Nile Basin Initiative

Nile Technical Regional Office (ENTRO)
Nile Basin Initiative Trust Fund / IDA

EASTERN NILE TECHNICAL REGIONAL OFFICE

Eastern Nile Watershed Management Project

Cooperative Regional Assessment (CRA) for Watershed Management

TRANSBOUNDARY ANALYSIS
ABAY-BLUE NILE SUB-BASIN
FINAL

January 2007

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ANNEXES

ACRONYMS

ADLI	Agricultural Development Led Industrialization
ACT	African Country Almanac
AHD	Aswan High Dam
BS-GRS	Beneshangul-Gumuz Regional State
CBPWM	Community Based Planning and Watershed Management
CGIAR	Consultative Group for International Agricultural Research
CRA	Cooperative Regional Assessment
CSA	Central Statistical Office
CV	Coefficient of variation
DTM	Digital terrain Model
DIFID	Department for International Development
ENSAP	Eastern Nile Subsidiary Action Programme
ENTRO	Eastern Nile Technical regional Office
ETB	Ethiopian Birr
FAO	Food and Agricultural Organization
f.o.b.	Foreward on Board
FNC	Forest National Council
GAS	Gash Agricultural Authority
GEF	Global Environmental Fund
GIS	Geographic Information System
HCENR	Higher Council for Environment and Natural Resources
HELP	Hydrology for Environment, Life and Policy
IDEN	Integrated Development of the Eastern Nile
IDP	Internally Displaced Person
IFAD	International Food and Agricultural Development
IFPRI	International Food Policy Research Institute
IGADD	Inter Governmental Agency for Drought and Desertification
ILO	International labour Organization
ILRI	International Institute for Livestock Research
IUCN	International Union for Conservation of Nature and Natural Resources (World Conservation Union)
JAM	Joint Appraisal Mission
JIT	Jonglei Investigation Teak
JMP	Joint Multipurpose Programme
km	Kilometre
km^2	Square kilometre
km^3	Cubic kilometer (1 billion m^3)
MARD	Ministry of Agriculture and Rural Development
masl	Meters above sea level
MWR	Ministry of water Resources
MOPED	Ministry of Planning and Economic Development
MCM	Million Cubic Meters

MW	Mega Watt
MERET	Managing Environmental Resources to Enable Transitions to More Sustainable Livelihoods
MIT	Massachusetts Institute of technology
N	Nitrogen
NBCBN – RE	Nile Basin Capacity Building Network – River Engineering
NBI	Nile Basin Initiative
NCS	National Conservation Strategy
NGO	Non-government Organization
NSWO	New Sudan Wildlife organization
NTEAP	Nile Transboundary Environmental Assessment
NTFP	Non Timber Forest Product
ORNL	Oak Ridge National Laboratory
RFPA	Regional Forest Priority Area
SDIT	Southern Development Investigation Team
SDR	Sediment Delivery Ratio
SLM	Sustainable Land Management
SMF	Semi-Mechanized Farm
SNNPRS	Southern Nations, Nationalities and Peoples Regional State
SRTM	Shuttle Radar Terrain Mission
SWC	Soil and Water Conservation
SWHISA	Sustainable Water Harvesting and Institutional Strengthening Project
t	ton
UNDP	United Nations development Programme
UNEP	United Nations Environmental Programme
UNSO	United Nations Sudano-Sahelian Organization
USAID	United States Agency for International Development
USLE	Universal Soil Loss Equation
WB	World Bank
WBISPP	Woody Biomass Inventory and Strategic Planning Project
WM	Watershed Management
WUA	Water Users Association

ACKNOWLEDGEMENTS

This Trans-boundary Sub-basin Report has benefited considerably from written comments and recommendations received from the three National Steering Committees, the World Bank and ENTRO.

The Consultants wish to acknowledge and express their sincere appreciation to the three national Steering Committees, World Bank Staff members and ENTRO Staff members for their very positive comments and recommendations on the four Transboundary Analysis Sub-basin Reports.

EXECUTIVE SUMMARY

The Transboundary Analysis component comprises an integrated, cross-border analysis of the watershed system in order to identify the main watershed characteristics and watershed challenges in each of the Sub-basins and the opportunities and benefits of cooperation in watershed management. This Report examines the Abbay-Blue Nile Sub-basin. The analysis has been undertaken in five stages:

- National level analysis for the agreed Sub-basins;
- Regional Workshop to assure interaction between the national level activities and foster a regional understanding of common issues;
- Consolidate the three national level analyses into a system-wide analysis of issues and opportunities to improve livelihoods;
- Identify additional benefits of cooperation in watershed management by identifying potential additional cross-border positive and negative impacts of watershed related interventions;
- Distil from the system-wide analysis the greatest system-wide opportunities for high impact cooperative watershed management.

The first two stages are complete. National level reports were produced for Egypt, Ethiopia and Sudan. These were considered at a Regional Workshop held in Alexandria, Egypt from 24th-26th July 2006 and subsequently revised in response to comments received from the three National Coordinating Committees, ENTRO and the World Bank. This report constitutes the results of the last three stages.

The Abbay-Blue Nile Sub-basin covers an area of 311,548 km^2. This sub-basin extends from the western Ethiopia to the lowlands of Sudan, meeting the Main Nile at Khartoum. The Dinder and Rahad rise to the west of Lake Tana flow westwards across the border joining the Blue Nile below Sennar.

Chapter 2 provides an understanding of the basin-wide bio-physical and socio-economic situation. Chapter 3 examines the basin-wide watershed management issues. It first examines the land policy issues in both Ethiopia and Sudan. It Ethiopia although land registration is proceeding, it has adopted a narrow focus and has not seized the opportunity to link land tenure security with land investment, poverty reduction and improved livelihoods. In Sudan the 1970 the Unregistered Land Act is seen as the root cause of land tenure problems and natural resource conflicts in the north.

In both countries devolution of power to regions and states is an avowed government policy. There is a complex institutional framework within which interventions must be coordinated for effective watershed management to operate. Ethiopia has draft legislation to establish River Basin Organizations whose purpose is to address these problems. In Sudan, whilst there is provision for Strategic Land Use Planning at the State level this has not been implemented.

The physical and technical issues are then examined, in particular the issues of sheet and gulley soil erosion, high sediment loads in the rivers and the consequent siltation of both small dams in the highlands, in the Roseires, Senner and Aswan High dams and in the canals of the Geizera-Managil and Rahad Irrigation schemes. Estimates are made of the reductions in agricultural production due to soil erosion and to breaches in soil nutrient cycles and loss of nitrogen and phosphorous. Estimates are made of the loss of land due to "kerib" gully erosion.

Chapter 4 looks at the opportunities for in-country and trans-boundary benefits from watershed management activities in a basin-wide perspective. Opportunities to reduce soil erosion, nutrient breaches, declining soil fertility and crop production and sediment loads are assessed and where possible quantified. Some potential negative impacts of substantial reductions in sediment load such as river bed and bank erosion are noted. The need to undertake a comprehensive surveyed of under or non-utilized large semi-mechanized farms is stressed and opportunities to revert these lands back to the State for redistribution to small-scale cultivators, agro-pastoralist and pastoralists are identified. It is stressed that this should be part of integrated strategic and community level planning and supported by a strengthened agricultural extension and research. In-country and trans-boundary benefits accruing to the watershed management interventions are identified and quantified.

Finally the trans-boundary analysis examines a number of opportunities for cooperative watershed management and other cooperative activities. A framework for analysis is presented that identifies four types of benefits: to the river (ecological), from the river (socio-economic), reducing costs because of the river (political-economic) and finally beyond the river (economic and social). Some potential modes of cooperation are identified: basin-wide information exchange on hydrology and land cover; coordinated basin-wide watershed management planning; synergies from outputs of the various CRA's and coordinating activities in a number of other international programmes; trans-boundary trade and economic development and potential positive interactions amongst the proposed interventions. A summary of cumulative benefits from watershed management interventions are provided in broad terms.

1. BACKGROUND

1.1 Introduction

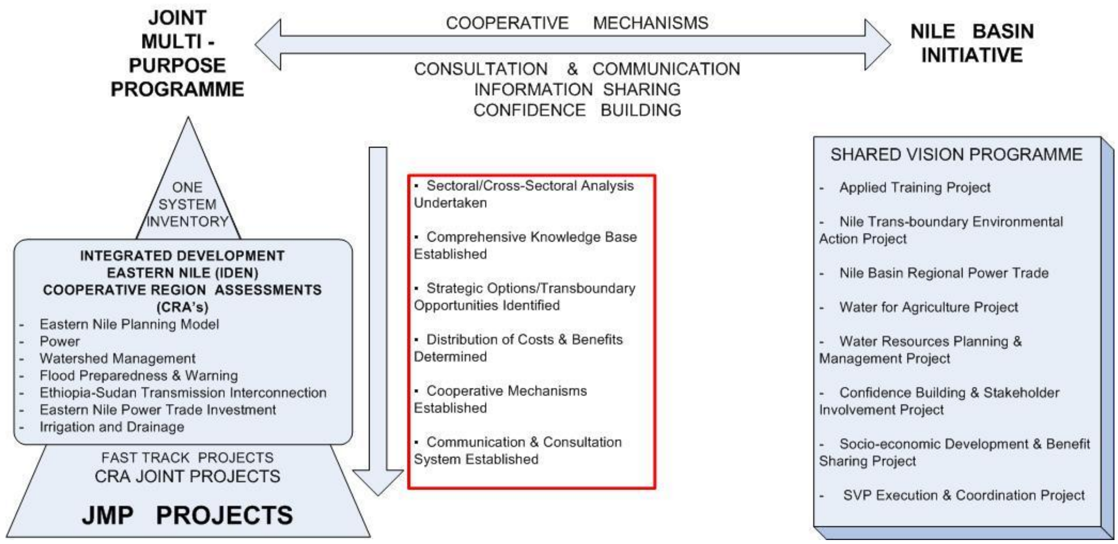
The Eastern Nile Basin Watershed Management Cooperative Regional Assessment (CRA) is in support of the Eastern Nile Subsidiary Action Programme (ENSAP). ENSAP, which includes Egypt, Ethiopia and the Sudan, seeks to initiate a regional, integrated, multi-purpose programme through a first set of investments. The first project under this initiative, referred to as The Integrated Development of the Eastern Nile (IDEN) comprises seven components:

- Eastern Nile Planning Model,
- Baro-Akobo Multi-purpose Water Resources Development,
- Flood Preparedness and Early Warning,
- Ethiopia-Sudan Transmission Interconnection,
- Eastern Nile Power Trade Investment
- Irrigation and Drainage
- Watershed Management

The results of the analyses of the sectoral CRA’s will be brought together in the design and decisions in a joint multi purpose programme (JMP) of interventions. The general elements of a CRA are (i) institutional strengthening, (ii) a participatory process for building trust and confidence, and (iii) to gain a transboundary understanding the watershed system from a basin wide perspective.

The results of the Watershed Management CRA will provide valuable input to the JMP planning. The CRA will highlight some of the major issues relevant to the JMP, identify transboundary benefits and develop long term cooperative arrangements for monitoring land use change, sediment loads and impacts on livelihoods.

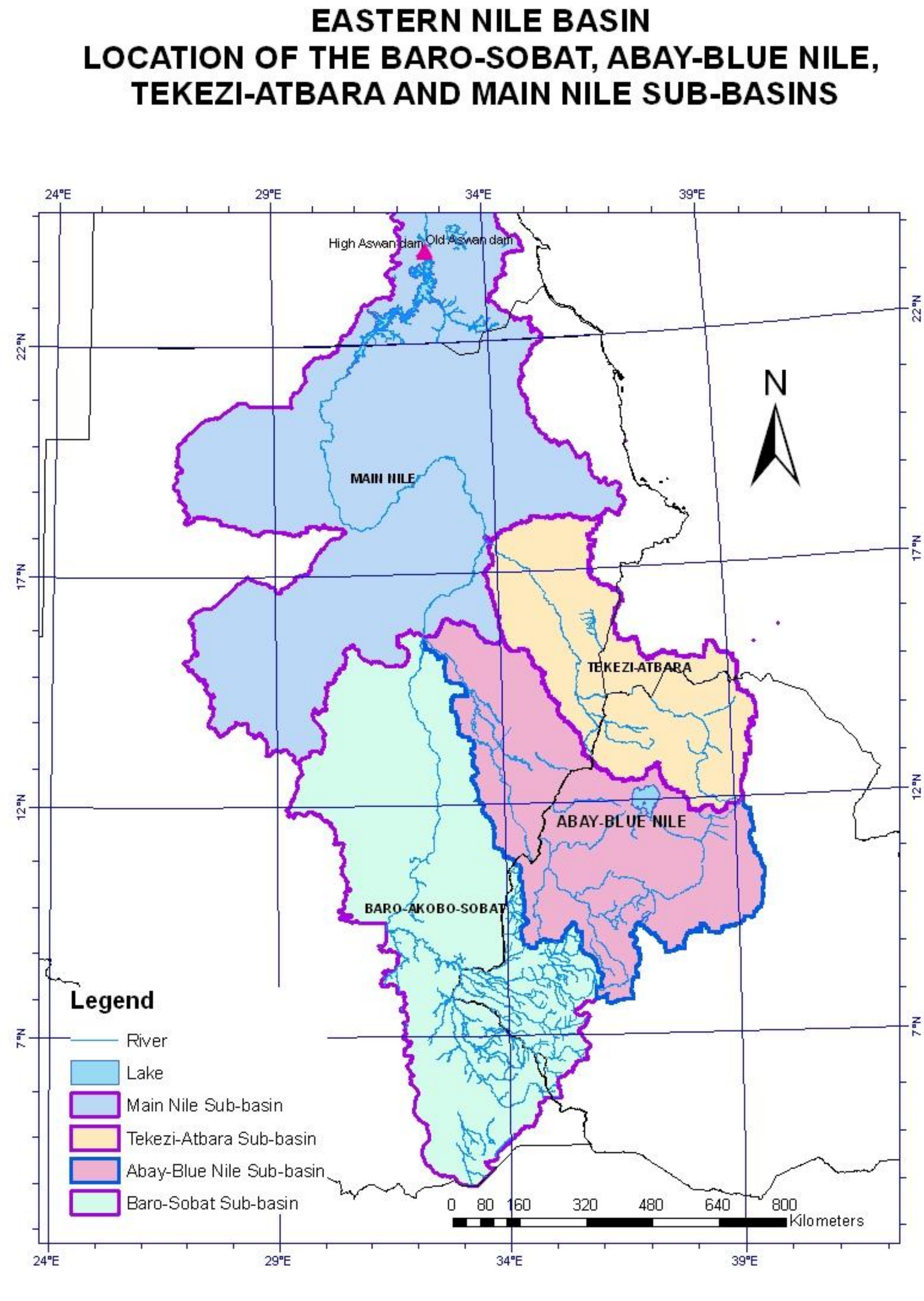
Figure 1. Relationships among and processes of the IDEN CRA's, the Joint Multi-purpose Programme and the Nile Basin Initiative's Shared Vision programme



1.2 Primary Objectives of the Watershed Management CRA

The project focuses on four watersheds: the Abbay/Blue Nile, Tekeze/Atbara, the Baro-Akobo-Sobat and the main Nile from Khartoum to the Aswan High Dam (Map 1). The primary objects of the Watershed Management CRA are to develop a sustainable framework for catchment management in order to:

- Improve the living conditions of all peoples in the three sub-basins
- Create alternative livelihoods
- Achieve food security
- Alleviate poverty
- Enhance agricultural productivity
- Protect the environment
- Reduce land degradation, sediment transport and siltation.
- Prepare for sustainable development orientated investments.



Map 1. Eastern Nile Basin: with the Tekeze-Atbara, Abbay/Blue Nile, Baro-Akobo-Sobat and the Main Nile Sub-basins.
Source: Basin boundaries: USGS/gtopo30/HYDRO30.

1.3 The Scope and Elements of Sustainable Watershed Management

1.3.1 Watersheds and River Basins

River basins, watersheds and sub watersheds and their hydrological processes operate in systemic way within a nested hierarchy but often in complex spatial and temporal patterns. For example, the linkages (or coupling) between vegetation cover, soil erosion (or soil conservation) and sediment yield at the micro-watershed level and the sediment load and sedimentation downstream at the macro-watershed level often do not have simple linear relationships. Terminology is generally based on area (although this is of necessity rather arbitrary).

Table 1. Watershed Management Units and Hydrological Characteristics

Management Unit	Typical area (km2)	Example	Degree of coupling
Micro-watershed	0.1 -5km^2	Typical watershed adopted by MERET interventions (Ethiopia)	Very strong
Sub-watershed	5 – 25km^2		Strong
Watershed	25 -1,000km^2		Moderate
Sub-basin	1,000 – 10,000km2	Guder, Anger	Weak
Basin	10,000 – 250,000km2	Abbay-Blue Nile	Very weak

After World Bank (2005)

In micro and sub-watersheds there is a strong coupling between the catchment area and the channel. Vegetation and land management practices closely control the runoff and the export of water, sediment and dissolved load into the stream channel. There is also a close coupling between groundwater and the river. In medium to large basins coupling between the catchment and the river is weak. The dominant process in basins of this size is transfer of material through the channel network and there is often temporary storage of sediment. Thus, the channel acts as a conveyor belt intermittently moving pulses of sediment during flood events. There is additional sediment from stream bank erosion and drifting sand.

1.3.2 Approach Adopted to the Eastern Nile Watershed Management CRA

> ***" In view of the multi-sectoral nature of the problem (land degradation, fuelwood demands, population pressures, illiteracy, lack of alternative sustainable livelihoods, etc.) a comprehensive and integrated approach is required, as traditional watershed management actions, in this case, would treat the symptoms, as opposed to address the root causes which lead to the spiral of degradation and poverty.***

> ***The preparation of an integrated watershed program in the Eastern Nile region will require a holistic approach and interaction between national level and regional studies through a Cooperative Regional Assessment (CRA)."***

(Terms of reference: Cooperative Regional Assessment in Support of the Eastern Nile Watershed Management Project.)

Clearly, the approach to be adopted in developing a framework for watershed management for the Eastern Nile Basin needs to be very broad in order to address a wide-range of objectives based on stakeholder perspectives across multiple levels and countries. The objectives to be addressed go beyond developing and conserving land, water and vegetation in the four sub-basins in the three countries. They include but are not limited to:

- Improving the management of land and water, their interactions and externalities;

- Linking upstream and downstream areas, and integrating environmental concerns with economic and social goals;

- supporting rural livelihoods by linking interventions in other "non-watershed" sectors (e.g. health in pond development, training in non-farm employment activities);

- addressing equity and gender concerns in the distribution of costs and benefits of watershed interventions (e.g. positive and negative externalities at various levels);

- identifying opportunities for incremental benefits accruing to cross-border coordinated interventions, including those being developed for the other IDEN CRA's and the Joint Multi-purpose programme (JMP);

- identifying global benefits (e.g. conservation of tropical forests, biodiversity and carbon sequestration) that accrue from national and regional level interventions.

At the same time it will be important to maintain a "Watershed Perspective". This is necessary to avoid loosing focus on the unique upstream-downstream characteristics of watersheds and river basins. Maintaining such a perspective will avoid the danger of the analysis failing to develop a "system-wide" understanding of the basin-wide issues and thus the identification of transboundary opportunities to improve livelihoods and achieve poverty reduction. Finally, a Watershed perspective will enable the identification of basin-wide synergies from cooperative transboundary interventions.

Another essential element of the Watershed Management CRA approach that distinguishes it from many Watershed Management approaches is the "Regional Process": i.e. building capacity, trust and confidence among riparian stakeholders. This is being made operational through a continuous process of regional stakeholder consultation.

FAO[1] (2006) has undertaken a review of lessons learnt from decades of Watershed Management Programmes and outlined a new approach to watershed management that is emerging from the "Integrated Watershed Management" approach that has served the past two decades. The review of lessons learnt identified a fundamental dilemma about integrated watershed management programmes and sustainable development processes:

- Should watershed management programmes incorporate sustainable development objectives by providing benefits and services that are not directly related to natural resource management? or
- Should they be embedded in broader sustainable development processes, by ensuring that sustainable development considers land and water issues?

The first option referred to as "programme-led" integrated watershed management has prevailed often because of insufficient coverage by line agencies. Embedded watershed management focuses on those aspects of sustainable livelihoods that are directly linked to natural capital assets. Other elements that are relevant to sustainable development – off-farm livelihood diversification, education, health, etc – are less relevant to watershed management programmes. Partnerships between watershed management programmes and other institutions working on livelihood, poverty alleviation, land reform, education, and health issues make it easier to address environmental and social issues effectively.

The new approach termed "Embedded Watershed Management" differs in a number of important ways from the previous approach. These are outlined in Box 1.

[1] Undertaken in collaboration with the European Observatory of Mountain Forests, International Centre for Integrated Mountain Development, Red Latinoamericana de Cooperacion Tecnica en Manejo de Cuenncas Hidrograficas and the World Agroforestry centre.

Box 1. Comparison between (programme led) Integrated and Embedded Watershed Management

Integrated Watershed Management	Embedded Watershed Management
Environment and Social issues are strictly related and cannot be addressed separately.	Most watershed problems are related to socio-economic issues, but there is always scope for measures and actions that specifically address environmental issues.
Watershed management programmes should have a sustainable development mandate and aim at both natural resource and sustainable livelihood goals.	The mandate and goals of watershed management programmes should focus on natural resource management **FOR** sustainable livelihoods and development.
Integrated programmes to address environmental and livelihoods issues comprehensively should be developed.	Sectoral programme focussing on watershed natural capital assets should be developed. Issues that are not related to natural resource capital should be addressed in collaboration with other programmes or institutions.

Along with integration, "participation" has been another essential attribute of watershed management practice for more than 20 years. However, it now clear that beneficiaries (people, communities) are not the only important actors in participatory watershed management. Collaboration between watershed management programmes and stakeholders (including downstream interest groups and countries) at many levels is now seen as essential. This shift is linked to the administrative decentralisation process that many countries have adopted in past decade. The differences between the two approaches are set out in box 2.

Box 2. Comparison between Participatory and Collaborative Watershed Management

Participatory Watershed Management	Collaborative Watershed Management
Focuses on communities and people and targets grassroots social actors: households and small communities.	Focuses on civil society and targets a variety of social and institutional actors, including local governments, line agencies, enterprises as well as technical experts and policy makers.
Based on assumption that sound natural resource management is a public concern shared by all social actors.	Based on the recognition that stakeholders have particular – sometimes contrasting – interests in natural resources, which need to be accommodated.
Seeks (claims) to make decisions through bottom-up process, by which grassroots aspirations are progressively refined and turned operational action.	In decision-making, seeks to merge stakeholders aspirations and interests with technical experts recommendations and policy guidelines through a continual two-way (bottom-up and top-down) negotiation process.
Centred on watershed management with local government assisting.	Centred on local governance process, with the watershed management programme acting as facilitator and supporter.
Aimed at creating a consensus, presuming that conflict can be solved through dialogue and participation.	Aimed at managing social conflicts over natural resources, based on awareness that dialogue and participation can mitigate conflicts but not solve them structurally.

Most government and donor funded watershed management programmes follow a clearly defined project logical framework specifying what has to be achieved and how. Objectives, outputs and activities are defined during identification and formulation stage, often based on limited information. This planning approach is not compatible with the new approach to watershed management, which requires greater flexibility in programme design.

Strategic watershed planning needs to take into account different temporal and spatial scales and accept a degree of uncertainty. It can be implemented at scales ranging from small upland watershed to entire trans-boundary river basins. Whilst small-scale projects have the advantage of face-to-face interaction with stakeholders they have limited impact at the watershed or river basin level. The design and operation of local programmes must consider upstream-downstream linkages and a methodology for multi-level watershed, sub-watershed and micro-watershed planning needs to be developed. Scaling-up of successful local experience is critical for the new generation of watershed management programmes.

1.4 Purpose and Scope of the Transboundary Analysis and its relationship to the Distributive Analysis

1.4.1 The Whole process

The National and Sub-basin Transboundary component and the Distributive Component form a sequential set of analyses each building upon and contributing to the next. The three sets of Reports when completed will form a whole.

The National level analysis includes (i) a review of successful experiences of interventions to address watershed interventions (with a specific view of approaches aiming at improved livelihoods); (ii) stakeholder consultations in selected relevant locations; (iii) a detailed problem and solution analysis for each watershed for current trends in land degradation; (iv) a discussion on policy and institutional issues conducive as well as hindering successful interventions on the national level; and (v) an outline of the long-term capacity building and monitoring needs to evaluate successes/impacts of interventions on the watershed on local livelihoods, agricultural output and sedimentation control.

The Country-level trans-boundary analysis provided a "with borders" view whilst the Sub-basin-level analysis provides a “without borders” view of the watershed system and associated livelihoods. The analyses identify opportunities for increasing the net benefits of watershed management interventions in the basin. The Distributive Analysis component will then reinsert borders, to analyze the distribution of costs and benefits that will accrue across countries under alternative watershed management intervention scenarios.

1.4.2 Transboundary Analysis Component

The Transboundary component comprises an integrated, national and a cross-border analysis of the watershed system in order to identify the main watershed characteristics and watershed challenges in each of the Sub-basins and the opportunities and benefits of cooperation in watershed management. The analysis is being undertaken in five stages:

- National level analysis for the agreed Sub-basins;
- Regional Workshop to assure interaction between the national level activities and foster a regional understanding of common issues;
- Consolidate the three national level analyses into a system-wide analysis of issues and opportunities to improve livelihoods;
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The first two stages are complete. National level reports were produced for Egypt, Ethiopia and Sudan. These were considered at a Regional Workshop held in Alexandria, Egypt from 24th-26th July 2006 and subsequently revised in response to comments received from the three National Coordinating Committees, ENTRO and the World Bank.

The four Trans-boundary Sub-basin Reports constitute the final three stages in the Transboundary Analysis Component. The results of the Country level and the Sub-basin level analyses will then feed into the Distributive Analysis component.

In this Report chapter 2 consolidates the results of the national level analysis into a system-wide analysis of watershed behaviour and associated livelihoods for the Abbay-Blue Nile Sub-basin. Chapter 3 identifies the common watershed management problems and issues experienced within each Sub-basin. The linkages between the watershed management problems that were identified at the national level are now articulated at the Sub-basin level.

Chapter 4 examines the opportunities and potentials for in-country and trans-boundary benefits accruing from watershed management interventions. In particular, potential additional cross-border benefits that may accrue to interventions not identified in the national level analysis are now identified. Thus, some interventions may accrue benefits in only one country, but it is important to identify interventions that can also accrue benefits in downstream countries. Additionally, some benefits may accrue across the Eastern Nile Basin as well as globally. Some impacts of national level watershed management interventions may have potential negative impacts on downstream and these also need to be identified and mitigating measures proposed.

In chapter 5 basin-wide opportunities for cooperative watershed management activities and related activities are examined. Thus, as well as cross-border benefits from national level interventions, additional benefits may accrue to cooperative interventions. These can include interventions that re-enforce or mutually support other IDEN and JMP interventions. There may also be potential benefits from linkages to other on-going national (the MERET and SWISAR programmes in Ethiopia) and international level programmes (for example the CGIAR project for improving livestock water productivity in the Nile Basin).

Potential synergies and the cumulative impacts of the various proposed interventions are examined. This analysis looks beyond the traditional watershed management options to other cooperative options that include but are not limited to trans-boundary biodiversity conservation, trans-boundary agro-industrial development, trans-boundary livestock disease control, trans-boundary watershed management planning, and trans-boundary watershed management monitoring.

The revised Country Reports now constitute the Annexes to the four Sub-basin reports and contain the detailed national-level analysis. What were identified as National concerns in the Country reports are now located within the specific Sub-basin context. Of necessity, the detailed results from the Country reports are consolidated and where necessary summarized in the Sub-basin Reports.

2. BASIN-WIDE BEHAVIOUR AND LIVELIHOODS: BIO-PHYSICAL AND SOCIO-ECONOMIC SITUATION

2.1 Bio-physical Situation

2.1.1 Watershed and Rivers

The Abbay-Blue Nile Sub-basin covers some 311,548 km^2. The Abbay's traditional source is Gish Abbay in West Gojam and flows northward as the Gilgel Abbay into Lake Tana. Four other major rivers also flow into Lake Tana. The Abbay exits from the southeastern corner and cuts a deep gorge first south then westwards. Along the way it is joined by a number of tributaries: Beshilo, Derame, Jema, Muger, Finchaa, Didessa and Dabus from the east and south; and the Suha, Chemoga, Keshem, Dera and Beles from the north. The Abbay exits Ethiopia near Bambudi and becomes the Blue Nile.

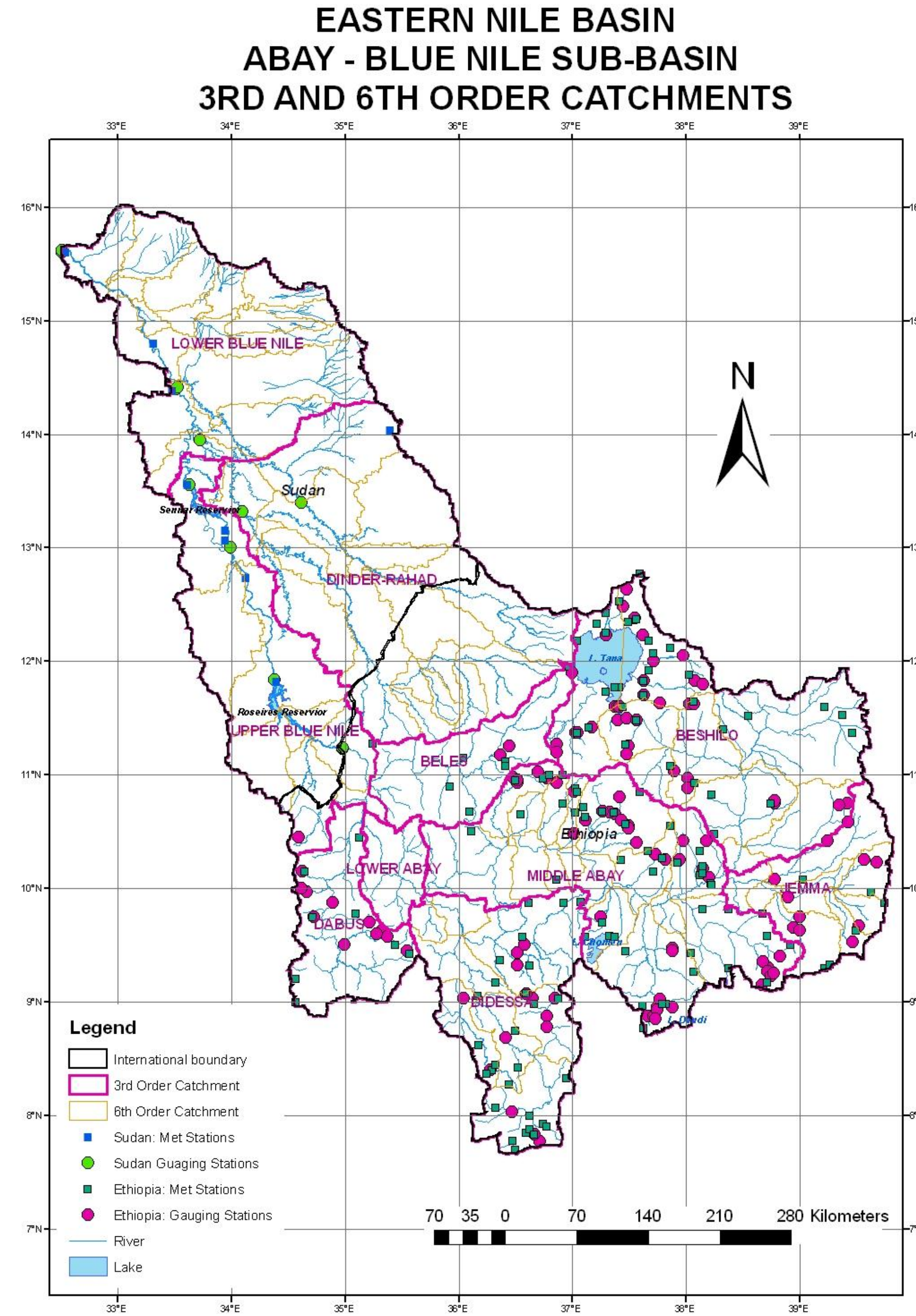
The Dinder and Rahad rise to the west of Lake Tana flow westwards across the border joining the Blue Nile below Sennar. They generally cease to flow during the dry season. On entering the Sudan the Blue Nile flows across a wide clay plain derived from unconsolidated sediments before joining the White Nile at Khartoum.

The Sub-basin is divided into 10 3rd order catchments and 103 6th order catchments using the Pfafstetter system. This system is based on the topology of the drainage network and the drainage area (Verdin, 1997). The source of the data is the USGS/EROS gtopo30 HYDRO1k data set published by UNEP/DEWA/Grid. The areas of the 3rd Order catchments are shown in table 2.

Table 2. Abbay-Blue Nile Sub-basin: Pfafstetter 3rd Order Catchments - Area (km2) and % of Area

3rd Order Catchment	Area (km2)	% of total Sub-basin area
LOWER BLUE NILE	42,860	14%
DINDER-RAHAD	62,011	20%
DABUS	14,488	5%
LOWER ABAY	5,530	2%
DIDESSA	29,247	9%
MIDDLE ABAY	47,199	15%
DURAME	15,409	5%
BESHILO	47,037	15%
UPPER BLUE NILE	33,804	11%
BELES	13,963	4%
SUB-BASIN	**311,548**	

Source: Basin boundaries: USGS/gtopo30/HYDRO30



Map 2. Abbay-Blue Nile Sub-basin: Pffaftetter 3rd and 6th Order Watersheds

Source: Basin boundaries: USGS/gtopo30/HYDRO30. Gauges/met stns. ENTRO GIS Database

In Ethiopia there are some 117 river gauging stations (for which 30 have some sediment load data) and 141 meteorological stations for which there are some records. However, in a number of cases gauging station records are for a limited number of years or for a limited number of in any one year (Rodeco, 2002). Similarly with the meteorological data many station records are for a limited period and in some records are missing (Conway, 1997). In Sudan there are 15 river gauging stations (for which 4 have some sediment load data) and 9 meteorological stations. Similar data problems exist with the Sudan data (Abdalla Abdalsalem Ahmed, 2006).

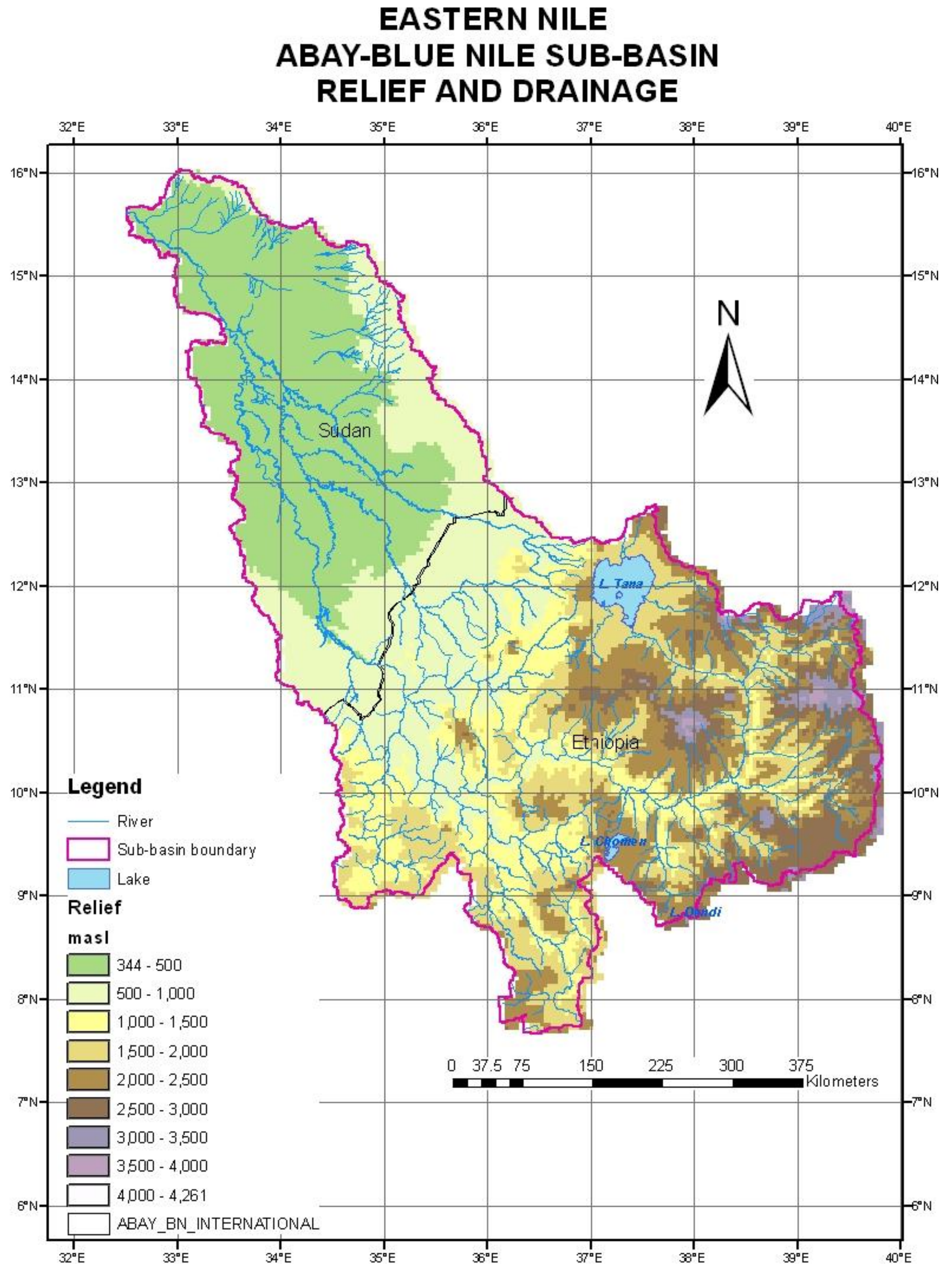
2.1.2 Relief

Two main landscape units are observed in Abbay-Blue Nile Sub-basin. A mountainous relief that extents in Ethiopia and a flat piedmont starting close to the Ethiopian border and extending out across the Sudanese portion (Map 3).

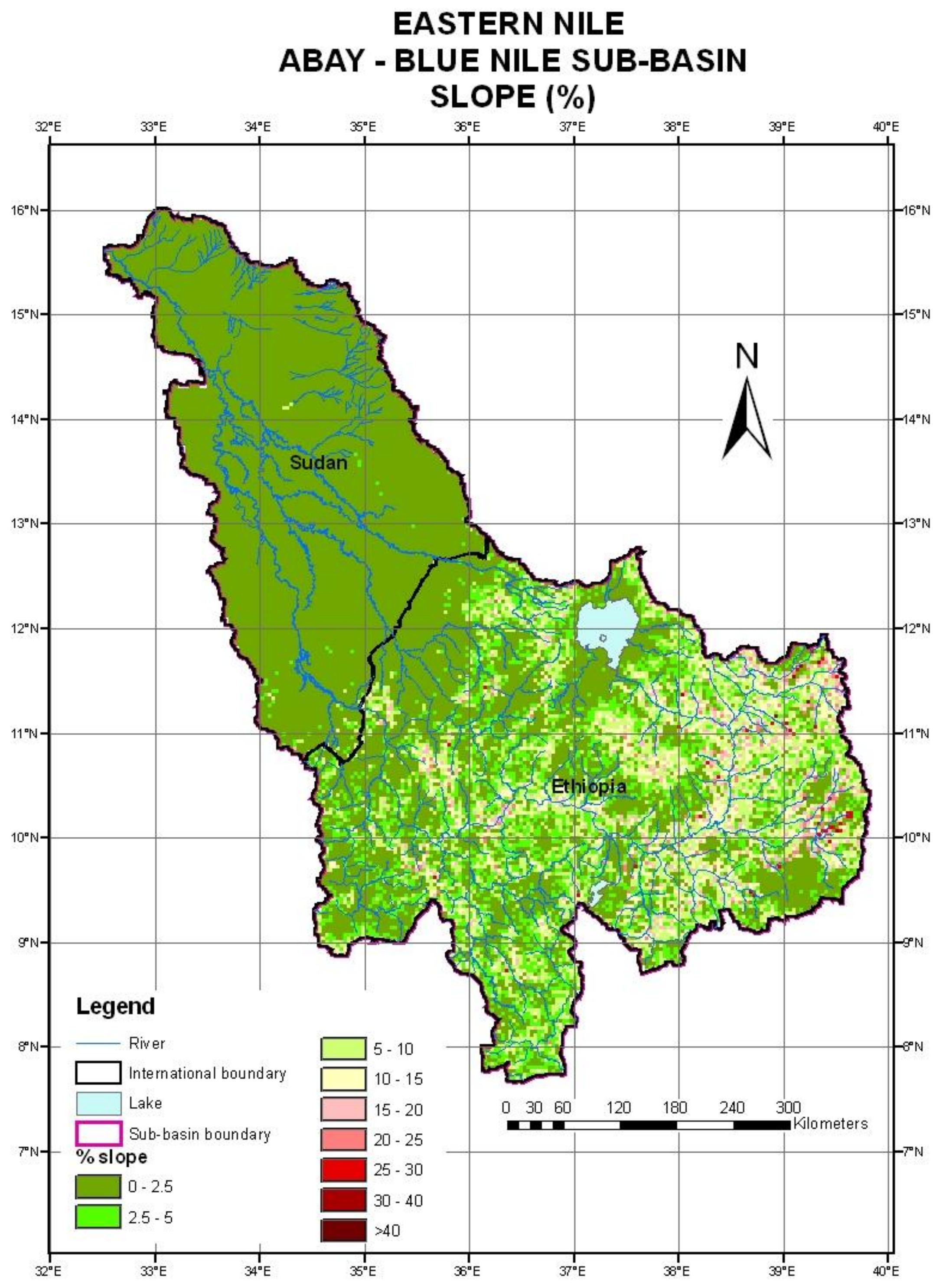
The Ethiopian Highlands generally present a gently undulating plateau from 2,000 to 2,500 masl with isolated volcanic remnants rising above the plateau to 3,500 to 4,200 masl. The Abbay River and its tributaries are deeply incised into the plateau leaving a series of isolated tablelands separated by deep gorges.

In the Ethiopia the lowlands are undulating to rolling between 600 to 1,000 masl with isolated hilly or mountain outliers rising to 2,700 masl. Towards the border with Sudan and extending westwards to the Main Nile the topography is almost flat or slightly undulating, with just the occasional granite jebel rising above the clay plain. The lowland region between the Atbara River and the Blue Nile is occupied by the Butana Plains.

Given the extent of the lowlands, in proportion with the mountainous relief, most of the sub-basin is characterized by slopes lower than 2.5 percent (Map 4).



Map 3. Abbay-Blue Nile Sub-basin: Relief and drainage
Source: Shuttle Radar Terrain Mission (SRTM 90) digital terrain model.



Map 4. Abbay- Blue Nile Sub-basin: Slope (%)
Source: Derived from SRTM DTM using ARC-GIS Spatial Analyst

2.1.3 Climate

(i) Rainfall

Rainfall ranges from nearly 2,000 mm/yr in the Ethiopian Highlands to less than 200 mm/yr at the junction with the White Nile (Map 5). The highest rainfall values are recorded on Mount Choke to the south of Lake Tana and on the mountains south of the Abbay River.

