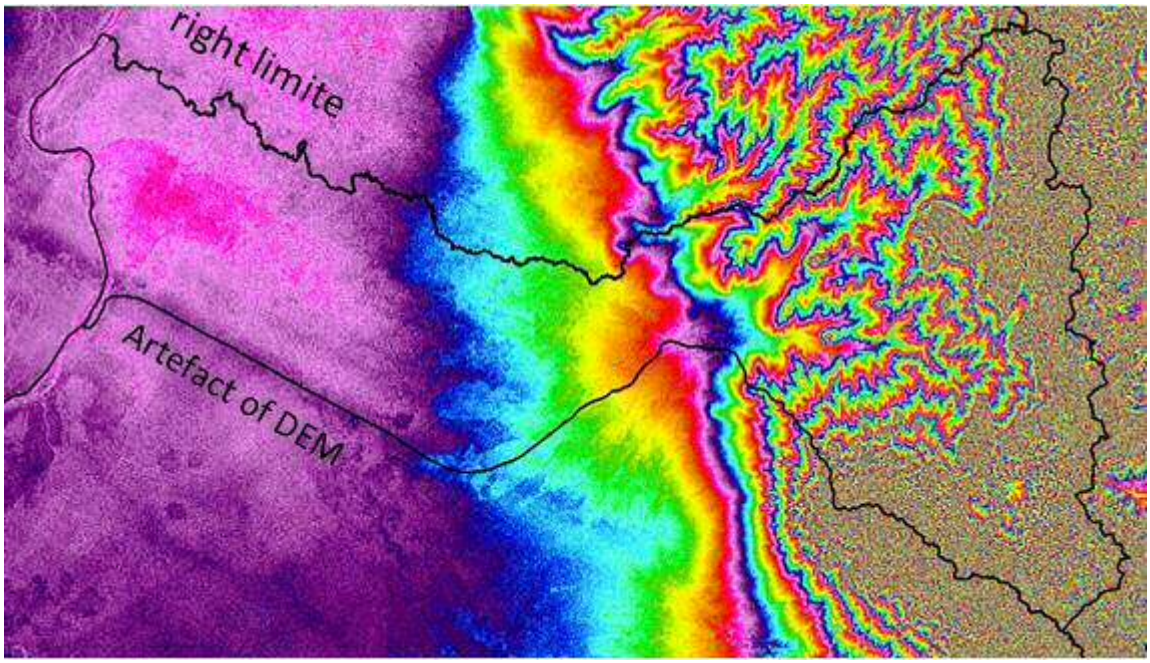


Figure 27: Potential real delineation of the BAS basin to the North

However, even considering this artefact, it keeps difficult to determine the real basin limit. Actually, we can notice that the newly proposed limit, is surprisingly parallel with the general direction of artefacts, and therefore a doubt remains on their influence.