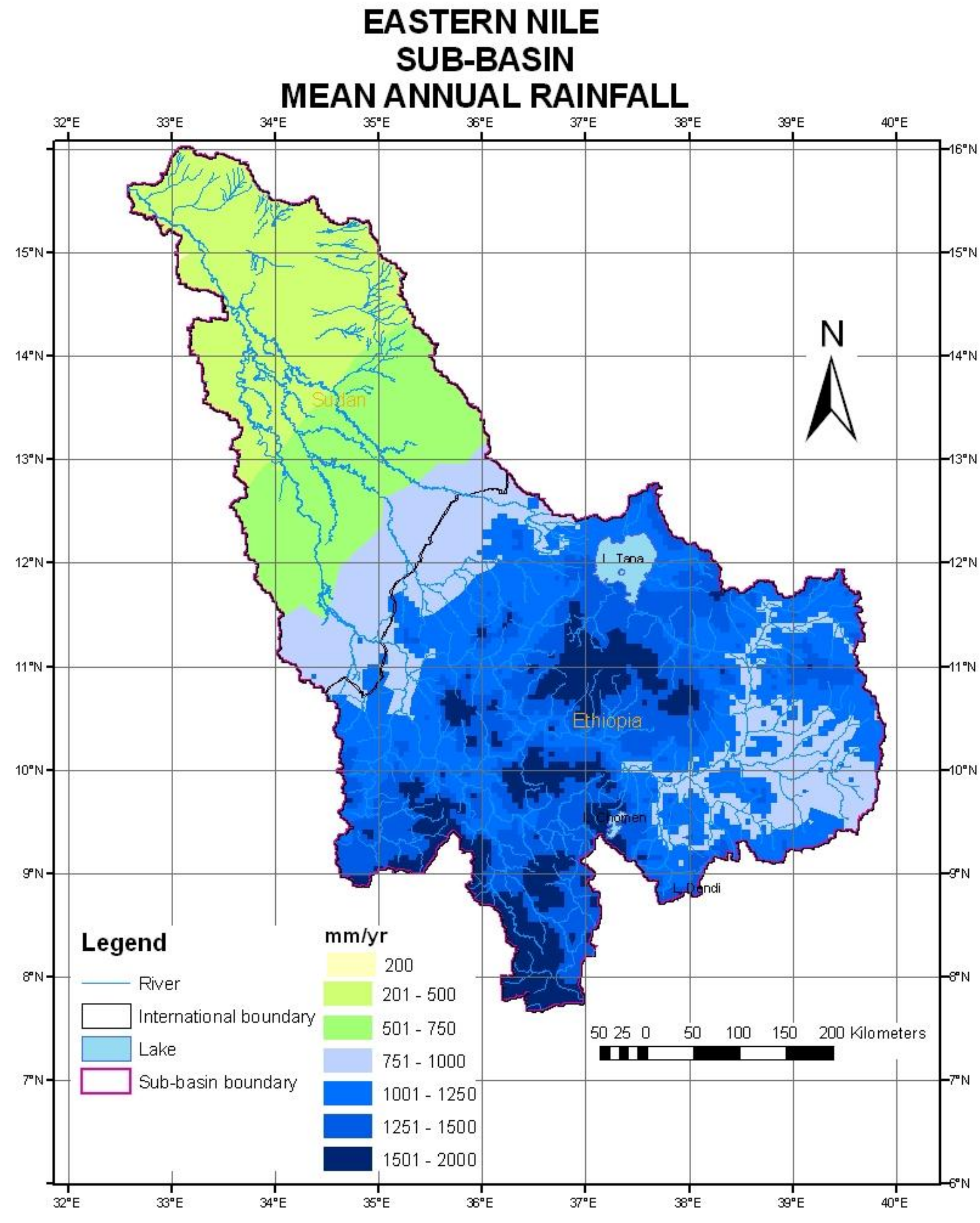
Within the highlands of Ethiopia, a uni-modal wet season is found to the west of the Simien massif. The wet season lasts about four months, from June to September. East of the Abbay the rainfall pattern in bi-modal, characterized by two wet seasons. The "*Belg*", or short rainy season, occurs from mid-February to mid-May. However, the rainfall is characterized by inter-annual and inter-seasonal variations. This short rain period is of some agricultural importance, particularly in the north-east where annual rainfall is low. The "*Kiremt*" or main rainy season lasts from June to September.

In Sudan the rainfall isohyets trend in an east-north-east to west-south-west direction, with rainfall decreasing north-westwards from where the river leaves Ethiopia. Rainfall ranges from about 800 mm/yr at the border to less than 200 mm/yr at the junction with the White Nile with a coefficient of variation (CV) as high as 100 percent.

(ii) Temperature

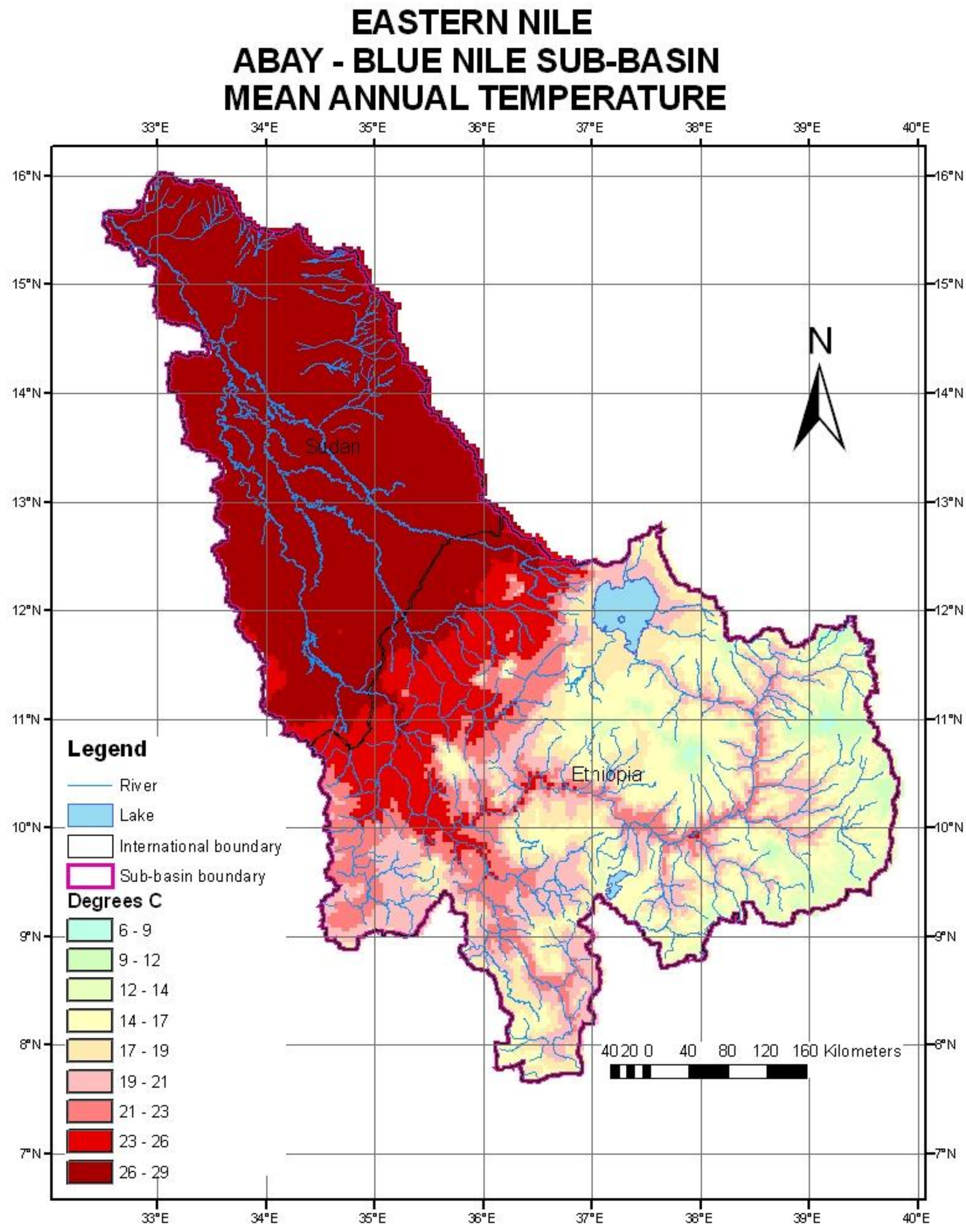
Highest mean annual temperatures occur in the north-eastern clay plains of Sudan (Map 6). Daily minimum and maximum temperatures in January are 14°C and 33°C and those in May are 24° and 44°C respectively in Sudan.

The spatial distribution of temperature values is strongly related to altitude. The area located in the highlands of Ethiopia is characterized by lowest minimum mean monthly temperatures that range between 3 and 21^{o}C, and that occur between December and February.



Map 5. Abbay – Blue Nile: Mean Annual Rainfall (mm/yr)

Source: ENTRO GIS Database



Map 6: Abbay-Blue Nile Sub-basin: Mean Annual Temperature (degrees C)
Source: ENTRO GIS Database

2.1.4 Geology

The geology of Abbay-Blue Nile sub-basin can be summarized as follows: the Highlands the Sub-basin is composed of basic rocks, mainly basalts, while the Ethiopian lowlands are mainly composed of Basement Complex rocks as well as metamorphic rocks, such as gneisses and marble. Where the Abbay has cut through the basalts there are restricted areas of limestones and then sandstones before the Basement Complex is reached.

The main part of the Sudan Lowlands is underlain by deep unconsolidated colluvial sediments of tertiary and Quarternary age. To the north are older Basement Complex rocks and the Nubian Sandstones. The Nubian Sandstones are located in the northwest corner and overly uncomfortably the Basement Complex rocks and comprise mainly sandstones, siltstones and conglomerates.

2.1.5 Soils

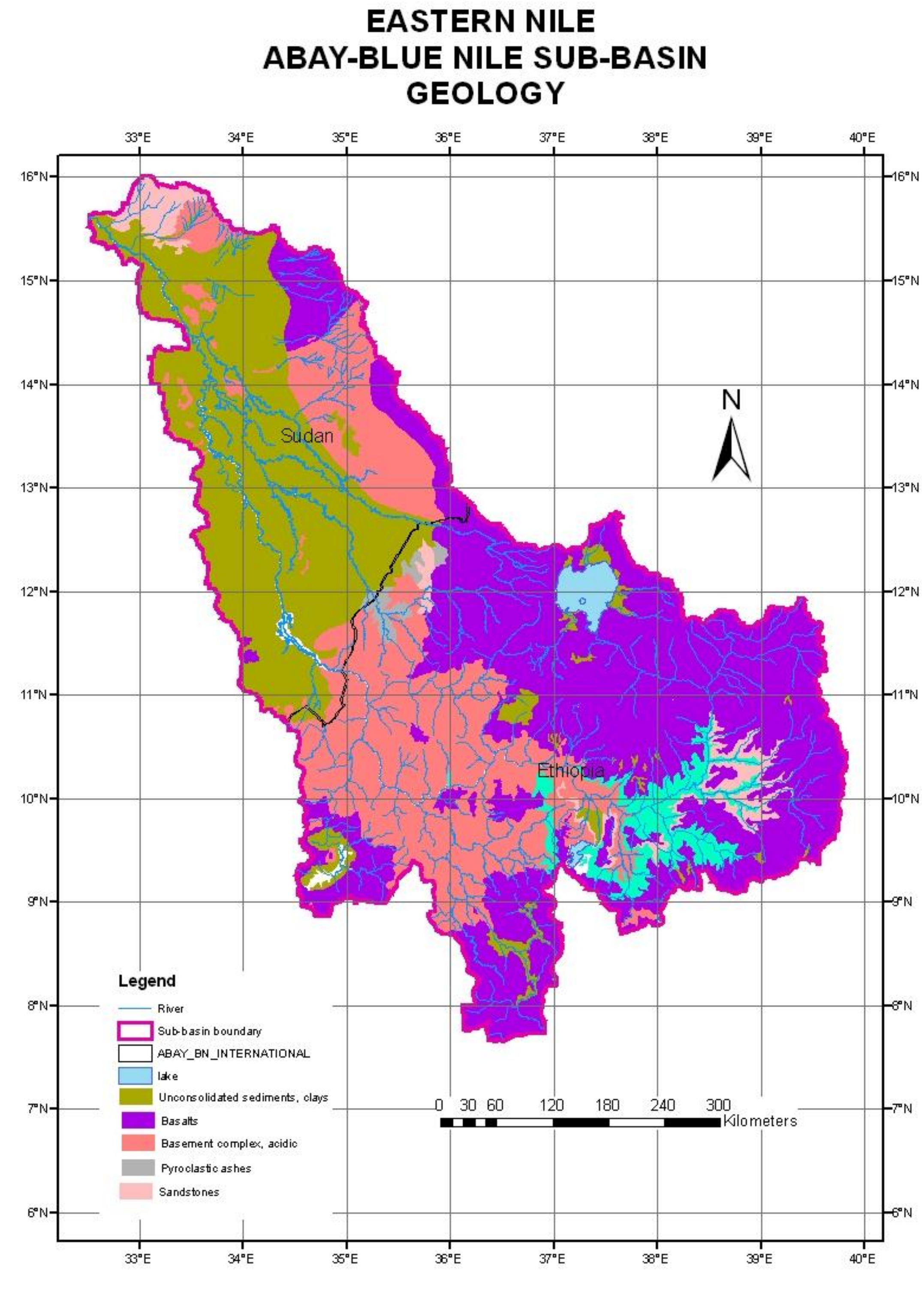
The Vertisol – Nitisol boundary runs almost along the international boundary. Nitisols (24%) dominate the western Highlands whilst shallower and more infertile Leptosols (19%) occupy the eastern Highlands. Vertisols (29%) dominate the unconsolidated sediments of the Sudan plains.

On the flat plateaus in the Ethiopian Highlands are extensive areas of Vertisols. On the deep soils in the high rainfall areas around Lake Tana there are extensive areas of Luvisols.

Table 3. Abbay-Blue Nile Sub-basin: Dominant Soil Types - % of Area

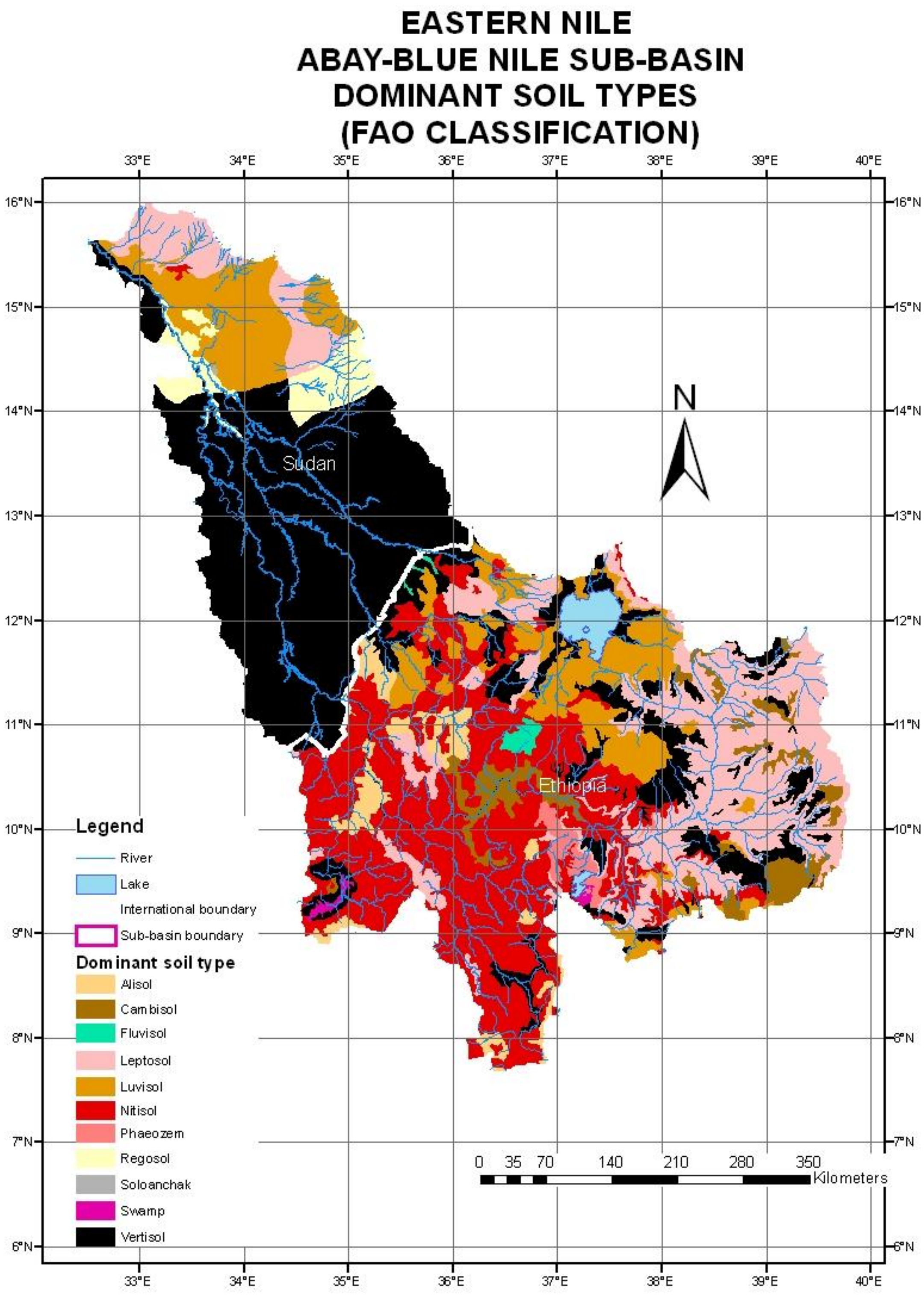
Soil Type	% Area
Vertisols	28.9%
Nitisols	23.9%
Leptosols	18.7%
Luvisols	12.7%
Water body	5.1%
Cambisols	3.6%
Regosols	2.8%
Alisols	2.8%
Phaeozems	0.9%
Fluvisols	0.4%
Swamp	0.2%
Solonchaks	0.0%

Source: FAO, 1998 "Soil and Terrain Database for Northeast Africa



Map 7. Abbay-Blue Nile Sub-basin: Geology

Source: FAO, 1998 "Soil and Terrain Database for Northeast Africa



Map 8. Abbay-Blue Nile Sub-basin: Dominant Soil Types (FAO Classification)

Source: FAO, 1998 "Soil and Terrain Database for Northeast Africa

2.1.6 Vegetation

(i) Semi-desert Scrub and Grassland

In the far north between the 75 and about 250 mm isohyets "Semi-desert Scrub" is the most prevalent vegetation type, and comprises a varying mixture of grasses and herbs, generally with a variable scatter of shrubs up to 4 meters high interspersed with bare earth. Grasses are mainly annuals in Sudan. Heavy grazing and low rainfall ensures that there is insufficient dry matter for annual fires. In years of low rainfall and heavy grazing there can be an almost complete failure of annual plant growth.

South-eastwards, from the 250 mm to the 360 mm isohyet, the vegetation type becomes "Semi-desert Grassland". Much of this vegetation is now covered by the Gezira and Managil Irrigation Schemes. On the heavy alkaline clay soils the natural vegetation is grassland without trees or shrubs.

(ii) Acacia Thorn-land alternating with Grassland

Between the 360 mm and 570 mm isohyets on the heavy clays grassland merges into *A. mellifera* thornland. Other tree species include *A. nubica, C. decidua, Cadaba glandulosa, C. rotundifolia and Boscia senegalensis.* The last three species often persist after A. mellifera has been cleared. Much of this vegetation is being cleared for small-scale sedentary and large-scale semi mechanised agriculture.

Grass species include *Cymbopogan nervantus*, *Sorghum purpereo-sericeum*, *Hypparhenia ruffa*, *Tetropogan cenchriformis* and *Cenchrus cilliaris*. Sufficient grass dry matter is produced to provide material for annual burning.

(iii) Acacia seyal-Balanites Savanna

Above 570 mm to the escarpment with Highland Ethiopia there is increasing dominance by *A. seyal* in association with *Balanites aegyptiaca*. *A. senegal* is retained for gum arabic harvesting whilst *A. seyal* is used for charcoal production. *B. aegyptiaca* becomes increasing prevalent because it is fire resistant, does not produce good charcoal and is hard to cut.

The grasses tend to occur in pure stands of *Hyparrhenia anthistirriodes* or *Cymbopogon nervatus* with *Sorghum spp*. in the higher rainfall areas. These grasses become largely unpalatable to livestock during the dry season. There is abundant material for annual fires.

(iv) Terminalia-Combretum (Deciduous) Woodland

These woodlands are found in the higher rainfall areas, generally with above 700 mm mean annual rainfall. Apart from the two dominant species others include: *Boswellia papyrifera, Lannea schimperi, Anogeissus leiocarpus, and Stereospermum kunthianum.* The main land use systems are agro-pastoral and shifting cultivation.

Lowland bamboo (O*xytenanthera abyssinica)* occurs in two man forms: in pure continuous stands with few or no trees or shrubs (dense bamboo) and as clumps scattered with woodland and shrubland (open bamboo). A total of 273,817 ha of dense bamboo and 220,747 ha of open bamboo have been mapped (WBISPP, 2003). In the dense pure stand of bamboo comprising the Ambessa Chaka Forest, LusoConsult estimated an average of 8,124 live culms per hectare whilst the density of culms in open “clumped bamboo/woodland-shrubland” is probably about 20 percent of that in the dense pure stands.

(v) Riverine Woodland

In the Lowlands (below 1,500 masl) pure stands of riverine woodland – “*sunt*” – are increasingly under pressure. The first trees to colonize a newly formed river bank are *Salix subserrata* and *Tamarix nilotica*. As the bank builds up xerophytic species such as *Ziziphus spina-christi* become established. On the lower terrace *A. nilotica* establishes itself, with *A. seyal* on the higher ground.

In the upper parts of the Abbay/Blue Nile Sub-basin these are varied and have been little studied. They include *Apodytes dimidiata*, *Carrisa edulis*, *Euclea racemosa*, *Ficus vasta*, *Syzygium guineense*, *Mimusops kummel*, Phoenix *reclinata*, and *Tamarindus indica*.

(vi) Montane High Forest

Highland high forest areas represent less than 2 % of the basin and are now much fragmented and located in relatively small patches. Three main types are found; (a) Undifferentiated Afro-montane Forest (Transitional Broadleaf Forest and (bi) Mixed Juniper-Podocarpus Upland Evergreen Forest), and (c) Single Dominant Evergreen Forest (*Juniperus procera*).

(a) Undifferentiated Afro-montane Forest (Transitional Broadleaf Forest)

These forests are found as dispersed patches of forest in areas southwest and southeast of Lake Tana north of the Abbay River and in West Wellega south of the Abbay. They are found between 1,500 to 2,700 masl where annual rainfall is between 700 and 2,200 mm. Mean annual temperature ranges between 14° and 20° C.

North of the Abbay the main area of natural forest occurs some 150 kms southwest of Lake Tana where some 32,450 ha of high forest occur. South of the Abbay overlooking the Anger Valley are some 80,500 ha of high forest. In these areas the annual rainfall is 1,800-2,200 mm. This sub-type appears transitional to the mixed broadleaf forests of the highlands in the upper Baro-Sobat-White Nile Sub-basin. The species composition is similar to these forests but without either *Podocarpus gracilior* or *Aningeria adolfi-friederici*. The two main canopy species are *Albizia gummifera* and *Olea welwitschii*. Many of the other species are those found in “disturbed” forest.

Another more humid sub-type occurs around Lake Tana on the islands and on the Zege Peninsula. Canopy trees include *Albizia gummifera,* with *Ehretia cymosa, Millettia ferruginea* and *Mimusops kummel*.

East of Lake Tana just to the north of Addis Zemen in North Gonder Zone is the Tara Gedam Monastery forest. This appears to be a seral stage of this type of forest. It has a canopy of *A. abyssinica*, with understory trees of *Bersama abyssinica*, *Ficus thonningi*, *Maesa lanceolata*, *Ritchiea albesii*, and *Schrebera alata*.

(b) Mixed Juniper-Podocarpus Upland Evergreen Forest)

The Anabe and Denkoro forests in North Wello have been studied by Mesfin Tadesse. The main canopy species are *J.procera* and *P. gracilor* between 20 and 30 meters high, with a well developed strata of small to medium trees, chiefly *O. europaea cuspidata*, *Allophylus abyssinicus*, *Celtis africana*, *Croton macrostachyus*, *Dombeya spp.*, *Ekebergia capensis*, *Olea hochstetteri* and *Prunus africana*.

(c) Single dominant Montane Dry Evergreen (*Juniperus procera*) Forest

This type of forest is found on the plateaus and hills in North and South Wello, North and South Gonder and North Shewa between 1,600 and 3,200 masl. Annual rainfall is between 500 and 1,500 mm and often but not always bi-modal in distribution. Mean annual temperature is between 12°C and 18°C.

It comprises an open forest tending towards Juniper woodland with a canopy of 10 to 15 meters. The dominant species is *J. procera* often with *Olea europaea cuspidata* in the canopy. Species in an upper strata below the canopy include *Acokanthera schimperi*, *Bursama abyssinica*, *Calpurnia aurea*, *Dombeya torrida* and *Teclea nobilis*. In the lowest strata *Psydrax schimperii* and *Carissa edulis* occur. In some areas the number of *Juniperus* trees is very small and the canopy is then dominated by *O. europaea cuspidata*. Where disturbance has been more severe *A. abyssinica* dominates the canopy and few if any *Juniperus* or *Olea* are seen.

(vii) Mountain Woodlands

These woodlands are found at higher altitudes above 2,500 masl. Common species are *A. abyssinica, Protea, Cussonia, Hagenia abyssinica, Erica arborea, and Hypericum.*

(viii) Afro-alpine Grasslands and Erica Woodland

These alpine grasslands are generally found above 3,200 masl. Mean annual temperature is generally below 11 degrees C and frost will occur most nights. No rainfall stations are found at this altitude but it is generally agreed that rainfall increases up to 3,800 masl and then starts to decrease. Palatable grasses found in this grassland type include *Eragrostis spp*., *Deschampsia flexuosa*, *Helictotrichon milanjianum*, *Molinia caerulia*, and *Poa spp*.

On Mount Choke substantial areas of giant heather (*Erica arborea*) woodland occur.

(ix) Wetlands

Four major types of wetland occur in the Sub-basin: (a) the lowland wetlands of the Dinder-Rahad catchment located mainly within Sudan, (b) lacustrine wetlands that fringe Lake Tana and lake Fincha'a, (c) narrow valley bottom wetlands found in western Ethiopia south of the Abbay, and (d) the very wide valley wetlands of the upper Dabus river also in western Ethiopia south of the Abbay.

(a) Dinder-Rahad Wetlands

These wetlands are located on and between the Dinder and Rahad rivers and are locally known as "*maya'as*". They are depressions along and between the rivers. The area way from the river is covered with fossil streams and rivers. The depressions are abandoned meanders which have formed forming "ox-bow" lakes. These lakes however are ephemeral as they gradually silt up, fill with swamp vegetation and then as they silt up dry out.

(b) Lacustrine Wetlands

These are located fringing Lake Take and in the lower Gishe Abbay River and around Lake Chomen. Those around Lake Tana have been considerably reduced in extent, most particularly around the Fogera Plain having been converted to cropland. The Fogera plains are fed by the Rib River and bounded by the Gumera River to the south. A perennial swamp has formed at their junction. Lake Tana also floods back 1.5 meters during the rainy season. The vegetation along the Lake shore is almost purely papyrus whilst inland swamp grasses such as Echinochloa spp. and Cynodon aethiopicus dominate. These form excellent dry season grazing. A number of globally threatened birds occur including the Wattled Crane, the Lesser Kestral, Pallid Harrier and Great Snipe.

Those around Lake Chomen comprise two main wetlands: the Fincha'a to the north and the Chomen to the south. They are separated by a low ridge. Water flows from Chomen into Fincha'a through the ridge. The Fincha'a swamps cover some 28,000 ha and the Chomen an area slightly larger. The streams flowing to the swamps are short (average about 9 kms) and thus rainfall over the swamps is an important source of water for the swamps. During the rains the water level rises by some 2 meters. The swamps are covered by floating vegetation the dominant species being the perennial grass *Panicum hygrocharis* (EWNHS. 1996). The wetlands are of particular conservation importance as a location for the globally threatened Wattle Crane.

(c) Narrow Valley-bottom Wetlands

These are mainly located in the high rainfall areas southwest of lake Tana and in the western Highlands south of the Abbay River. A survey and inventory of wetlands in the Amahra Region (Enyu Adgo et al., 2005) found that many of these wetlands were under threat due to land degradation and sedimentation, and the lack of bylaws and community rules regarding their use. Many are used for dry season grazing, hay production, thatching grass and grass mats (*cheffe*).

In the area between Gimbe and Nejo within the Dabus and Abbay sub-basins many wetlands are used for cultivation. Because of severe degradation on the upland granite soils the wetlands have become vital elements in sustaining peoples' livelihoods. However, in some areas there have been reports of over-draining of these wetlands leading to the destruction of their delicate hydrography and loss of value for cultivation (Wood, 2000).

(d) Upper Dabus Wetlands

The Upper Dabus comprises two wide (50 kms) shallow east-west trending valleys of seasonal and permanently flooded grassland and sedges. The area is very remote and no research appears to have been carried out on these extensive wetlands. The area is little utilized except along its edges for dry season grazing. The area acts as a sponge retaining runoff and prolonging the main peak of the Dabus flow.

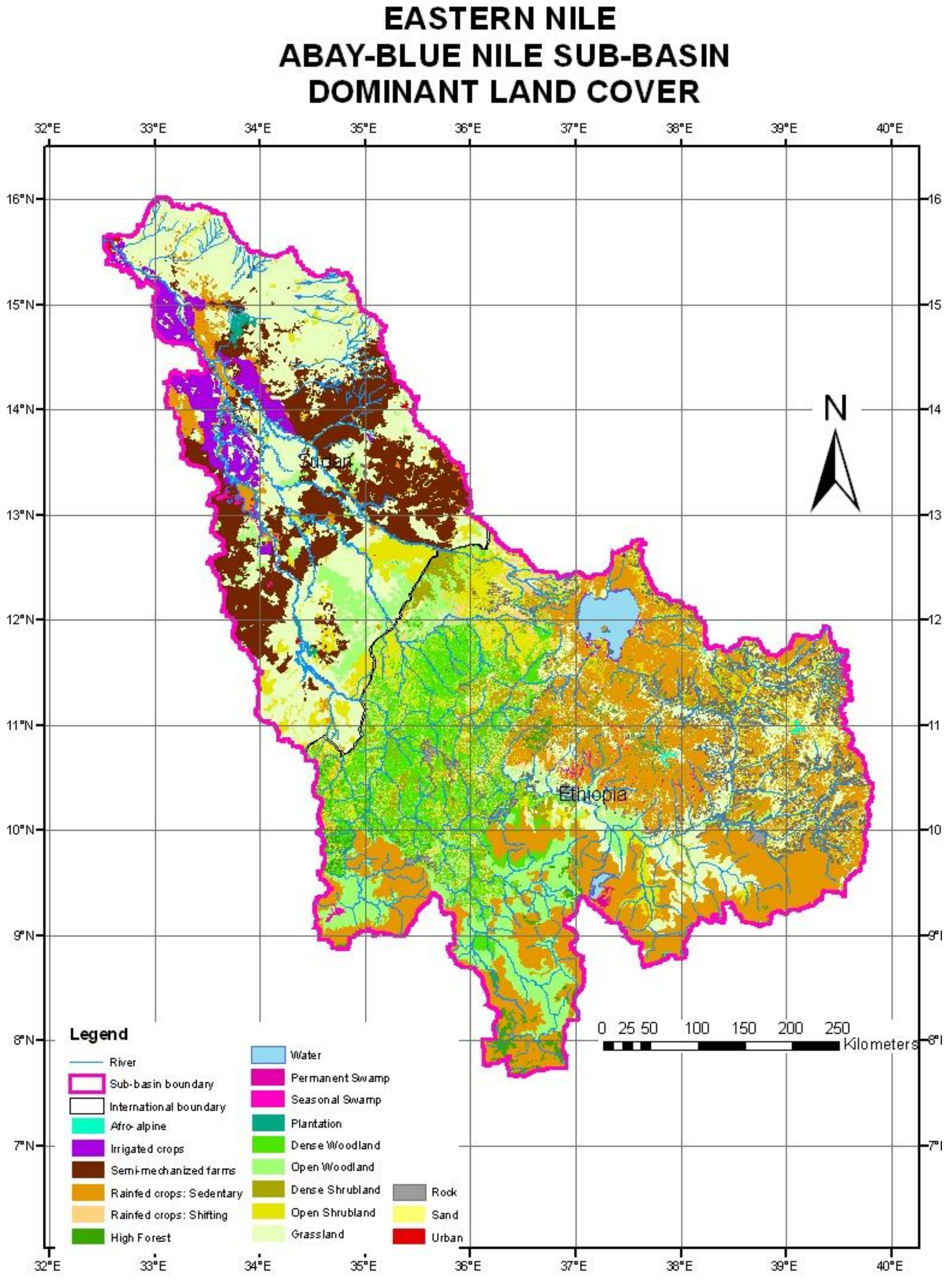
2.1.7 Land Cover

Map 9 indicates the Land Cover for the Sub-basin. The data source for Sudan is the FAO Africover map and that for Ethiopia was WBISPP-MARD Land Cover Maps for Amhara, Beneshangul-Gumuz and Oromiya Regional States. The two land cover classifications were standardized to the FAO Land Cover Classification System (LCCS) (FAO, 2000). Table 4 indicates the areas of the dominant land cover types. Woodlands and Shrublands cover some 28 percent and grasslands 25 percent of the Sub-basin. Cultivated Land:Sedentary rainfed cropping covers nearly 26 percent of the area mainly located in the Ethiopian Highlands. Cultivated land:Semi-mechanized farms cover 10 percent and Cultivated land:Irrigation 2.6 percent. In fact much of the Gezira and all of Managil Schemes lie in the White Nile Sub-basin.

Table 4. Abay-Blue Nile Sub-basin: Dominant Land Cover

Landcover Type	Area (ha)	% Total
Rainfed Crops: Sedentary	8,037,337	25.8%
Grassland	7,777,274	25.0%
Woodland	5,225,555	16.8%
Shrubland	3,671,919	11.8%
Cultivated land: Semi-mechanized farms	3,123,087	10.0%
Cultivated land: Irrigated Crops	815,480	2.6%
Rock	732,392	2.4%
High Forest	429,777	1.4%
Water	420,103	1.3%
Cultivated land: Rainfed Crops: Shifting	340,930	1.1%
Plantation	211,977	0.7%
Bare land: Loose sand	128,804	0.4%
Seasonal Swamp	94,518	0.3%
Permanent Swamp	51,831	0.2%
Built up: Urban	65,136	0.2%
Grassland: Afro-alpine	28,680	0.1%
SUB-BASIN	**31,154,800**	

Source: FAO Africover Sudan (2002) & WBISPP-MARD (2001 -2003)



Map 9. Abbay-Blue Nile Sub-basin: Dominant Land Cover
Source: FAO Africover Sudan (2002) & WBISPP (2001 -2003)

2.1.8 Hydrology

(i) Surface Water

Although the Abbay basin is the second largest drainage area in Ethiopia, it has the highest runoff, estimated to be 51 km^3/yr. The Abbay basin accounts for 50 percent of water runoff in Ethiopia. It also contributes 62 percent of the Nile discharge into Lake Nasser/Nubia and 72 % of the total Ethiopian contribution to the Nile waters.

The Abbay river has a channel length of 922 km and falls 1,295m from Lake Tana (1,785 masl) to the Sudan border (490 masl). Shortly after leaving Lake Tana, the river plunges over the spectacular Tis-Isat falls and, thereafter enters the deep Abbay river gorge. Comparing the mean monthly discharges of Abbay river at Lake Tana and at the Sudan border indicate that there is a 10 times increase in discharge between that at Lake Tana and at the Sudan border (Tables 5a and b).

Table 5a: Mean monthly discharge of the Abbay River at the outlet to Lake Tana (m^3/s)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Av/ Max/ Min
Mean	83	55	34	19	11	9	31	174	345	312	205	130	**117**
Max	151	108	66	29	19	19	71	341	645	556	351	229	**645**
Min	29	19	12	5	2	1	10	35	71	82	58	41	**1**

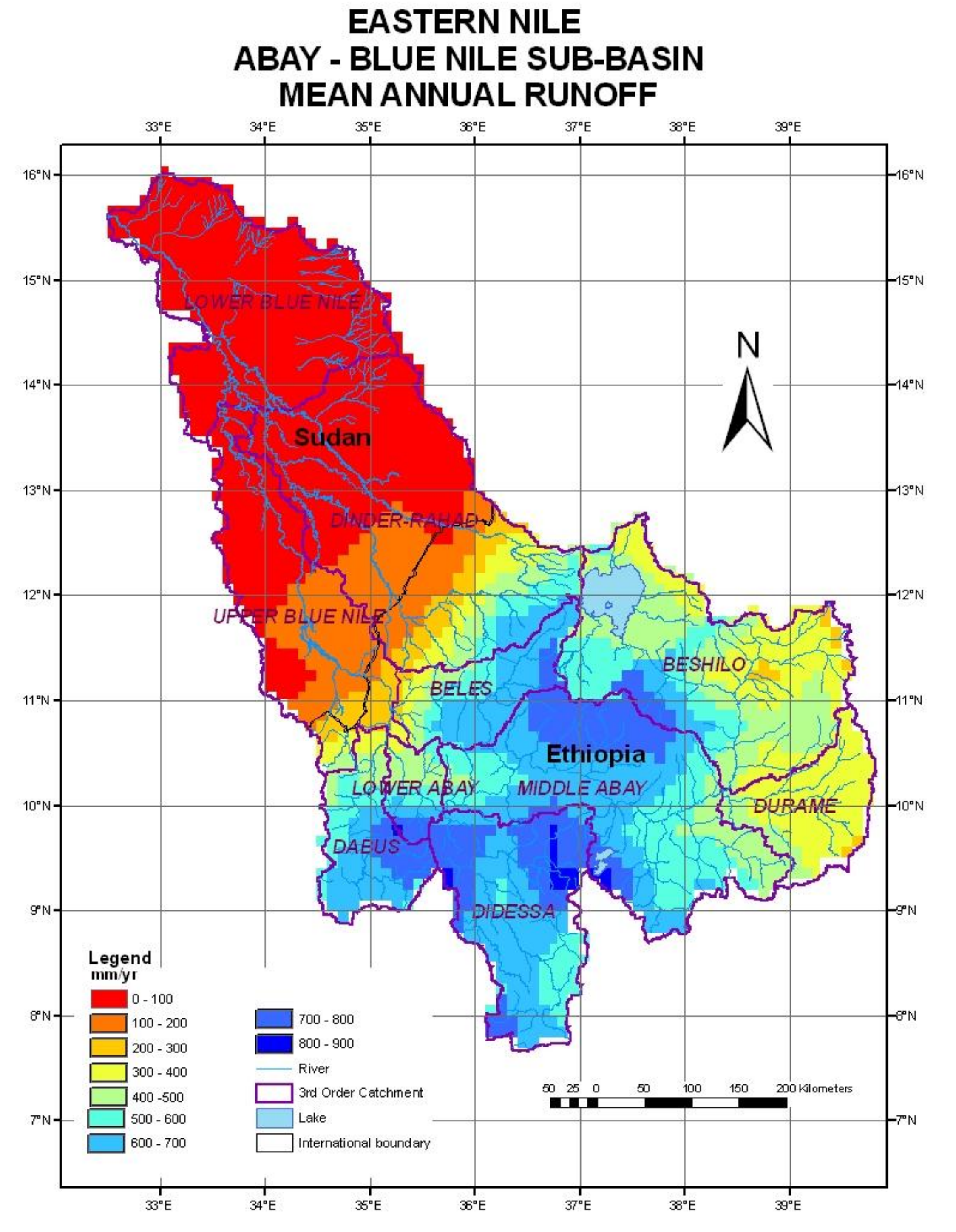
Note: altitude - 1,785 masl; Catchments area, 15,321Km2; Length of record 1960 – 1992.
Source: MWR, Addis Ababa, 2006

Table 5b: Mean monthly discharge of the Abbay River at the Ethiopian/Sudan border (m^3/s)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Av/ Max/ Min
Mean	345	229	162	141	240	722	2,841	5,634	4,340	2468	1,019	526	1,556
Max	527	434	306	194	470	1453	6,018	6,988	5,919	3,708	1,551	755	6,988
Min	212	137	93	81	99	472	1,930	3,693	2,813	1,305	681	324	81

Note: altitude - 490 masl; Catchments area, 172,254Km^2; Length of record, 1961 – 1979.
Source: MWR, Addis Ababa, 2006

Map 10 shows the spatial pattern of the mean annual runoff (mm/yr) in relation to the 3rd order catchments. The highest runoff areas are located to the southwest of Mount Choke, the East Wellega and the West Wellega Highlands. The Didessa, Dabus, Middle Abbay and Beles Catchments have the highest runoff rates. The Beshilo, Durame and Dinder-Rahad have significantly lower rates.



Map 10. Abbay – Blue Nile Sub-Basin: Mean Annual Runoff (mm/yr)
Source: USGS/gtopo30/HYDRO30.

Table 6 presents the area and gross runoff depth of the various catchments and sub-catchment of Abbay basin. The runoff from the individual drainage unit is gross runoff, which means, no allowances are made for evaporation and other channel losses.

Table 6. Area and average gross runoff depth of the sixteen main drainage basin units of the Abbay river basin (rank order by gross runoff depth)

Unit Name	Area (Km^2)	Gross runoff depth (mm)
Didessa	19,943	651
South Gojam	17,029	543
Guder	7,123	537
Anger	8,027	527
Lake Tana	15,294	514
North Gojam	14,618	486
Dabus	21,367	466
Beshilo	13,453	455
Fincha	4,154	450
Muger	8,318	423
Jemma	16,033	422
Welaka	6,517	410
Wombera	13,163	410
Beles	14,426	378
Rahad	8,401	339
Dinder	15,128	276
Abbay at border	**202,994**	**255**

Source: MWRI, Addis Ababa, 2006.

Lake Tana, some 73 km long and 68 km wide, is the largest freshwater lake in Ethiopia. It is located at 1,786 masl and has a surface area of 3,042 km^2, accounting for 50 % of the total inland water of Ethiopia. The lake stores 29.175 km^3 of water which seasonally fluctuates between 1,785 and 1,787 masl. The lake is shallow and has a mean depth of 9.53 m, while the deepest part is 14 m.

The catchment area, totalling 15,054 km^2, contributes a mean annual inflow of 10.3 km^3 from 61 water courses, including four main catchments, namely; Gilgel Abbay (5,004 km^2; west), Ribb (2,464 km^2; east), Gumara (1,893 km^2; south-east) and Megech (2,620 km^2; north) (Map 13). The outflow from the lake is 3.7 km^3/yr. The remainder or 64% of the inflow is mainly lost by evaporation.

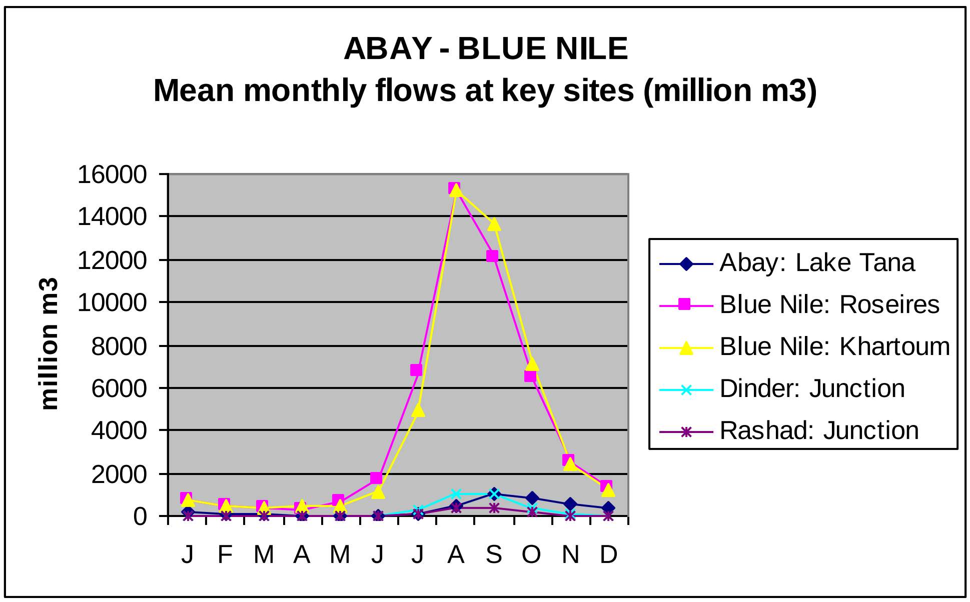
Prior to the construction of Chara-Chara weir in 1996, the mean outflow of Abbay River from the lake was 114 m^3/s (max outflow of 204 m^3/s). The monthly mean outflow ranged from 10 m^3/s (May and June) to more than 350 m^3/s (Sept. and Oct.). The outflow is now regulated by Chara-Chara weir and the discharge is now standardized at 110 m^3/s (Amhara REPLAU, 2004).

The Blue Nile drops 120m between the Ethiopian border and Khartoum. There is little or no flow from the Rahad and Dinder during the dry season. Mean (1920-

2000) annual discharge at the border is approximately 50.0 km^3 with an addition 4.0 km^3 coming from the Rahad and Dinder.

There are considerable seasonal variations in flow. The monthly low flow of the Blue Nile is 302 million m^3/month in February and the peak flow 13,151 million m^3/month in August. In contrast to the White Nile the flow is highly seasonal being concentrated between July and October (figure 2). The peak flow at Roseires occurs in August whilst that at Lake Tana outlet is September indicating that the downstream tributaries are peaking earlier.

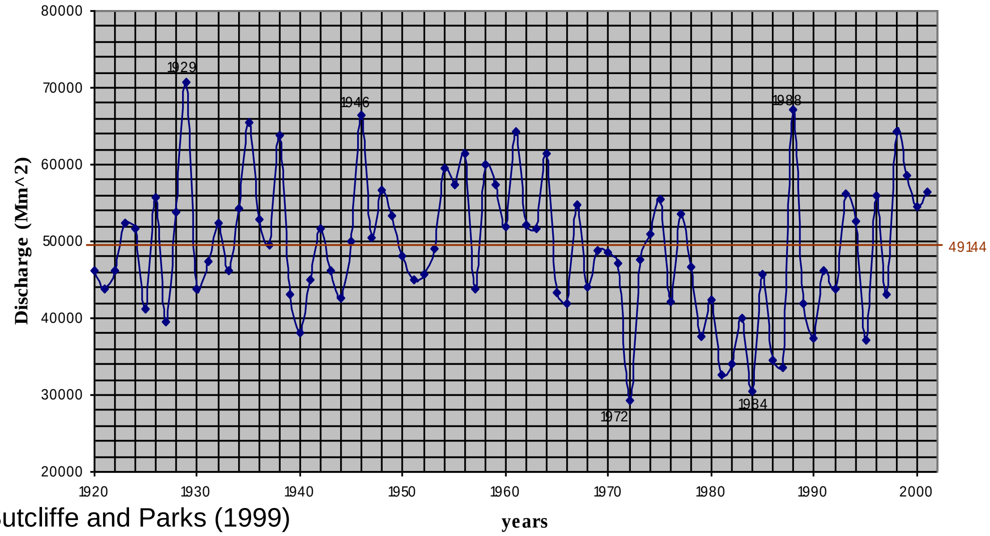
Figure 2. Abbay - Blue Nile Sub-basin: Mean monthly discharge at key sites (million M3)



Source: Sutcliffe and Parks (1999)

Similarly, there are considerable variations in annual discharge. The annual discharge for the Blue Nile from 1920 to 2001 is shown in figure 3.

Figure 3. Sudan – Blue Nile Sub-basin: Blue Nile Hydrograph 1920-2001 (million m^3)



Source: Sutcliffe and Parks (1999)

Between 1920–1960 the annual discharge appeared to have oscillated around the mean. From 1960 to 1984 there appears to have been a general decrease in discharge until 1985. Thereafter discharges have gradually increased.

(ii) Groundwater

In the highlands the ground water is almost exclusively confined to consolidated rocks, which include basalts, limestone and sandstone and metamorphic basement rocks. The retention capacity of these rocks is low and any groundwater is linked to the occurrence of fractures within these rocks. The presence of a thick basalt cap overlaying the normally better yielding sedimentary rocks restricts possible recharge of these areas and limits exploitation of shallow aquifers, such as springs and wells.

The presence of deep gorges along the Abbay escarpment also provides relatively free drainage for the aquifers which may emerge as springs in the lower slopes. This effectively draws the groundwater table down deeper in the locality of the escarpment which significantly reduces the potential storage ability of the aquifers.

On the Sudan plains the hydro-geological system comprises two aquifers: an upper and a lower (Farah, E.A. et al., 1997). The upper aquifer includes mainly the Upper Geizera Formation, the upper part of the Lower Geizera formation in the area between the Blue and White Nile, and the upper part of the Lower Omdurman Formation to the north of the Blue Nile. The lower aquifer is developed mainly in the deeper Nubian Sandstones.

The water storage in the lower aquifer is some eight times that of the upper aquifer. Except for a few isolated localities water quality is free from impurities for drinking and irrigation requirements.

2.2 Socio-economic Characteristics

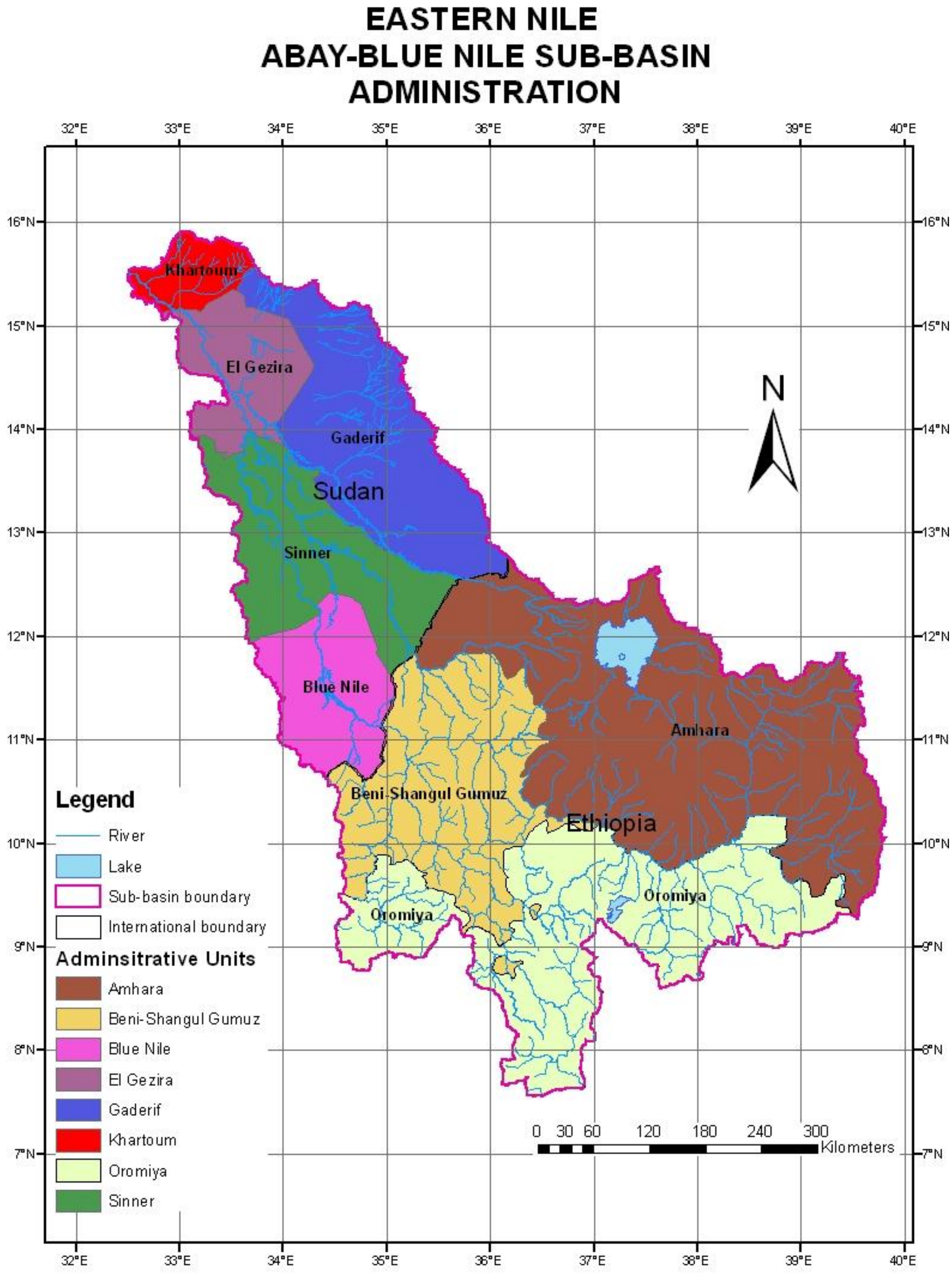
2.2.1 Administration

In the Sudan there are five states and in Ethiopia three Regional States partially located within the Sub-basin: 35 percent of the Sub-basin area is in Sudan and 65 percent in Ethiopia (table 7).

Table 7. Abbay-Blue Nile Administrative States/Regional States and their areas (km2)

State/Regional State	Area (km2)	% of Sub-basin
SUDAN		
Sinnar	30,106	**10%**
Blue Nile	19,162	**6%**
El Gezira	15,686	**5%**
Gaderif	38,929	**12%**
Khartoum	6,880	**2%**
		35%
ETHIOPIA		
Amhara	93,565	**30%**
Beni-Shangul Gumuz	44,676	**14%**
Oromiya	62,478	**20%**
		65%
Sub-basin	**311,481**	

Source: Sudan: ENTRO GIS data base: Ethiopia WBISPP GIS database.



Map 11. Abbay-Blue Nile Sub-basin: Administrative States/Regional States

Source: Sudan: ENTRO GIS data base: Ethiopia WBISPP GIS database.

2.2.2 Population

(i) Population Numbers and Distribution

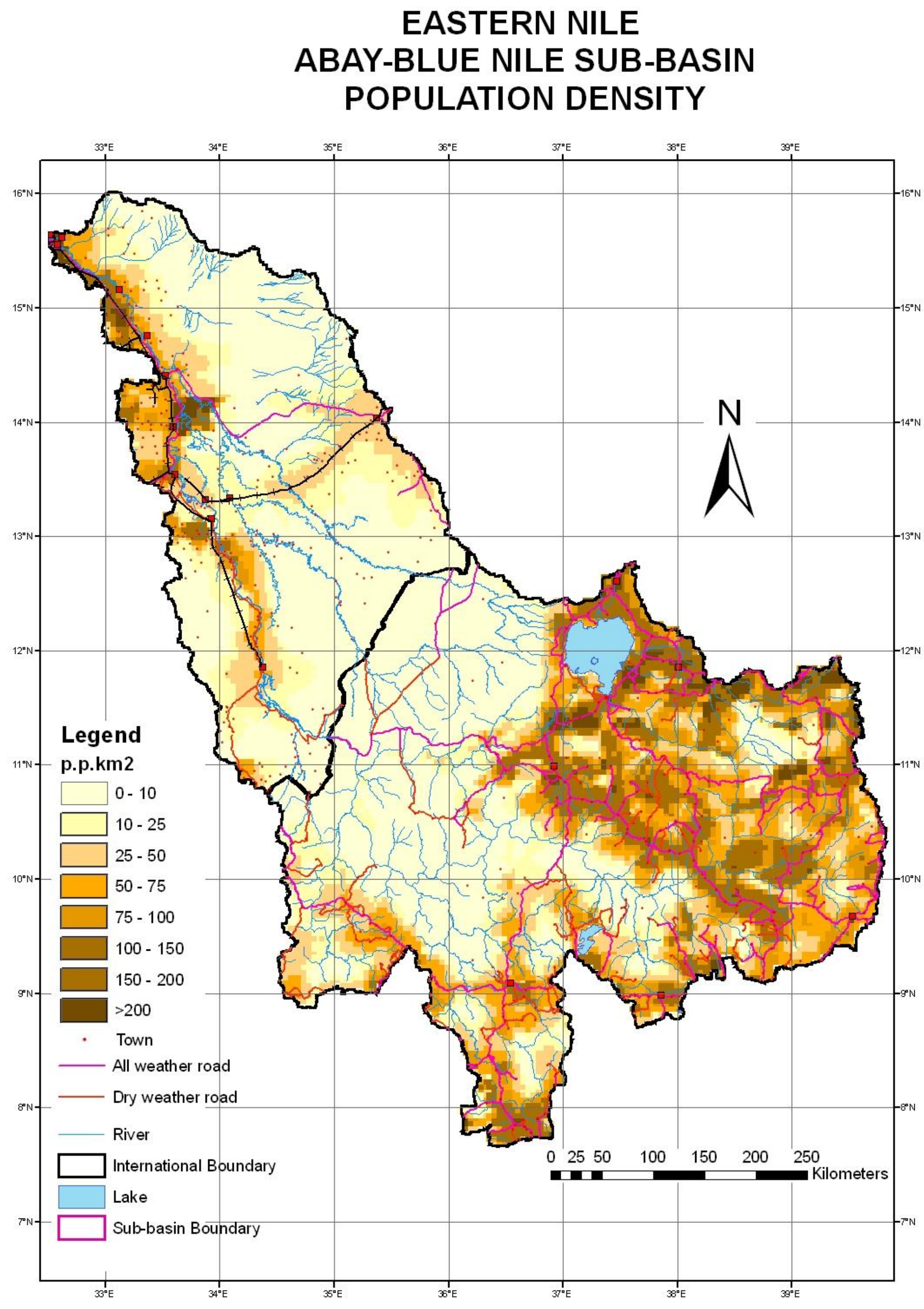
The LandScan 2002 Global Population Database developed by Oak Ridge National Laboratory (ORNL) of the United States provides 2002 population estimates on a 1km grid. This was clipped by the State and Regional State boundaries within the Sub-basin to provide population estimates within the Sub-basin by State/Regional state. National census estimates of the rural-urban distribution were used to provide estimates of total rural and urban populations. These are shown in table 8.

Table 8. Abbay-Blue Nile Sub-basin: Total, Rural and Urban population estimates by State/Regional State for 2002.

State/Regional State	Total pop.	Rural pop.	Urban pop.	Rural %	% of Sub-basin total	Pop density ppkm2
Amhara	10,256,425	9,230,783	1,025,643	90%	45%	99
Beni-Shangul Gumuz	452,427	420,757	31,670	93%	2%	9
Oromiya	5,601,177	4,985,048	616,129	89%	24%	80
Blue Nile	338,291	253,042	85,249	75%	1%	17
El Gezira	1,919,580	1,489,594	429,986	78%	8%	117
Khartoum	2,105,800	280,071	1,825,729	13%	9%	296
Gaderif	1,151,050	818,397	332,653	71%	5%	28
Sinner	1,091,640	782,706	308,934	72%	5%	34
	22,916,390	**18,260,398**	**4,655,993**			

Sources: Ethiopia: CSA, 1999. Sudan: UN Population Fund & Sudan Central Bureau of Statistics. (2002). LandScan 2002 Global Population Database developed by Oak Ridge National Laboratory (ORNL)

In Ethiopia high population densities are clearly related to the Highlands (i.e. above 1,500 masl). There densities generally exceed 75 p.p.km^2 where as in the Lowlands densities are below 25 p.p.km^2. This is a reflection of the favorable natural and health environment of the Highlands for human settlement. In Sudan high population densities are located along the Blue Nile River and the main road that runs parallel to the river. The west-east band of high densities is located along the Sennar-Gederef railway line and not the main Khartoum to Port Sudan road. The urbanization of Khartoum and Gezira States accounts for their high overall densities.



Map 12. Abbay – Blue Sub-basin: Population densities and distribution.

Source: LandScan 2002 Global Population Database developed by Oak Ridge National Laboratory (ORNL)

(ii) Demographic Characteristics

Population growth rates and other demographic characteristics are shown in table 9.

Table 9. Abbay-Blue Nile Sub-basin: States/Regional States - Demographic Characteristics

State	Rural Gth rate %	Urban %	% <15yrs	% >60yrs	Sex ratio M/F	Crude birth rate	Crude death rate	Infant mort. male**	**Infant mort. female ****
Blue Nile	3.00	25.2	42.7	3.7	108.3	38.5	12.3	137	**122**
Gadarif	3.40	28.9	43.1	3.7	105.3	40.3	11.7	135	**122**
Khartoum	4.00	86.7	36.5	3.8	111.3	33.7	8.8	98	**85**
El Gezira	3.00	22.4	42.5	4.4	96.8	38.5	9.5	101	**76**
Sinnar	2.60	28.3	44.5	4.0	98.8	39.9	10.9	121	**109**
Amhara	2.55	10.4	43.25	6.0	99.9	36.6	10.9	83***	
Beneshangul-Gumuz	2.43	9.0	44.49	4.7	101.4	37.2	12.6	104***	
Oromiya	**2.56**	**11.8**	**44.98**	**5.5**	**99.6**	**38.3**	**10.9**	**86*****	

Source: Ethiopia: CSA, 1999. Sudan: UN Population Fund & Sudan Central Bureau of Statistics. (2002).
*Rural rate
** per 1000 live births
*** male& female

In Sudan there is a moderately strong relationship between infant mortality rates and poverty rates (table 12) with Gaderif and Sinner States both having high infant mortality and poverty rates, although the case of Blue Nile confounds this relationship. In Ethiopia likewise there is a close relationship between the higher infant mortality and poverty rates in Beneshangul-Gumuz compared Amhara and Oromiya regional States.

(iii) Literacy and Education

The literacy and primary school enrolment rates for the States/Regional States in the Sub-basin are shown in table 10.

Table 10. Abbay- Blue Nile Sub-basin: States/Regional States – Literacy and Primary School Enrolment Rates

State	Literacy >15yrs % Average	Literacy >15yrs % Male	Literacy > 15yrs % Female	Pop. 6-13yrs	Total Primary school enroll.	% enroll.
Blue Nile	31.3	41.8	20.4	143,305	48,914	34.1
Gaderif	55.6	72.9	38.4	311,547	142,313	45.7
Khartoum	73.6	81.1	65.0	795,983	659,028	82.8
El Gezira	65.2	75.5	55.8	658,547	538,183	81.7

Sinnar	52.0	64.5	40.0	267,649	146,090	54.6
Amhara	17.8	23.5	12.1	4,102,557	2,483,603	61.0
Beneshangul-Gumuz	17.7	24.9	10.5	268,462	238,931	89.0
Oromiya	22.4	29.3	15.6	2,240,471	1,440,311	64.0

Sources: Sudan: Sources: Sudan: UN Population Fund & Sudan Central Bureau of Statistics. (2002). Ethiopia: World Bank, 2004.

In Sudan high enrollment rates are clearly related to the high rates of urbanization in Khartoum and El Gezira States. Interestingly in Ethiopia the highest rates of enrollment are in relative remote Beneshangul-Gumuz Regional State.

(iv) Water and Sanitation

The percent population with access to drinking water and sanitation facilities are shown in table 11.

Table 11. Abbay-Blue Nile Sub-basin: States/Regional States – (a) Percent Population Access to Drinking Water, (b) Sanitation Facilities

(a) Drinking Water by Source

State	Piped into dwelling	Public tap	Deep Well/pump	Dug Well/ bucket	River/canal	Rainwater	Others
SUDAN							
Blue Nile	12.3	2.1	9.3	2.1	33.2	27.9	13
Gaderif	12.6	18.8	27.7	13.9	13.8	9.4	3.6
Khartoum	59.8	3.5	29.5	2.4	0.2	1.6	2.9
El Gezira	47.2	14.1	16.6	6.6	12	0.2	3.3
Sinnar	30.2	11.3	32.4	0.6	8.1	9.3	7.6
ETHIOPIA	**Tap**		**Protected well/spring**	**Un-protected well/spring**	**River/lake/pond**		**Other**
Amhara	9.1		12.3	41.6	36.3		0.3
BSG	12.5		5.7	0.2	63.1		0.4
Oromiya	11.2		11.2	34.2	43.1		0.3

Sources: Sudan: Sources: Sudan: UN Population Fund & Sudan Central Bureau of Statistics. (2002). Ethiopia: World Bank, 2004.

In terms of provision of piped water supply the urbanized States of Khartoum and El Gezira are clearly better endowed than the other more rural States. In Ethiopia the rate pf protected water supplies (tap and protected spring/well) is similar across all the regional States. Wells and springs are the more prevalent source in the highland Regional States of Amhara and Oromiya, with rivers and ponds the more prevalent in lowland Beneshangul-Gumuz regional State.

(b) Sanitation facility by type

State	Flush to Sewage System	Flush to septic tank	Traditional pit latrine	Soak away pit	Others	Missing	No facilities
Blue Nile	--	3.5	56.0	3.2	0.4	0.8	36.0
Gaderif	--	5.0	31.7	3.1	0	0	60.1
Khartoum	1.1	11.2	73.8	0.9	3.1	0.4	9.5
El Gezira	--	4.2	51.7	2.1	1.7	0.2	40.0
Sinnar	--	2.7	46.6	5.3	2.1	0.7	42.7
	Flush - private	**Flush – shared**	**Pit - private**	**Pit - shared**	**Other**		**No facilities**
Amhara	**1.6**	**1.2**	**18.2**	**16.2**	**1.1**		**61.7**
BSG	**2.2**	**3.9**	**30.3**	**0.3**	**1.7**		**61.6**
Oromiya	**1.8**	**1.4**	**33.4**	**22.4**	**1.1**		**39.9**

Sources: Sudan: Sources: Sudan: UN Population Fund & Sudan Central Bureau of Statistics. (2002). Ethiopia: World Bank, 2004.

Khartoum with its relatively low and Gaderif with its high rate of no sanitation facilities follow the pattern of piped water provision. With the remaining States the relationship is not as clear. In Ethiopia the rates of no sanitation facilities do not parallel those for protected water supplies.

2.2.3 Livelihood Characteristics

(i) Poverty

The JAM Report (2005) defined the poverty rate in Sudan as the proportion below 40 percent of an economic status index based on asset ownership. Unfortunately the index is not defined. The poverty line in Ethiopia is set using a basket of food items sufficient to provide 2,200 kcals per adult per day. Together with a non-food component this represents Ebirr 1,070 in 1995/96 prices. Clearly, the two measures are not directly comparable. The results are shown in table 12.

In Sudan rates are higher in Gaderif and Sinner States than the other 3 States. The JAM Report considers that poverty rates in the traditional agricultural sector have increased in the last decade notwithstanding the increases in agricultural productivity. In Ethiopia poverty rates are higher in the lowland Regional State of Beneshangul-Gumuz than in the two highland Regional States of Oromiya and Amhara. Overall, rural rates have declined since 1995 and urban rates had increased.

Table 12. State/Regional Poverty Rates in Sudan and Ethiopia

State/Regional State	Rural	Urban	Total
SUDAN			41-60%
Gaderif			41-60%
Sinner			21-40%
El Gezira			21-40%
Blue Nile			21-40%
Khartoum			21-40%
ETHIOPIA			
Amhara	32%	35%	32%
Beneshangul-Gumuz	56%	41%	55%
Oromiya	37%	49%	38%

Sources: Sudan – JAM Report (2002). Ethiopia SDPRP Report, 2003)

(ii) Socio-cultural Aspects of the Population

Within the Sub-basin the political boundary between Sudan and Ethiopia is mirrored by socio-cultural as well as by physical boundaries.

Within the Sudan a substantial proportion of the population in the Blue Nile Sub-basin live and work on the large irrigation schemes and semi-mechanized farms or in service and processing industries related to these developments. Many in the past followed pastoralist and agro-pastoralist livelihoods, but who for one reason or other lost their livestock and became sedentarized.

There are a number of groups of people who retain their original way of life, although now somewhat altered. The Rufa'a al-Hoi are an Arab speaking Muslim nomadic people with sheep, cattle and camels and are divided into two groups: the northern Badiya located on the Blue Nile (dry season) and who move north towards the Dinder River (wet season); and the southern Badiya who used to move between the Yabus (in the dry season) and the Gezira/Managil schemes In the wet season). As well as livestock production gum collection (from *A. seyal*) and sorghum cropping supplement livelihoods.

In the past two decades and particularly after the 1984 drought, there have been an increasing number of Rufa'a al-Hoi people without livestock becoming sedentarized. Following the abolition of the Native Authorities many sedentary villages ran their own village councils and the power of the Rufa'a al-Hoi declined. The recent installation of the Federal structure has further weakened the power of the Rufa'a al-Hoi and so increased that of the sedentary people.

The Kenana are also Arab speaking pastoralists who move between the Blue Nile northwards beyond the Dinder River. They come into contact with the northern Badiya group of Rufa'a el-Hoi along the Blue Nile.

The Fulani are in fact a mixture of many ethnic groups from West Africa who moved into the Funj in the mid 1940's, were expelled to western Sudan in 1954 but have since returned. They have the West African long horned cattle that are fast walkers but poor milkers. The Fulani follow the same transhumant patterns as the Rufa'a al-Hoi but at slightly different times usually leaving the dry season grazing area later. They are said to remain out of contact with government tax and veterinary agents, often moving at night. They are known to cross the border into Ethiopia in the vicinity of the Dinder national park.

The Ingessana is a name given to the people living in the Ingessana Hills with a distinctive language and culture. They are predominantly agriculturalists cultivating the foothills. Cattle, goats and camels are socially and economically important. Livestock are kept in the hills during the wet season and move either south-eastwards to the Machar Marches and the Yabus, and to the east to the Blue Nile and the border with Ethiopia. They maintain a spirit of cooperation with the Rufa'a al-Hoi and many Ingessana work as herders for them. As well as the Ingessana there are a number of smaller groups who practice sedentary agriculture. These include the Berta, Gumuz and Burun, and along the Blue Nile many peoples from western and northern Sudan who arrived after the Mahdist rule.

Within Ethiopia in two of the three Regions located within the basin one ethnic group tends to be predominant. Only in the Beneshangul-Gumuz region are the various groups more evenly distributed. There are over 55 ethnic groups represented in the Amhara Region. However, the main groups are Amhara with 91 percent and Agew with 4% of the rural population
There are 6 major ethnic groups represented in the Beneshangul-Gumuz Region. The relative proportions are:

Jebelaw/Koma/Mao	-	29%
Gumuz	-	25%
Amhara	-	20%
Oromo	-	12%
Sinashi	-	7%
Agew	-	3%

In the Oromiya Region as a whole there are over 71 ethnic groups. The main groups are Oromo and Amhara with 88.7 and 7 percent of the rural population respectively.

2.3 Agriculture

2.3.1 Main Agricultural land Use Systems

The main agricultural land use systems in the Abbay-Blue Nile Sub-basin in Sudan and Ethiopia are relatively distinct except along the international border where the ago-environment in one case and cultural affinities in another have given rise to very similar systems. Nevertheless, three broad systems can be identified: (i) rainfed cropping, (ii) irrigated cropping and (iii) extensive livestock production (with minor cropping). Differences in the scale of operations, tenure type and to a lesser extent cropping patterns give rise to a number of recognizable sub-categories. These are summarized in table 13.

Table 13. Main Agricultural Systems in the Abbay-Blue Nile Sub-basin

Main Category	Scale of operations	Tenure type	Main Components	Location
RAINFED CROPPING	Small-scale traditional; sedentary	State land: Individual and Communal use rights	Cropping (Cereals, pulses, oil seeds) Small Livestock holdings (Communal grazing, crop residues)	Ethiopia: Highlands
	Small-scale traditional; shifting	State land: Individual and Communal use rights	Cropping (cereals, pulses): Small livestock holdings (Communal grazing, crop residues)	Ethiopia & Sudan: Lowlands
	Large-scale: Semi-mechanized	State land: Medium-term Leases	Cropping (Sorghum, cotton, sesame)	Ethiopia & Sudan: Lowlands
IRRIGATED CROPPING	Small schemes Small-scale operations (< 1.0ha) Gravity:	State Land: Individual use rights: additional to rainfed land	Cropping (cereals, vegetables)	Ethiopian Highlands
	Small-scale:(<20 ha) Pump	Individual Freehold	Cropping: Sorghum, wheat, Alfalfa	Blue Nile
	Large schemes Small-scale (< 1.0ha) Gravity:	State Land: Individual use rights: additional to rainfed land	Cropping (cereals, vegetables)	Ethiopian Highlands
	Large scheme: small-scale operations (<40 feddans) Gravity	State land: Individual long-term leases	Cropping: Cotton, Sorghum, wheat Small-livestock holdings	Sudan: Gezira and Rahad Schemes
	Large scheme: large-scale operations	State land	Cropping: Sugar	Ethiopia: Fincha'a Sudan: Senner and Guneid Sugar Schemes
LIVESTOCK	Small-scale: Extensive Pastoral Transhumant	State land: Communal use (grazing, water) rights	Cattle, small-ruminants	Sudan
	Small-scale: Extensive Agro-pastoral Transhumant-sedentary	State land: Communal use (grazing, water) rights	Cattle, small-ruminants Small-scale cropping	Sudan

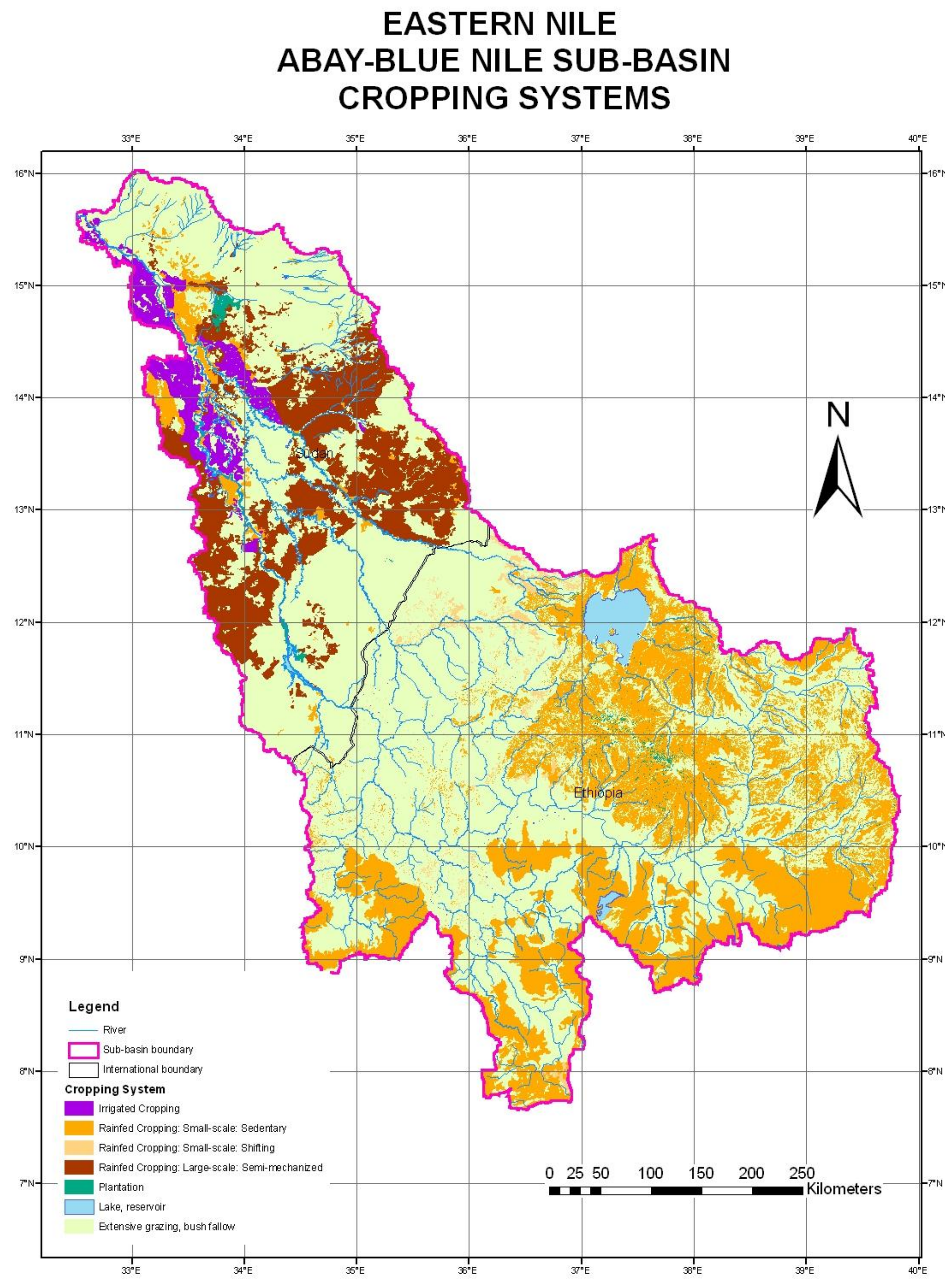
Rainfed cropping operates at the traditional small-scale and the large and semi-mechanized scale (Map 13). The former is under individual use rights for cropping and communal use rights for grazing and fuelwood collection. Mixed cropping and livestock production are the main production components. In the Highlands cropping is sedentary whilst in the lowlands it incorporates bush fallowing and shifting cultivation. In both the highland and lowland systems use of improved inputs (chemical fertilizer and seeds) is low. Conversely, the large-scale semi-mechanized systems are under state lease-hold tenure (25 years leases) and a number of cultural operations (ploughing, harrowing and seeding) are mechanized. Nevertheless, the use of improved inputs (fertilizer, seed) is minimal.

There are a number of sub-categories of irrigated cropping. A convenient division can be made firstly between large and small schemes[2]. In Ethiopia large schemes are represented by the Fincha'a and Koga Schemes and in Sudan by the Gezira[3] and Rahad Schemes. The small schemes include both traditional and modern small schemes in Ethiopia and the small pump schemes along the Blue Nile in Sudan.

The large schemes are divided those with large and those with small-scale operations (not possible to separate out in Map 13 because of the small areas of the latter). The large schemes with large scale operations: one Ethiopia and the other in Sudan both are under sugar cane production. The large schemes with small-scale operations can be divided between those in Ethiopia that have small farms with cropping use rights on State land and those in Sudan with tenancy rights.

The one large scheme with small-scale operators in Ethiopia within the Abbay-Blue Nile Sub-basin is still under construction. The two major schemes in Sudan in the sub-category are the Gezira and the Rahad. In the Gezira Scheme some 60 percent of the land is owned by the State and 40 percent compulsory leased by the State from the original freeholders (World Bank, 2000, Wallach, 2004). The Sudan Gezira Board (SGB) manages all land within the Scheme and leaseholders are not allowed to sub-lease. Tenancies are for 20 feddans (8 ha) and can be inherited and sub-divided to a maximum of one half. There are 114,000 tenancies but with half tenancies this may be as high as 120,000. Most tenants use hired labour. Cropping intensity is 70 percent with a 5 course rotation (cotton. sorghum, groundnuts, wheat and fallow. Given the very low profitability of cropping, most tenants have taken up livestock production. The Rahad scheme has similar characteristics.

[2] The difference between the two is necessarily arbitrary but 5,000 ha is a convenient division.
[3] The Managil Extension to the Gezira Scheme is within the White Nile Sub-basin.



Map 13. Abbay-Blue Nile Sub-basin: Major Cropping Systems
Sources: FAO Africover Sudan (2002), WBISPP (2001-2003)

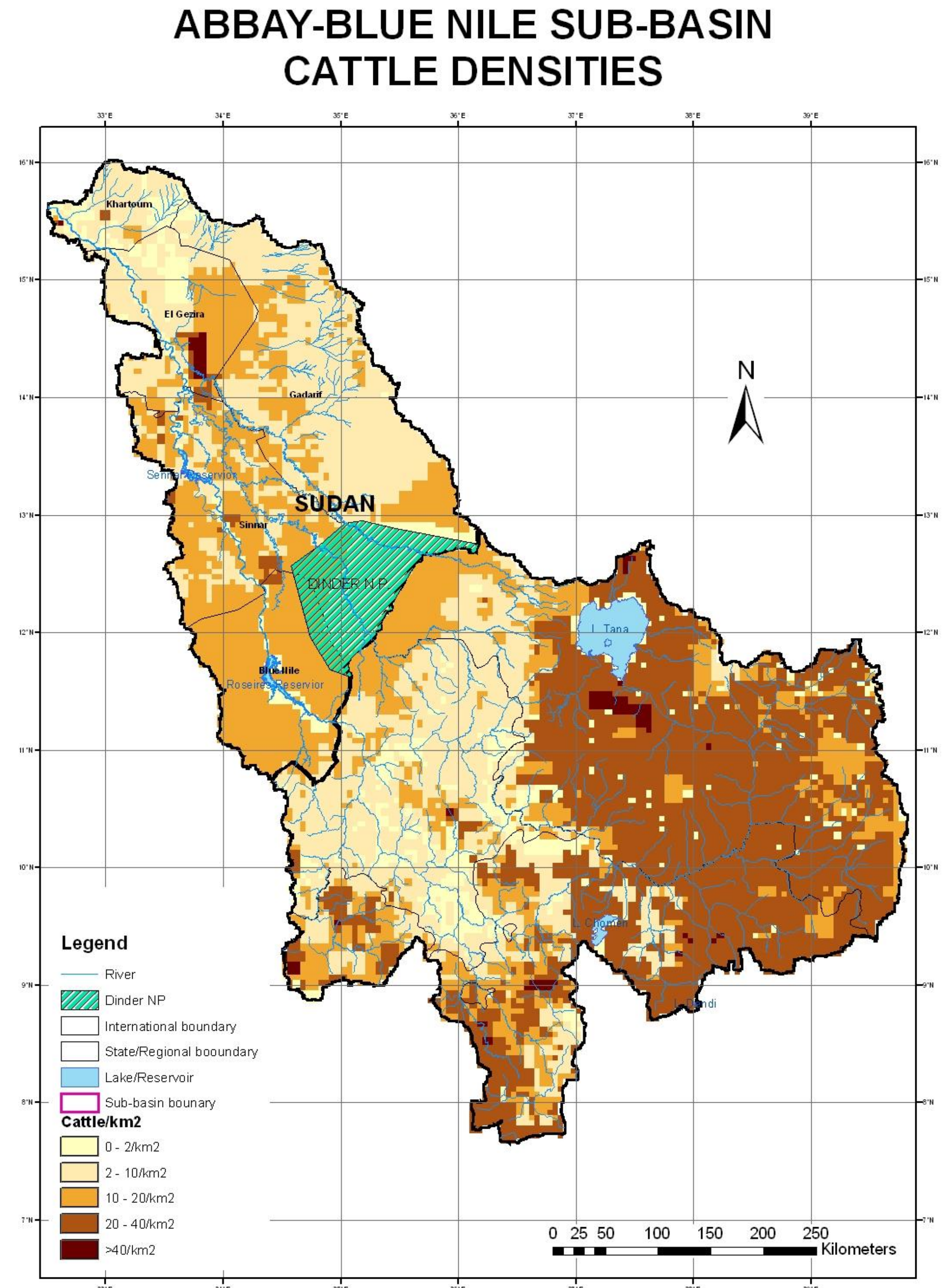
The small irrigated schemes can be divided into gravity and into pump schemes. The gravity schemes are found mainly in the Ethiopian Highlands and comprise both traditional and modern schemes. Traditional irrigation has a long antiquity in Ethiopia and generally uses local materials (wood and stone), whilst the modern schemes generally use cement and brick for the main structures. Farmer-built water control programs fed mainly by groundwater are common along the foothills of the valley sides and in the valley bottoms of the Nekemte-Arjo-Didessa area. Farmers have use rights to cropping in the same way as their rainfed land. Plots are small (< 1.0 ha). The main crops are cereals and vegetables. The pump schemes along the Blue Nile in Sudan have freehold tenure dating back to the early 20th century. The main crops are cereals, fruit and vegetables. Recently bananas have become a valuable cash crop.

In the rainfed small-scale systems and on the large irrigation schemes livestock are an important component and livelihood strategy despite the small number per household. They provide additional sources of income and thus help to spread the risks associated with rainfed cropping. In the highlands they are a valuable source of soil nutrients and in fuelwood scare areas of fuel. In Sudan dung is not used as farmers believe they are a source of weeds (Kibreab, 1996).

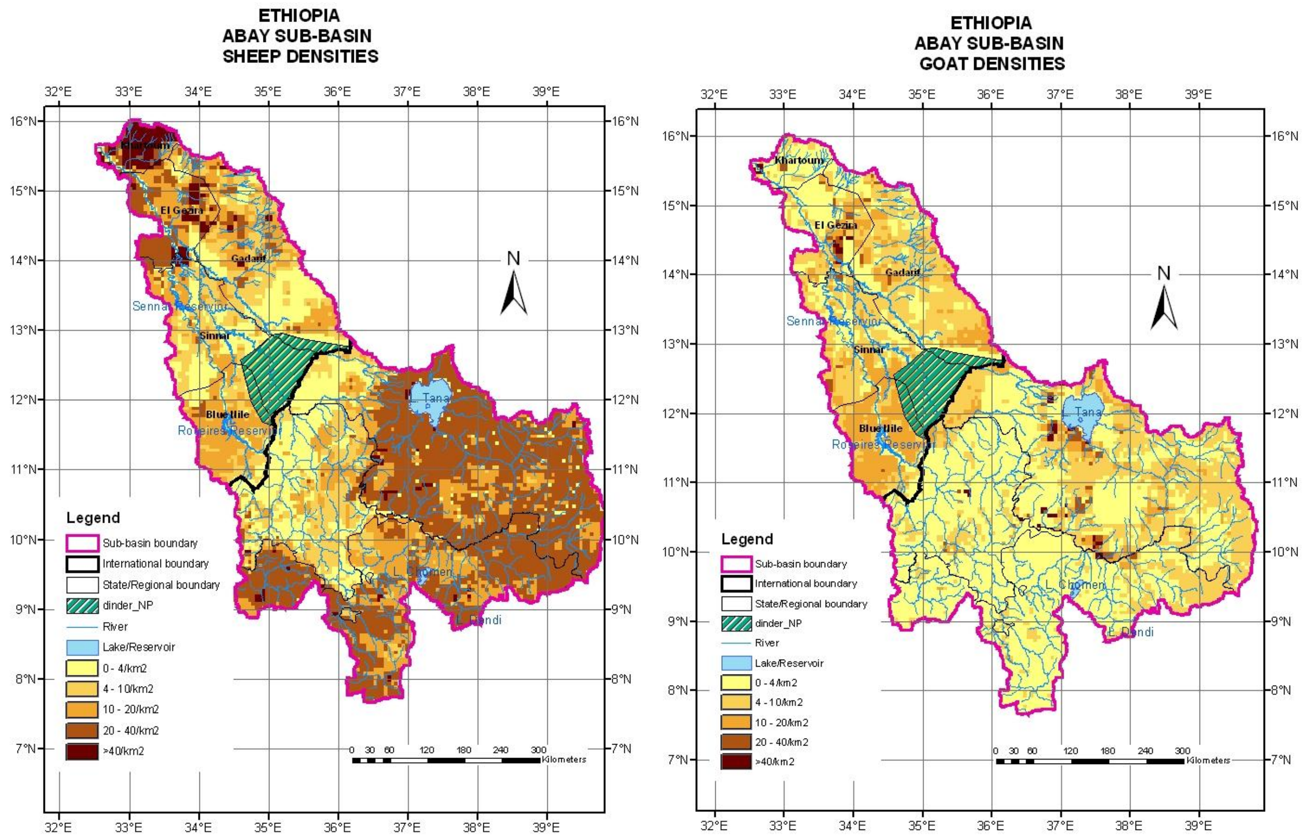
The extensive livestock production systems are distinguished only by the inclusion of some rainfed crop production. The reliance on crop production may in fact change in both the short and long-term due to the high variability of rainfall. Over the past two decades many households have and are still making the transition from pastoralism to agro-pastoralism to sedentarized crop cultivation and vice versa as household and external conditions change. These changes in household production systems are the result of the massive losses in household and community livestock assets during the drought of the early 1980's exacerbated by the increasingly loss of wet season grazing areas and water resources from the big expansion of large-scale semi-mechanized farms during the 1980’s and 90’s. With the restoration of exports to Middle East livestock production makes a significant contribution to the agricultural GDP.