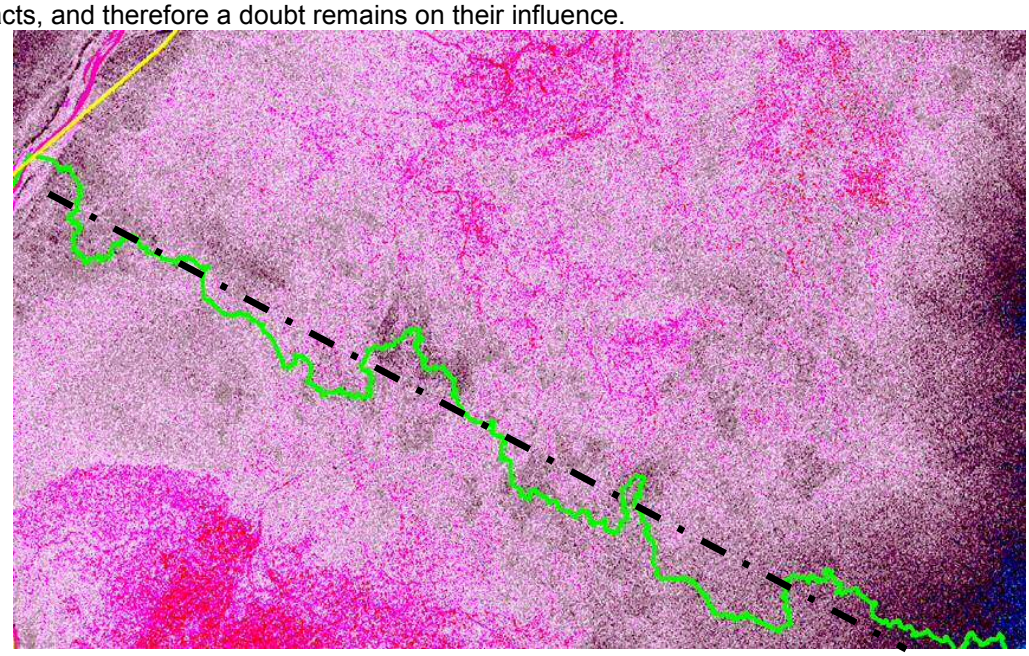


Figure 28: Correlation between supposed real limit (green) and the general direction of artefacts (doted).

Only a very accurate analysis of the satellite images will allow to confirm as far as possible this limit. In the image below, the probable limit is crossing a hydrographic network A (blue arrow), meaning that it is not correct at this position.

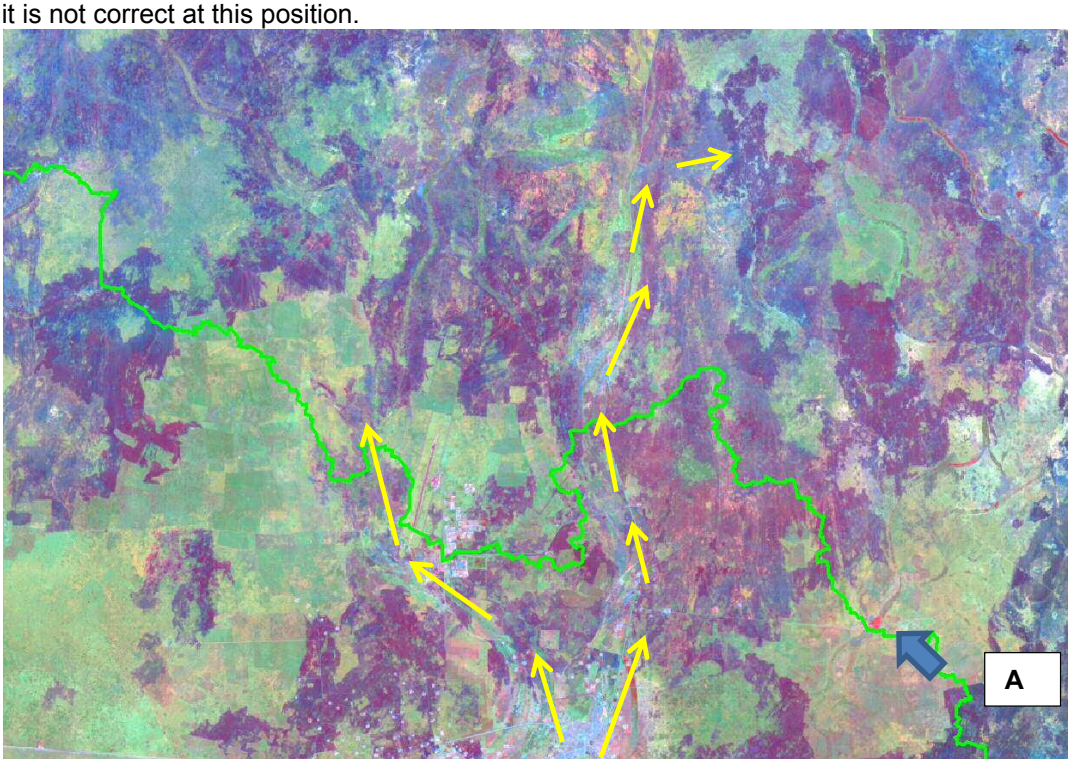


Figure 29: Detail of probable limit of BAS basin on background of Landsat 8 image

However, the image also reveals the presence of paleo networks (yellow arrows), which contribute to a difficult interpretation and therefore the real limit of the BAS basin. Unfortunately, radar imagery do not bring significant information on this spot, probably because of a very confusing land cover.

This area is very flat, and the DEM only cannot serve to determine the limit. On the contrary, a more accurate mapping (1/50,000 or 1/25,000) would allow to better understand the global hydrologic/hydraulic functioning and if one or several connections are to be considered in the BAS.

As already seen in other sub basins, interconnections are numerous between neighboring catchments, and it is possible that the A network (blue arrow) would be such a connection.