Data from the FAO Livestock Atlas for Africa are used to derived Map 14 and 15 to show the distribution of cattle, sheep and goats. Whilst the maps indicate that the Dinder National Park has no livestock it is known that in fact there are considerable incursions of livestock into the park. The high densities of cattle in the Ethiopian Highlands and low densities in the Lowlands are readily apparent. In the wooded Lowlands south of the Dinder Catchment the area is infested with tsetse fly and trypanosomiasis is very prevalent. In Sudan densities are relatively high in the higher rainfall areas of the southeast. Elsewhere the large areas of semi-mechanized farms and large-scale irrigation schemes largely preclude even moderate densities of cattle, although as indicated above livestock are an important livelihood strategy for tenant and labourer households in these schemes.

The distribution of sheep and goats are essentially reversed: with higher densities of sheep in the Ethiopian Highlands than the Ethiopian or Sudan Lowlands, with the picture reversed with respect to goats. Overall densities of sheep are nearly everywhere higher than goats. In Sudan they are the preferred animal for export to the Middle Eastern countries.



Map 14. Abbay-Blue Nile Sub-basin: Cattle densities
Source: FAO (2003)



Map 15. Abbay-Blue Nile Sub-basin: Sheep and Goat Densities
Source: FAO (2003)

2.3.2 Agricultural Marketing

(i) Crop Marketing

In Ethiopia the State has withdrawn totally from agricultural marketing, whilst in Sudan the Government retains some controls in sorghum and gum arabic marketing.
During the 1990's the Government of Sudan removed many of the crop price and marketing controls it had instituted in the decade previously. The power of the large Commodity Boards was considerably reduced. Heavy marketing charges and State agricultural taxes were also largely removed. The result was immediate with agricultural growth of 10.8 percent in the 1990's compared with only 0.8 percent in the 1980's. Uncertainty as to the government's intents on whether to restrict sorghum exports also contributed to a decline in the area planted to sorghum on the semi-mechanized farms. For most of the export crops, markets are in the hands of private traders who operate through primary (village); secondary (Locality) and main "terminal" markets (State). The government can still intervene in the sorghum market by restricting exports or through its influence on cropping patterns (through cheap credit) on the large irrigation schemes.

The export of Gum Arabic is still controlled by the Gum Arabic Corporation but local marketing and processing is possible. In Blue Nile State Gum producers and processors collaborate.

In Ethiopia farmers bring their grain to markets 5 to 20 kms from their villages, with about 80 percent of their cash sales occurring immediately after harvest. There is little or no information available to farmers to enable them to determine what crops to plant and hoe much. Grain prices are generally not negotiated in advance and are seldom influenced by cultural or social relations between seller and buyer. Farmers sell to the small merchants or assemblers in the market towns.

Smaller merchants are constrained by lack of financial credit, storage, transport facilities and are subject to a low capital turnover. Because small traders' capital is tied up in inventory the large merchants can exert considerable influence on grain prices in the absence of any competition. Wholesale traders are the principal agents in inter-regional grain movements[4] buying in surplus markets and selling in deficit markets and to Addis Ababa and regional capitals. They handle about 45 percent of the estimated 2.6 million tons of grain sold annually. This is approximately 28 percent of total annual grain output. At the national level the 10 percent of the largest traders command about 43 percent of wholesale trade.

[4] Gebremeskal Dessalegn et al (1998) "Market Structure, Conduct and Performance of Ethiopia's Grain Markets", Working Paper 8, Grain Market Research project, MEDAC, Addis Ababa, January 1998.

Brokers are intermediaries between the wholesale traders and the merchants in the main markets (regional capitals and Addis Ababa). There are two types of brokers. The first is involved in storage, paying transport charges for wholesales, remitting money to the wholesaler and arranging return of empty sacks. The second merely facilitates the grains sales at the main market.

However, there is an increasing involvement in grain marketing of large incorporated private enterprises that may change the marketing structure by their superior access to credit, transport and connections with government. These currently control the marketing of fertilizer. Retailers in the towns buy from the wholesalers and sell in smaller quantities to consumers in convenient locations.

There are a number of characteristics of the grain marketing chain. Firstly, there is little transformation along the marketing chain. Bulk grain is sold in unprocessed form. Thus, few market services are provided by the intermediaries in the chain. Secondly, it is common to change the sack at any point in the chain where there is a change of ownership, thereby increasing the costs. Allied to this, there is a complete absence of a system of grading for grain. Consequently, traders generally trade with people they know, thus restricting the size of the market. Finally, one third of grain traded is sold by producers directly to consumers.

(ii) Livestock Marketing

In Sudan the livestock marketing structure is long established and is based on primary markets at the village level, secondary markets at the provincial level and five terminal markets. The largest terminal market is in Omdurman, which also has three other smaller terminal markets for domestic consumption. Terminal markets are also located at Kosti and El Gedarif.

The livestock marketing system is highly broker-dominated (Yacob Aklilu, 2002). The brokers buy livestock from the villages and on-sell to brokers in the secondary markets who in turn sell to brokers in the terminal markets. Agents organize the trekking of animals up the marketing chain. The seasonality in livestock purchasing has led to the practice of feedlots around major markets. Most livestock are purchased “on trust” with payments being made some time after the original purchase with the producer being paid last. Marketing margins are extremely high because of the long distances travelled, costs of trekking, watering, feeding and numerous taxes. In July 2002 the average price at the primary market was one-eighth of the f.o.b. price.

In Ethiopia livestock markets function at three levels: primary, secondary and terminal markets. Primary markets are located at the village level with a supply of less than 500 head, where producers (farmers and pastoralists) sell to small traders, other farmers and pastoralists (replacement animals) and local butchers (Yakob Aklilu, 2002).

Secondary markets are trader and to some extent butcher dominated markets, with an average weekly volume of 500 - 1,000 head, consisting of finished, breeding and draught stock. These are located mainly at the Regional capitals. Though they serve local consumers, they mainly feed the terminal markets. The secondary markets also supply live animal exporters and meat processors. Supply of livestock to the primary, secondary and terminal markets is through trekking. Traders and producers use traditional stock routes. Cattle are walked 35-40 kms and shoats 15-25 kms a day. Staging points are chosen according to customary practices. A 1995 study indicated that costs of a 100 kms trek are EBirr1.15 per cattle and Ebirr0.16 per shoat. Weight losses of about 9 percent (18-40 kgs/head/trip) occur over a 7-8 days trek. Trucking is limited to large scale traders who purchase at distant primary and secondary markets to supply the terminal markets.

Farmers come to markets with no prior knowledge of prices and may take back animals if the price is too low. However, pastoralist who may have trekked some distance take what price is available.

2.4 Forestry and Agro-forestry

2.4.1 Forestry Contribution to the Economy

In Sudan in the Abbay-Blue Nile Sub-basin approximately 10.7 million m^3 of wood fuel and charcoal (per capita consumption of 1.4 m^3) are consumed forming about 80 percent of the total energy consumption. Woodlands provide all building materials in rural areas. They constitute 33 percent of the national livestock feed as browse. They also provide a number of non-timber forest products the most important of which is gum arabic.

In addition to these products the woodlands give a number of services which have no direct monetary values such as environmental protection, increase in crop production, conservation of soil fertility, biodiversity, protection of cultural heritage, forming habitat for wildlife and eco-tourism attraction.

The contribution of forestry sector to the GDP is around 3.3 percent in 1999 but taking into account the outputs collected/consumed by local communities the forestry sector's contribution to the national economy is around 12% of the national GDP (Forest Products Consumption Survey, 1995).

The situation in Ethiopia is not dissimilar to that in Sudan. In Ethiopia in the Abbay-Blue Nile Sub-basin some 23.4 million m^3/yr of fuelwood and charcoal (wood equivalent) are consumed as fuel forming about 65 percent of domestic energy consumption. Browse is of little importance in the Ethiopian Highland livestock systems. However, resins are of importance in the Lowlands north of the Abbay River. As most passes into the domestic market through informal channels data on harvesting levels are not known, although national estimates are of 2,067 tons of gums and resins were harvested with 65 percent being consumed within the country, the remainder being exported. The official figures for timber production do not include timber and poles produced and used outside the official marketing structures, in particular, for domestic use in rural areas.

2.4.2 Agro-forestry

In Sudan the main components of agro-forestry are the harvesting of Gum Arabic and browse for livestock as mentioned above. The Gum Arabic Belt (GAB) in the Abbay-Blue Nile Sub-basin comprises the major part of the low rainfall woodland savannah zone extending from the border with Ethiopia to the Main Nile almost all on clay soils. There is a distinct difference between the clay and the sand provenances of *Acacia senegal* in terms of their water-use efficiency and gum yield (Raddad & Luukkanen, 2006). The clay provenances were distinctly superior to the sand provenances in all traits studied especially in their basal diameter and crown width. The clay provenances are adapted for fast growth rates and high biomass and gum productivity.

There are a number of direct (production) and indirect (environmental) benefits accruing to gum production (Barbier, 1990). In terms of direct benefits the trees provides fodder for cattle, sheep, goats and camels. Older trees (i.e. 15 years or more) that no longer produce good quality gum are often cut for fuelwood and for charcoal production. In terms of indirect benefits the deep tap root and its extensive lateral root system means that it assists in reducing soil erosion and water runoff and for stabilizing soils. Because of its leguminous characteristics the tree fixes nitrogen, which encourages grass growth for grazing by livestock. The trees can act as wind breaks and can assist in the stabilization of shifting sand and moving dunes.

Seasonal labourers from other parts of the country migrate to the Gum Arabic Belt (GAB) seeking employment and thus its production system supports and extends livelihood strategies.

Currently, Gum Arabic production is unstable due to climatic factors and marketing policies, in particular the ban on private companies exporting unprocessed Gum Arabic. The floor prices paid by the government-owned Gum Arabic Corporation as a percent of export prices (f.o.b. Port Sudan) declined from 70 percent in 1994 to only 21 percent 2000/2001 (World Bank (2003). In 1990-1992 the government temporarily waived controls and the percent of export price rocketed to 160 percent! The gum Arabic plays an important role as major source of foreign exchange, accounting for 13.6 percent of the annual export income excluding petroleum.

In Ethiopia agro-forestry takes the form of planted trees (invariably *Eucalyptus spp.*) around the homestead and indigenous trees left in croplands. In the Highland areas north of the Abbay River *Eucalyptus spp*. dominate on-farm trees comprising nearly 90 percent of all on-farm trees. In the Highlands south of the Abbay River the proportion of Eucalyptus spp. fall to about 40 percent of on-farm trees and to virtually zero in the Lowlands, with indigenous and cash crop trees (mainly coffee in the Highlands) making up the remainder.

Prior to 1991 cutting of trees was prohibited and as a consequence very little on-farm tree planting took place under the Derg. With the installation of the Transitional Government the prohibition on tree planting was lifted and the tenure and use rights to planted trees were secured. With the accelerating economy and the subsequent building boom, there was a tremendous increase in the demand for construction poles in all the major and many of the minor centres. This in turn triggered an increase in on-farm tree planting of Eucalyptus.

However, the speed and the degree of response varied considerable within and between areas. Those areas with good market access exhibited the highest rates of planting, whilst those areas away from road access, areas with lower and more variable rainfall (eastern part of the Upper Abbay-Blue Nile Sub-basin) and those areas with considerable stocks of indigenous trees (Highland areas south of the Abbay River and the Lowlands) had much lower rates of Eucalyptus planting.

Trees in croplands are generally moderately to heavily pollarded for timber, fuelwood, forage and to reduce shade.

2.5 Transport and Communications

There are no major road linkages between Ethiopia and Sudan within the Abbay-Blue Nile Sub-basin. Dry weather tracks cross the border at three points: Bambudi on the north bank of the Abbay-Blue Nile, Bizen and Kurmuk both south of the Abbay-Blue Nile. The main roads in Ethiopia terminate at Guba (north of the River) and Assossa (south of the river). On the Sudan side of the border the closest main road to the border terminates at Ad Damazin (Map 16).

Within Sudan there are two primary (asphalt) and one all-weather secondary roads.

(a) Primary Roads

Khartoum- Wad Medani (187kms) – El Gederif (187kms)
Wad Medani - Sennar (107kms) – Damazin (278kms)

(b) Secondary Roads

El Gederif – Metema (159 kms)

Other roads are generally in poor condition and on the clay plains often impassable during the rains.

There is one railway line: Khartoum – Sennar - Gederif

Within Ethiopia because of the extreme dissection of the highlands by the Abay River and its tributaries road infrastructure is not well developed. As can be seen on map 16 the all-weather roads tend to be confined to the ridges and plateaus between the deeply incised rivers. For example, the Abay has only three road crossings. Thus both road construction and vehicle running costs are high.

Within the Abay basin the length and density of all weather and dry weather roads is as follows:

Table 14. Length and density of All-weather and Dry-weather Roads.

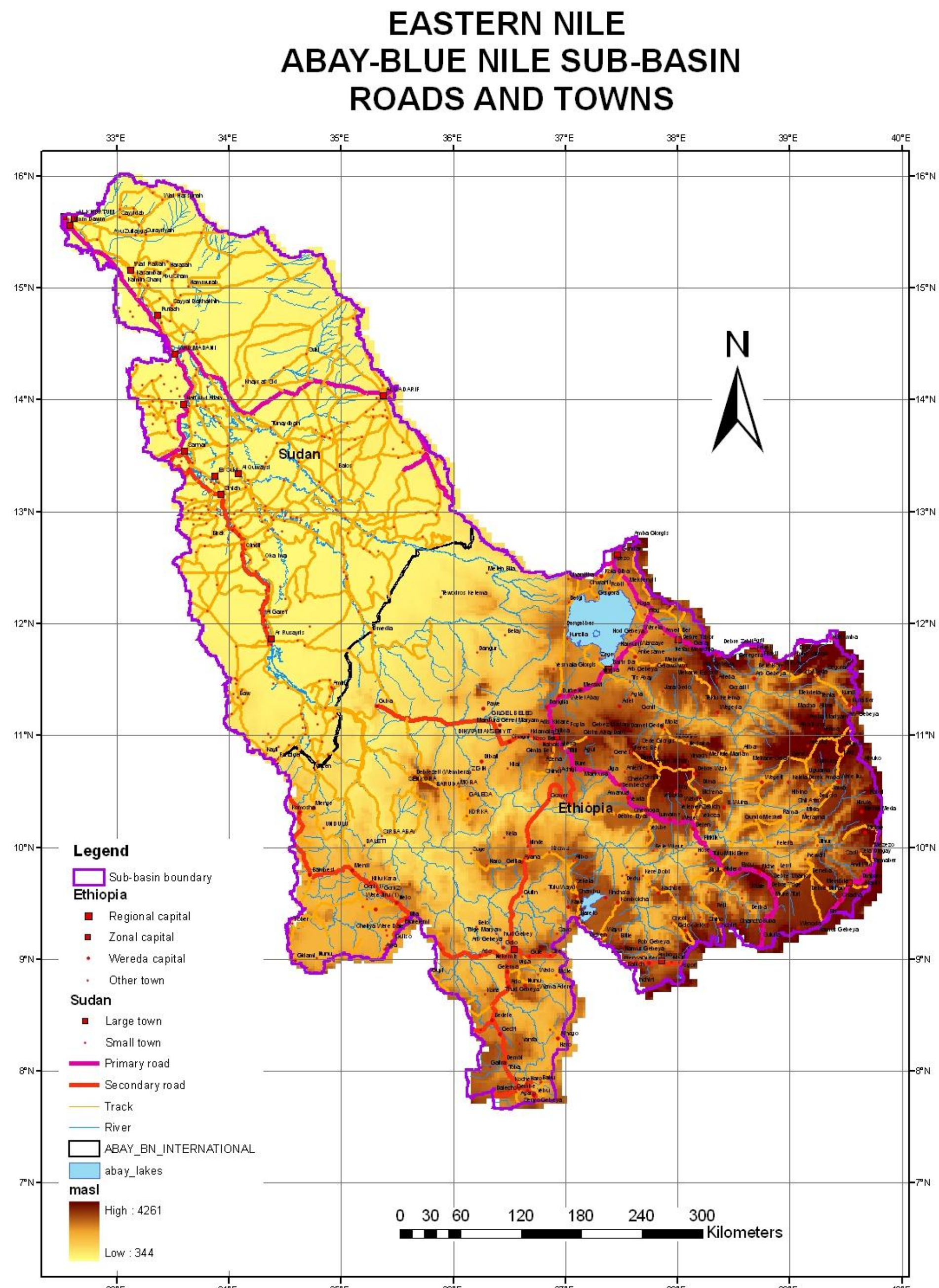
TYPE	**LENGTH (KM)**	DENSITY (km/1,000km2)
All weather	6,324	**32**
Dry weather	2,922	**68**
Total	**9,246**	**47**

The length of all-weather roads is significantly greater than dry-weather roads. This may be a reflection of the degree to which dry weather roads have been mapped. The road density for Amhara, Beneshangul-Gumuz and the western part of Oromiya Regions are as follows:

Amhara	-	46	kms/1000km^2
BSG	-	29	"
Oromiya – West Wellega	-	17	"
Oromiya – East Wellega	-	38	"
National	**-**	**31**	**"**

The road density is much lower in the sparsely populated Beneshangul-Gumuz Region and West Wellega Zone of Oromiya.

In terms of accessibility to all-weather roads some 45 percent of the area of the Sub-basin is more than 15 kms distance. The main areas of inaccessibility are located in the western parts of North and South Wello in the Abay Gorge; the middle and the Lower Abay Gorges; and the western Lowlands of the Dinder and Beles Valley



Map 16. Abbay-Blue Nile Sub-basin – Roads, Railways and Towns

Source: Sudan Afriroads (2002) and FAO Africover. Ethiopia: Ethiopian Mapping agency 1:50,000 map sheets.

3. SUB-BASIN-WIDE WATERSHED MANAGEMENT AND LIVELIHOOD ISSUES

3.1 The Underlying Causes of Natural Resource Degradation

3.1.1 The Framework of Analysis

Whilst many of the proximate causes of resource degradation are well known the underlying causes are often less obvious and difficult to discern.

Some of these such as poverty and population pressure may at first seem obvious but recent research into these factors has revealed that the linkages between one or more factors and continuing resource degradation are far from clear. For example, in Ethiopia after nearly ten years of detailed research into the underlying causes of resource degradation by many natural, social and economic scientists the picture that has emerged is often mixed and contradictory. In many cases the underlying causes that are identified are very specific in time, place and situation.

The land and water use systems in the Abbay-Blue Nile Sub-basin are highly varied and reflect not only the natural resource base, but also the complex social, cultural and economic characteristics of the land users and the economic, institutional and policy environment in which they operate. Land use systems have their own dynamics responding to endogenous and exogenous factors that have impacts on user livelihoods and the properties of natural resources and environmental services. This analysis seeks to establish any causal linkages between land use systems and trends in these properties and services.

The International Food Policy Research Institute (IFPRI) has over the past decade developed an appropriate framework for analyzing the dynamics of change of the complex web of factors (Scherr et al., 1996) (fig. 4). Pressure or “shift” variables (e.g. changes in population/migration, markets and market prices, land tenure institutions) will induce changes in baseline conditions such as natural resource endowments of households and communities, household assets, market integration and local institutions (e.g. property rights).

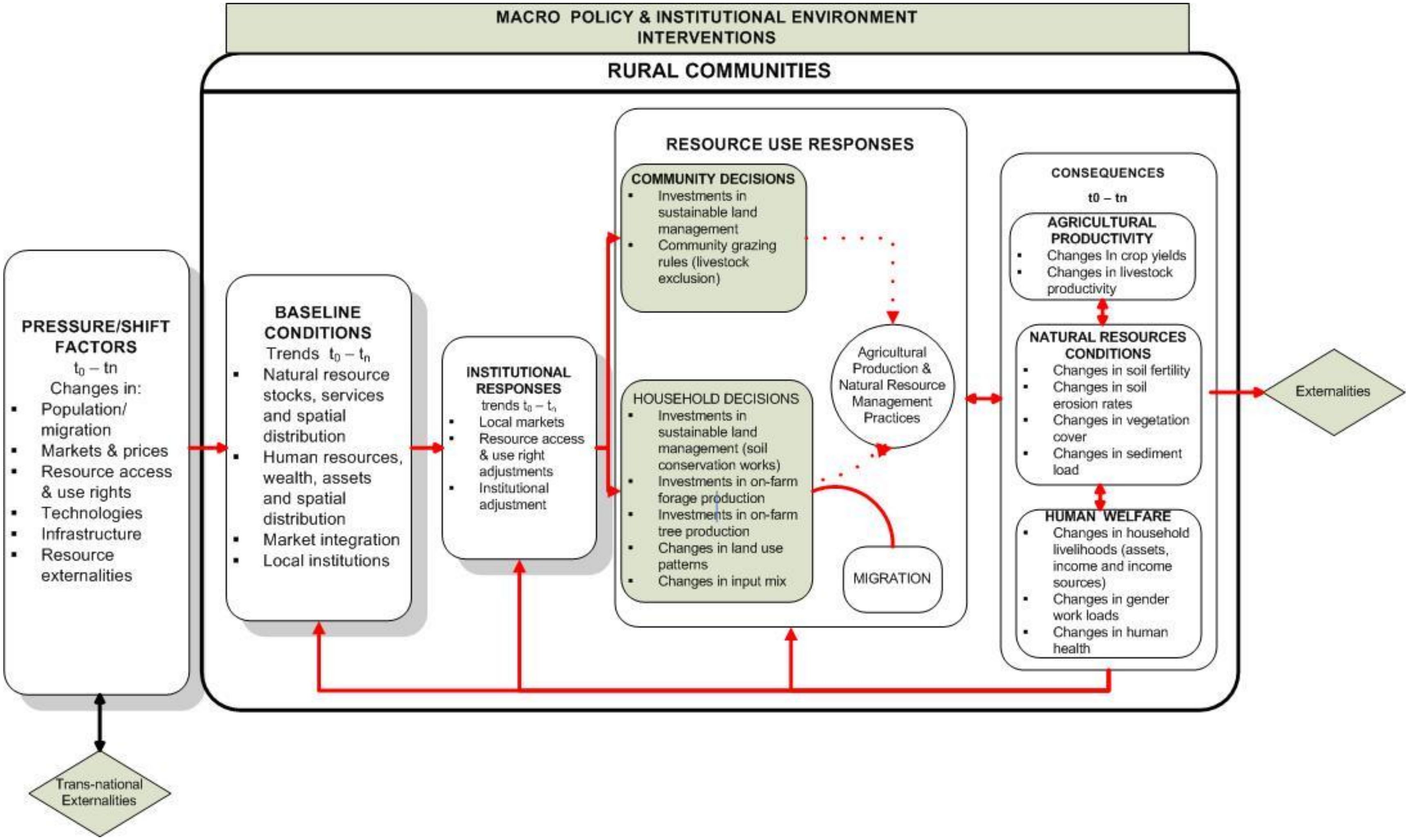


Figure 4. Framework of Analysis for Natural Resource Degradation in the Sudan.
Source: Scherr, S.J. et al., 1996

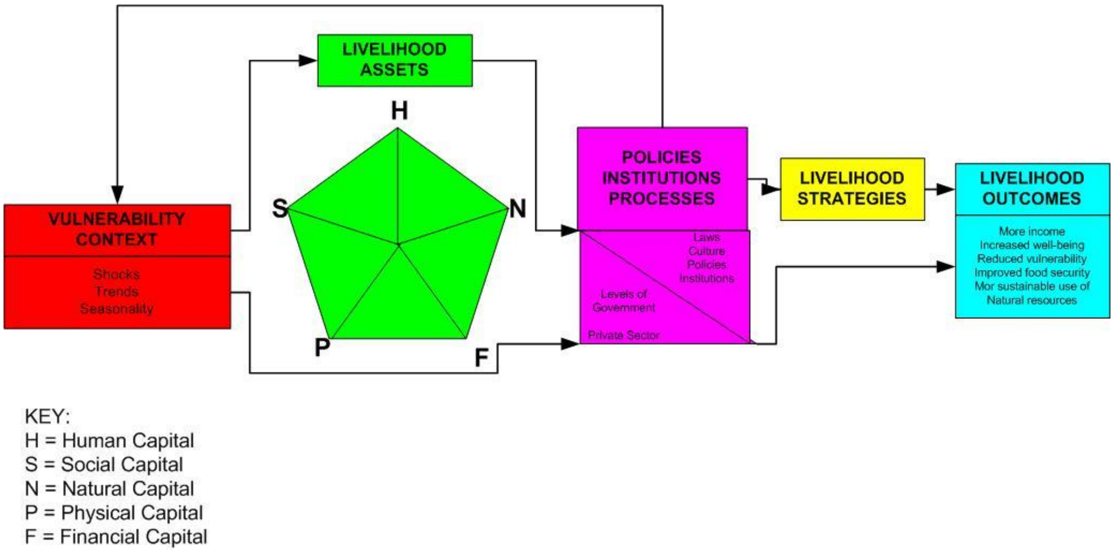
These shifts can in turn induce responses at the community and household level. Of particular importance and of relevance to the present analysis are the community and household decisions with regard to investments (or non investments) in agriculture, soil conservation, and small-scale irrigation. Other responses could include changes in natural resource management systems (e.g. livestock exclusion zones, rangeland management systems). These responses in turn can have positive or negative impacts on agricultural productivity, the condition of natural resources (soil fertility, forage production) and on human welfare (health, livelihoods). At each of these stages negative or positive feed back mechanisms may operate. The public policy environment (e.g. agricultural research programmes, resettlement policies, land access policies) and interventions (e.g. in infrastructural development) can influence this temporal process at various levels.

The "poverty-natural resource nexus is where livelihood activities of households and the communities to which they belong, and the natural resource base interact. These are represented by the two boxes in figure 5 as "household decisions" and "community decisions".

At this detailed level of the household the “Sustainable Livelihoods Framework” (DIFID (2001) has become a common diagnostic tool in development planning and interventions (figure 10). The Framework promotes poverty eradication, protection and better management of the environment and places emphasis on people rather than resources. “Livelihood” comprises the household’s assets (social, human, natural, physical and financial capital), their livelihood outcomes (or objectives) and the livelihood strategies they adopt in attempting to achieve these. These occur within a “Vulnerability Context”, i.e. the shocks, trends and seasonality of conditions that affect assets, strategies and thus outcomes. Finally “Transforming Structures and Processes” include the policy and institutional framework that affects and is affected by assets, strategies and outcomes.

There are similarities between the IFPRI and the DIFID frameworks and in fact the detailed livelihoods framework “nests” within the household and community boxes of the IFPRI framework. These frameworks have been used to analyse why rural households do or do not adopt sustainable land management (SLM) strategies and investments.

Figure 5. A Framework for Household and Community Livelihoods Analysis in a Poverty-Natural Resources Context.



Source: DIFID (2001)

3.1.2 Patterns and Extent of Poverty

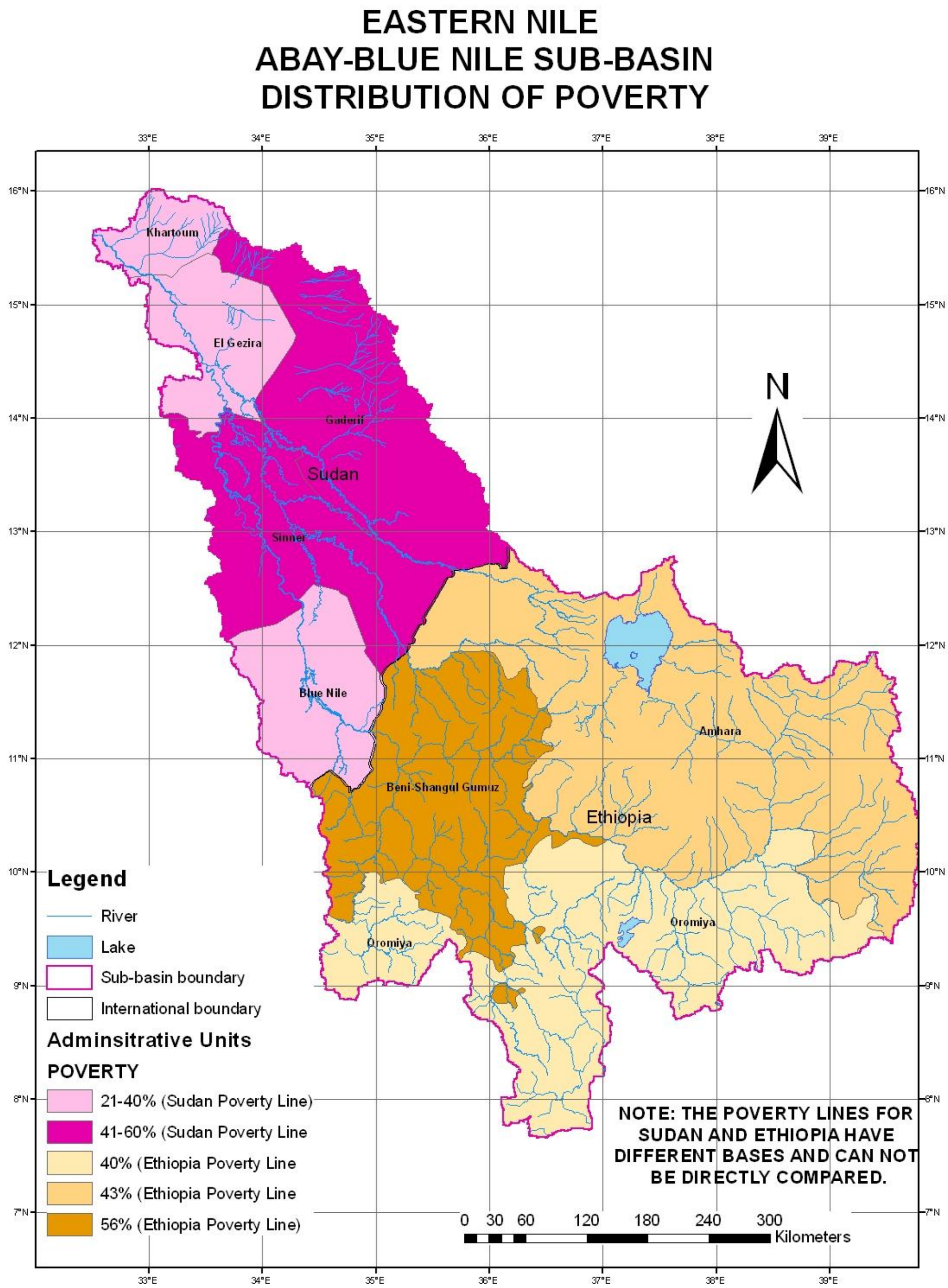
The basis for determining the poverty lines in Ethiopia and Sudan are different and thus can not be compared with each other[5]. The percentages of population below the official poverty line are shown in Map 17.

In Sudan Gezira and Blue Nile States have lower poverty rates than do Gaderef and Sinner States. In Ethiopia poverty rates in Amhara and Oromiya Regional States are very similar with those in Beneshangul-Gumuz regional significantly higher.

The extent and dynamics of poverty in the Sudan since the 1990's has been examined by the Joint Assessment Mission (JAM, 2005). Despite the sustained growth since 1997 many experts believe that poverty has remained widespread and has actually increased. The gap between the "haves" and the "have nots" has increased. Thus whilst the traditional agricultural sector has shown a rebound in the past decade this is only to levels that prevailed before the massive droughts of the early 1980's. In Ethiopia a comprehensive review of poverty was undertaken (FDRE-MOFED, 2002) as input to the Country's Sustainable Development and Poverty Reduction Programme (SDPRP).

[5] Sudan US$1.00 per capita per day. Ethiopia basket of food and essential non-food goods worth EBirr 1,070.00 per capita per year (approx. US$0.34 per capita per day) in 1995/96 prices.

Between 1995/96 and 1999/2000 in Ethiopia rural poverty rates declined by 4.2 percent, although it increased in urban areas (by 11.1 percent).



Map 17. Distribution of percent of population (Sudan- Total) and Ethiopia (Rural) below the official poverty line as determined in each country.
(Sources: Sudan (JAM, 2005), Ethiopia (FDRE-MOFED, 2002).

3.2 The Macro Policy and Institutional Environment

The key policy issue in both countries is that of land tenure, although the details differ. In Ethiopia and Northern Sudan State owns the land although in the Sudan some but limited rural freehold does occur. In Southern Sudan Land Policy is based on customary law, although there are considerable differences in how it is applied in the different regions.

3.2.1 Policy Issues in Ethiopia

(i) Validity of the ADLI policy

Berhanu Nega (2004)[6] questions the success of the ADLI strategy and advocates a more balanced development strategy with urbanization given as important a place as agricultural development. He stresses the importance of the overall very low labour productivity in agriculture as another, or even the main, reason inhibiting development of Ethiopian agriculture. On the basis of Government production statistics, he claims that whatever the achievements of ADLI in raising productivity in some specific areas, it has not been able to raise overall productivity at the national level. Poor extension coverage is not the reason, as some 34 % of the farmer population is said to participate in the ongoing extension program. The fact that more and more marginal land with less than the national average productivity is coming into cultivation, is given as a more plausible explanation.

The ADLI strategy is also said to be too much a supply side strategy with little consideration to demand conditions. In good harvest years because of the low purchasing power of the urban population and limited opportunities of exporting surpluses to the international markets, prices fall sharply and so discourage farmers to invest in surplus production.

The author, quoting others, argues that recent history shows that the claim that agricultural development can be the engine for overall development is not correct. Rather that development of agriculture in Ethiopia is constrained by the low levels of urbanization.

Nevertheless, two points are clear:

- agricultural development should be based both on improved input supplies and on favourable market conditions,

[6] Berhanu Nega (2004) "Is Agricultural Development Led Industrialization a viable strategy for Ethiopia?" - Paper prepared for a symposium to celebrate the 50th anniversary of Alemaya University, 2004.

- better linkages between the agricultural sector and others are indispensable for overall economic diversification and development.

In spite of the overall picture, small positive changes are noticeable during the last few years. Newly introduced water harvesting practices, together with small-scale and micro-irrigation development, have resulted in agricultural diversification. This can be observed in local markets, which show both a diversified supply of agricultural produce and an increasing demand (willingness to pay higher prices). Factors such as price liberalization, improved access to markets (new roads) and nutrition education are thought to be at the basis of it.

(ii) Land Policy and Institutional Issues in Ethiopia

In Ethiopia the Federal Government has overall responsibility for land Policy but devolves the Land Administration to the Regional Governments. However, there is no federal institution responsible for land administration (ARD, 2004). Rural dwellers have usufruct rights to land, may lease and bequeath to immediate relatives but may not sell or mortgage their land holdings.

The four large Regions (Tigray, Amhara, Oromiya and SNNP Regions) have issued their own Land Use and Administration Proclamations and are undertaking programmes of land registration. The current land registration programmes lack consistency, including the way land is administered and user rights granted (World Bank, 2005). The most noticeable differences are in their organizational structures, inheritance and the provisions of permitting sub-leases.

Currently, the land registration programmes have a narrowly technical focus. They are not taking the opportunities to link land reform and security of title with economic investment in sustainable land management, poverty reduction and improved livelihoods. A key constraint is that land cannot be used as collateral for formal credit.

Whilst in the Highlands the boundaries of the lowest administrative unit for land administration - the *kebele* – are well known and established, this is less so in the Lowlands, where there are relatively large areas that are not settled. Land for commercial agriculture is allocated by the Regional Investment Bureau but there is no formal cadastral survey, environmental impact assessment or monitoring of subsequent land development.

3.2.2 Land Policy Issues in the Sudan

The root cause of land tenure problems in the North is the 1970 Unregistered land Act which stated that "*any land of any kind occupied or unoccupied which* *has not been registered before the commencement of the Act shall be the property of the government and shall be deemed to have been registered as such*". Under this law vast areas of subsistence farm land, forest and pasture have been converted for cash crop production without replacing the lost pasture resources. Traditional corridors of animal movements were blocked generating increased levels of resource based conflict (JAM Vol.III, 2005).

Apart from the freehold land (that constitutes about 1 percent of the area) there are two main types of agricultural land: (i) registered land, and (ii) unregistered land. The registered leases are typically for 25 years, carry use rights and lease conditions relating to environmental protection and sub-leasing. However, the leases normally cannot be sold and thus cannot be used as collateral for formal credit. Unregistered land with tradition use rights has usually been established through unlawful settlement and clearing and cultivation by individuals and groups. Communal land is under the control of the community or local ethnic group. Such land can normally be inherited but it cannot be used for collateral.

The current land policy thus limits access to credit for the vast majority of farmers who cannot use land as collateral. Secondly, the policy of 25 year leases does not provide incentives for sustainable land development and capital improvement. Thirdly, on land not demarcated by cadastral surveys, conflicting land use rights have been a source of conflict, especially between pastoralists and sedentary farmers.

Although the JAM states that land reform is a necessary pre-requisite for improved agricultural productivity and poverty reduction, the Report is silent on how this will be achieved. A Land Commission has been appointed and is currently considering the matter.

The general policy of the Forest National Corporation (FNC) aims at extending the reserved forest area to reach a national goal of 20 % of the country's area, increase the afforested area in and outside the reserved areas and raise the popular awareness of the importance of forests in the conservation of the environment and economic development. There are some 1,195 Forest Reserves covering 7 million feddans (3.9 million ha) located within the Atbara, Blue Nile and Sobat Basins. In addition there is an unknown but even larger area of State Forest land. Much of this has become degraded under pressure from charcoal and fuelwood extraction and logging. Much of it requires restocking. The FNC have limited resources to undertake this work.

Much of the Forest lies within close proximity to communities. Whilst the FNC employ a few local people in their nurseries the forests contribute little in terms of support to livelihoods. The FNC control all wood extraction and charge royalties that provides a substantial proportion of their funds. However, they are only able to effectively manage a small proportion of the state forest land.

3.2.3 Institutional Issues

(i) Complexity of the Institutional Framework

The Abbay-Blue Nile Sub-basin encompasses two countries: Ethiopia and the Sudan. Currently there is very little coordination of Watershed Management activities across boundaries. However, Waterbury (2002) makes the point that effective international cooperative mechanisms depend as much on establishing effective cooperative mechanisms at the national level.

Both Ethiopia and Sudan are implementing devolution of substantial authority for planning and implementing development activities to Regional Administrations. Whilst allowing for development activities to be more closely aligned with regional/local aspirations, there are potential problems for coordination in river basins that encompass more than one administrative Region by the addition of another layer of administration. Within Ethiopia there are three Regional State administrations (Amhara, BS-G and Oromiya) and with Sudan five State administrations (Gederef, Khartoum, El Geizira, Senner and Blue Nile).

In Ethiopia, whilst a Master Plan study has been undertaken for the Abbay River Basin, there is no formal institutional mechanism for Basin-wide watershed planning and coordinated development activities. This is currently under review and a draft Proclamation setting out the institutional setup for river basin development almost complete. The objective of a River Basin Organization will be to:

"trigger, promote, coordinate, enhance and monitor the Integrated Water Resources Management process in the river basin falling within its jurisdiction and to administer the basin's water resources for the socio-economic welfare of the people in an equitable and participatory manner without comprising the sustainability of the aquatic ecosystems".

The Abbay Basin is one of the 12 basins designated. Each River Basin organization will have a Basin High Council with federal and Regional representation and with provision for other Stakeholders as considered necessary; and a River Basin Authority.

Whilst this may take care of institutional coordination and harmonization at the macro level there are no provisions for such coordination and harmonization at the small/micro watershed level. This has emerged as a problem with the small dam programme being undertaken independently of the watershed management programme, resulting in widespread sedimentation of dams. A moratorium has been placed on the dam programme until the institutional problems can be resolved.

In Sudan there is provision for State-wide land Use Planning although this has yet to be implemented. As yet there is no provision for a Basin-wide institutional setup on the lines of the Ethiopian model or at the small/micro- watershed level. The UNESCO-HELP Project has proposals to undertaken Basin-wide integrated studies of the Gash, Atbara and Blue Nile Basins.

(ii) Land Registration in Ethiopia

The national law vests primary rights in the state with the decentralised administration of land to the Regions. However, there is no federal institution responsible for land administration[7]. At the regional level institutional structures vary in each Region, each having adopted a different approach to land administration institutional structures. The current land registration programmes lack consistency, including the way land is administered and user rights granted[8]. The most noticeable differences are in their organizational structures, inheritance and the provisions of permitting sub-leases.

Currently, the land registration programmes have a narrowly technical focus. They are not taking the opportunities to link land reform and security of title with economic investment in sustainable land management, poverty reduction and improved livelihoods.

(iii) The facilitating role of government

In Sudan and Ethiopia Government still maintains a strong control of all development activities in the country. The inherent danger to this is the adoption of a top-down approach and attitude. In a more open dialogue with development partners at all levels, government would benefit more from an exchange of knowledge and experience of other organizations and institutions.

Numerous activities of government capacity building are being undertaken but these alone will not be effective if not paralleled by a change in attitude. One of the main challenges is to improve information management (exchange of information between organizations, dissemination to lower levels, and building up of a common institutional memory). This would provide the fuel for the engine of up-scaling of successful but isolated development activities.

[7] ARD for USAID (2004) "Ethiopia: Land Policy and Administrative Assessment".
[8] World Bank (2005) "Rural Land Policy in Ethiopia: Aide Memoir",

(iv) Watershed Management Planning

There is a need to address discontinuities in the government structure with regard to the overall “cycle” of project identification, planning, coordination, stakeholder consultation and participation, and implementation. Currently, it is not clear who has the responsibility for watershed management and at what level. Thus, these responsibilities need to be better demarcated. It is not necessarily a problem that various organizations take up responsibilities in watershed management as long as there is a workable level of harmonization. In addition, those taking the responsibility or being given a mandate should be able to build up the required capacity to fulfil their task.

Watershed management planners should not plan in isolation but, at all levels, ensure timely consultation with implementers and beneficiaries. Plans should include arrangements for implementation, and at the lower levels, these should be agreed upon by implementers. In the ideal case, planners would also be responsible for (coordination of) implementation, provided that they have the capacity to do this.

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(iv) Capacity to Undertake Watershed Management

There is still a need for improved awareness of watershed management concepts, principles and their implications. Watershed management planning at watershed level is a different subject than planning at the grassroots level. At **higher levels**, planning is strategic and concerned with development pathways in selected “development units or domains” (as used in this regional assessment), planning frameworks, and identification of priority areas. At the **lower level**, planning is concerned with modus of implementation.

Watershed management, as an integrated or holistic approach, should be interpreted more pragmatically. A **holistic approach** to watershed management will need to encompass a detailed and comprehensive understanding of the underlying social, economic and policy causes behind land degradation, poverty, food insecurity and a limited range of livelihood possibilities. In more pragmatic terms, holistic means e.g. that during situation analysis it should be realized that the causes of specific problems may need to be sought in other sectors or disciplines.

Integration does not mean that implementation has to cover all possible sectors of integrated rural development. It means that development or sustainable land management interventions are put into context one with another (e.g. SWC to increase moisture availability to agricultural production; improved stoves as to reduce the need for fuelwood and depletion of forest cover). Targets of integrated approaches should not be set too ambitiously and should not exceed implementers’ capacities. The level of detail and relative levels of responsibility among the various stakeholders will depend on a thorough understanding of local circumstances and various options may emerge rather than a single “blueprint” for implementation.

Devolution of responsibilities to lower levels of government administration is an official policy of both governments. A constraint to its effective implementation in both countries is the low level of capacity: both in numbers and technical expertise, particularly at the lowest levels.