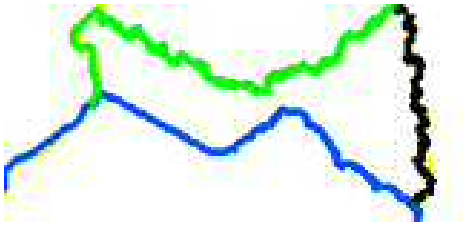
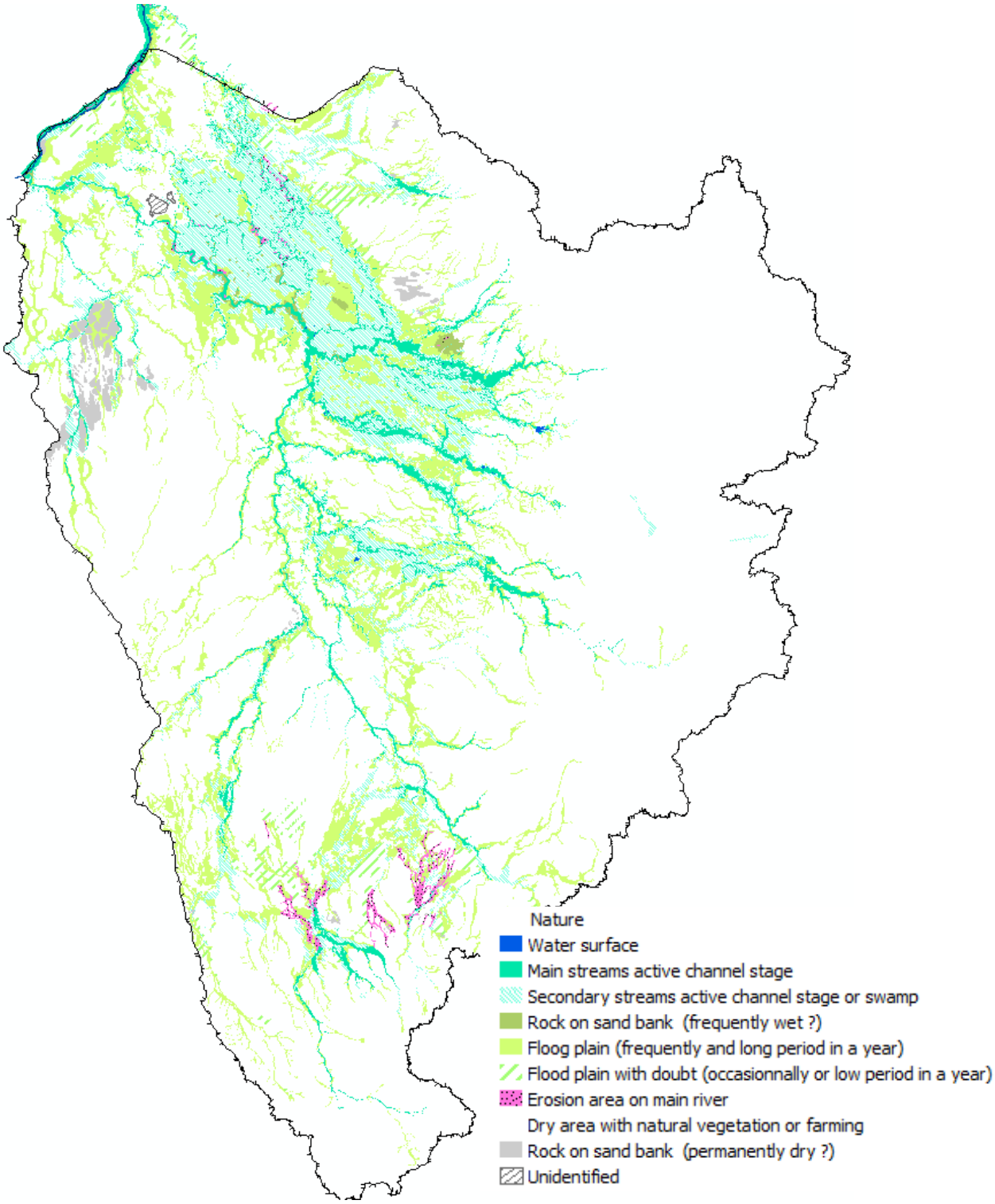


Figure 30: Possible limits for the Northern part of BAS basin (to be further investigated)

As a summary, it is quite difficult to find the final word regarding the real limit of the BAS basin. However, it is sure that the previous limit used is wrong.

5.4 FLOODED AREAS MAPPING

Mapping of flooded areas is based on the hydrographic network and satellite images (visible and radar) analysis at 1:100 000 scale.



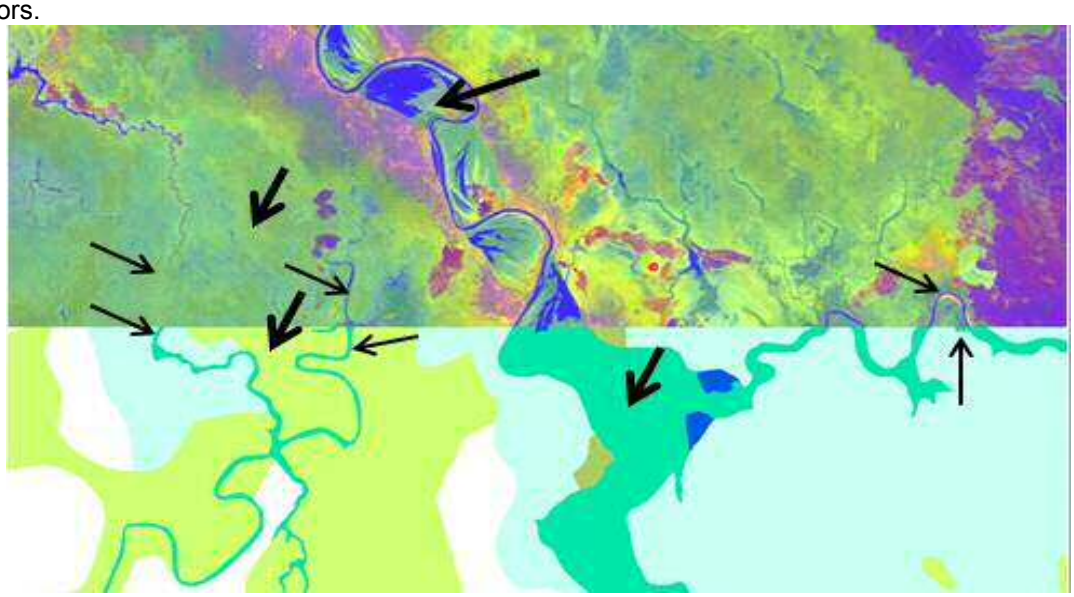
Due to non-exhaustive image data (only 2 years for Landsat at dry season, and only 1 year and two seasons for radar images) this mapping corresponds to an assessment of flooding areas. Indeed, flooding varies with intensity of rainfall each month and from year to year, so this map cannot be considered as exhaustive.

Based on available data, it was easy to delimit permanent or very often flooded areas but delimitation was more difficult for flooded areas limited at two or three months / year, or one to three times in a decade.

METHODOLOGY:

Presence of water is hard to determine on satellite image due to vegetation coverage. On visible images (Landsat) as on radar images (Sentinel), the water presence is not a direct information. The only case with no doubt (100%) is for open water without vegetation (floating vegetation or rooted).

The limit of active channel is quite easy to determine on Landsat image because the permanent water in soil is marked by dark colors. For other areas, we must introduce probability and interpolation factors.