Ethiopia now has a substantial capacity building programme to support its decentralization policy and a Ministry of Capacity Building has been established (Ministry of Capacity Building, 2002). The "wereda" is seen as the front-line administrative unit for all development efforts. Increasing financial, administrative and technical

In Sudan "Capacity Building and Institutional Development" is the first of nine "clusters" of the Joint Appraisal Mission's Report and is seen as fundamental to the success of Sudan's programme of equitable and sustainable development.
In both countries these are long-term programmes and there will be no quick solution to this problem. The JAM is aiming to have effective institutions and the desired capacity by 2011.

3.3 Livelihoods, Poverty and Land Degradation: Pressure-Shift Factors

3.3.1 Vulnerability Context

However, Map 17 only provides averages across the State or Regional State and is unable to capture the distribution of poverty levels across the population at this level. It is known for example that tenants on the Gezira Scheme are barely able to make a living from current irrigated cropped area and cropping pattern (see paragraph 2.3.1 above). Given the Sudanese poverty rates quoted here are "total" a higher incidence of poverty in rural areas may be masked by much lower urban rates. The JAM Report acknowledges that poverty rates are significantly higher in the traditional agricultural sector (see above). In Ethiopia even where there is a separation between urban and rural rates, simple averages mask a wide variation in poverty rates amongst individual households.

The lower rates of poverty in Blue Nile and El Gezira States are a reflection of the assured access to generally low risk irrigated cropland along the Blue Nile. An assured and low-risk production environment clearly reduces the incidence of poverty. It enables households to build up assets that reduce their vulnerability to sudden changes in circumstances. In these areas land is generally held in freehold and perceptions of tenure insecurity are low. Where leaseholds prevail the general secure natural asset base, the availability of physical (pumps, irrigation water) and financial (seasonal credit) assets creates an environment for secure and sustainable livelihoods and low vulnerability. In Blue Nile State rainfall is less variable than to the north in Gederef State and thus not as high a risk environmental.

Conversely, in the traditional rainfed cropping areas in Gaderef State rainfall is extremely variable in amount and timing, presenting a high risk environmental both for crop and livestock production. In the severe droughts of the early 1980's many pastoral peoples lost nearly all their livestock assets. Here, the opposite conditions prevail, where it is not possible to build-up household assets, and there are many cases where these have actually declined through land degradation (e.g. kerib land) or alienation of assets (e.g. to the large semi-mechanized farms).

Where livestock are the main livelihood capital assets these too depend on the same high risk environment as well as dwindling rangeland resources in the face of expansion of large semi-mechanized farms. The coping mechanisms that communities and groups have developed over millennia to deal with and recover from natural calamities have been insufficient in the face of insecurity and alienation of basic natural resources. Livestock assets provide a buffer in times of need. Where access to water and forage has becoming limiting for the reason set out above vulnerability to shocks and hazards such rainfall variability and drought becomes more acute.

In eastern areas of the Ethiopian Highlands rainfall variability is higher than the western parts and present a high risk environmental for rainfed cropping. Here it is exacerbated by the general low fertility status of soils and by their high degree of erodibility.

3.3.2 Livelihood Assets

The Ethiopian SDPRP Report outlines a number of other determinants of poverty. It is interesting that a number of these also occur in the analysis (World Bank, 2002) of Egypt's poverty and thus are likely to be applicable to Sudan also. The dependency ratio is very important in determining poverty status in rural areas. Studies indicate that if the dependency ratio increases by one unit, a household's probability of falling below the poverty line increases by 31 percent. Households with more children under 15 years and those with people older than 65 years are particularly vulnerable to falling into poverty. This underscores the importance of adult labour in the welfare of rural households.
Female headed rural households face a 9 percent higher probability of being poor than male-headed households although other factors such as age and education play an important role and need to be taken into consideration when targeting. Farm assets such as oxen are important poverty reducing factors: an extra ox reduces poverty probability by 7 percent.

3.3.3 Livelihood Strategies

Households cultivating exportable crops (chat, coffee) have a much lower probability of being poor. Living near towns and better access to markets has a poverty reducing effect. Although counter-intuitively, households involved with off-farm activities, which are more likely to be available near towns, are 11 percent more likely to be poor. This is because such activities are seen as a coping mechanism for poor people rather than a way of accumulating wealth. In Sudan, temporary migration to access non-farm income is also a very common livelihood strategy. However, as discussed below this can negatively impact households' ability to invest in sustainable land management investments because of the reduction in households' human assets.

3.3.4 Population Pressure and Land Degradation

Currently there are two basic hypotheses regarding the relationship between population growth and land degradation. The “neo-Malthusian” hypothesis predicts that agricultural production is unable to keep pace with population growth leading to falling agricultural production per capita, and increasing negative impacts on natural resources including land, water, forests and biodiversity. More recently, a more optimistic perspective has developed following from the work by Ester Boserup (1965) and others. This perspective emphasizes the responses of households and communities to population pressures that include a reduction in fallow periods, intensified use of labour and land, development of labour-intensive technologies and institutional changes. However, more recent evidence suggests that more specific conditions seem to be needed to get a Boserupian scenario to operate. These have been identified in the Machakos study as secure tenure, efficient markets, cash crops, supporting social organization and proven SWC measures. The evidence accrued so far in Ethiopia is mixed.

Grepperud (1996) tested the population pressure hypothesis for Ethiopia using econometric analysis, and found that when population and livestock pressures exceeded a specific threshold rapid degradation of land takes place. The threshold was the population and livestock carrying capacity of the land. Pender et al (2001) found in Amhara region of Ethiopia that high population densities were related to the decline in fallowing and manuring. They also found the high population densities were related to increasing land degradation and worsening household welfare conditions.

In Sudan there are many references to the impact of the massive expansion of the Semi-mechanized farms on the loss of land both for cultivators and pastoralists. This in fact has caused extra pressure on natural resources in addition to that exerted by natural population increase. The eastern part of Sudan has seen a substantial increase in population from both West African countries as well as from western Sudan.

A major environmental impact of this land pressure has been the degradation of the rangelands in the Abbay-Blue Nile Sub-basin (exacerbated in part by a decline in rainfall over the past two decades). In the rainfed croplands the environmental impact has been on reduced length of fallow periods and a consequent decline in crop yields. Other environmental impacts have been the additional pressure on the Dinder National Park and loss of habitat and species biodiversity.

3.4 Poverty Natural Resource Degradation Nexus: Determinants of Household and Community Decisions to Invest or Not Invest in Sustainable land Management Strategies and Investments

3.4.1 Livelihood Assets

In Sudan decisions to adopt sustainable land management technologies depend on households' asset endowments (human capital) and on community mutual support networks (social capital). These are particularly of relevance in traditional rainfed shifting cultivation agricultural system. Here there is a need for labour for the frequent clearing to access land of better fertility as well as for weeding. It is also true for pastoral families because of their need for herding different animal types (camels, cattle, sheep and goats) in different places and times. In efforts to maintain livelihoods some household members have had to leave the farm in order to seek wage employment (livelihood strategy). This has led to a reduction in households' human capital and the lack of labour for cultivation and herding (a negative livelihood outcome).

Community mutual support networks and mechanisms (social capital) are particularly important to pastoralists in high risk environments. These included a number of mechanisms for transferring livestock between families after losses incurred during a drought as "obligatory" gifts – in practice a form of capital investment. This enables a household's herd to be restocked. With the almost total loss of livestock assets during the very severe droughts of the early 1980's these mutual support mechanisms have been put under very severe stress and have in a number of cases broken down completely (Omer E. Egemi, 2002).

In Ethiopia Mahmud Yesuf and Pender (2005) have undertaken a comprehensive review of research undertaken into identifying the determinants of the adoption or non-adoption of land management technologies in the Ethiopian highlands. This report and a number of IFPRI/ILRI reports on research undertaken between 2000 and 2004 provide a comprehensive picture of many of the underlying causes of land degradation in Ethiopia. Other useful reviews include the NTEAP (2005) Study, Alemayehu Tafesse (2005) and Herweg (1999).

Decisions to adopt sustainable land management technologies depend on households' asset endowments. Labour availability has been found to be a positive determinant of chemical fertilizer adoption, trees and terrace construction. However, simply using family size to measure labour availability was found to be misleading. The results of studies into the effect of farm size on land management technologies have been mixed. Both positive, negative and no relationships have been found between farm size and fertilizer adoption. However, with those technologies that take up space (terraces, bunds, trees) a positive relationships were found between farm size and adoption.

Livestock assets have been found to be positively related to adoption of fertilizer, planting of perennial crops, use of manure and contour ploughing. Gender (a human capital variable) does affect adoption of land management technologies. Male headed households use more labour and oxen draught power and apply manure, reflecting a cultural constraint on women ploughing in Ethiopia. The results for fertilizer adoption were mixed, with female headed households in northern Ethiopia likely to use more fertilizer and the reverse in southern Ethiopia. Positive relationships were found between education and adoption of soil conservation measures although the results for fertilizer adoption were mixed.

Related to poverty, household assets and the vulnerability context are the concepts of profitability of the improved land management technology, the farmers' perceptions of risk and of farmers' private discount rates. Private discount rates are a measure of a person's time preference or time horizon. The shorter the time horizon the higher is the discount rate. Short time horizons are the result of a number of factors, tenure insecurity, poverty, and high risk environment. Many farmers have high private discount rates – as high as 70 percent even in the high potential farming area around Debre Zeit near Addis Ababa (Holden et al., 1998). A number of studies have found that adoption of soil and water conservation technologies is negatively related to high discount rates. However, where a technology is risk reducing (e.g. terraces that conserve soil moisture) adoption is much more likely.

3.4.2 Policies, Institutions and Processes

Agricultural development and land tenure policies and institutions adopted by the Government of Sudan over the past three decades have seriously constrained the traditional rainfed agricultural sector's ability to invest in SLM strategies and investments. These include almost total focus of improved inputs, extension and research to the irrigation sector (World Bank, 2002). This has been compounded by the Land Policy that has favoured the expansion of the rainfed semi-mechanized farm sector with the impacts outlined above.

In the traditional small-scale traditional rainfed cropping systems periodic bush fallowing is vital to restore soil fertility and suppress noxious weeds (e.g. *striga*) and thus forms a major sustainable land management strategy. The massive expansion of large-scale semi-mechanized farms in the Sub-basin has severely reduced land available for bush fallowing in the traditional farming systems. This combined with population increases and expansion of cropland, have led to reductions in areas under fallow with a consequent decline in yields.

3.4.3 Other Determinants of Household Decisions to Invest or Not Invest in Sustainable land Management Strategies and Investments

Whilst household "poverty" itself may be a constraint to invest or not in SLM investment other factors are also involved. These are included in the "pressure/shift" factors of the IFPRI framework and are endogenous to the household and its assets.

(i) Poor Access to markets, roads and off-farm employment opportunities and Land Degradation

Better access to markets and roads mean lower transport costs for agricultural inputs and outputs and thus lower input costs and higher market prices. Thus better access is likely to lead to increased adoption of improved land management technologies, and poor access to lower adoption rates. However, better access may lead to better opportunities for off-farm employment. Here the potential impact on adopting or not adopting improved land management technologies is ambiguous as off-farm employment may reduce labour inputs but increase availability of financial capital for on-farm investment.

Howe and Garba (2005) found that reliance on traditional forms of transport pose considerable barriers to the development of an exchange economy and locks the farmers into subsistence form of livelihood. Pack animals offer a considerable advantage over human transport, with a cost reduction of approximately 50 percent. However, the average costs of mule transport of EBirr 16.7 ton/km compare very unfavourably of EBirr 0.6-0.9 ton/km for local truck costs. With such high costs of transport for low value food crops such as maize ort sorghum makes a net return unlikely.

However, the evidence from Ethiopia of better access to markets and adoption of soil and water conservation technologies is mixed. In the eastern parts of the Upper Abbay-Blue Nile Sub-basin households with poor access were more likely to adopt labour intensive SWC structures than those with good access. Declining fallows and increasing use of manure closer to towns suggested increasing intensification of agriculture where access was better.

The use of fertilizer was everywhere positively associated with increased accessibility.

The relationship between off-farm employment and the adoption of SWC structures appears to be very context specific. In many areas adoption of fertilizer and SWC adoption was negatively associated with off-farm employment. However in the high potential area of Amhara region the relationship was positive.

In Sudan, seasonal migration for non-farm income is has become an established livelihood strategy for many rural agricultural households. This has had a negative impact on crop and livestock production because of reduced household labour supply the high labour requirements for land clearing for shifting agriculture (Kibreab, 1996) and for transhumant herding (Abdel G.M. Ahmed, 2002). Given the booming service, construction and industrial sectors in Khartoum this trend is likely to continue. Improvements in land management (fertilizer, improved seeds, and timely cultivation) can help in reducing labour requirements and thus release essential labour for non-farm income (see Lowe, 1983 for how this operated in Swaziland and Botswana).

Gordon and Craig (2001) point out that a sound and less risky agricultural base together with improvements in infrastructure, education, health and financial services provide a strong foundation for the expansion of opportunities for non-farm income. They suggest that the decentralization process that is now underway in e.g. Sudan and Ethiopia, offers a way forward. The proportions of households dependant on agriculture in Ethiopia and Sudan but increasingly less so in Egypt are 85 percent, 70 percent and 37 percent respectively. However, the contribution of agriculture to each country’s GDP is only 45 percent, 37 percent and 8 percent respectively and declining in all cases, with the Service and Industrial sectors providing the remaining and increasing proportions. Much of the latter’s activities are taking place in the major urban centres, but also in the small and intermediate centres.

(ii) Issues of Land Tenure Insecurity

Issues of land tenure here include insecurity of tenure, ability to use land as collateral and the transferability of property rights and the impacts these have on land investment or factor (land, labour or capital) allocation. This is a complex subject in Ethiopia.

The Federal Rural Land Administration proclamation (No. 89/1997) defines in broad terms individual land use and disposal rights. It delegates responsibility for land administration to the Regions. The four large Regions of Tigray, Amhara, Oromiya and SNNP have also enacted Proclamations for the Administration and

Use of Rural land. Currently a land registration programme is underway in these regions. However, land redistribution has not been ruled out in both federal and regional proclamations. A US-AID Study[9] indicated that reports from kebelle administrations that redistribution is possible even with Land Registration Certificates.

Land tenure issues and their impacts on land management and technology investment in Ethiopia have been well studied over the past decade, and Mahmud Joseph and Pender (2005) provide a very comprehensive summary of the empirical evidence that is now available. Much of the evidence relating to impacts of tenure issues on land management and potential investment in improved land management is also of relevance to the situation in Sudan even if the context is somewhat different.

Tenure insecurity in Ethiopia emanates from a number of causes. A major source was periodic land redistribution to reallocation land to land-poor households. In northern Ethiopia the indications are that in areas where redistribution has occurred investment in terraces was lower, but that the use of fertilizer and tree planting was higher. This suggests that redistribution may favour short term investments in land management but hinder long term investments. The investment in tree planting (a short to medium term investment) may be due to a desire to increase tenure security or merely because trees are normally planted around the homestead.

In Oromiya Region tenure insecurity derived not from redistribution but from the expected sharing of land among family members. In one area investment in coffee planting was reduced with increased tenure insecurity, but another study found that farmer's resource poverty had a greater impact. A number of studies in northern Ethiopia also found evidence that resource poverty had a much greater effect on farmer's decisions to adopt or maintain soil conservation structures.

It is also possible that lack of rights to transfer or mortgage land may reduce farmer's incentives to invest in land improvement. A number of studies found that a perceived right to mortgage or to transfer use rights of land were positively associated with greater investments in constructing terraces and in tree planting. The evidence from studies on comparing land investments on owner-land and leased-land (mainly sharecropped) was mixed. Some studies found lower land investment on leased-land whilst other found no difference. However, on leased land the use of labour, improved seeds and fertilizer was lower as was production.

In summary the effects of tenure insecurity on land investments in Ethiopia appear to be mixed depending on whether the investments themselves affect

[9] ARD for US-AID (2004) "Ethiopia land Policy and Administration Assessment", US-AID, Addis Ababa.

security. Insecurity appears to hinder larger investments (e.g. terraces) than smaller and periodic investments (e.g. fertilizer, manuring). Redistribution is not the only source of insecurity, obligations to share land with younger family members is also an important source.

In Sudan the research literature is silent on the impacts the massive expansion of the large-scale semi-mechanized farms have on perceptions of tenure insecurity on the part of small-scale farmers and pastoralists, notwithstanding the voluminous literature on the impacts of land lost. Thus how far this is a factor in constraining decisions to invest in SLM investments is not clear. As indicated above the physical shortage of land may be a more deciding factor.

(iii) Impact of Agricultural Extension, Research and Credit Programmes on adoption of Land Management Technologies

In Ethiopia the agricultural extension programme has strongly promoted fertilizer and improved seeds supported by credit. Studies indicate that greater access to credit increases farmers' likelihood of using fertilizer. However, risk is the crucial factor in the low rainfall areas in determining whether farmers will take credit for fertilizer even where it is readily available. The source can also determine the uptake of credit and specific use of the credit. This is probably a reflection of the technical advice that comes with the credit.

One study shows that credit uptake increased the adoption of fertilizer but reduced investments in soil and water conservation, contributing to increased soil erosion. The increase in fertilizer price since 2002 with the removal of the subsidy led farmers to increase the cultivation of crops requiring low fertilizer applications and reduce investment in soil conservation where the intervention was yield decreasing (e.g. soil bunds taking up cropland). Studies indicate that the impact of extension on the uptake of improved land management is probably more positive in the high potential areas.

In Sudan the neglect of the traditional rainfed cropping and pastoral sector in terms of extension, research and credit has been highlighted as a key constraint to their development and adoption of SLM investments (World Bank, 2002). The inability of the large-scale semi-mechanized farm to use their land as collateral for credit may be an inhibiting factor in their adoption of SLM investments.

3.5 Physical and Technical Issues

3.5.1 Issues of Soil Erosion and Sedimentation

(i) Technical considerations

Soil sheet erosion rates have been determined using the Universal Soil Loss Equation (USLE) modified to Ethiopian conditions by the Soil Conservation research Project (Hurni, 1983) within the Geographic Information System (see Annex 1 for the full description of the methodology). Except for the kerib land in Sudan little work has been done in Ethiopia on gully densities and erosion rates. Taking research work undertaken in Tigray and in Zimbabwe an estimated contribution to sediment load of 20 percent of that of sheet erosion has been used. Estimates of gully erosion in the kerib land have been obtained using aerial photos (Hassan M. Fadun et al., 2005) and mapped using 2000 Landsat TM imagery by this Project.

Not all sediment eroded within the landscape reaches the drainage system. The proportion that does is termed the sediment delivery ratio (SDR). The SDR is the ratio of sediment delivered to the drainage system as a proportion of the total soil eroded. Eroded soil not reaching the drainage system is deposited within the landscape where the energy for transport becomes insufficient. This is normally where the slope changes from steep to gentle (i.e. footslopes) or where the land cover changes to a type that causes the reduction in transport energy (e.g. area closures with substantial herbaceous and/or woody biomass).

Once sediment reaches the drainage system there is a complex pattern of temporal and spatial lags between soil eroded in the landscape and the suspended sediment load in large rivers. These lags are caused by storage of variable lengths of time of sediment within the river system as sandbanks and alluvium in floodplains. As a general rule sediment yields (mass of sediment/unit area of catchment) decline with increasing catchment size (Walling, 1983) but there may be circumstances in which this does not occur (see below).

The locations of the various types and degrees of soil erosion and deposition within the Abbay-Blue Nile Sub-basin are shown in Map 18.

(ii) Over-view

The main area of sheet erosion is within the Ethiopian Highlands. Gulley erosion occurs in both Ethiopia and Sudan. On the large Semi-mechanized and small traditional farms the key soil degradation problem is nutrient mining. They are located on the clay plains north and south of the Blue Nile.

The main locations for sedimentation are the Roseires and Senner dams, and the irrigation canals within the Geizera-Managil and Rahad Irrigation Schemes. High suspended sediment loads affect pumps for irrigation and increase costs of water purification for domestic and industrial water supplies. Sedimentation is negatively affecting the wetlands of the Rahad and Dinder river systems, in turn affecting human and livestock water supplies and biodiversity.

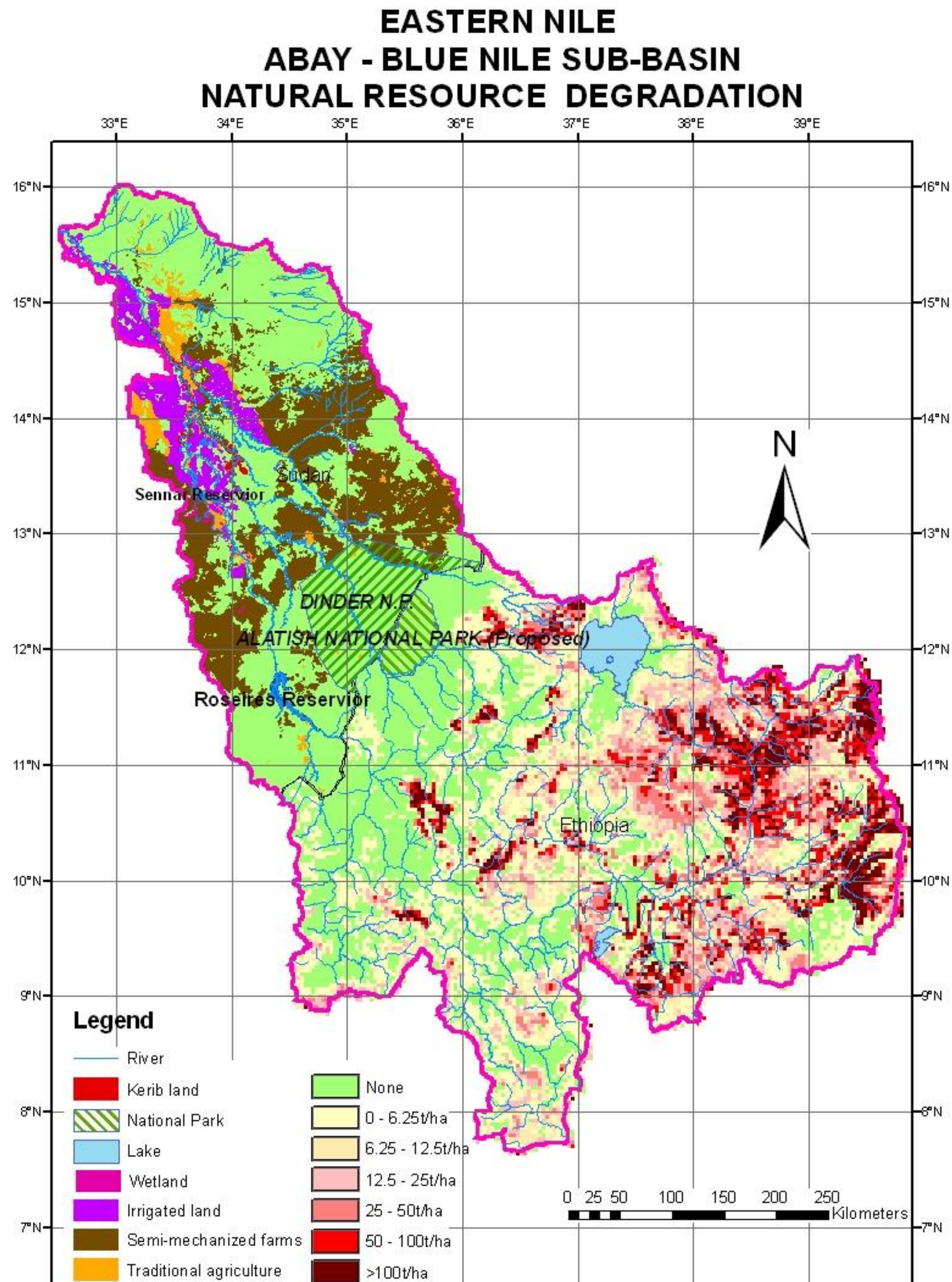
(iii) Sheet Erosion

(a) Scale and Extent

Most sheet erosion in the Sub-basin occurs in the Ethiopian Highlands. Some sheet erosion occurs within Sudan, mainly on and around the rock hills (*Jebels*), which have become devoid of vegetative cover. Most of this is deposited on the footslope and does not enter the drainage system. Some water induced soil movement also occurs on the flat clay plains, but given the poorly developed surface drainage system little sediment reaches the main rivers.

Four main areas of high sheet erosion are found in the Abbay basin. The steep slopes around Mount Choke in East and West Gojam stand out as a significant area with a high sheet erosion hazard. This is an area with high rainfall causing problems in developing physical soil conservation structures because of the problems of providing effective water disposal structures.

The second widespread area of high erosion hazards occurs north and east of the Abbay River in the Lake Tana Basin. This area includes the steep cultivated slopes around Mounts Guna (South Gonder) and Molle (South Wello). A third more restricted area is found in the upper Jema sub-basin in South Wello on the high hills north and west of Debre Birhan. A fourth area is found south of the Abbay and encompasses the upper and middle steep and cultivated slopes of the Middle Abbay Gorge Sub-basin in East Wellega. Two subsidiary areas with a high erosion hazard can be seen in the Upper Didessa Valley and along the escarpment hills to the west of Lake Tana in the upper Dinder and Beles valleys.



Map 18. Abbay-Blue Nile Sub-basin: Distribution of Soil Degradation and Sedimentation.

The total soil eroded within the landscape in the Abbay Basin is estimated to be 363.4 million tons per annum and that from cultivated land[10] is estimated to be 122.2 million tons per annum. Thus about 66 percent of soil being eroded is from non-cultivated land, i.e. mainly from communal grazing and settlement areas.

The area of cropland subject to "unsustainable" (i.e. loss exceeds soil formation or 12.5 tons/ha/yr) are 968,900 ha, 104,000 ha and 956,900 ha in the Amhara, BSG and Oromiya areas of the Basin respectively. Thus some 2.03 million ha of cultivated land have unsustainable soil loss rates.

Of the total 363.4 million tons of soil eroded a proportion is re-deposited within the landscape, the remainder reaching streams and rivers. At the Basin level the estimated SDR (39%) indicates that approximately 61 percent of sediment remains in the landscape and does not reach the stream system, a higher proportion than the Tekeze Basin. This estimate is much lower than the 90 percent estimated by the Ethiopian Highlands Reclamation Study (EHRS) but closer to the estimate by Hurni (1985) of 70 percent.

(b) Impacts on Agricultural production

On-site impacts of soil erosion are reductions in agricultural productivity. Productivity is reduced because of nutrient and organic matter losses and reduced water holding capacity caused by reduced soil depth.

The impact of reduced water holding capacity caused by soil erosion was estimated using the method used by the National Conservation Strategy of Ethiopia (Sutcliffe, 1993). This relates declines in soil productivity to declines in the soil's water holding capacity using the soil life model of Stocking and Pain (1983) as the framework. Using a model developed by FAO (1986), the Water Requirements Satisfaction Index, the relationships were established between declining soil moisture capacity and crop yield, the minimum required soil depth for cultivation and the maximum depth beyond which there is no impact on crop and pasture yield. This method allows the calculation of different yield losses for different erosion rates. The areas of cropland under different soil erosion rates were obtained by overlaying the wereda map with the soil erosion map in the GIS. Yield reductions caused by different rates of soil loss are shown in table 14.

[10] "Cultivated land" as identified on the 1:250,000 landsat images. This may include areas of grassland, settlement, field boundaries etc. that are too small to discriminate separately. Invariably "cultivated" land is greater in area than land under crops as defined e.g. by the Central Statistical Office (CSA).

Table 14. Grain yield reductions due to loss of soil due to soil erosion and thus reduction in soil water holding capacity

Soil loss t/ha/yr	Soil loss mm/yr	Yield decline %
12.5	1	**0.2%**
25	2	**0.4%**
50	4	**0.8%**
100	8	**1.4%**

In the absence of remedial measures, crop losses from soil erosion accumulate until such time the soil profile is reduced to a depth where no production is possible. The total annual crop production lost due to soil erosion for the Abbay-Blue Nile basin is shown in Table 15, together with accumulated losses for 5, 10 and 25 years.

Table 15. Annual and Cumulative losses of crop production due to soil erosion (tons)

BASIN	ANNUAL LOSS T//YR	5 YRS (tons)	10 YRS (tons)	25 YRS (tons)
Abbay	**25,190**	**125,950**	**251,905**	**629,760**

The current annual crop grain production for the Abbay Basin is 4.35 million tons. The annual loss due to soil erosion as a proportion of total production is 0.6 percent in the Abbay Basin. However, after 10 years this rises to 6 percent and after 25 years to 15 percent of annual crop production.

(iii) Gully erosion

(a) Ethiopia

Although some work has been undertaken on gully formation and extension (Billie & Dramis, 1993), (Shribrus Daba et al., 1993), there is no information on gully distribution, density, erosion rates and sediment delivery ratios. Barber (1984) considers that much sediment from gullies is deposited on lower slopes without entering the drainage system. Stocking (1996) working Zimbabwe estimated sediment from gullies contributed approximately 18 percent of suspended sediment loads. Loss of cropland from gully erosion was considered to be insignificant.

Very recently research by the Universities of Makelle, Ethiopia and KU Leuven, Belgium in Tigray (Nyssen, J et al., 2005) have provided information of gulley erosion rates, sediment yields and sediment delivery ratios in northern Ethiopia. They report that gullies were initiated by a variety of changes in environmental conditions: removal of vegetation between fields, Eucalyptus planting in valley bottoms and new road construction. Gullies followed a sigmoidal evolution in volume, with a rapid increase until the mid 1990's when the rate of growth declined to almost nothing. This has been due to the considerable development of soil conservation structures and communal area closures that have occurred since 2000.

During the period of most rapid gully growth, soil erosion rates were between 13 – 27t/ha/yr. Currently the rates have slowed to 1.1t/ha/yr. The average rate of total years of gully evolution was 6.2t/ha/yr and they recommend this figure for sediment budgeting where conservation measures have not been implemented. The figure of 1.1t/ha/yr is approximately 10 percent of the weighted average soil erosion rate of 9.7t/ha/yr in the area. Approximately 50 percent of the sediment reached the drainage system, the remainder being deposited within the landscape.

Thus, where soil conservation measures have been introduced and gullies are relatively stable they contribute approximately 5 percent to sediment load. Where there are no conservation measures the average rate is 32 percent.

(b) Sudan

The main erosion problem in the Blue Nile Sub-basin is the gully erosion along the Blue Nile and Dinder Rivers producing *kerib* land. The plains are overlain with Vertisols (black cracking clays). The Vertisols develop very wide cracks during the dry season. At the onset of the rains water enters the cracks. Whilst the soils are covered with deep rooted vegetation there is no problem as roots take up any excess sub-soil water.

However, once this vegetation is removed there is excess water in the subsoil and tunnels develop in the subsoil. These eventually collapse leaving an incipient gulley. These gradually extend back into the plain stripping the soil away from the underlying weathered rock of unconsolidated sediments, which are extremely soft and erodible. The weathered rock is quickly gullied.

The Dinder is gullied for about 50 kms upstream from its confluence with the Blue Nile. The Rahad River does not appear to be affected except very locally near its confluence with the Blue Nile. However it is not as extensive nor has it gullied back to the same extent as it has along the Atbara. Most the kerib land along the Atbara has gullied upto 2.5 kms from the river, whilst along the Dinder it about 500 meters. It is possible that the Dinder is not as incised as the Atbara River.

An interpretation of 2000 Landsat TM imagery gave an estimate of 337,640 feddans (141,810 ha) of land that is affected. Some kerib land adjoins rainfed and some irrigated cropland. As no information is available on erosion rates it is difficult to estimate the impact on loss of cultivated land.

(iv) River bank Erosion

Possibly a bigger problem in terms of sediment delivery to the river is bank erosion, particularly along the Blue Nile. Much of it is a natural phenomenon caused by river meandering over flat flood plains and subject to a complex array of hydraulic factors. Along the Blue Nile bank material is mainly clay and silt.

Human influences can alter the very delicate balance of hydraulic forces and set in chain accelerated bank erosion. Excavation of soil for brick making and building, the removal of tree vegetation along the banks, different cropping patterns and dumping of material into the river can all causes accelerated bank erosion. A change from deep rooting fruit trees to shallow rooting bananas is reported to have caused accelerated bank erosion along the Blue Nile (Mekki Abdel Latif, 2005).

(v) Suspended Sediment in the Abbay-Blue Nile River System

Infrequent, unsystematic and incomplete suspended sediment data for the El Deim gauging station just across the border in Sudan is available. This has been analyzed by Group 1 of the NBCBN/River Morphology Research Cluster (Ahmed Musa Siyam et al., 2005). They estimated that the long-term mean suspended sediment at El Diem to be 123M tons. They estimated bedload to be 15 percent giving a total mean annual sediment inflow of 140M tons. This figure gives an annual sediment yield for the Abbay basin of 700t/km2/yr and a sediment delivery ratio of 39 percent. This figure is similar to SDR's quoted by Walling (1983) for central and eastern USA. The estimate is lower than that for the Tekeze Sub-basin (between 800 t/km2/yr and 65 percent respectively).

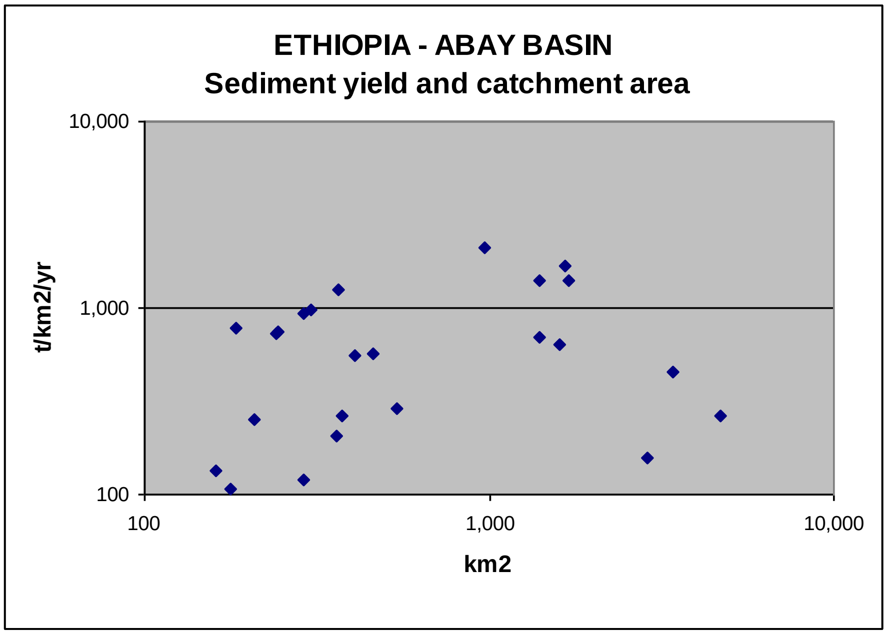
The Tekeze Medium Hydro Study (1998) quotes a much higher figure of 273M tons per annum as the mean annual suspended sediment load for Roseires. However, the sediment monitoring programme of the Sudan Hydraulic Research Institute recorded a figure of 135.6M tons for 2000 for the same station. Thus, the annual mean of 140M tons is more consistent with the NBNBN study.

The Ethiopian MWR has a number of intermittent sediment records for tributaries of the Abbay. Nearly all watersheds are less than 1,000km2 in area. They have been analyzed and tabulated by three sources: (i) The Abbay Basin Master Plan Study, (ii) the Tekeze Medium Hydro Study, and (iii) a study undertaken by Rodeco for MWR (2002). There are a number of discrepancies between the data sets and some stations are included one data set and not the other, and vice versa. Figure 6 is a scatter diagram of sediment yield against basin area using the Abbay Master Plan data.

There is no clear relationship between sediment yield and watershed area indicating that a number of other factors have a much stronger influence. In the

Study undertaken in Tekeze Basin these were found to be variations in lithology, landuse, gully density and connectivity (Nigussie Haregeweyene et al., 2005) and given the similar conditions in the Abbay Basin the same factor are also likely to be responsible. The sediment yield estimates are generally lower than those recorded for small dam catchments in the Tekeze basin.

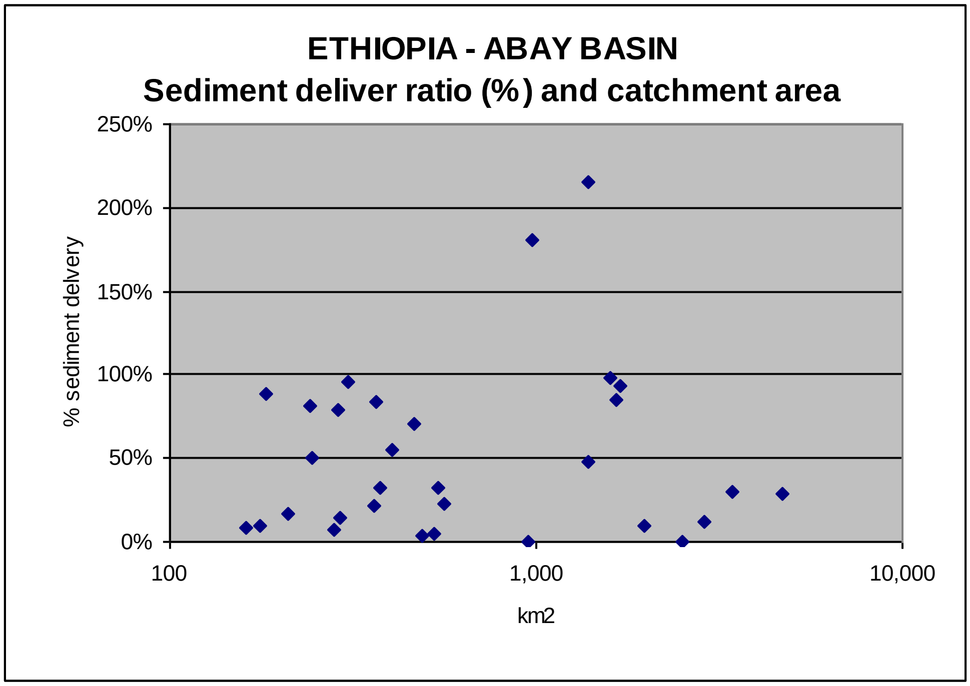
Figure 6. Ethiopia – Abbay Basin: Sediment yield (t/km2/yr) and catchment area for medium catchments (100 – 5,000 km2).



Source: MWRI, Addis Ababa.

In order to estimate the sediment delivery ratio the gauging stations were located by wereda and the mean soil erosion rate of the wereda used to generate an estimate of the total erosion within the catchment. The scatter plot of these estimates is shown in figure 7. Two catchments show SDR's of >100 percent. In these cases the amount of soil erosion within the catchment could have been under-estimated. Again there is no clear relationship between basin size and SDR and there is a slight but not statistically significant positive trend line in contrast to the generally published figures. The mean SDR is 49 percent but with a coefficient of variation of 100 percent.

Figure 7. Ethiopia – Abbay Basin: Sediment delivery ratio and catchment area for medium catchments (100 – 5,000 km2)



Source: MWRI, Addis Ababa.

There is no significant difference between the sediment yields of small and large catchments, with the mean of the small catchments close to that of the large catchments. This would indicate that there is little or no storage of sediment within the Abbay river system, a factor normally attributed to declining sediment yields with increasing catchment areas. This is to be expected given the steep gradients in both tributary and main rivers. Given the relatively high sediment delivery ratios and very similar sediment yields it would appear that the Abbay River system is also relatively efficient in delivering and removing eroded sediment from the landscape.

From the data on suspended sediment discharge at three key stations on the main Abbay River, it appears that most of it comes from the tributaries located in the south and west parts of the basin. The average suspended sediment at Bahir Dar station, where Abbay leaves Lake Tana, is about 2.2 million tons per year, or about 143 t/km^2/yr; the average suspended sediment at Kessie station (on the bridge between Addis Ababa and Debre-Markos) is 49.4 million tons per year, or 751 t/km^2/yr, while the average suspended sediment measured at the El Diem station of the Sudanese border is 140 million tons per year, or 700t/km^2/yr (Table 16).

Table 16. Suspended sediment discharge for selected hydrometric station within the Abbay basin

Station	Length of record	Catchment area (km^2)	Sediment load ('000 tons/yr)	Soil loss in ($t/km^2/yr$)	Annual av. discharge (m^3/s)
Gilgel Abbay, near Merawi	1980-1992	1,664	2,821.0	1,695.3	58.17
Gumara, near Bahir Dar	1980-1992	1,394	1,937.1	1,390	27.18
Megech at Azezo	1980-1992	462	263.0	569	7.5
Abbay at Kessie	1982-1992	65,784	49,404.0	751	450.5
Muger, near Chancho	1980-1992	489	38.2	78	9.26
Abbay at Bahir Dar	1980-1992	15,321	2,191.0	143	111.32
Guder at Guder	1980-1992	524	47.2	90	12.63
Birr, near Jiga	1980-1992	975	2,075.4	2,129	17.86
Dura, near Metekel	1980-1992	539	386.5	717	
Angar, near Nekemte	1980-1985	4,674	701.9	150	62.79
Dabana, near Abasina	1980-1984	2,881	452.9	157	57.35
Angar, near Gutin	1982-1983, 1986-1992	1,975	176.3	89	
Beles, near Metekel	1983-1992	3,431	1,563.3	456	51.38
Abbay at Sudan border	1980-1991	172,254	140,000.0	700	1555.73

Source: Abbay Basin Master Plan Study.

(vi) Dam and Reservoir Siltation

(a) Impacts of Soil Erosion

The most important off-site negative impacts of soil erosion are sedimentation of streams and water storage infrastructures. High sediment loads in streams pollute water supplies, and cause siltation of dams, reservoirs, water-harvesting structures and irrigation canals, reducing their effective capacities, shortening their service lives, and incurring high maintenance cost, at national, community and individual levels.

The two main dams in the Blue Nile Basin are Roseires completed in 1966 with a storage capacity of 2.4 km^3 and the Sennar completed in 1925 with a capacity of 0.7 km^3. The hydro-electric facilities at each of the dams have installed capacities of 250 MW and 15 MW at Roseires and Sennar respectively. Both dams are affected by siltation. The Sudan Ministry of Irrigation and Water Resources report that sedimentation in the Roseires Dam rose from 300 million m^3 in 1970 to 1,264 million m^3 in 2000 resulting in a loss of 38.3 percent of its designed capacity. Sedimentation is now reducing the live storage. As well as the loss of storage impact on crop area that can be irrigated there is also a reduction of hydro power generation. In addition, there is damage to turbine blades caused by the heavy suspended sediment.

Because the dam gates have to be kept open and turbines closed down during the high flood peak to avoid excessive siltation there are corresponding losses of irrigation water and hydro power.

In 1991 some 9.78 million m^3 of silt entered the irrigation canal system of which 62 percent is deposited in the canals with the remainder being deposited in the fields (World Bank, 2002). Desilting of the 17,244 kms of irrigation and 10,650 kms of drainage canals in the Gezira scheme alone is an enormous and expensive operation estimated in 1997-98 to cost SD1,366.8 million.

High sediment loads in the rivers used as sources for domestic and industrial water supplies cause problems and additional expenditures for water treatment plants.

3.5.2 Issues of Soil Degradation and Loss of Agricultural productivity

(i) Relevance to Transboundary Analysis

A key issue of soil degradation within the Sub-basin is declining soil fertility, the immediate cause of which is soil nutrient "mining". Whilst some of the underlying causes may be nationally specific (e.g. land policy) the impact on the rural population of the Sub-basin is the same: declining livelihoods and increasing rates of poverty. For this reason it is considered a basin-wide issue.

(ii) Ethiopia

In the Ethiopian Highlands the immediate causes are the burning of dung, removal of grain and soil erosion. Within the Abbay Basin some 1,751,600 tons of dung collected from crop fields (about 40% of total dung produced) and some 3,207,046 tons of crop residues were burnt as household fuel. This resulted in a loss of some 44,060 tons of N and 9,250 tons of P.

An estimated 515,626 tons of grain is removed from cropland annually. This would account for an additional 10,292 tons of N and 2,058 tons of P being removed.