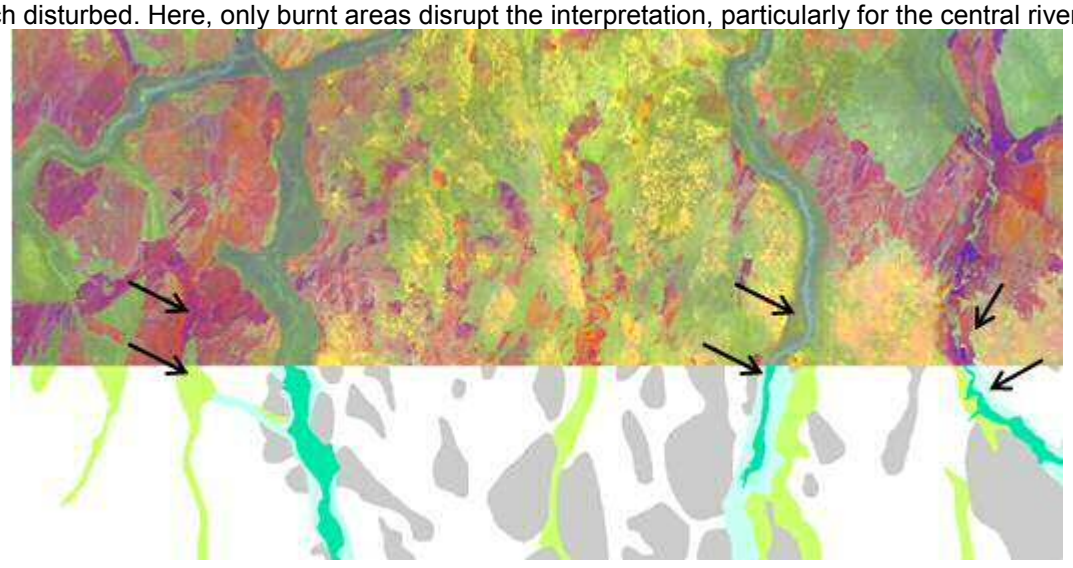


Some areas are easy to interpret. It is the case for marshes and main streams.

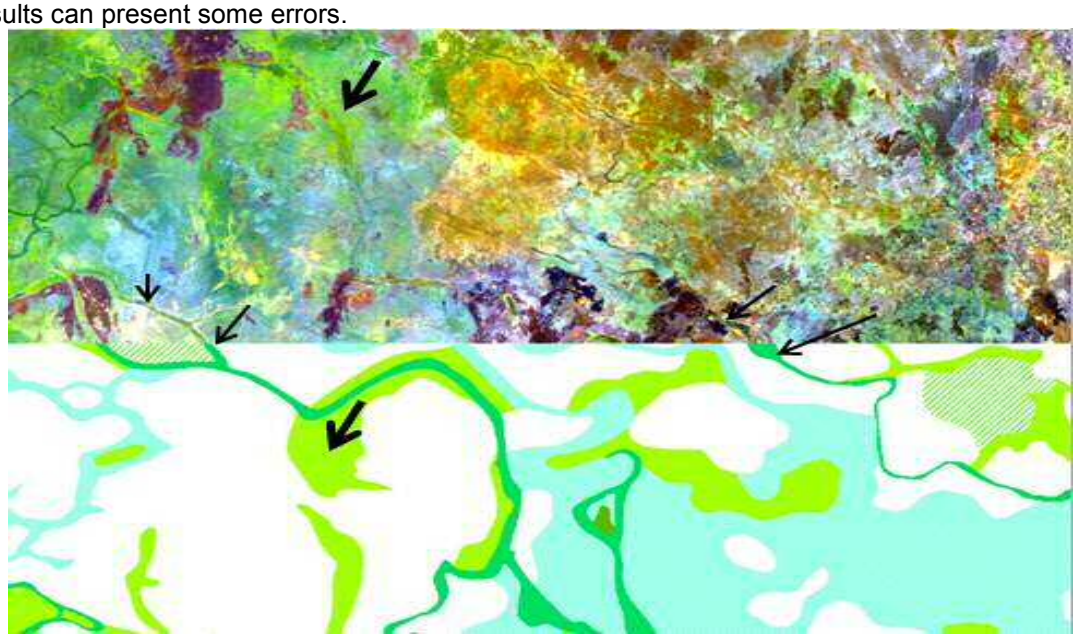
The example above shows (see arrows) the correlation between interpretation and Landsat image.

The flood plain (yellow-green) corresponds to areas frequently flooded in a year and for a long period. This information is generally completed by radar information. But, as we understand from examples A, B, C on page 23, this information is complex for interpretation and we chose to limit interpolation to obtain an accurate result with less supposition. There is therefore a possibility that these flooded areas are undervalued.

On the example below, the correlation is easy and relatively good when the area is simple and not much disturbed. Here, only burnt areas disrupt the interpretation, particularly for the central river.



In this zone, there are lots of disruptions due to burnt areas or differences of vegetation or altitude. Results can present some errors.