Another source of soil nutrient losses at the field level is soil erosion. Hashim et al (2000) estimate nutrient loss as:

*Nut Loss = Soil loss * Nutrient concentration of topsoil * Enrichment ratio*
where the enrichment ratio refers to the ratio of the additional minerals and organic matter in eroded soil compared with the original soil. Barber (1983) estimated an enrichment ratio of 2 for eroded N and organic matter. As only

about 2 percent of the total N and P is available in any one year replenishment costs should be based on this proportion. Using Barber's estimated annual nutrient losses from different soil erosion rates losses of available N would be approximately 7,058 tons and 1,233 tons of available P on 7.4 million ha of cultivated land losing 101.8 million tons of soil annually.

The estimated annual gross losses of soil nutrients to cultivated land are summarized in table 17.

Table 17. Ethiopia – Abbay Basin: Estimated gross losses of N and P soil nutrients from three sources.

Source of loss	tons N	tons P
Dung/residues as fuel	44,060	9,250
Grain removed	10,292	2,058
Soil erosion	7,058	1,233
TOTAL	**61,410**	**12,541**

Against these N losses are annual increments of N from rain, dust, non-symbiotic fixation and symbiotic fixation. These are estimated to be 15 kgs per ha for the cultivated land in Ethiopia, or 111,260 tons per annum in the Abbay Basin. There is thus a net annual loss of available N from cultivated land of approximately 37,640 tons or 5.1 kgs/ha of available N.

The rate of loss of nutrients is nearly 2.5 times the rate of loss occurring in the Tekeze basin, confirming the work of other workers (e.g. Desta et al, 1999, World Bank, 2004) that soil nutrient breaches and decline in soil nutrient status is major problem in the higher rainfall areas. It is noticeable that in contrast to the Tekeze Sub-basin where the greatest losses are from burning dung and residues, losses from grain removal make the largest contribution to total losses in the Abbay Basin.

(iii) Sudan

(a) Semi-mechanized Farms:

Within the Abbay-Blue Nile basin in Sudan there are approximately 7.454 million feddans (3.131 million ha) of large to medium semi-mechanized farms (SMF)[11]. However, a proportion of this land has gone out of production and in some cases has been abandoned. The FAO/WFP crop survey for 2005 estimated cereal production from the SMF Sector for Gederef State as 589,000 tons. Average yields are 0.36 tons per ha, which suggests that approximately 1.636 million hectares were under crops. The Africover estimate for land under SMF's in Gederef State (in 2000) was 3.1 million hectares. This suggests that in 2005 (a

[11] Africover mapping of rainfed cropping with large to medium size fields.

good rainfall year with high sorghum prices) only 50 percent of the SMF land was cropped.

During the 1990's the area harvested on the SMF's contracted by 2.4 percent per annum whilst yields declined even further by 5.1 percent per annum (World Bank, 2005). This resulted in a decline of GDP from SMF sector of 6.7 percent.

These reductions in yield are partly due to a decline in soil fertility in the absence of fallowing or fertilizer application. There has also been a decline in productivity partly due to the build-up of weeds (including striga) and partly to an expansion onto marginal land resulting in destruction of soil structure, soil erosion and soil fertility. The removal of natural predators (snakes and cats) has led to an increase in rats and other vermin. Insect eating birds have disappeared leading to a big increase in the use of insecticides and insect damage.

With only approximately 50 percent of the land being cropped and yields declining at just over 5 percent per annum this represents a substantial waste of natural resources.

(b) Small-scale Traditional Farm Sector

There are approximately 1,129,240 feddans (474,282 ha) of small-scale rainfed cropping. Spatial expansion of the traditional sector is severely constrained by the SMF's and the State Forest reserves. This is resulting in shortening fallow periods and thus declining crop yields. Sorghum yields in the traditional crop sector have declined in line with those in the SMF sector and are currently about 0.4 tons/ha, down from about 0.9 tons/ha in the 1970's.

3.5.3 Changes in Vegetative Cover

(i) Definition of terms

Removal of woody vegetation for fuel consumption has often been blamed for "deforestation" leading (eventually) to "desertification". More recently the blame for deforestation has been laid at the door of agricultural and settlement expansion. "**Deforestation"** is here defined (following Reitbergen, 1993) as:

> *The permanent conversion of "forest" to non forest land cover and land use.*

For this purpose "Forest" in the context of "Deforestation" includes high forest, woodland and shrubland. It is land with woody biomass cover where the crown cover exceeds 20 percent. Selective timber felling, and browsing by cattle, coffee cultivation or harvesting BLT under the trees do not fall within the definition of deforestation. Similarly, clearing for cultivation followed by bush fallowing, where fallow periods are of sufficient length to allow full regrowth of secondary forest, woodland or shrubland, should be not included.

Wood cleared for agriculture involves a complete change in land cover from shrubland, woodland or forest to "non forest land" and an almost complete removal of wood in the area cleared. However, wood removed for fuel does not involve a complete and instant change in land cover. Shrubland, woodland or forest may remain as those land cover types for a number of years. Instead, there is a gradual erosion of wood stocks and "**degradation**" of land cover rather than "deforestation". Dense woodland gradually becomes open woodland, which may then gradual become open shrubland. This may in turn become "grassland" with scattered trees.

The conclusion is therefore that **the two processes are different and cannot be directly compared**. Clearing woody biomass for agriculture is a sudden and complete process. The "degradation" of woody biomass stocks caused by wood removal for fuelwood and charcoal is gradual and partial.

(ii) Deforestation and Degradation of Woody Biomass

(a) Ethiopia

In the northern Highlands in the Abbay-Blue Nile Basin there is little or no potential for expansion of agriculture except in very local situations. However, south of the Abbay River in Oromiya Region there is some potential for agricultural expansion and this taking place into areas covered by shrubland, woodland and forest. In the western lowlands, mainly encompassing Beneshangul-Gumuz Region there remains considerable areas for agricultural expansion. Hitherto settlement and expansion of agriculture in these areas have been constrained by the presence of human diseases (particularly malaria) and cattle diseases (particularly trypanosomiasis).

In the late 1970's a large-scale mechanized farm of 96,000 ha was cleared and developed in the lower Didessa and Anger Valleys. It experienced continued declining yields and following the fall of the Derg it was abandoned. Such was the efficiency of the clearing of the original woodland that even after 10 years it remains grassland with no woody vegetation.

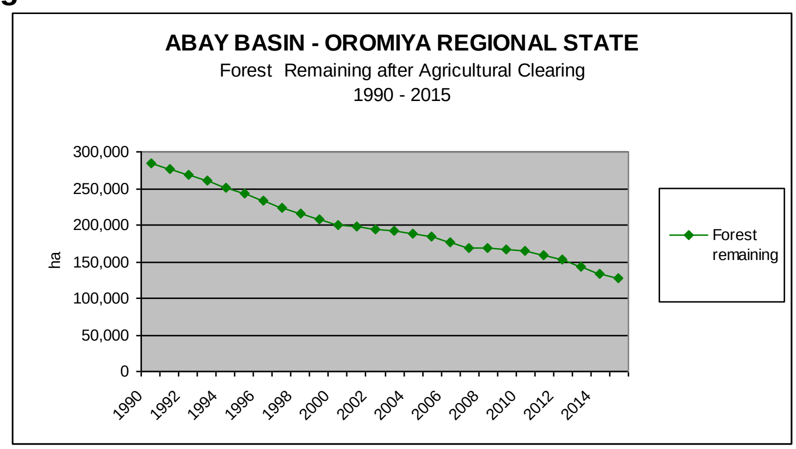
Since 1991 a new voluntary resettlement programme is being implemented in Oromiya region and to a much lesser extent in Amhara region. The main areas for resettlement are in the Didessa and Anger valleys. The Pawi scheme has also continued to receive settlers. In BSG Region some 128,000 ha have been allocated for medium-large scale agricultural investment.

There has been no monitoring of landcover changes in response to the new resettlement and agricultural investment programmes. The WBISPP attempted to forecast future landcover changes resulting from natural population increase in Oromiya and BSG Regions, using 1990 and 2000 as the base years respectively[12]. Because of the ease of clearing, the landcover change model assumed that potentially arable land with shrubland would be cleared first, followed by woodland and then forest.

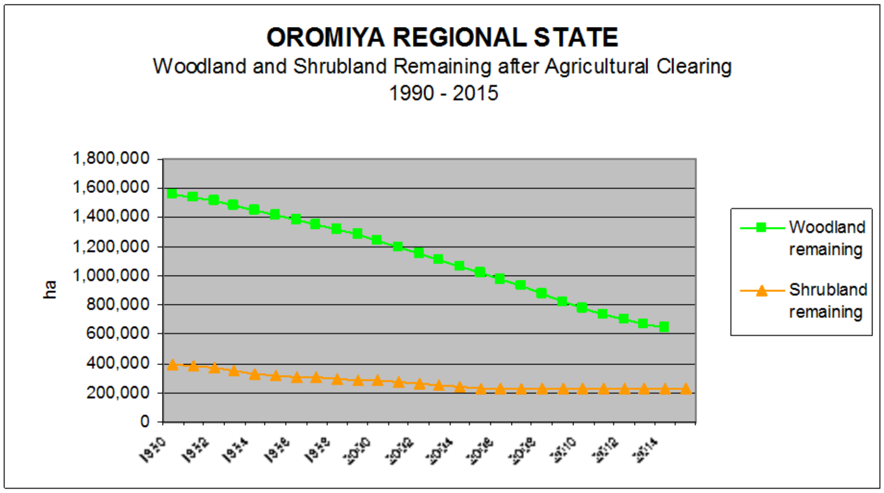
"Forest" here follows the definition of Friis (1992) who defined "Forest" as "*a relatively continuous cover of trees, which are evergreen or semi-deciduous, only being leafless for a short period, and then not simultaneously for all species. The canopy should preferably have more than one story.*" Woodlands are "a continuous stand of trees with a crown density of between 20 - 80%. Shrublands are defined as "a continuous stand of shrubs with a crown density of between 20 -100 %. There may be scattered individual trees with a crown cover of less than 20% or scattered clumps (i.e. less than 0.5 hectare) of trees (as modifiers)."

The analysis was conducted at the wereda level using current population growth rates and crop, grazing and settlement land requirements of the existing farming systems. The results for Oromiya region which is main highland, and BSDG Region which is mainly lowland are shown in figures 8 (a) and (b).

Figure 8 (a) and (b) Ethiopia - Abbay Basin – Oromiya region: Shrubland, Woodland and Forest Remaining after Agricultural Expansion from Natural population growth: 1990 – 2015



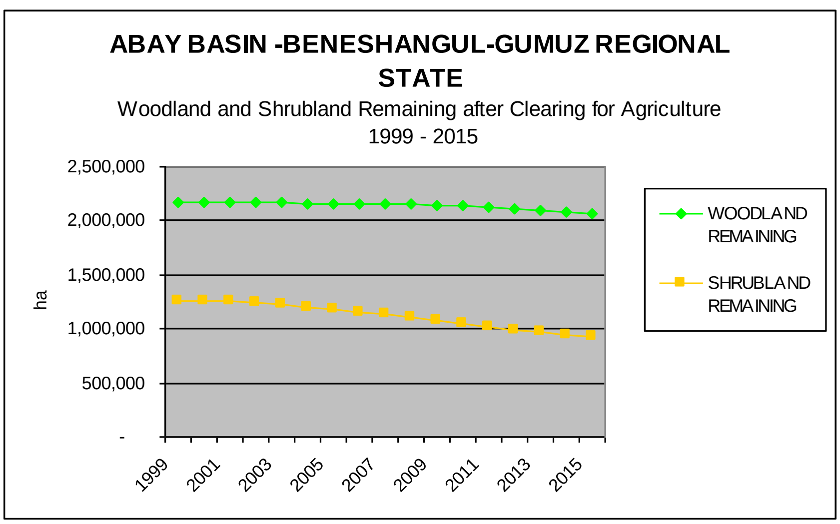
12 Oromiya landcover was mapped using 1989 landsat imagery and BSG using 2000 imagery.



By 2015 some 56 percent of forests, 61 percent of woodlands and 43 percent of shrublands will have been cleared for agriculture and settlement as a result of natural population increase. No account is taken of resettlement and migration, or of expansion of large-medium scale commercial agriculture.

In BSG given its low population densities the rates of clearing are much lower. The woodland and shrubland remaining after agricultural expansion between 2000 and 2015 are shown in figure 9.

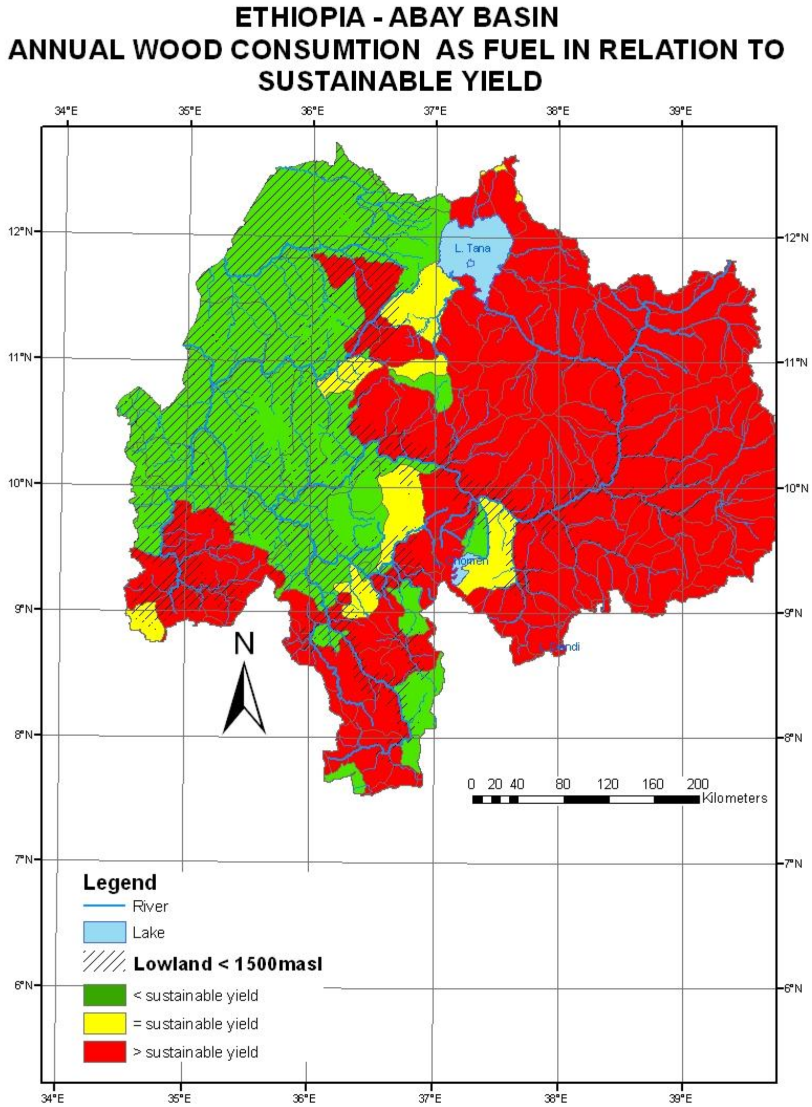
Figure 9. Abbay basin – Beneshangul-Gumuz Region: Woodland and Shrubland remaining after agricultural expansion: 2000 – 2015.



In BSG some 5 percent of *Acacia-Commifera* woodland and 27 percent of shrubland are estimated to be cleared for agricultural expansion due to natural population increase. Again no account is taken of expansion of agriculture for irrigation (e.g. the Beles scheme), resettlement for rainfed agriculture or large-medium scale commercial agriculture.

Removal of wood in excess of the sustainable yield (after accounting for removal of dead wood and fallen branches, leaves and twigs) leads to declining stocks, which in turn leads to declining yields and so to progressive degradation of woody biomass. The proportion of sustainable annual woody biomass yield consumed as fuelwood by wereda is shown on Map 9. Note that this does not include wood removal for new house construction and current house maintenance.

It can be seen that the pattern of weredas consuming in excess of sustainable yield mirrors that of the weredas with high proportions of their area experiencing moderate to severe soil erosion (see Map 18).



Map 18. Ethiopia – Abbay Basin: Annual woody biomass consumption as fuel in relation to annual sustainable yield.

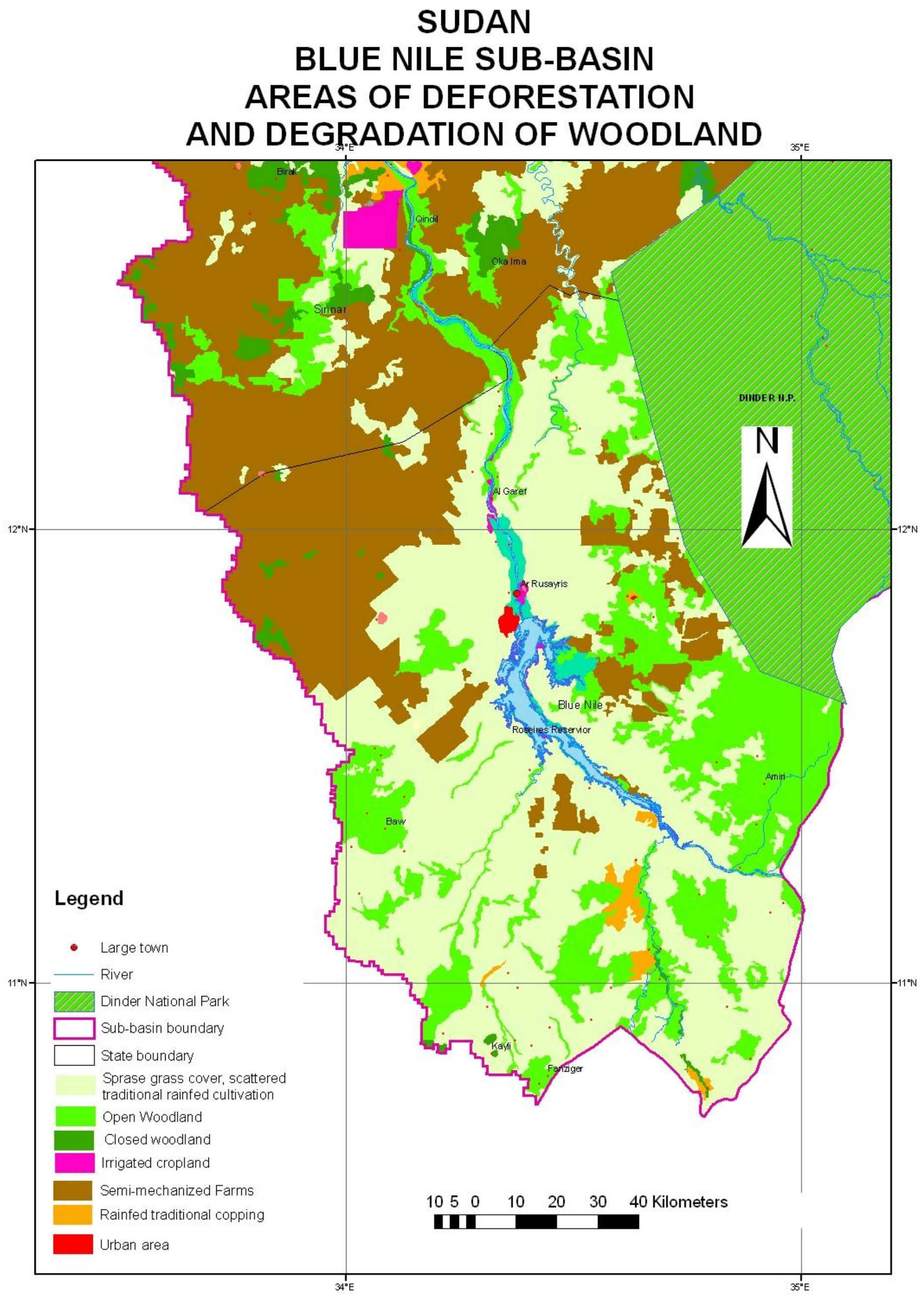
Most weredas that are consuming more wood than the sustainable yield are located in the highlands a clear reflection of the low population densities in the lowlands. The map shows the current rates of consumption and supply. In practice there is substantial development of on-farm trees in many areas of the higher rainfall areas of the highlands. However, in the drier areas of the eastern highlands development of on-farm tree production has been slower, partly because of the more difficult tree planting environment and partly because of the lack of markets for construction poles.

(b) Sudan

Substantial areas in the Abbay-Blue Nile Sub-basin have been cleared to make way for the Semi-mechanized farms. These now cover some 1.32 million ha. This was formerly woodland and shrubland. The clearing has been particularly severe in the west of the Blue Nile and towards the Ingessena Hills. Map 19 indicates the encroachment of these farms towards the Ingesenna Hills (near to Bau). An unknown area of Semi-mechanized Farms is abandoned each year because of falling crop yields. Because the land is totally cleared of all tree cover and combined with years of constant harrowing and disking the tree seed bank in the soil has been completely destroyed. The abandoned areas are a waste land with no tree cover. The quality of the grass cover is very poor because of the very low levels of soil fertility.

The remaining woodlands are under severe threat from fuelwood harvesting and charcoal production. The latter is mainly for export to the urban centres as far away as Khartoum. It can be seen on Map 19 that there are large areas of grassland (mainly fallow land with scattered cultivation) where the tree cover has been removed. In addition to the local population the area has received considerable numbers of IDP's. Collecting fire wood and charcoal production has become an important livelihood strategy in the area.

The Fast Track assessment provides data for Bau Locality where there are 12 weekly markets with weekly sales of 800 m^3 at each market, 1,000 m^3 of charcoal per market, 50 m^3 for furniture and 100 m^3 for lime processing. This adds up to 22,900 m^3 per week across all markets or some 1.15 million m^3 a year. Glen (1996) estimated the wood stocking density around Roseires at 5.04 m^3 /ha. This would indicate some 224,180 ha of woodland are being cleared annually.

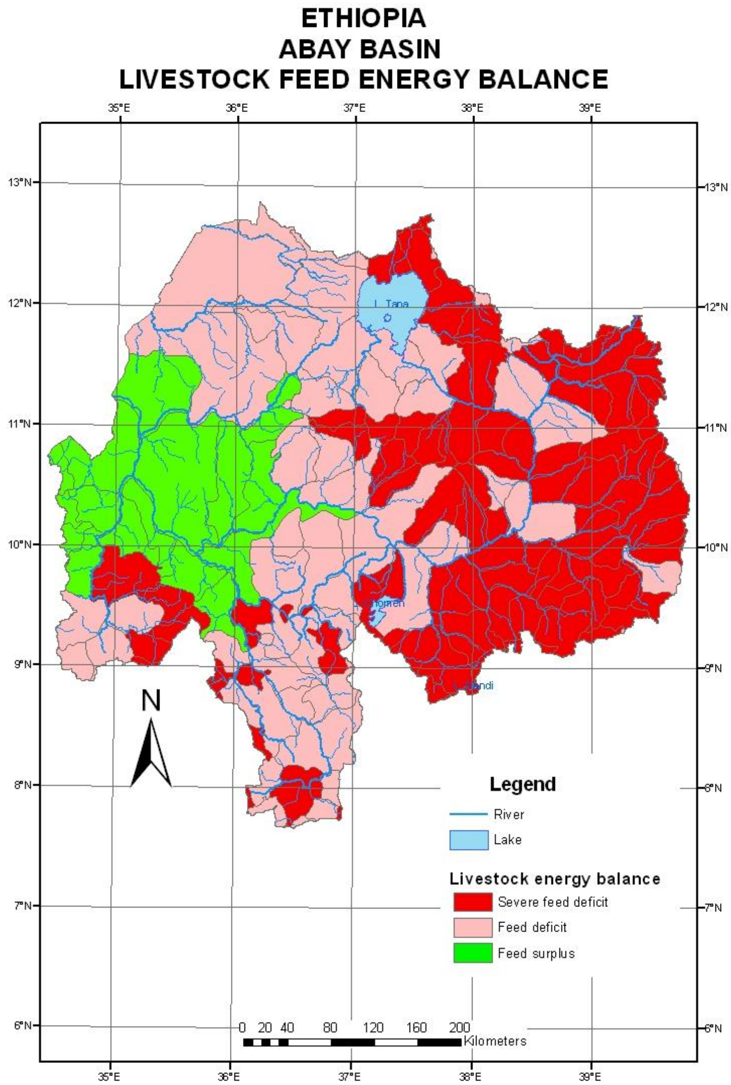


Map 19. Abbay-Blue Nile Sub-basin – Sudan: Areas of Deforestation and Woodland Degradation

(iii) Degradation of Herbaceous Biomass

(a) Ethiopia

An indicator of overgrazing can be determined by examining the livestock feed energy balance at the wereda level. Energy requirements of all livestock are computed using energy requirements for maintenance, draught power and lactation, and balanced against estimates of energy supply from natural pastures and crop residues (WBISPP/MARD, 2003). The results for the Abbay Basin are shown in Map 20.



Map 20. Ethiopia – Abbay Basin: Livestock Feed Energy Balance by Wereda.

The main areas of livestock feed deficits are the upper slopes of Mount Choke in East and West Gojam, the eastern weredas in North Shewa and South Wello, with more isolated areas in East and West Wellega. These areas are largely coincident with the areas of high soil erosion hazard.

(b) Sudan

The loss of pasture land due to the expansion of the Semi-mechanized farms has put additional grazing pressure on the remaining rangelands. These have become severely degraded due to overgrazing. This has been exacerbated over the past two decades by declining rainfall. Rangeland degradation has taken the form an increase in unpalatable species or species of low forage quality. This in turn reinforces overgrazing. The Ministry of Agriculture now estimate that 50 percent of the rangelands are degraded.

3.5.4 Assessment of the Extent and Degradation of Wetlands in the Abbay Basin

(i) Ethiopia

The WBISPP landcover map covering the Abbay Basin estimates the area of permanent swamp as 49,943 ha and of seasonal swamp 59,250 ha. Much of these wetlands are located in the highlands. The most extensive are found around the shores of Lake Tana, around the shore of Finchaa reservoir and in the headwaters of the Dabus River. However, across the highlands are hundreds of small poorly drained valley bottoms.

A survey and inventory of wetlands in the Amahra Region (Enyew Adgo, 2005) found that many of these wetlands were under threat due to land degradation and sedimentation, and the lack of bylaws and community rules regarding their use. Many are used for dry season grazing, hay production, thatching grass and grass mats (*cheffe*).

In the area between Gimbe and Nejo within the Dabus and Abbay sub-basins many wetlands are used for cultivation. Because of severe degradation on the upland granite soils the wetlands have become vital elements in sustaining peoples' livelihoods. However, in some areas there have been reports of over-draining of these wetlands leading to the destruction of their delicate hydrography and loss of value for cultivation (Wood, 2000).

(ii) Sudan

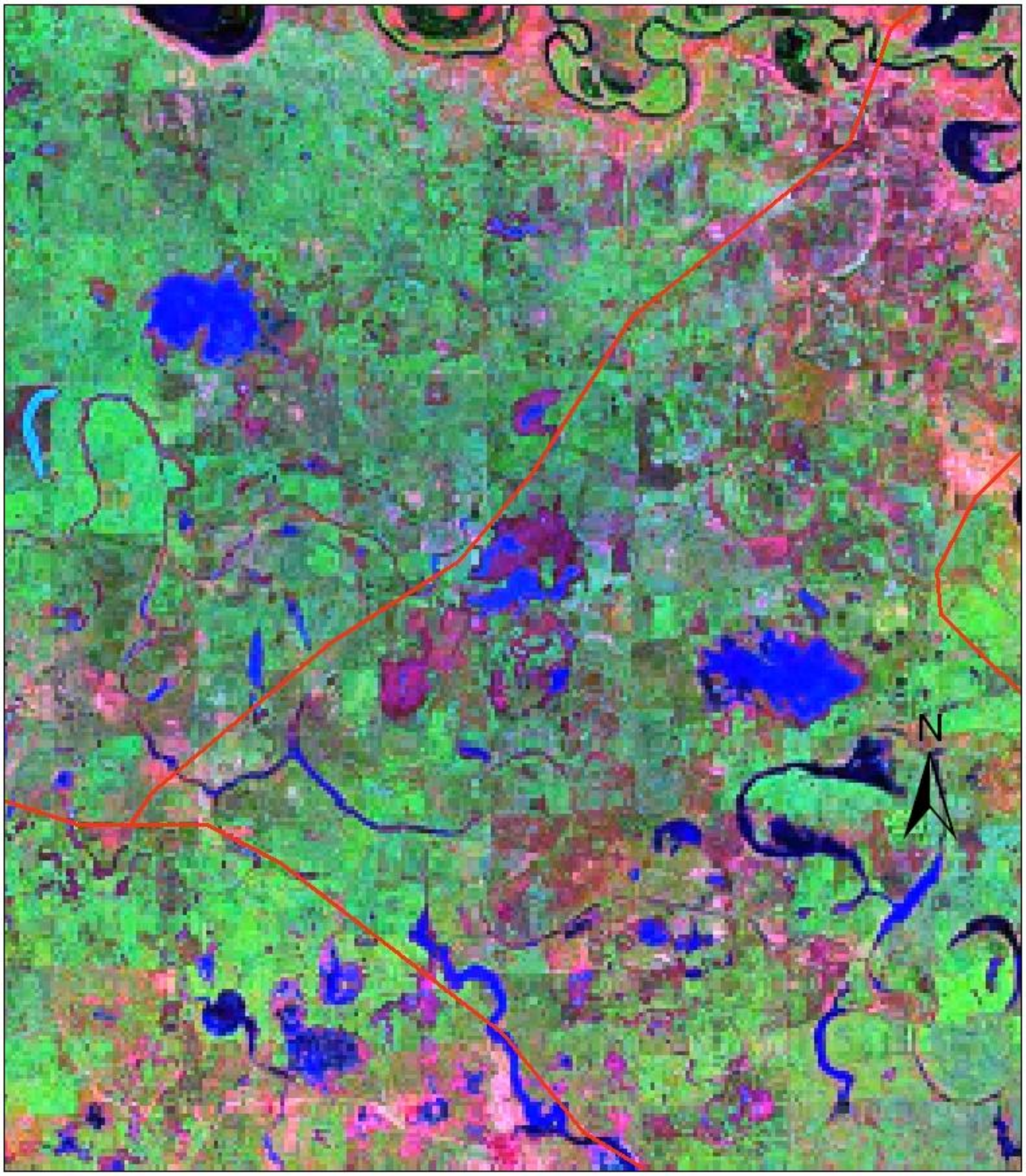
Wetlands are important components of the hydraulic system. However, they are part of environmental, socio-economic and household livelihood systems which influence and are influenced by them (Abbot and Aferwork Hailu, 2001). The hydrological system is the key environmental linkage. Upper-catchment and upstream wetland land use affects spring and stream flows and groundwater recharge. These in turn affect the sustainable on-site wetland use such as cropping, grazing and reed collection. Similarly, these on-site activities will affect users of the wetland downstream. These complex hydrological processes have implications for wetland management and management institutions not only at the local level, but also at the State and National levels in terms water policies, institutional and cooperative mechanisms and legislation.

The agricultural system has close linkages to the wetland system through cropping systems within the wetland, grazing systems and other extractive systems (reed cutting, apiculture, medicinal plant collection). The system has internal linkages to population growth, labour and oxen constraints, indigenous knowledge, urban market opportunities (e.g. for vegetables), livestock holdings and the need for forage.

Both systems have very close linkages to households and their livelihood assets and their food security strategies. Wetland cultivation and grazing provide important elements in households' food security strategies. Wetland conservation, which protects the natural state of wetlands has important social and economic benefits to local users. It is the poorest members of the community who rely most heavily on wetlands for collection of reeds and craft products for sale as well as for water supply. Conversion to agriculture can seriously jeopardize the hydrological functioning of the wetland and reduce or destroy its environmental services (stabilizing runoff, water purification, hydrological recharge, biodiversity) and natural products (reeds, water supply, medicinal herbs).

The main wetlands in the Blue Nile Sub-basin are located on and between the Dinder and Rahad rivers and are locally known as "*maya'as*". These are depressions along and between the rivers. The area way from the river is covered with fossil streams and rivers. The depressions are abandoned meanders which have formed forming "ox-bow" lakes. These lakes however are ephemeral as they gradually silt up, fill with swamp vegetation and then as they silt up dry out.

**SUDAN
BLUE NILE SUB-BASIN
MAYA'A WETLANDS
AND SEMI-MECHANIZED FARMS**



Map 21. Blue Nile Sub-basin: Example of Maya'a Wetlands between the Dinder and Rahad Rivers.

The vast majority of these wetlands are found outside the Dinder National park and most are within large to medium semi-mechanized farms. The area shown in map 53 is largely covered with large rainfed farms. There appears to be very few of these wetlands within the park. Thus the greatest danger to the Dinder-Rahad wetlands is from agriculture.

This area is frequently subject to severe flooding. Wetlands have the capacity to "buffers" flood peaks allowing the flow to pass through the system more easily. Many of the Dinder-Rahad wetlands are now cut-off from the main river systems by the expansion of large-scale rainfed agriculture. It is not known how far this is responsible for the recent flooding and far they are due to silting up of small lakes and ponds from sediment derived from the Ethiopian highlands. However, it a subject that requires immediate and detailed investigation.

3.5.5 Assessment of the Extent Reforestation and Increases of Vegetation Cover in the Abbay Basin

(i) Assessment

Whilst there is evidence of the removal and degradation of natural vegetation cover, there is considerable evidence that there has been an increase in on-farm tree planting and plantations, almost entirely of *Eucalyptus* species. Farm surveys of the numbers of trees owned and planted by farmers in Amhara and Tigray Regions have revealed that considerable planting of trees (mainly Eucalyptus) has taken place since 1991 (WBISPP/MARD, 2003).

Prior to 1991 there was very little on-farm tree planting. The reasons were firstly, that between 1975 and 1991 cutting of on-farm trees was prohibited, and secondly that between 1975 and 1989 there were frequent re-distributions of farmers plots. The net result was a strong feeling of insecurity of tree and land tenure that strongly discouraged farmers investing in tree planting. Following the change of Government in 1991 the prohibition on tree cutting was withdrawn and redistribution of holdings was much reduced and since 2000 had stopped. As a consequence perceptions of tree tenure security became stronger. This was coupled with a very large increase in the demand for construction poles following the surge in economic growth and the increase in building construction from 1992 onwards.

Farm surveys in the Amhara Region have shown that there has been a massive increase in the planting of on-farm trees (mainly Eucalyptus spp.) between 1993 and 2000, and that this continues. In Tigray tree planting did not commence until about 1997 and the cumulative totals of trees planted on-farm by 2000 was very much smaller than those in Amhara Region. In the Woina Dega land use system 40 percent of trees were less than 3 years old and thus not ready for harvesting.

Unfortunately, the surveys carried out in Oromiya Region were undertaken too early (1993-4) to pick-up these trends. However, a survey of Pole Merchants in Addis Ababa in 2004 indicated that poles are being transported from considerable distances in Oromiya Region. Further, visual evidence of the age of on-farm Eucalyptus trees in the Highland Cereal Land Use Systems in many parts of Oromiya Region indicates that considerable on-farm tree planting has occurred since 1993 in these Regions also. Thus it is likely that on-farm rates of tree planting since 1993 in the Highland Cereal Systems in Oromiya and SNNP Regions have been similar to those in Amhara Region.

Generally, the rate of on-farm tree planting has been highest in areas where rainfall is adequate and also where road access to pole markets is good. Thus in Amhara Region on-farm tree planting has been most intense in East and West Gojam and least in Wag Hamre and North Wello. Away from the main roads demand for poles in local markets is quickly satisfied. Where transport and marketing of poles and linkages with urban pole traders is well organized then on-farm trees planting can be very intense. Interviews with farmers in West Gojam indicated that individual farmers face considerable constraints in getting their poles marketed - particularly if they are off the main road - because of the problems in meeting up with pole merchants.

At a more local level detailed Bewket (2003) has studied changes in woody biomass in the Chemoga Watershed in Gojam (Bewket, 2003). This study found that stocks of woody biomass had increased over the past four decades, and these constituted mainly homestead woodlots of Eucalyptus.

(ii) Impact on Water Yield

In another study of the Chemoga Watershed, (Bewket and Sterk, 2005) examined the changes in stream flow patterns with reference to the dynamics of land cover. The results showed that between 1960 and 1999 annual stream flow decreased at a rate of 1.7 mm/yr whereas annual rainfall decreased only at a rate 0.29 mm/yr. The decrease in stream flow was more pronounced in the dry season to which a statistically significant decline of 0.6 mm/yr was observed, whilst rainfall showed no discernible trend. Wet season rainfall and flows showed no trend. Analysis of extremely low flows confirmed that low flows declined with time.

Using aerial photographs land cover changes were examined between 1957 and 1982, and 1982 and 1998. Over the past four decades the major change in land cover was the increase in cultivated land from 60.4 to 66.6 percent. Closed canopy forest cover increased 2.4 to 3.6 percent. This was attributed to plantation (mainly Eucalyptus) activities during the Derg, and planting of trees by households since 1991 (again mainly Eucalyptus). Woodland and shrublands declined during the first period (1957 – 82) and increased over the second period (1982-1998). The increase in the second period was attributed to hillside closures. The significant change was in the amount of Eucalyptus that had been planted during the second period.

The changes in stream flow were ascribed to increase in cropland, increase in Eucalyptus planting and overgrazing. Another cause was the increased abstraction of water due to the increase in population during the study period. The increase in Eucalyptus has led to an increase in evapotranspiration over the previous land cover. Local people confirmed that Eucalyptus dried out the land, but that the economic returns were substantial. Decreased dry season flows indicate a decline in groundwater resources.

3.5.6 Trends in Soil Degradation in the Abbay Sub-basin with no Watershed Management Programme

(i) Introduction

In the centuries before 1975 there had been a slow drift of people from the north moving south to less populated areas. Following the Land Reform of 1975 internal movement within rural areas became difficult particularly in the north where cropland was already short. Peasant Association[13] Committees allocated land and first preference was always given to dependants of existing families. Nevertheless, there was continued migration into the sparsely forested areas of the southwest.

During the early 1980’s a Resettlement Campaign resulted in large numbers of people being moved from the high population density areas to areas in the western Lowlands. Two strategies were followed: (i) movement to large Resettlement Camps, and (ii) a less intensive approach where families were “integrated” into existing highland areas mainly in the southwest. There were many documented instances of involuntary resettlement and following the change in Government in 1991 many of the large Resettlement Camps emptied with people returning to their home areas.

Since 2003 a new official voluntary resettlement programme is in place (Government of Ethiopia (2003). Movement of settlers is confined to within-region movement only – no inter-Regional movement of people is envisaged (the "restricted" migration scenario of (Sonnerveld, 2004). The programme is designed to take into account lessons from resettlement programmes in the past. The main destination weredas in the Abbay Sub-basin are :

[13] Areas with defined boundaries approximately 1,500 ha in extent with about 300 – 400 families.

Abbay Sub-basin: Quara, weredas in West and East Wellega, Jimma and Illubabor Zones.

Both the 1984 and 1993 CSA Population and Housing Census have data on the numbers of people who were born out the wereda they were living in the time of the census. There are two main of reasons why these censuses cannot be used to estimate the direction and size of population movements between 1984 and 1993. The Censuses do not indicate the weredas of origin of migrants. Secondly, many weredas have changed names, boundaries or have been amalgamated between the two censuses.

(ii) Methodology to Determine Expansion of Cultivated Land – 2005 to 2025

In order to make an approximate assessment of the possible trends in the expansion of cultivated land over the next 20 years a two pronged approach has been adopted. Firstly, a subjective assessment has been made based on observations made on land cover and settlement changes during field trips over a period of 20 years. Secondly, data at the wereda level on the population support capacity status[14] was used to define four catagories of wereda:

- Catagory 1: weredas that (in 2005) were cultivating in excess of the land classified as being "arable" for rainfed cropping (i.e. FAO Crop Suitability Classes S1 to S3). These were said to be "Critical" in their population support capacity.
- Catagory 2: Weredas that were using all the land classified as being "arable. These were said to be "At capacity" in terms of the support capacity.
- Catagory 3: weredas that would reach their support capacity within 10 years at current population growth rates using current levels of farm technology.
- Catagory 4: weredas that would reach the support capacity by or after 20 years.

It was assumed that weredas in the first category would be unable to expand their rainfed cropland any further and thus cropland soil erosion rates in the absence of SCC interventions would continue at their current levels. Weredas in category 2 would expand their area of cropland at the current population rates with each incremental farm family converting the current farm size (specific to each farming system) plus an addition 50 percent to cover the area for settlement upto the 5th year, when no further expansion would be possible. Using the same assumptions, weredas in the third category would be able to expand the area of

[14] Taken from the population support capacity analysis undertaken by the WBISPP for Tigray, Amhara, Oromiya, SNNPR, BSG and Gambela Regions.

cropland without restriction upto the 10th year and those in the 4th category would expand for the full 20 years.

(iii) Subjective Assessment of Population Movements

There appears to be have been little expansion of cropland over the past 20 years in much of the north and east of the Highlands in the Sub-basin. Where cropland has expanded it has been the infilling of patches of land between existing cultivated areas. The reported frequent redistributions of existing cropland land are testimony to this.

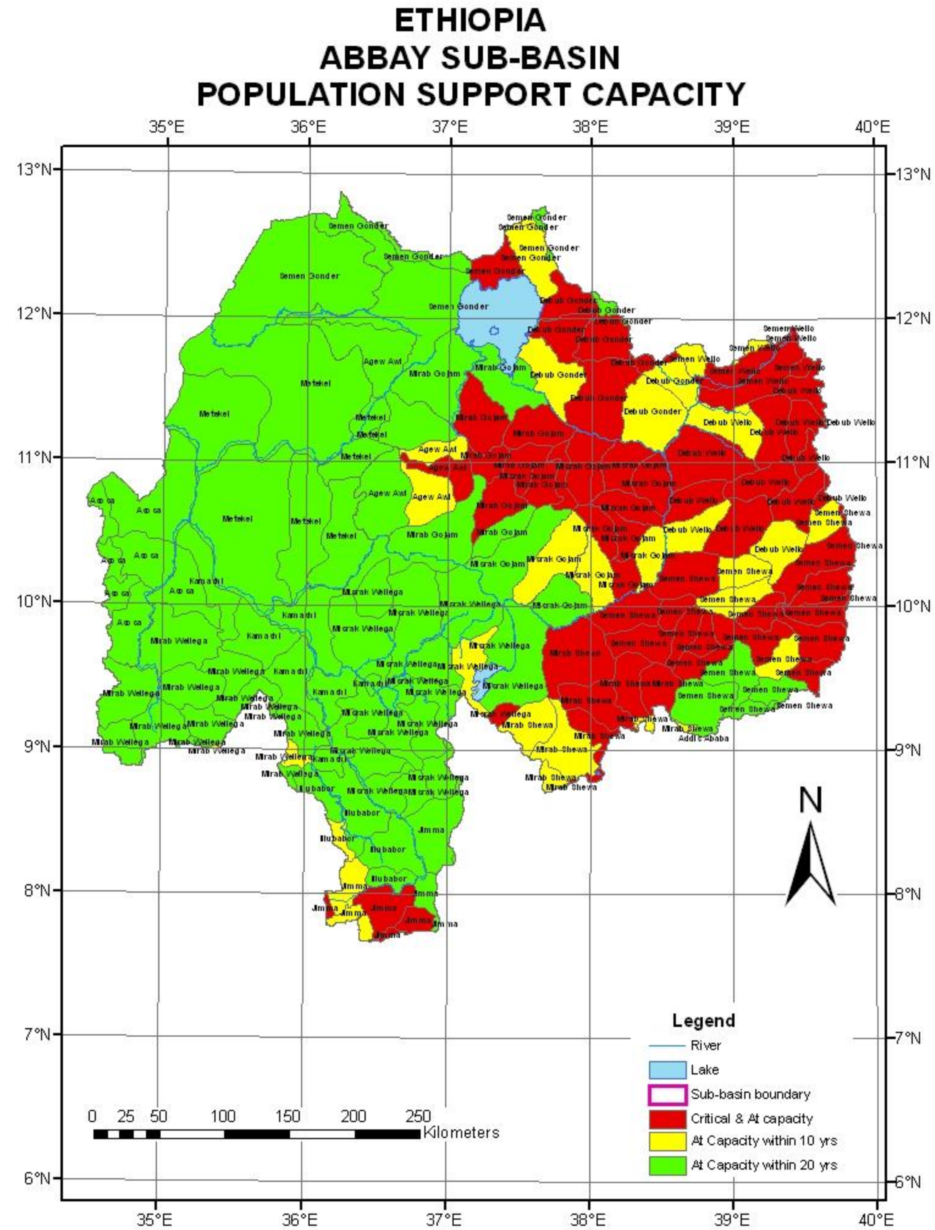
In the late 1980's and early 1990's voluntary migration of people from north to south of the River Abbay has seen agricultural expansion into the Lower Didessa and Anger valleys. More recently this cross-river migration has ceased but resettlement sponsored by the Oromiya Regional Government has reinforced settlement in these valleys. Although soils are derived from Basement Complex rocks and thus highly erodible slopes are relatively gentle.