Annex 3: Rainfall stations selected in the Baro-Akobo-Sobat basin

ANNEX 3.1: 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
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

ID	Station name	Lat	Long	Source[1]	StartDate	EndDate	Accuracy[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
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

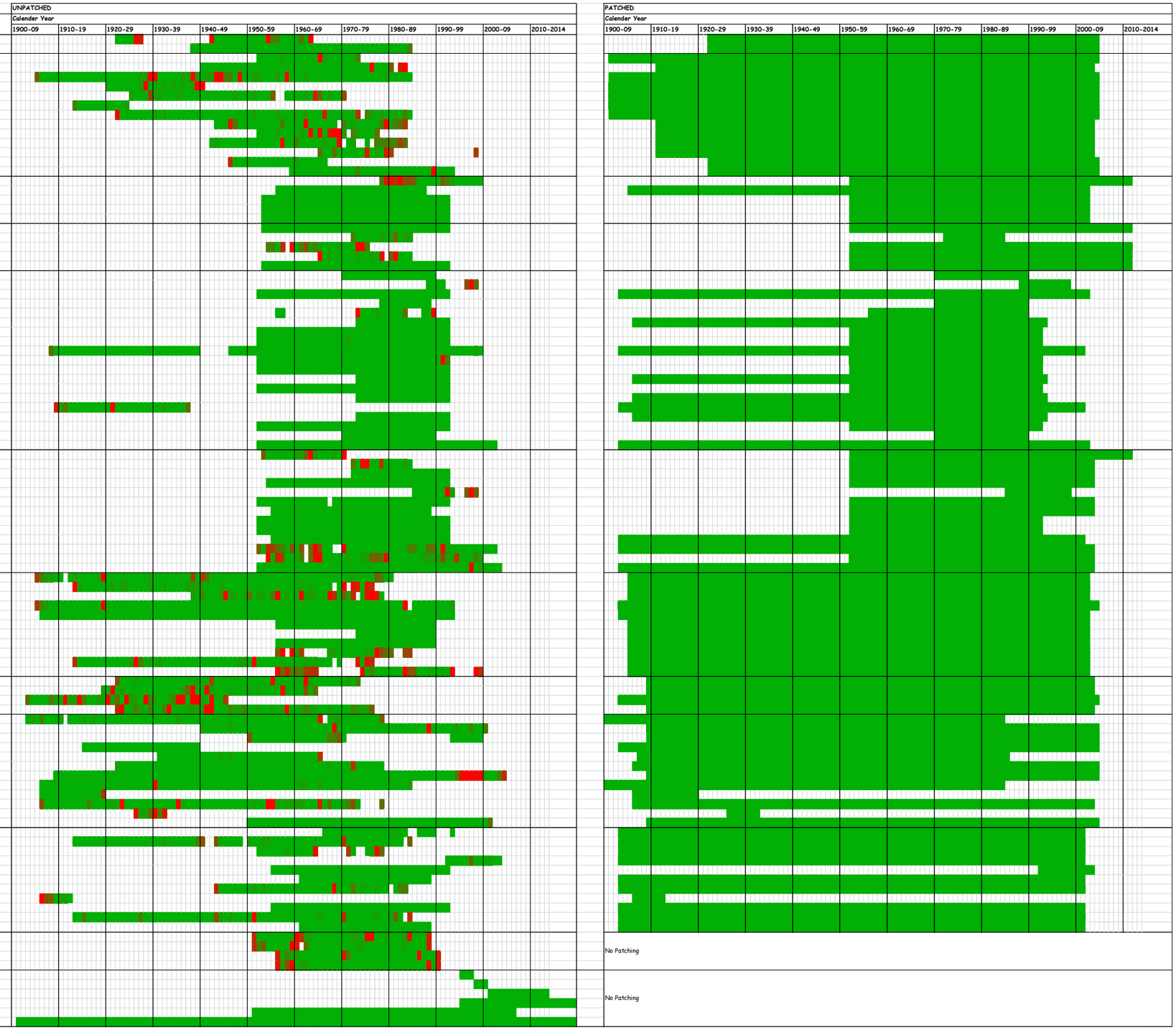
ID	Station name	Lat	Long	Source[1]	StartDate	EndDate	Accuracy[2]
96	Kitgum Centre VT	3.300	32.883	MWE	4/30/2014	9/30/2003	1
97	Atiak Dispensary.	3.267	32.117	MWE	1/31/1942	5/31/1977	2
98	Palabek Divisional Hqs	3.433	32.583	MWE	6/30/1939	2/28/1981	1
99	Padibe	3.500	32.817	MWE	1/31/1942	12/31/1983	1
100	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

ANNEX 3.2: 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
	2352Saiya	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		



No Patching

No Patching

Annex 4: 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