The second main area of agricultural expansion has been on and down the western escarpment towards the western lowlands in the Dinder, Beles and Dara valleys. These are areas of steep slopes and high rainfall and are very susceptible to soil erosion.

The third area of agricultural expansion over the past two decades has been into the upper parts of the Abay Gorge. Rainfall amounts are lower than the western escarpment and slopes are steep and susceptible to soil erosion.

(iv) Assessment of Cropland Expansion using the PSC Catagories

The spatial distribution of the three categories of weredas is shown in Map 22.



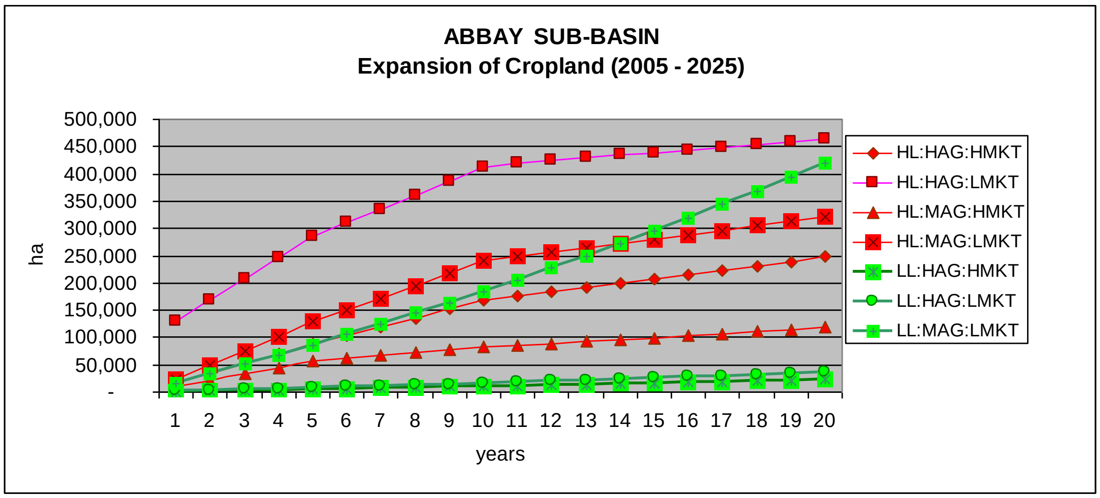
Map 22. Ethiopia: Eastern Nile Basin: Distribution of weredas of the three Population Support Categories
Source: WBISPP/MA

Most of the category 1 and 2 weredas are located in the eastern Highland areas of the Sub-basin. Clearly, the main areas were unrestricted expansion of cropland will occur or the western Highland s and Lowlands.

The results of the analysis are shown in Chart form below for the Sub-basin.

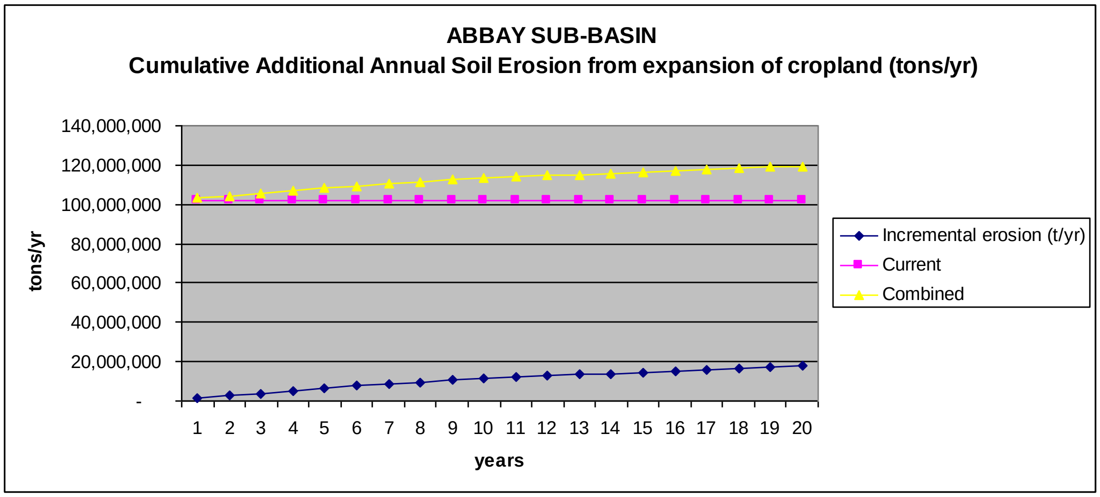
In the Abbay Sub-basin the main expansion of cropland will take place in the two Highland domains with High Agricultural Potential and Poor market access and in the domain with Medium Agricultural Potential and Poor market access. (figure 10) One Lowland Domain will also see a considerable expansion in cropland: the domain with Medium Agricultural Potential and poor market access. After ten years all Highland domains see a decline in the rate of expansion as weredas reached their population support capacities. The total expansion of cropland within the Sub-basin by the year 2025 is estimated to be 1.63 million ha or approximately 22 percent of the current area. Because inter-Regional resettlement is currently not permitted the potential for cropland expansion in the Lowlands is not realized.

Figure 10. Abbay Sub-basin: Expansion of Cropland by Development Domain 2005 – 2025 (ha)



The additional annual soil erosion by the year 2025 occasioned by the expansion of cropland is estimated to be 17.7 million tons or an increase of 17.4 percent of the current annual loss (figure 11).

Figure 11. Incremental annual soil erosion (tons/yr) from the expansion of cropland (2005 – 2025.)



3.5.7 Loss of Biodiversity

The Dinder National Park, which was proclaimed in 1935 is located within three States: Sennar, Blue Nile and Gedarif. It boundaries follow to the north of the Rahad in the north, to the south of the Dinder in the south and the Ethiopian border to the east, and covers an area of 8,960 km^2. It is also a designated Biosphere Reserve and has been designated under the Ramsar Convention as an international Wetland. Immediately across the border within Ethiopia the Amahra regional State have designated an area as the Alatish National Park

The Park lies on a transition ecotone between two floristic regions: the Ethiopian High Plateau and the arid Saharan-Sudanian biomes. It also lies along the boundary of two major faunal Realms of the world: the Palaearctic and the Ethiopian. It is also located along a major north-south flyway of migratory birds.

It has a high level of biodiversity with over 160 species of birds, 27 species of large mammals and unknown number of small mammals. It comprises the last extensive tract of woodland in eastern Sudan. Its importance to conservation can be summarized as follows (ArabMAB, 2006):

- The proximity of the Park to the desert and semi-desert makes it an important buffer zone for the vegetation cover of central Africa in addition to its significance in providing genetic material for the rehabilitation in the semi-arid and arid areas.

- The park is an important watershed area protecting the most important feeders of the Blue Nile, the Dinder and Rahad rivers.

- The Park, together with the south-western corner of the Ethiopian Plateau make a complete Ecosystem for wild animals, for which the Park is the dry season habitat for migratory species.

- The park supports a high diversity of fauna and flora, including such animals of international conservation importance as the African elephant, African buffalo and the lion.

There are three groups of people who have an interest in the park. The first is the original inhabitants of the areas - a small group of Maganu people who continue to live in the south-eastern part. This community has a unique culture that needs to be preserved. They depend on subsistence farming in the rainy season and supplement their diet by collecting fruits and wild honey. In the dry season they move to the Dinder for fishing.

The second group are pastoralists and agro-pastoralists who enter the Park in the Dry Season looking for forage and water because much their rangeland has been converted into semi-mechanized farms. Included in this group are the Um Barrarow or Falata who use the Park in the dry season along the Dinder River and move into Ethiopia during the wet season. They burn the tall grasses in the dry season to make green grass available, but in doing so eliminate susceptible herbs and shrubs.

Around the Park are a considerable number of Internally Displaced Peoples taking refuge from the war in Dafur in the 1970's and are settled along the Dinder ands Rahad rivers and enter the Park for fishing, fuelwood and honey collection but also for illegal hunting and present the most serious threat to the wildlife. It is estimated that 100,000 people live around the park in 36 villages.

The Dinder and the Rahad Rivers and their tributaries drain the Park. They rise in the Ethiopian Highlands and are highly seasonal almost drying out in the dry season. Due to the abrupt change in gradient the rivers meandering a large number of cut-off meanders have been formed locally called *Maya'as*. They are generally flat and cover an area some 0.16 to 4.5 km2. Rain and flood water fill them during the rainy season. The maya'as provide a valuable source of water and forage for domestic livestock and wildlife, as well as unique habits rich in biodiversity.

Under natural conditions there is a constant evolutionary sequence of the formation of young maya'as that are deeper with clear water. Gradually they pass through stages of becoming gradually silted up. Over long periods of time with the meandering new maya'as are being formed. The spectrum runs from young productive maya'as to old non-productive dry ones.

With the accelerated erosion in the Ethiopian Highlands this gradual and long term evolutionary process has been disturbed because increased flood peaks and high sediment loads. The area is now subject to annual flooding and many of the Maya'as are becoming silted up with a consequent loss of habitat biodiversity and forage productivity.

In Ethiopia the Amhara regional Government has proposed to develop the Alatish Regional Park in Quara wereda of North Gonder Zone, almost opposite the Dinder national Park in the Sudan. The area represents the Sudan-Guinea Biome. The park has been gazetted as a Regional Park and demarcated. However, the Park lacks national legislation and international recognition (Cherie Enawgaw et al., 2006).

The Park covers an area of 2,666 km2 to the north of the Dinder River, which forms its southern boundary, and to the south of the Gelegu River that forms its northern boundary. The Alatish and other ephemeral streams drain the central area. Its altitude ranges from 500 to 900 masl. The main vegetation is woodland, shrubland and lowland bamboo thicket. Studies so far have revealed that the Park contains 48 mammal species and 180 bird species. It contains such endangered species as *Loxodonta africana, Panthera pardus* and *Panthera leo*.

The area is intact with no permanent settlement, although Fellata pastoralists enter the Park in the dry season with over 10,000 head of livestock. The northern and eastern sides have a 2 kms buffer zone, but the southern boundary has no buffer zone as it border Beneshangul-Gumuz regional State.

The Gumuz people have settled to the south of the Park and practice poaching and fishing along the Dinder River. Settlement is increasing and agriculture expanding along the northern boundary and numbers are being swelled by migrants from other parts of Amhara region. People enter the Park area to collect honey, gums and resins.

There is an urgent need to collaborate with the Beneshangul-Gumuz Regional government and with the Government of Sudan to secure the area. The Ethiopian Wildlife Conservation Organization has strongly recommended that the Alatish Park been proclaimed a National park and that in the future it should form part of a Transboundary Park with the Dinder National Park. There is also an urgent need to develop a park management plan in participation with local communities.

4. OPPORTUNITIES AND THE POTENTIALS FOR IN-COUNTRY AND TRANSBOUNDARY BENEFITS FROM BASIN-WIDE WATERSHED MANAGEMENT ACTIVITIES

4.1 Observations and lessons learnt for Watershed Development in Ethiopia

4.1.1 Historical overview

In Ethiopia a major review of past watershed management activities started following the fall of the Derg and the formation of the Transitional Government of Ethiopia in 1991, although some evaluations had started before. A number of studies have evaluated the pre 1991 watershed management activities in particular the “narrative” or “discourse” that shaped the very large soil and water conservation programme that was implemented during this time (Hoben, 1995, Rahmato, 2003). Other studies have focussed on more technical aspects of the conservation structures (Herweg, 1992). An overall assessment has been provided by Alemneh Dejene (2003) and may be summarized as follows:

- In many areas there were substantial benefits with improved soil conservation, planting of woodlots and improved pastureland.
- Many structures were costly in terms of land taken out of production, labour inputs for physical structures were very high, and there was little attempt to incorporate indigenous soil and water conservation techniques. In some areas structures were technically inappropriate and caused water logging.
- The programme focussed narrowly on arresting soil erosion without considering the underlying causes of low soil productivity, the socio-economic factors and the need for immediate tangible benefits to be attractive to poor farmers.
- The programme adopted a very “top-down” approach in its planning and implementation. There was little or no consultation with farmers or communities on felt needs. Woodlots were implemented with no harvesting plans.
- Although a “watershed” approach was adopted the basin size was too large to acquire an understanding of the socio-economics of

land degradation and farmers willingness to invest in improved land management.

The result was that many structures and woodlots were destroyed following the change in government.

Since 1993 watershed management activities in Ethiopia have undergone a radical change in approach. Alemayehu Tafesse (2005) provides an overview and assessment. The major programme is the MERET (Managing Environmental Resources to Enable Transitions to More Sustainable Livelihoods") Project, which is a successor to the previous large scale Soil and Water Conservation Project (ETH-2488, Phase I, II, III, IV) that ran from 1982 to 2002. An assessment of this Project is provided by Gete Zeleke (2005).

The most important change has been from a highly centralized to a decentralized approach. The new approach uses local level participatory planning as its main tool. The community is in control of decisions regarding development options to implement. The focus is on resource conservation as well as productivity enhancement.

The basic unit for planning is a micro-watersheds (200-500 ha) at the Kebele level. However, although watershed logic is followed it respects community boundaries. Food for work is used for community motivation. Self-help is increasingly encouraged, however with limited results. Quality control and maintenance of good standards are seen as very important, but in reality are facing serious constraints that threaten sustainability. An appropriate and effective system of monitoring and evaluation should ensure timely and useful feed back to the overall programme.

4.1.2 Observations and Lessons Learnt

(i) Priority for interventions

The strong relation between SWC and food aid, the latter being concentrated in food deficit areas, has led to a relative neglect of this work in food sufficient or surplus areas such as West Gojam and Wellega in the Abay Basin and many parts of the Baro-Akobo basin. In these areas similar works are required but with an emphasis on erosion control. This is confirmed by many, also by the WFP Mid-Term evaluation (2005).

(ii) Innovative approaches

The better linkage between SWC, water harvesting and agricultural diversification (based on micro-irrigation) that have been introduced by the MERET project, were certainly innovative for the Ethiopian context. It is fully compatible with the “improved ADLI policy” and is now applied by all.

Promising trials of genuine community participation have been practiced in a SNV supported project in Bugna wereda (N.Wolo in Tekeze basin), and in a project of SOS-Sahel in Meket wereda in the far north of the Abbay basin. Agreements had been made with Kebele leaders that farmers could use the 20 days of unpaid “community participation” labour for SWC on their own lands, and that these lands were exempted from land re-distribution. In both cases, the wereda did not have the capacity to adopt these approaches after project termination in 2002. SOS-Sahel is still active in Meket, in capacity building to weredas and in impact studies of land certification. It is up-scaling local-level NRM to Wadla wereda.

(iii) Technology innovation

Some important technology innovations have taken place in watershed treatment. Currently these are at a small scale. The former GTZ-supported Integrated Food Security Project in South Gondar (ANRS), now coming under the SUN programme, had put the largest possible emphasis on biological measures, both for on-farm conservation and for gully stabilization. Introduction of Vetiver grass was strongly promoted there and by MFM in Illubabor in the Baro-Akobo Sub-basin.

The most substantial change has been the greater emphasis on water resource development enabling the expansion of micro-irrigation, and thus agricultural/ horticultural diversification and commercialization. This change has been introduced by the MERET Project but has now been adopted by most actors. Water resource development (e.g. construction of shallow wells) is a logical step following improved water retention through SWC measures. It proves to be most productive in watersheds where SWC is widespread. An example is the case of Abraha Atsbaha Tabia, in the Northern Zone of Tigray in the Tekeze-Atbara Sub-basin, where long term activities in separate Kebeles have now resulted in an aggregated protection of almost the entire watershed (of some 3,000 hectares).

(iv) Water harvesting

Water-harvesting (e.g. ponds, small earth dams, river diversion) has become an essential ingredient of SWC programmes, although it has known limitations. The IDEN-ENSAP Watershed management Study (ENTRO, 2003) reviewed water harvesting experiences in Ethiopia and concluded as follows:

- Pond and canal seepage are limiting factors, reflecting problems in design, construction and supervision.
- Inflows from harvesting areas have been less than expected due overly optimistic runoff coefficients.
- Excessive sedimentation is a problem, pointing to need to integrate water harvesting with the overall catchment management.
- Pond water is insufficient for dry season irrigation, and is often actually used for supplementary irrigation in the wet season.
- Water should be used on high value crops, but horticultural crops have high input costs and have limited storage capacity (where markets are thin).
- Water borne diseases (malaria and bilharzias) and safety need to be considered.
- Success was achieved where both technical and social aspects were adequately covered.

(v) Impacts and implementation efficiency

Local level watershed protection has been undertaken for three decades, at enormous cost. Large areas have been treated now, particularly in the Tekeze Sub-basin. The NRM Department in Tigray admits that “impacts are not yet in relation to the efforts made through time”, but that the achievements are considerable:

- about 25 % of cultivated land treated,
- 200,000 hectares under area closure,
- 300,000 hectares of natural forest being exploited in a proper way.

Improved crop transformation and improved livelihood conditions are also mentioned as main achievements.

Research activities (Mekele University, project’s own evaluations, and in earlier days, the SCRP) have shown that SWC has a positive impact in terms of erosion control, moisture retention and land rehabilitation. The Inter-University Cooperation Project (IUC) of Mekele University estimates that terracing on cropland produces an average net increase in crop production (including the loss of land) of 3 %. Revival of natural springs is also mentioned as an important indicator.

However, the cost efficiency of all the work is rarely questioned. After many years of SWC practice, field observations still lead to similar conclusions:

- SWC implementation follows a blanket approach, structures are often over-designed; no flexibility or refinement in measures can be observed based on varying terrain conditions,
- maintenance is generally inadequate or lacking,
- there is a strong predominance of mechanical, loose rock structures which could be replaced in many places by cheaper, biological measures contributing in the same time to productivity,
- quality control is limited to target fulfilment and is not concerned with optimum impact of measures.

The type of data collected with regard to SWC implementation generally focuses on physical achievements (i.e. length of terracing, seedlings produced, etc).

After three decades of massive soil conservation campaigns, it is possible to trace exactly how much food was spent, but it is not possible to say what the impact has been on agricultural production, farm incomes, which areas have been covered (and even covered how many times) and whether the work was carried out in an efficient way.

(vi) Some selected cost figures

A few data on average overall costs of micro-catchment treatment are available:

- King and Leul Kasahay (2006) estimate the average cost of micro-catchment treatment following the CBPWM approach, at about US$180,000 for a catchment of some 200-500 hectares, i.e. about US$ 360-900/ha or ETB 3,000-8,000/ha.
- GTZ has calculated an average cost of US$ 115,500 (ETB 1 million) per micro-catchment, which is in the same order of magnitude (two thirds) of the previous estimate by King and L.Kasahaye.
- The evaluation report of Irish Aid activities calculated a cost of ETB 3,000 /hectare (85 % of which is SWC and gully treatment) for investment cost only and excluding project overheads. The same document reports the possibility to recover the program investment costs of ETB 1.8 million within 3 years.

- The IUC project (Mekele University) gave as a rough estimate an average cost of about ETB 5,000/hectare, to be repeated every 10 years.

- The MDG needs assessment document estimated unit costs of watershed treatment to amount to an average of 2,500 – 3,000 ETB/ha (based on standard WFP work norms, including materials and equipment but excluding project overhead costs).

The above indicative figures all relate to activities compensated in food or in kind, and are probably based on the same standard work-norms developed by MoARD and WFP. The variation is probably related to different average intensity of works assumed, and different proportions e.g. of hillside closure (relatively cheap) and gully treatment (expensive).

The dominant role of food aid is also expressed in WFP project budgets. In the overall budget for the 2003-2006 MERET programme, the combined cost of food commodity and of local transport/storage/handling amounts to US$ 40.7 million, which is 94 %, of the total WFP contribution plus 92 % of GOE contribution. Other direct operational costs (staff, training, capacity building, M&E, equipment and materials) take only 6 % of the WFP contribution, and 8 % of the GOE contribution.

(vii) Budget transparency

The pattern of actors in watershed activities, amounts of work achieved, and budgets dispensed, is often complex, especially in weredas where several donors are active. It may be assumed that individual donors know what they have spent. Also, for larger donors, such as WFP, special regional and wereda project coordinators are nominated. But the form of support varies from direct compensation by food or cash to budget support, and is entered differently into the wereda overall budget (block grants, federal budget support, direct payment per activity. In addition, food-aid may be used for identical activities under different headings (FFW, employment generation under the safety net programme) and food is also distributed directly as relief aid.

Individual wereda technicians keep records of works performed within their respective areas or responsibilities. But no annual synthesis is made at the wereda level of all activities carried out, differentiating between donor, source of funding, and type of activity (paid or unpaid). Also, the conversion of works performed into areas treated, is a mathematical and artificial one. No cartographic record is kept of areas treated. After some years, as a result of high staff turn-over, nobody knows anymore who has done what and where.

The need for greater transparency and better record keeping is obvious. Given the ongoing land degradation and the enormous amounts of work ahead, it will be necessary to know better how and where to select future priority areas, and at what costs these could be treated.

(viii) Positive experiences but limited up-scaling

The recent document on a joint EEFPE/IFPRI stakeholder analysis (Gete Zeleke et al., January 2006) reports that "enormous efforts in massive land rehabilitation were undertaken since the 1980s, with the aim of arresting land degradation and improving rural livelihoods in the country. Despite these efforts, there has been limited success in controlling land degradation, in comparison to the efforts applied, the organizational structure and the resources mobilized. The problems with past conservation efforts were largely rooted in a lack of understanding of the important interface between resource conservation and agriculture, and of the factors that motivate farmers to invest in sustainable land management (SLM) over the long run.

(ix) The Role of Food/Cash for Work

The overriding role of food-for-work is often ignored. Possibly, the support provided by food or cash is taken for granted without realizing that,

- in the approach followed, it has only been the availability of food/cash that has made the work possible,
- the cost of watershed protection activities is almost entirely determined by the cost of food rations,
- the amounts of food/cash available automatically sets the upper limit for potential implementation achievements,
- the very existence of FFW/CFW has created a "dependency syndrome" and in general discourages individual initiative by farmers.

In a regional round table discussion on watershed management, with participants from many organizations (government, donors and NGOs) dealing with watershed management, "a number of participants held that food/cash-for-work is a major obstacle to scaling up. The concept has been institutionalized in such a way that farmers are unwilling to undertake any measures without payment, even when these are to their own benefit".

There are some examples of voluntary replication, for example in the Irish Aid supported activities in Tigray, where 200 hectares were said to have been implemented on a voluntary basis. Also some cases were reported and observed where farmers have dug shallow wells without external support (of a lower technical standard but unpaid).

In its cost-benefit analysis, the MERET project (WFP, 2005) also reports some (un-quantified) voluntary replication, especially of measures that can be implemented on individual basis and which contribute to production increase (mainly biological measures). The changing approach towards local level participatory planning (LLPP) is given as the main reason for improved farmers commitment and more positive appreciation of measures. Limiting factors for replication (of both labour intensive measures and private forestry activities) mentioned by farmers, are mainly inadequate availability of labour and lack of capacity and skills (almost 60 % of respondents). Lack of food aid or capital are mentioned by 35 % of respondents. Land tenure problems score surprisingly low (only 2 %).

According to GTZ replication rates are better in non-food-deficit weredas where farmers have not developed as strong a dependency syndrome. This is also experienced by others, e.g. the NGO “Menschen für Menschen” (People for people), working far from areas affected by the dependency syndrome, and facing no problems with their approach of genuine, unpaid, community participation.

(x) Building on the Past

The MERET/WFP project has been operating some 25 years (under different names), and offers a wealth of experience. The approach to this project has changed considerably over the years, reflecting experience of what does and does not work, and paralleling changes within government, as outlined above. Thus, the early approach to watershed management was large scale and top down; the achievements proved not to be sustainable and, in some cases, were detrimental. This has been attributed largely to the unmanageable size of the target areas and the lack of community participation (WFP mission 2002). Over the last 10 years, paralleling the decentralization process, the project has been re-designed to a ‘bottom-up’ project, owned and driven by communities. Target areas have been reduced to micro-catchments – or community catchments – on a scale of 200 to 500 ha. And the focus has shifted from protection – conserving the resource base – to production and improvement in rural livelihoods. This is in line with national policies and with international experiences. Most organisations working in watershed management now follow similar practices.

Overall, the various experiences provide guidance on what is implementable and at what rate. The 2005 guidelines Community-Based Participatory Watershed Development build on local experience and provide a reference to the projects.

The experiences in watershed management (including water harvesting) suggest a few key considerations for future projects:

- Community ownership and institutional structures are basic to project success
- The ‘building blocks’ for watershed management should be community catchments in the 200-500 ha range
- Larger projects (e.g. the current projects) should be seen as target areas for coverage by ‘micro-projects’ at the 200-500 ha level i.e. should be assemblages of micro-watersheds grouped and linked at a broader scale
- Conversely, larger projects can ‘add value’ by allowing physical integration of the micro-projects and by allowing a more holistic approach than possible at the micro scale
- 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 standard models.
- Implementation is easiest in areas offering most immediate benefits, i.e. in moisture-stressed areas. By extension, water conservation offers more immediate and visible benefits than soil conservation.
- Extensive support by Development Agents is required for project implementation. Optimum support levels are around 3 diploma level development agents per development centre. This has important implications for project implementation and management. The scale of the proposed projects will make major impositions on the capacity of the Regional Bureaux of Agriculture. Future projects may need to either provide support to these bureaux or to have a separate implementation management (albeit linked to the bureaux)
- Payment (food or cash for work) will most likely be required for a large part of project implementation.
- A key issue yet to be resolved is how to ‘scale up’ from the micro-watersheds to larger areas – a question to which upcoming watershed management projects should make an important contribution.
- 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. This emphasizes the importance of markets and marketable products to offset the cost of investment in conservation.
- Key constraints are institutional capacity limitations at Regional, Wereda and Kebele/community levels; free grazing of livestock; the requirement of external support (generally food-for-work) to support community mobilisation; and lack of maintenance after completion of the project.

- There are no evaluation data available on post project benefits as compared to baseline situations. Most observers agree that, within the moisture deficit and food insecure Weredas, crop and forage production benefits are positive. MERET has undertaken an economic analysis which suggests that activities are economically viable.
- Despite the previous point, there is limited evidence of community driven watershed management and self-replication is limited. Efforts have been, and remain, primarily supply-driven by government and donor agencies, and supported by payment (food or cash for work).

(xi) Integrated watershed management

Considerable experience has been built up in the Eastern Nile Basin and elsewhere in the world on the technological aspects of integrated watershed management. In particular there has been an increasing emphasis on biological measures using where possible locally available materials and away from physical structures. Biological measures include those under the headings of better “land husbandry”, “crop husbandry” and “livestock husbandry”.

At the small dam watershed level, technical interventions will need to be developed in an integrated manner that takes into account the nested nature of watersheds and the hydraulic system. Small dams need to be integrated into other components of the watershed management plan with catchment management interventions being implemented in the upper micro-catchments and moving progressively downstream. Similarly, external water-harvesting measures will need to be similarly planned and executed. In-field water harvesting measures will need to be integrated with soil fertility enhancing measures if full benefits are to be achieved.

Proposed interventions will need to range beyond soil and water conservation technologies and include inter-linked technologies related to crop, animal and tree husbandry.

A thorough understanding of the land use systems and their inter-linking components will ensure that any potential technical interventions will not adversely impact on and where possible support the other components in the system.

4.2 Observations and lessons learnt for Watershed Development in Sudan

4.2.1 Land Development

Over the past four decades extensive areas have been cleared for large-scale mechanized rainfed cropping authorised and un-authorised. The impacts on natural resources and the traditional agricultural and pastoral sectors have been outlined in para. 3.5.2 (c) of this Report and in the Sudan Country report.

The key lessons learnt from the development of the semi-mechanised farms have been the need for proper land use planning that takes into consideration the needs and aspirations of the local peoples and communities; the often complex linkages between the natural resource base and their livelihood strategies. The case of transhumant pastoralists is a particular case in point given their herding complex strategies over time and space. The elements of "proper" land use planning include a solid knowledge of the physical natural resource base, a thorough understanding of the local peoples' and communities' livelihoods (vulnerabilities, assets and strategies) and well established and transparent procedures for consultation and conflict resolution.

A lack of effective monitoring has allowed un-authorised land clearing and a lack of adherence to the environmental conditions attached to the leases. Despite a legal requirement to establish tree shelter belts little or nothing has been implemented by the lessees. A lack (until very recently) of a comprehensive social, economic and environmental impact evaluation of the semi-mechanized farm sector has meant that the very negative impacts on local peoples and communities' livelihoods, on the country's natural resource base and the local, regional and national economies have officially gone unrecorded.

4.2.2 Land tenure and Land Use

Yagoub Abdalla (2003) has detailed the complexities and some the lessons learnt relating to land tenure and land use in Northern Sudan. This can be summarised as follows. The Land Settlement and Registration Act of 1925 provides for rights and interests over land use such as cultivation, pasture, wood cutting, occupation, passage, water resources. Local customary systems of land tenure ("*dar*") operate in lands away from the Nile river. The Native Administration exercised rights of land distribution through sheikhs. Each village posses a defined area for disposition to individuals. Land not distributed is left ("ghifar") for distribution to migrants or held as a reserve. This land is used as communal grazing for the villagers and transhumant pastoralists.

Unfortunately the Unregistered Land Act of 1970 (that gave government ownership of "unregistered" land) did not provide for existing and long-established usufruct rights. The subsequent expansion of the semi-mechanized farms particularly affected pastoral rights of passage, water and grazing over large areas of "unregistered" land.

The situation was further complicated when the Native Authorities were abolished in 1972 and their land distribution powers initially transferred to the local government officers and later to the State. Neither level of government were conversant with the tradition systems of land use not did they have knowledge for planning or controlling land use. This created an administrative vacuum. The Native Authorities were reinstated in the late 1980's although as Abdel Ghaffaar Ahmed (2002) many of the traditional hierarchy did not have detailed knowledge of the traditional systems, and settled agricultural interests that had assumed influence in the intervening period were antagonistic to the needs of transhumant pastoralists..

In 1984 the Civil Transaction Act introduced the Islamic principal of "*manfaa*" (usufruct). This has been defined as the right to use land the ownership of which belongs to another. Usufruct rights include those of (i) cultivation, (ii) pasture use, and (iii) forest products. More importantly, the same Act contains general principals and guidelines for granting benefits over agricultural land. These include (i) protection of the integrity of villages, natural resources, the environment and animal assets, (ii) agriculture has priority over other benefits where it s production is beneficial to the public.

Finally, the Constructive Planning and Land Disposition Act of 1994 established two inter-level councils at the State level for planning and policy making for land use and land disposition: one for urban and one for agricultural purposes. The latter is normally composed of representatives of all natural resource institutions plus the survey and land registration departments.

The picture that emerges from the experience of the past 35 years is the need for a land use plan. Such a "Plan" would need to bring together in an equitable and transparent manner the various systems of land allocation and use rights: traditional, Islamic and State. In this way the Plan would provide a framework in which effective policies and legislation could develop.

4.2.3 Community Participation

The community driven Area development Schemes (ADFS) have been cited as an example of successful rural development (Yagoub Abdalla Mohamed, 2005). An assessment of the programme found that:

- the programme had broken new ground in fostering the principals of local participation in the development process;

- the programme had succeeded in developing grass-roots institutions;
- a change had been witnesses in the attitude and thinking of all stakeholders: beneficiaries, government officials and development workers with respect to a participatory approach;
- the programme had established close linkages between environment, proper resource use and development; and
- Traditional organizations played important roles in mobilizing villages for self-help activities.

The Mission Completion Report of the Screening and Ranking of the Six Proposed Fast Track Watershed Management Projects in Sudan (ENTRO, 2005) reported many instances of successful natural resource conservation projects that had been achieved through effective community participation. In the Upper Atbara near Shuwak a local NGO had mobilized a community through active participation in a number of environmental management activities (soil terraces, eradication of mesquite, distribution of gas stoves, etc). In the Lower Atbara the mission found a strong basis for community participation that had developed out of the ADS programme. Here it was the Women's' Voluntary Society with 33,000 members.

Near Dongola an NSO and SOS Sahel supported projects were very strong in empowering villagers and implemented successful shelter-belts to combat encroaching sands. A later evaluation indicated that to be sustainable the project should have involved the FNC from the outset as they would be responsible for support on completion of the UNSO and SOS Sahel support.

A joint SOS/FNC natural forest project in Western Sudan demonstrated that a joint community and government partnership can be an effective way of managing and conserving natural forests. The communities established Village Forest Societies who together with the local leadership actively managing the forests areas, harvesting and fire control.

4.2.4 Community-based Approach to Rinderpest Eradication

In the early 1990's cattle in the Southern Sudan were being decimated by rinderpest. Because of the security situation vaccination teams were unable to access many areas. From 1993 onwards a large scale community-based animal health worker (CAHW) system was developed. The programme was successful in eradicating rinderpest from Southern Sudan.

A subsequent evaluation (Cately et al., 2005) of the success of this programme determined a number of factors in its success:

- regardless of the relief environment an understanding of livelihoods and attention to local knowledge and skills, local institutions (e.g. the cattle camps) and local demand was developed and encouraged;

- from the onset of the programme payment for services was adopted and accepted, and the basic principle of payment for clinical services established and so ensuring the sustainability of the programme;

- the international agencies, NGOs and donors were persuaded to adopt an innovative and flexible approach to the programme allowing for experimentation and evaluation;

- community involvement was not restricted to planning and design but extended to include impact assessment and evaluation;

4.2.5 The Role of Gum Producers' Associations in the Rehabilitation of Gum Arabic in North Kordofan

During the droughts of the 1980's there severe loss of gum arabic trees in North Kordofan. Higher prices during the early to mid 1990's encouraged farmers to restock their gum gardens and they were supported by the Restocking of the Gum Belt Project (RGB). In order to assist farmers in this process the project supported the establishment of Gum producers' associations (GPA) (Nagla Mahgoub Hamadain Jepory, 2003).

The main aims of the programme were to:

- reduce the dependence of farmers-gum producers on the informal credit system (*Al shail*);
- maintain cooperation amongst the groups in the rural areas through social organization;
- the sensitize the rural population and raise awareness about their environment and the role gum producing and trees have on it;
- activate cooperative marketing of agricultural products; and
- coordinate with companies and organizations working in the fields of rural development.

The establishment of the GPA followed an intricate system of village surveys, identification of potential members, financing and marketing. Civil society organizations such as the GPA's have proven that they are viable and effective.

4.2.6 Local level Land Use and State Level Planning

The resource use conflicts in and around the Dinder National Park have been described in 8.3.4 above. The terminal report of the 200-2004 Phase stated (inter alia) that land use planning was considered a pre-requisite for local peoples' livelihood security. In fact the project had undertaken Land Use and Livelihoods Participatory Planning Workshop to ascertain participants' interpretations on current land use problems.

The Terminal Report also identified a land use situation that was characterized by sever asymmetrical power relations and referred to the delays in developing State-wide Land Use Plans. However, whilst the lack of a State-wide Land Use Plan had not prevented some effective local level land use planning the need for such a Plan might be needed where resource conflicts extended beyond the locality. This is particularly so where it is necessary to plan and implement livestock trekking routes and water supply provision across and within areas of large-scale farms. The cases of the resource conflicts between pastoralists and semi-mechanized farms on the Butana Plains and the Funj are examples of these.

4.2.7 Improving Governance of land and water Resources

The on-going IFAD supported Land and water Governance project in the gash Delta is providing an example of an innovative approach to improved land and water governance in order to promote equity, economic efficiency and sustainability. Whilst this example refers to an irrigation scheme many of the principles that underlie the approach have relevance to other aspects of watershed management. The features of the innovations are:

- There is now a clear definition of roles, responsibilities, authorities, financing mechanisms among the three key stakeholders: the farming communities, the Gash Delta Agricultural Authority (GAS) and the Ministry of irrigation and Water Resources;
- Clear entry and exit rules for leaseholds have been established. Leaseholds would be would be fixed with increasing control of flood waters. Enforcement of entry and exit rules would be devolved to the Water Use Associations (WUA's).

- Land allocation, land development and water management at the lower levels and later to the block level is devolved to the water Users associations.

- WAU's would be established around existing farmers groups.

- Collection of water fees would be devolved to the WUA's.

These options were chosen by the farmers and the farmers Union played a key role in facilitating the initial and subsequent participatory phases. The introduction of these changes was facilitated by a commitment of the MIWR at both local and federal levels.

The key principles of this innovative approach and which have application elsewhere are:

- It puts people first. It reverses the traditional approach of starting with infrastructure.

- Effective land and water governance is at the core of the approach. Without security of tenure farmers are not likely to invest in land.

- If people are to engage effectively they need the capacity to do so. This means developing the institutional structures that enable individuals to function effectively as well as a favourable social and economic environment within which they can work. Individuals will need to develop new skills and practices.

- New institutional structures are needed but local, well established informal institutions (such as the Farmers Union) can provide the foundation on which to build.

4.3 Opportunities for Watershed Management Interventions in the Abbay-Blue Nile Sub-basin

4.3.1 Strategic Considerations

It is known from lessons learned that watershed management planning can be undertaken at various levels, but **implementation has to take place at grass root level**. The conventional options for purely administrative and regulative solutions to land and water use problems appear to have reached their limits. It is becoming increasingly apparent that a more consensual approach to natural resource management is a more attractive solution for harmonizing interests of resource users, managers and regulators. Allowing and facilitating local communities to develop their own resource management systems is proving a more effective, economic and efficient approach than central or regional government control.

Sustainability of achievements requires ownership of its users and these are the local communities. A sense of ownership is created only through their **genuine participation** in planning and decision making. Decision making should not be the privilege of nominated leadership only. Motivation for genuine participation can only be based on **tangible benefits** and a sustained resource-base. Many benefits can be achieved through integrated watershed management for improvement of livelihoods.

The requirement of genuine participation sets preconditions to the organizational structure and approach of watershed management projects. Emerging lessons from watershed management projects in Ethiopia, Sudan and elsewhere include the following:

- A participatory project cannot be target-driven right from its start. In its initial phase, the project design should focus on the process of establishing participation rather than on seeking to achieve physical targets. It also requires appropriate institutional development at community-level; appropriate in the sense that institutions are created (or strengthened if already existing) to respond to the emerging needs, and may therefore differ from place to place. Needs depend on priorities in watershed management activities, functionality of existing traditional institutions and prevailing group dynamics within a community. A standardized institution for all communities (such as a village watershed committee) will be an imposed one and will undermine the feeling of project ownership in the community.

- It is important to strive for a simple organizational and coordination structure, based on existing structures and clearly stipulating linkages with higher levels (need for support.

- Institutional arrangements are required that allow for multi-disciplinary and multi-agency collaboration and across ministries, contributing to breaking through single sector approaches.

4.3.2 Technical Interventions: Levels and boundaries of analysis

It is often stated that a watershed approach to development conflicts with the administrative and political reality and that their boundaries rarely coincide. Implementation activities are initiated and carried out within an administrative jurisdiction. This argument is countered by pointing out that the physical world has no respect for administrative or political boundaries and activities in the upper part of a watershed can serious impact on people in the lower parts in another administrative or political jurisdiction. In practice the two approaches need to be complementary and an administrative/political realism should be superimposed on watershed planning to obtain administrative support and action.

Watershed management is a system-orientated concept with a holistic approach to problems and potentials. For this reason it will be necessary to identify “bundles” of interventions that complement each other where possible in a synergistic way. Given the cross-sectoral, sustainable livelihoods and poverty focus of the Watershed Management CRA with its stated objective of tackling the underlying problems of natural resource degradation in the East Nile Sub-basins, many of these “bundles” will comprise technological, institutional and policy components.
Most technological interventions are targeted at the agricultural[15]/pastoral household and rural community level although some are targeted at medium scale watersheds. The organizational, institutional and policy interventions/recommendations are targeted at the higher administrative and political levels.

In addition, strategic choices in development have to be made to achieve the following:

- balanced identification of priority areas for watershed protection, based on an agreed set of criteria;

- dual attention for both rehabilitation of degraded food-insecure areas and timely protection of strongly eroding high potential areas,

4.3.3 Technological Interventions: Basic Considerations

Considerable experience has been built up in Ethiopia, Sudan and elsewhere in the world on the technological aspects of integrated watershed management. In particular there has been an increasing emphasis on biological measures using where possible locally available materials and away from physical structures.

A thorough understanding of the land use systems and their inter-linking components will ensure that any potential technical interventions will not adversely impact on and where possible support the other components in the system.

At the micro/mini watershed level technical interventions will need to be developed in an integrated manner that takes into account the nested nature of watersheds and the hydraulic system. For example the development of small dams should be integrated into other components of the watershed management plan with catchment management interventions being implemented in the upper micro-catchments and moving progressively downstream. Similarly, external water-harvesting measures will need to be similarly planned and executed. In-field water harvesting measures will need to be integrated with soil fertility enhancing measures if full benefits are to be achieved. Proposed interventions

[15] Included here are tenant farms on government irrigation schemes, farm workers on large-scale mechanized farms and as well as smallholder farmers.

should range beyond soil and water conservation technologies and include inter-linked technologies related to crop, animal and tree husbandry.

4.3.4 Targeting Interventions

(i) Development Domains

In Ethiopia the MoARD Guidelines for Watershed Management provide details of many land management options. The suitability of these options depends on the bio-physical and socio-economic characteristics of a particular area. Given the large number of agricultural/pastoral household units and their extremely wide range of environmental, social and economic circumstances, it is necessary to stratify households and communities into some form of spatial unit. For this reason it has been necessary to sub-divide the three Sub-basins into spatial units of similar environmental, socio-economic (include market access) conditions and related problems and potentials. These form the basis of “**Development Domains"** (Pender, Place & Ehui, 1999). These have a common set of interventions, impacts, costs and benefits.

Three criteria have been used to define the Development Domain: (i) agricultural potential, (ii) accessibility to markets, and (iii) Highland or Lowland.

Agricultural potential is defined on length of growing period (LGP) and rainfall variability (CV). Thus high agricultural potential weredas have LGP >6months or 4 months with rainfall CV <100 percent. Low agricultural potential weredas have an LGP <3 months or 4 months with rainfall CV >100 percent. Medium potential weredas lie between these values.

Access to markets is also a key factor in targeting interventions. Areas with good access to markets have advantages in terms of producing high value perishable crops, livestock intensification and greater possibilities for off-farm income. Conversely, areas remote from markets will need to focus more on higher value but easily transportable commodities such as small livestock and apiculture. Good market accessibility is defined as being within 4 hours vehicle travel time to a town of >50,000. Highland and Lowland are defined as >1500 masl or <1,500 masl respectively. Pender at al (1999) used population density as their third criterion. However, in Ethiopia the Highland/Lowland distinct covers not only population density but a range of socio-cultural and environmental factors.

Within each Development Domain are a number of Farming Systems that have been described in the Sub-basin Socio-economic descriptions. The distribution of In terms of targeting specific land management technologies the available evidence suggests that there is a clear distinction between frequently moisture stressed and areas that are infrequently stressed. The pattern of high risk of moisture stress is similar to that of the Development Domains but includes a southward extension just to the west of the eastern rim of the Abay Basin. This area does not receive the short (or *belg*) rains experienced by the area just to the east and is not picked up in the wereda level analysis.

Highland domains with high agricultural potential generally occur to the west whilst those with lower potential occur in the drier east. Lowland Domains have medium agricultural potential given their higher rainfall.

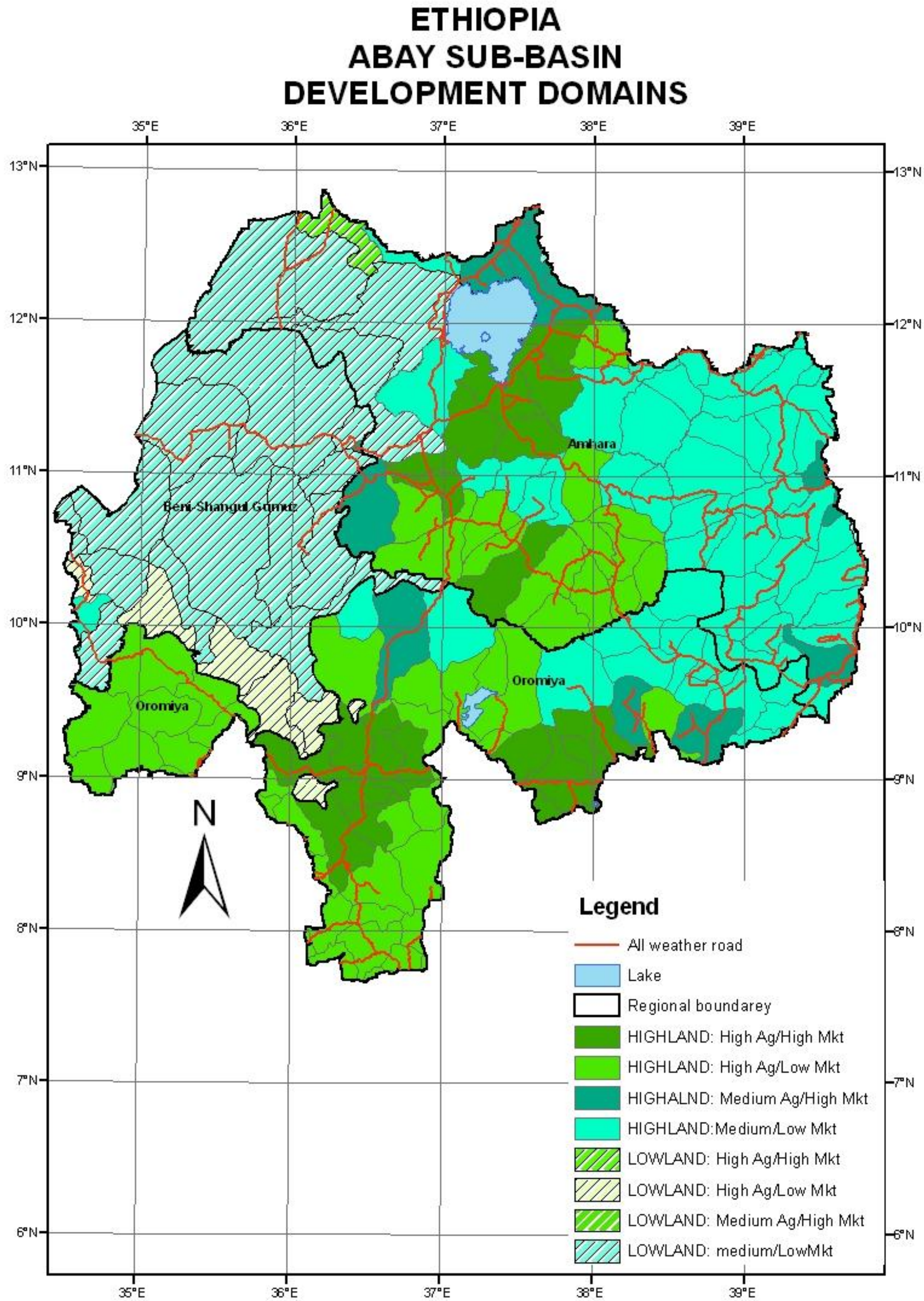
A matrix showing the occurrence of the Farming Systems within each Domain is shown in table 18.

Table 18. Ethiopia – Abay Sub-basin: Occurrence of Farming Systems within Development Domains.

FARMING SYSTEM	ACCESSIBILITY	HIGHLAND			LOWLAND		
		High Potential	Medium Potential	Low Potential	High Potential	Medium Potential	Low Potential
T1	High Mkt Access						
T1	Poor Mkt Access					**X**	
T2	High Mkt Access						
T2	Poor Mkt Access				**X**	**X**	
T3	High Mkt Access						
T3	Poor Mkt Access	**X**	**X**				
T4	High Mkt Access		**X**				
T4	Poor Mkt Access	**X**	**X**				
T5	High Mkt Access	**X**					
T5	Poor Mkt Access	**X**					
T6	High Mkt Access	**X**					
T6	Poor Mkt Access	**X**					
T7	High Mkt Access	**X**					
T7	Poor Mkt Access	**X**					

FARMING SYSTEMS – ABAY SUB-BASIN:
T1 (LOWLAND) = SHIFTING SORGHUM+MAIZE (INCLUDES SHIFTING SORGHUM)
T2 (LOWLAND) = FINGER MILLET+SORGHUM+MAIZE
T3 (HIGHLAND) = WHEAT+BARLEY
T4 (HIGHLAND) = TEFF+WHEAT/TEFF+WHEAT+MAIZE
T5 (HIGHLAND) = TEFF+MAIZE+SORGHUM
T6 (HIGHLAND) = MAIZE+TEFF (COFFEE/WHEAT)
T7 (HIGHLAND) = ENSET + MAIZE/WHEAT

Only the Highland wheat+barley and the Lowland Finger Miller+soirghum+maize farming systems occur in two Domains.

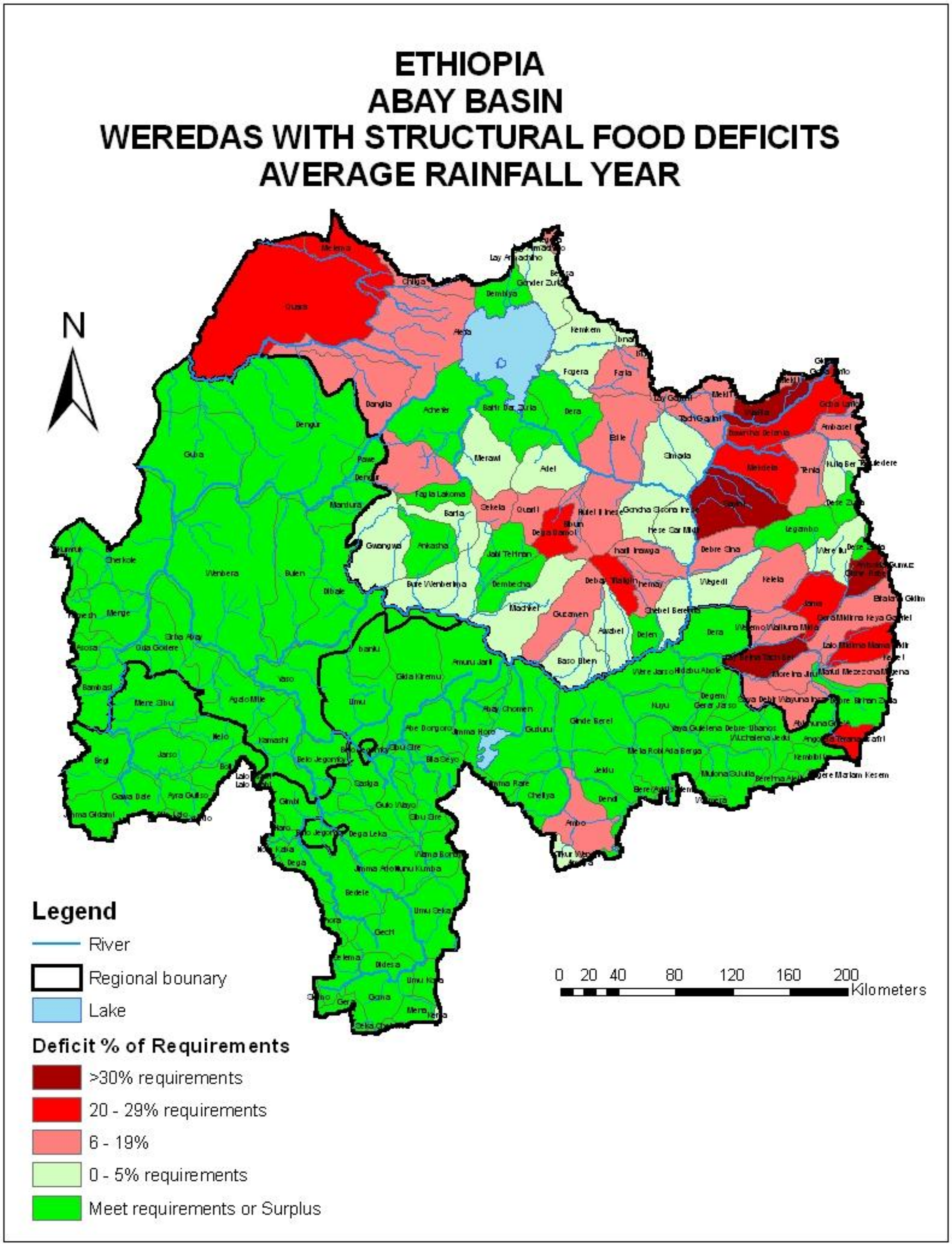


Map 23. Ethiopia – Abay Sub-basin: Development Domains.

(ii) Question of Priorities

Whilst a distinction is made between "High", "Medium" and "Low" Agricultural potential areas this is done to more effectively target technical and other strategic interventions and in no way suggests any priority for implementation. Opinion appears divided on whether resources should be targeted only at food deficit weredas (as defined by the MoARD/BoARD's). An analysis by WBISPP indicates that some "Medium to High Agricultural Potential" weredas may be experiencing structural food deficits even in years with average rainfall as Map 24 indicates for the Abay Basin.

A strong case can be made for conserving areas with high and medium agricultural potential as well as those areas with severe land degradation. The former currently supply a substantial proportion of the food surplus that could supply food deficit areas either through normal marketing channels or through government assisted food for work programmes. Clearly, farmers' decisions to invest in sustainable land management in the high-medium potential areas are different from those in the low potential areas and thus different forms of government support strategies may be required. It is thus not a question of which areas to prioritize. It is a question of where to target specific interventions that are appropriate to specific areas.



Map 24. Ethiopia – Abay River Basin: Weredas with Structural Food Deficit in Years with Average Rainfall.

Source: WBISPP (2003) Strategic Woody Biomass Plans for Amhara, Oromiya and BeneShangul Gumuz Regional States.

4.3.5 Technological Interventions by Development Domain

The following sets out a number of basic interventions by Development Domain. Many of the interventions require that they be integrated with other interventions. Some interventions are applicable to more than one Development Domain.

(i) HIGHLAND: High to Medium Agricultural Potential (Very low to low moisture stress risk) with Good market Access: - Located mainly in the Abay Basin.

(a) Overall Strategies:

These areas provide the greatest potential for agricultural development and are already some of the food surplus producing areas. A wide range of marketable agricultural production strategies are available. However, these areas are experiencing soil nutrient mining and declining soil fertility levels. With high population densities farm sizes are small. A key strategy is to intensify crop and livestock production taking advantages of synergies between crop and livestock production.

(b) On-farm Interventions:

External inputs: The use of fertilizer and improved seed is likely to be profitable in these areas given the declining nutrient status. Current fertilizer application rates and fertilized area are (except for Illubabor) already some of the highest in the two basins (but still only 20 – 45 kgs/ha). This intervention requires credit availability, nutrient responsive varieties and complementary crop and soil husbandry measures.

Improved Crop Husbandry: These include crop rotation, intercropping and strip cropping. Food self sufficiency is required as food insecurity pushes farmers to cereal mono-cropping. When integrated with external inputs increases water and nutrient availability.

Improved Soil Husbandry: The use of manure and compost increases soil organic matter and nutrients and increases water holding capacity. This intervention requires sufficient quantities of manure and residues, and labour. These interventions need to be integrated with improved animal husbandry interventions and the use of inorganic fertilizer.

Improved tillage: Contour ploughing assists in reducing runoff and soil movement.

Grass strips: Most effective on slopes less than 15 percent but can be used on steeper slopes. Best integrated with on-farm forage interventions and limited livestock access. Can also be integrated with on-farm multi-purpose tree production.

Fanyaa Juu: Graded in high rainfall areas and level elsewhere. Can be integrated with grass strips and trees to increase stability. However, they have high construction and maintenance labour requirement.

On-farm Forage Development: (i) Backyard improved forage: forage grasses (e.g. including but not limited to *Pennisitum purpureum*, *Panicum maximum*), tree legumes (*Leucaena leucocephala*) and pigeon pea. Undersowing into maize or sorghum with appropriate forage legumes. (ii) Improved hay production in drainage lines and bottomlands. (iii) Improved storage and treatment of crop residues.

On-farm Tree development: In many areas of Amhara Region the market for Eucalyptus coming saturated and there is a need to move away from Eucalyptus spp. to multi-purpose trees (for forage, small poles and fuelwood). This intervention could be integrated with the on-farm forage and the grass strips interventions.

(c) Interventions on Communal Lands

Cut-off Drains: A pre-requisite for in-farm soil conservation measures is a cut-off drain above cultivated areas. Even by themselves they can reduce in-field run-off and soil movement. However, it is important that water collected in the drain is safely disposed of into waterways.

Road and track drains: run-off from roads needs to be controlled with small check dams and safe outlets to streams.

Gully Stabilization: This requires the integrated stabilization of both the gully and its catchment area. This will require a combination of livestock exclusion (in both catchment area and gully), and vegetative and structural measures (check dams, etc) within the gully. This intervention can be integrated with a communal forage development programme.

Communal Forage Development: To be effective and sustainable this is best undertaken at the sub-kebelle (tabia) level. This intervention usually requires some form of area closure with cut-and-carry, or controlled grazing or controlled hay production and harvesting. The site of the intervention can vary from steep and degraded hillsides, poorly drained valley bottoms, and stream edge buffers. A key object is to reduce livestock movement. The process of natural re-generation can be supplemented with over-sowing of herbaceous (*Pennisitum* *purpureum*, *Panicum maximum*) or tree legumes (*Leucaena leucocephala*) and pigeon pea but this increases costs. The intervention can also be integrated with communal tree production.

Communal Tree Production: This is best integrated with communal forage development in area closures. As with communal forage development clear management and harvesting plans need to be established at the outset.

Small-scale Supplementary/full Irrigation: For high value marketable crops (vegetables, green maize). Given the good market access high value perishable crops can be grown. Alternatives are supplementary irrigation for larger areas when supplies are high and prices lower, and full irrigation of smaller areas when supplies are low and prices are higher.

(d) Other Strategies

Non-farm labour: Proximity to urban centres provides potential opportunities for non-farm labour, sales of fuelwood and handicrafts. To be sustainable this strategy requires skills training in such activities as brick-laying, carpentry, metal work, handicrafts, etc.

(ii) HIGHLAND: High to Medium Agricultural Potential (Very low to low moisture stress risk) with Poor Market Access: Located mainly in the Abay Basin.

(a) Overall Strategies:

The opportunities for marketable agricultural development in these areas are much more limited. Use of external inputs may be privately unprofitable (to farmers) but may be economically cheaper than importing food into the area (Pender at al., 1999). Marketable agricultural products will be limited to high value, low volume and non-perishable products. These could include crops such as onions and peppers, small livestock such as sheep and goats, and honey production. In parts of Ethiopia improved goat production by women has proved very successful, particularly for women-headed households. The strategy for own-consumption agricultural production should be to ensure food security. The long-term Government strategy is to improve accessibility to markets through feeder road and farm to market road construction.

(b) On-farm Interventions

Improved Soil Husbandry: The use of manure and compost increases soil organic matter and nutrients and increases water holding capacity. This intervention requires sufficient quantities of manure and residues, and labour. These interventions need to integrate with improved animal husbandry interventions.

Improved tillage: Contour ploughing assists in reducing runoff and soil movement.

Grass strips: Most effective on slopes less than 15 percent but can be used on steeper slopes. Best integrated with on-farm forage interventions and limited livestock access. Can also be integrated with on-farm multi-purpose tree production.

Fanyaa Juu: Graded in high rainfall areas and level elsewhere. Can be integrated with grass strips and trees to increase stability. However, they have high construction and maintenance labour requirement. Given the lack of market opportunities and thus high private costs involved, a case can be made for some form of subsidy given the potential reduction in externalities.

On-farm Forage Development: Backyard improved forage: forage grasses (e.g. including but not limited to *Pennisitum purpureum*, *Panicum maximum*), tree legumes (*Leucaena leucocephala*) and pigeon pea. The focus of the intervention is on improving small ruminant productivity.

On-farm Tree development: Given the lack of markets on-farm tree production will be for own consumption only.

(c) Interventions on Communal Lands

Cut-off Drains: A pre-requisite for in-farm soil conservation measures is a cut-off drain above cultivated areas. Even by themselves they can reduce in-field run-off and soil movement.

Road and track drains: run-off from roads needs to be controlled with small check dams and safe outlets to streams.

Gully Stabilization: This requires the integrated stabilization of both the gully and its catchment area. This will require a combination of livestock exclusion (in both catchment area and gully), and vegetative and structural measures (check dams, etc) within the gully. This intervention can be integrated with a communal forage development programme.

Communal Forage Development: To be effective and sustainable this best undertaken at the sub-kebelle (tabia) level. This intervention usually requires some form of area closure with cut-and-carry, or controlled grazing or controlled hay production and harvesting. The site of the intervention can vary from steep and degraded hillsides, poorly drained valley bottoms, and stream edge buffers. A key object is to reduce livestock movement. The process of natural re-generation can be supplemented with over-sowing of herbaceous (*Pennisitum purpureum*, *Panicum maximum*) or tree legumes (*Leucaena leucocephala*) and pigeon pea but this increases costs. The intervention can also be integrated with communal tree production.

Small-scale Supplementary Irrigation: For high value non-perishable marketable crops (onions, garlic, peppers) using supplementary irrigation for maximum area (given good storability season price fluctuations are small).

(d) Other Strategies

Honey production: In densely populated areas where land is short honey production is not affected by land or cash constraints. Improved hive can substantially increase production.

(iii) HIGHLAND: Low Agricultural Potential (moderate to high moisture stress risk) with Good Market Access: Located mainly in the Tekeze Basin.

(a) Overall Strategies:

A key strategy is the conservation of soil moisture to reduce risk of crop failure as well as to reduce the risk of using inorganic fertilizers. Soil and water conservation structures should be integrated with other improved crop and soil husbandry measures. Relatively higher urban market prices for cereals in these areas are likely to make fertilizer use profitable in years of average to good rainfall. Some form of crop insurance may be feasible in these areas. Urban centres in close proximity may provide opportunities for non-farm employment.

(b) On-farm Interventions

Improved Soil Husbandry: The use of manure and compost increases soil organic matter and nutrients and increases water holding capacity. This intervention requires sufficient quantities of manure and residues, and labour and thus need to be integrated with improved animal husbandry interventions.

Improved tillage: Contour ploughing assists in reducing runoff and soil movement.

Grass strips: Given the low and variable rainfall grass strips are not likely to be successful on their own, but might be used to supplement physical structures.

Stone terraces: These are more efficient in retain soil moisture that bunds or grass strips. In many parts of the Development Domain surface stones are readily available. The high rate of adoption indicates that many farmers appreciate their use for soil and soil moisture conservation.

On-farm Forage Development: tree legumes (*Gliricidia sepium*) which could be used to supplement low quality native grasses, grasses (e.g. including but not limited to *Pennisitum purpureum*, *Cenchrus ciliaris*) and pigeon pea for supplementary feeding of calves and lactating cows.

On-farm Tree development: In Tigray (and increasingly in Amhara) Region land on degraded hillsides is being allocated to individual households for tree production (tree planting on cropland is prohibited). Cultivation of tree legumes (*Leucaena leucocephala*, *Sesbania sesban*) on these individual hillside plots (as dual purpose forage and fuelwood trees).and of *Stylosanthes spp*. (Stylo). Stylos are very hardy and resistant.

(c) Interventions on Communal Lands

Cut-off Drains: A pre-requisite for in-farm soil conservation measures is a cut-off drain above cultivated areas. Even by themselves they can reduce in-field run-off and soil movement.

Road and track drains: run-off from roads needs to be controlled with small check dams and safe outlets to streams.

Gully Stabilization: This requires the integrated stabilization of both the gully and its catchment area. This will require a combination of livestock exclusion (in both catchment area and gully), and vegetative and structural measures (check dams, etc) within the gully. However, given to low and variable rainfall, vegetative measures will require longer to establish than in high rainfall areas. Initially, there may be a need for more emphasis on physical structures to allow vegetative measures time to establish.

Communal Forage Development: To be effective and sustainable this best undertaken at the sub-kebelle (tabia) level. This intervention usually requires some form of area closure with cut-and-carry, or controlled grazing or controlled hay production and harvesting. The site of the intervention can vary from steep and degraded hillsides, poorly drained valley bottoms, and stream edge buffers. A key object is to reduce livestock movement. The time taken for vegetation to recover will be longer than in high rainfall areas and harvesting of grass and trees will need to be delayed. It will be important that individual measures for improved fodder production are in place before closure.

Small-scale Supplementary/full Irrigation: For high value marketable crops (vegetables, green maize). Given the good market access high value perishable crops can be grown. Alternatives are supplementary irrigation for larger areas when supplies are high and prices lower or full irrigation of smaller areas when supplies are low and prices are higher.

Water-harvesting: This refers to the collection of water into small ponds or micro-dams for small-scale irrigation, human and/or livestock water supplies.

(iv) HIGHLAND: Low Agricultural Potential (Moderate to high moisture stress risk) with Poor Market Access: Located mainly in the Tekezi Basin.

(a) Overall Strategies:

A key strategy is the conservation of soil moisture to reduce risk of crop failure. Soil and water conservation structures should be integrated with other improved crop and soil husbandry measures. The opportunities for agricultural development for marketable produce in these areas are much more limited. The strategy for own-consumption agricultural production should be to ensure food security. Marketable agricultural products will be limited to high value, low volume and non-perishable products. These could include crops such as onions and peppers, small livestock such as sheep and goats, and honey production. In parts of Ethiopia improved goat production by women has proved very successful, particularly for women-headed households. The long-term Government strategy is to improve accessibility to markets through feeder road and farm to market road construction.

Improved Soil Husbandry: The use of manure and compost requires sufficient quantities of manure, residues and labour. Given the poor accessibility to markets, the strategy for improved livestock production is to focus on small ruminants. Quantities of manure are likely to be limited and reserved for marketable products such as onions and peppers grown on backyard gardens or in-fields.

Improved tillage: Contour ploughing assists in reducing runoff and soil movement and is already widely practiced.

Grass strips: Given the low and variable rainfall grass strips are not likely to be successful on their own, but might be used to supplement physical structures.

Stone terraces: These are more efficient in retain soil moisture that bunds or grass strips. In many parts of the Development Domain surface stones are readily available. The high rate of adoption indicates that many farmers appreciate their use for soil and soil moisture conservation.
On-farm Forage Development: tree legumes (*Gliricidia sepium*) which could be used to supplement low quality native grasses, grasses (e.g. including but not limited to *Pennisitum purpureum*, *Cenchrus ciliaris*) and pigeon pea for supplementary feeding of oxen and small ruminants for sale.

On-farm Tree development: In Tigray (and increasingly in Amhara) Region land on degraded hillsides is being allocated to individual households for tree production (tree planting on cropland is prohibited). As the pole markets are inaccessible the focus should be on cultivation of tree legumes (*Leucaena leucocephala*, *Sesbania sesban*) on these individual hillside plots (as dual purpose forage and fuelwood trees).and of *Stylosanthes spp*. (Stylo). Stylos are very hardy and resistant.

(c) Interventions on Communal Lands

Cut-off Drains: A pre-requisite for in-farm soil conservation measures is a cut-off drain above cultivated areas.

Road and track drains: run-off from roads needs to be controlled with small check dams and safe outlets to streams.

Gully Stabilization: This requires the integrated stabilization of both the gully and its catchment area. This will require a combination of livestock exclusion (in both catchment area and gully), and vegetative and structural measures (check dams, etc) within the gully. This intervention can be integrated with a communal forage development programme.

Communal Forage Development: To be effective and sustainable this best undertaken at the sub-kebelle (tabia) level. This intervention usually requires some form of area closure with cut-and-carry, or controlled grazing or controlled hay production and harvesting. The site of the intervention can vary from steep and degraded hillsides, poorly drained valley bottoms, and stream edge buffers. A key object is to reduce livestock movement. The process of natural re-generation can be supplemented with over-sowing of herbaceous (*Pennisitum purpureum*, *Panicum maximum*) or tree legumes (*Leucaena leucocephala*) and pigeon pea but this increases costs. The intervention can also be integrated with communal multi-purpose tree production.

Small-scale Supplementary Irrigation: For high value non-perishable marketable crops (onions, garlic, peppers) using supplementary irrigation for maximum area (given good storability season price fluctuations are small).

Water-harvesting: This refers to the collection of water into small ponds or micro-dams for small-scale irrigation, human and/or livestock water supplies.

(d) Other Interventions

Honey production: In densely populated areas where land is short honey production is not affected by land or cash constraints. Improved hive can substantially increase production.

(v) LOWLAND: Medium to High Agricultural Potential (Moderate to low moisture stress risk) with Poor Market Access: Located mainly in the Abay Basin and small area in the south-western part of Tekezi Basin

(a) Overall Strategies:

Soil fertility rather than soil moisture is the key constraint to crop production. South of the Dinder River tsetse fly infestation and trypanosomiasis is the key constraint to livestock production. Malaria is the key constraint to human settlement across the whole area.

Three overall development strategies are available in these areas. (i) Intensification of existing bush-fallowing cultivation; (ii) development of medium to large scale commercial agriculture, and (iii) large-scale irrigation.

(i) Intensification of Existing Extensive Cultivation

Currently most cultivation in this domain follows a bush-fallowing system. Locally cultivation is becoming more sedentary where fallow periods are becoming too short to enable vegetation to recover. Only in these areas are intensification interventions likely to be adopted.

Improved Soil Husbandry: In the absence of bush fallowing the range of appropriate improved soil husbandry interventions are limited. Use of chemical fertilizer would not be economic given the poor accessibility, high costs of transport and lack of markets. Weed composting is a traditional method of improved soil husbandry practiced in south and south-western Ethiopia and would be appropriate in this Development Domains Intensification is likely to take place of soils of highest fertility: alluvial and colluvial soils.

Small ruminants: As areas of vegetation are permanently cleared around villages and the tsetse challenge is reduced keeping of small ruminants is possible and provide an additional livelihood strategy.

(ii) Development of Large and medium Scale Semi-mechanized Agriculture

Since 1991 the State Farm rainfed sector has almost ceased to operate and one large State Farm in the Lower Didessa Valley has been totally abandoned following soil fertility decline. There has been a slow growth of the private large-scale rainfed cropping sector in the western Lowlands in the Beles, Dinder and Tekezi basins since the Investment Proclamation in 1995. Land is held on long-term leases from the Regional State Government. The main crops have been sesame and cotton. Most of these farms are located in areas close to the large mechanized farms in Sudan just across the border. In Sudan and in the lower Didessa Valley, the absence of 25 percent fallowing or soil fertility maintenance, soil fertility decline and falling yields have been experienced.

(iii) Large-scale Irrigation

There is one major irrigation scheme currently under development in the upper Beles Valley with plans to irrigate 5,000 ha. Others are planned in the Lake Tana Basin, the Anger and Didessa valleys south of the Abay River, as indicated in table 20.

(v) LOWLAND: Low Agricultural Potential (Moderate to low moisture stress risk) with Poor Market Access: Located in the Tekezi Basin.

(a) Overall Strategies:

Soil fertility and soil moisture are both constraint to crop production. Tsetse fly is not present in this Development Domain. Malaria is the key constraint to human settlement across the whole area.

Three overall development strategies are available in these areas. (i) Intensification of existing bush-fallowing cultivation; (ii) development of medium to large scale commercial agriculture, and (iii) large-scale irrigation.

(i) Intensification of Existing Extensive Cultivation

Currently most cultivation in this domain follows a bush-fallowing system. Currently population densities are so low that there is no immediate danger of fallow periods are becoming too short to enable vegetation to recover. However this may change if there is substantial development for resettlement, large scale rainfed or irrigated farming.

Small ruminants: As there is no tsetse challenge keeping of small ruminants is possible and can provide an additional livelihood strategy.

(ii) Development of Large and medium Scale Semi-mechanized Agriculture

The same caveats apply regarding soil fertility as in the Development Domain to the south apply here also. In addition, there is an added constraint of a much higher risk of soil moisture deficits occurring in this Development Domain.

(iii) Large-scale Irrigation

There is one major irrigation scheme being considered in the Humera area with plans to irrigate 43,000 ha.

4.3.6 Potential Impacts in Reducing Soil Erosion and Sedimentation

(i) Reducing Soil Erosion on Cropland and Non-cropland in the Ethiopian Highlands

There is currently a vigorous programme of watershed management interventions being undertaken in the Ethiopian Highlands of the Abbay Sub-basin. There has been a substantial investment in these structures by farmers in the moisture-stressed areas of the eastern part of the Sub-basin. This is partly because of the significant and visible benefits to physical soil and water conservation structures partly to the reduction of soil erosion but mainly to increased soil moisture and thus soil nutrient availability. The structures are mainly soil bunds.

In the higher rainfall areas of the west the up-take of soil conservation structures has been much slower. It is now recognized that vegetative measures such as grass strips are more likely to be adopted in these areas. These have been shown to almost as effective as physical structures in Anjeni, Gojam (Herweg & E. Ludi, 1999). After land taken up by the structures is taken into account crop yield increases of 14 percent were recorded on 12 percent slopes and no increase on 28 percent slopes. It has been estimated that grass strips trap between 57 (on 12% slopes) and 72 percent (on 28% slopes) of soil moved, with the remaining 28 to 43 percent passing through. With soil bunds and after land taken up by the structures is taken into account crop yield increases of 7 percent were recorded. It has been estimated that soil bunds trap 64 percent of soil moved. To estimate the impacts of both grass strips and soil bunds an average trapping efficiency of 65 percent was used.

It is estimated (from the map of bund adoption rates in Pender and Mahmud, 2005) that approximate 20 percent or 1,08 million ha of land requiring soil conservation measures (i.e. land over 5 percent slope) or some 5.43 million ha has already been covered with soil or fanya juu bunds. No information is available on the area covered by grass strips. At the current rates of implementation of soil bunds and assuming that a similar rate can be achieved for grass strips then some 2.05 million ha can be treated with bunds or grass strips over the next 10 years bringing the total treated area to some 60 percent of the total land requiring such treatment.

No information is available on the amount of gullies on crop or communal lands that have been treated. It was assumed that including reclamation work that had been in the past and adding this to the amount that could be achieved in the next 10 years some 60 percent of gullies on cropland would have been treated at the end of 10 years. From research undertaken in Tigray sediment retention after reclamation is 85 percent.

With these assumptions soil movement on cropland could be reduced from 101.8 million to 50.1 million tons. Assuming sediment delivery ratio of 39 percent then annual sediment to Abbay river system within Ethiopia could be reduced by 25.7 million tons (down from 42.8 million t to 17.0 million t/yr).

(ii) Increasing Vegetative Cover and Reducing Soil Erosion of Non-cropland in the Ethiopian Highlands

It is estimated that some 201.0 million tons of soil per annum are moved from non-cropland. An estimated 20 percent of additional soil is removed by gully erosion. "Non-cropland" is essentially communal lands that are used for grazing and fuelwood collection, and include the under-utilized degraded lands. These lands are generally much steeper with shallow soils that are unsuitable for crop production. They comprise some 70 percent of the total area.

There has been a strong programme of reclamation of these degraded communal lands in the Abbay Sub-basin within the past decade. These areas are closed to livestock and managed for cut-and-carry forage, community and individual woodlots. However, there is no information for the Abbay Sub-basin for how much land has been already been closed. An assumption of 10 percent is used (less than the 15 percent reported for the Tekeze Sub-basin).

Surveys have demonstrated that soil retention by these areas is almost 100 percent for catchment areas two to three orders larger than the closed area. As well as soil retention infiltration to groundwater is increased. Soil fertility increases leading to increased biomass production. Vegetative reclamation of gullies (with some physical structures) has been shown to be effective in reducing sediment delivery rates by over 90 percent.

Thus, the opportunities for significant reducing sediment delivery to the river system are very substantial. Assuming that 40 percent of the non-cropland could be brought under closure and sustainable forage or woodland management over a ten year period with a soil retention rate of 85 percent, this could reduce sediment delivery to the river system by approximately 28.22 million t/yr (from 90.45 million t/yr to 50.17 million t/yr). Gulley reclamation could add a further reduction of 2.05 million tons per annum.

(iii) Opportunities for Sediment Retention by the Micro Dam Programme

(a) Potential Sediment Reduction

Although the primary purpose of the dams is small scale irrigation, human and livestock water supplies a secondary impact is retention of sediment derived from crop and non-cropland soil (sheet, gully and river bank) erosion.

Current sediment yield rates for small dams (0.5 – 3 million m^3) average about 700 t/km^2 in the Abbay Catchment. At these yield rates the economic life is extremely short and currently the programme is on hold until the institutional problems of integrating the watershed management programme with the small dam programme can be resolved.

Assuming that these issues can be resolved, sediment yield rates could be reduced to at least the current minimum of 250 t/km2. With an average catchment of 10 km^2, a sediment retention rate of 80 percent[16] and assuming a ten year programme of 250 small dams within the Abbay Catchment, there is the potential to reduce sediment load in the Abbay system by some 0.5 million tons /yr (2,000t/yr/ dam).

(b) Other Costs and Benefits

However, there are other costs and benefits. There are at once (i) one in-country cost (provision of dead storage), (ii) other potential in-country costs (increased incidence of malaria and schistosomiasis) (iii) some in-country benefits (increased crop and livestock production, improved health from better water supplies), and (iv) some transboundary costs (reduced water yield through irrigated crop evapo-transpiration and thus reduced water for downstream users in Sudan and Egypt).

The health impacts of small dam construction in terms of bilharzias and malaria in northern Ethiopia have been quantified. The surveys compared disease incidence and health expenditures in villages within 3 kms distant and villages 8 kms or more from small dams (Ersado et al., 2001, Ersado, 2005). The study examined (*inter alia*) the impact of small dams and irrigation on production and consumption gains against health costs.

The study reveals that whilst agricultural yield and farm profits have increased as a result of the dams, the ensuing sickness from water vector diseases have led

[16] Only one of the 54 dams examined in the Tigray study had spilled since construction.

to significant declines in labour productivity and subsequently depressed the expected returns from the water investment. The health related problems also led to a reduction in off-farm income activities further adversely affecting households' livelihoods. To prevent such health hazards there would have to be a permanent malaria control programme within 5 kms of any dam. This would then transfer the current private costs being borne the local farm families to a public cost borne by the state.

The Feasibility Study for the TK5 Medium Hydro-power Dam on the Tekeze estimated the reduction of water yield from the construction of 20 micro dams (average 125,000m^3 capacity) as between 80 to 200 million m^3 per year (or between 4.0 and 10.0 million m^3 per dam. However, this figure appears very high. Waterbury and Whittington (2000) estimate an irrigation usage of 1.0 million m^3 per dam (irrigating 200 ha). This does not take into account seepage and evaporation losses from the dam itself.

Assuming a 50 ha dam with an annual evaporation rate of 1.5 meters would mean the dam would lose 75,000m^3. Seepage would return water to the river system via groundwater and thus is not lost. Some 250 dams would reduce water yield (using the lower estimate) by approximately 269 million m^3/yr or 0.53 percent of the Abbay flow at the border. In practice actual irrigated areas appear to about 100 ha or half the assumption used above.

(iv) Potential Sediment Trapping by the Proposed Karadobi Multi-purpose Dam.

There are a number of other potential large dams in the Eastern Nile basin that are now being seriously considered that will also have substantial impacts on suspended sediment loads downstream. The largest of these is the Karadobi Multi-purpose Dam on the Abbay within in Ethiopia. This is a high concrete dam with a planned volume of 26,480 million m^3. The Pre-feasibility Study (Norplan-Norconsult-Laymeyer, 2006) estimates the trapping efficiency of 86.5 percent over a 50 years period and trapping between 60.5 and 99.4 million tons a year. Thus the suspended sediment of the Abbay/Blue Nile would be reduced to between 9.4 and 15.5 million tons per year.

(v) Opportunities for Arresting Kerib Land formation in Sudan and its Restoration

Reclamation of kerib land would be pointless without taking steps to arrest its extension and encroachment into the adjoining croplands. The only way to achieve this is to take a buffer zone about 200 meters wide from the kerib edge out of cultivation and to plant deep rooting trees. It is essential that all livestock be excluded from the buffer as well as the kerib land. This would prevent the annual loss of 1,200 ha of smallholder farmland currently affecting communities whose livelihoods have already been constrained by the alienation of land for the Semi Mechanized Farms.

The short term strategy for reclamation would be livestock exclusion and land preparation in micro-catchments for multi-purpose tree production. Sown grasses could be used for cut and carry of fodder. There may be longer term opportunities to use some of the reclaimed land for crop (sorghum and sesame) production.

4.3.7 Opportunities to Reduce Soil Degradation and Loss of Agricultural productivity in the Abbay-Blue Nile Sub-basin

(i) Soil Nutrient Losses in the Highlands of the Abbay-Blue Nile Sub-basin.

(a) Burning Dung and Crop Residues

In a number of ways the investments required to reduce soil nutrient losses due to the burning of dung and crop residues is simpler and has a more immediate impact than reducing soil loss through erosion. On the supply side it requires a substitution by wood for dung and residues. As nearly 90 percent of rural domestic energy is for cooking, it is unlikely in the fore-seeable future to see a significant switch to kerosene, LPG or electricity for cooking, unless there is a large element of subsidy both for the capital investment and subsequent fuel purchase. On the demand side it requires a switch to more efficient stoves.

In the Abbay basin, particularly in the west where there has been a very substantial increase in on-farm tree planting, the process of fuel substitution is already underway (WBISPP/MARD, 2001). Since 1984 per capita dung use as fuel has been declining at an annual rate of nearly 3 percent.

The opportunities for reduced fuel consumption through improved stoves are substantial given the current energy inefficient rural stoves within the Abbay Sub-basin. Using current adoption rates of the mirte stove (for injera baking) and the lakech charcoal stove over a 10 year period, it was estimated that the Amhara Region would be saving 488,160 tons of wood per year (WBISPP/MARD, 2005). This is equivalent to 48,816 ha of Eucalyptus Plantation producing 10 tons/yr of woody biomass.

(b) Grain removal

The reduction in nutrient losses through grain removal can only be achieved by the application of organic (manure, compost) or chemical fertilizer. Organic fertilizers are being used but generally only of fields close to the homestead. The use of chemical fertilizer is conditioned by a farmer's land, labour and financial assets as well as access to seasonal credit. Farmers' perception of the risk to low and variable rainfall is high in the climatic environment of the eastern part of the Abbay Sub-basin and is a constraint to investment in chemical fertilizer for rainfed cropping, but less so in the high rainfall areas of the western part of the Sub-basin. The current losses of N would require 45,000 tons of Urea.

(c) Soil Erosion

The retention of soil nutrients potentially lost through soil erosion by stone bunds is not quite the same as that for soil retention. This is because soil organic matter and nutrients are preferentially removed by a factor of about 1.2 (the nutrient enrichment ratio). Thus, nutrient lost to cropland is the 35 percent of soil passing through the stone bunds multiplied by the factor of 1.2. Thus, some 6,749 tons of the present loss of 16,873 tons of N could be retained behind the stone bunds.

(ii) Opportunities to Arrest the Declining Rainfed Crop and Livestock Productivity in the Lowlands of Abbay-Blue Nile Sub-basin.

(a) Semi Mechanized farms

There are three major problems with respect to low and declining crop productivity:

- low soil fertility (leading to weed infestation, particularly striga);
- hard plough pan restricting deep root penetration (leading to low plant water uptake); and
- plant-soil moisture stress in low rainfall years.

However, there are a number of opportunities to arrest declining yields and increase productivity of rainfed sorghum.

Two approaches are possible with respect to low soil fertility: (i) use of chemical fertilizer, and (ii) periodic fallowing. In the frequent low rainfall years the use of chemical fertilizer particularly on the surface can have a detrimental impact on crop yield by causing surface root development and drying out of soil. Deep placement of fertilizer has been found to increase root develop, water uptake and grain yield, particularly of non drought-resistant varieties. Periodic fallowing uses up land but is effective in restoring soil fertility and suppressing weeds.

Research at the Gezira Research Station (Salih, 1997) demonstrated that sub-oiling (SS) produced a 25 and 13 percent increase in yield of irrigated cotton over disc harrowing and three bottom disc ploughing. This indicates that positive impacts from sub-soiling can be expected on rainfed sorghum. The Gezira Research Station also found that planting sorghum in the furrow or within tied ridges can increase sorghum yields by 60 to 90 percent of traditional flat planting on clay soils in a low rainfall year. In a wet year there was no impact of crop yield (Salih, op. cite).

Drought-resistant varieties of sorghum (e.g. *Gadambalia*) are now available are would be suitable for the rainfed cropping in the Blue Nile Sub-basin.

There are likely to be positive synergistic effects of using deep-placed fertilizer, sub-soiling, in-furrow planting and use of drought resistant varieties. Carried out on a large scale yields could be expected to increase from the current 211 kgs/feddan (500 kgs/ha) to 336 kgs/feddan (800 kgs/ha).

(b) Traditional Smallholder farms, Agro-pastoralists and Pastoralists

A key problem of the traditional rainfed smallholder farms is the declining period of fallow caused by restrictions on lateral expansion by SMF's to the west and State Forests to the east. The problems are similar with the respect agro-pastoralists and pastoralists and the loss of extensive wet season grazing areas to the SMF's and the consequent overgrazing and degradation of the rangelands.

It was estimated (para. 3.1.3 (c) above) that in 2005 (a good rainfall year with high crop prices) only 40 percent of the SMF's were being cropped. Given the recommendations of the JAM for a more equitable access to natural resources, as a first step it would be appropriate to undertake a survey of all SMF's to determine which areas were legally or illegally held, those areas being regularly cropped, areas which were under-utilized (cropped occasionally) and those which had been abandoned. This would enable a thorough review of all government leases. Illegally held, under-utilized or abandoned land could then revert back to the State. Provisions could be made for the State to purchase back leases of farms that were strategically important in the land redistribution and land use planning exercise.

The second step would be to undertake at the State level (but within nationally laid down guidelines and principles) a strategic land use planning exercise in consultation with all concerned stakeholders. This would seek to redistribute land that had reverted to State control, to smallholder rainfed farmers, agro-pastoralist and pastoralists based land suitability for rainfed cropping, intensive and extensive livestock production and where possible on the principle of prior use (i.e. the land was used by a concerned group (or groups) prior to alienation). It would important to clearly define access and use rules for individually and communally held land to ensure sustainability of natural resource use and to avoid resource use and access conflicts. Where possible, existing formal or informal institutions for land and water allocation would be used and strengthened.

Control of some of the State Forests adjoining communities could be passed from the FNC to those communities following a participatory planning exercise to develop a forest management and harvesting plan. The Community Forest Management Plan (FMP) would set out sustainable harvesting rotations for fuelwood and charcoal production, royalty rates and the establishment of a Community Development Fund in to which royalties would be paid.

The third step would be to provide a comprehensive programme of technical support (crop and animal husbandry), effective input distribution (improved seed, fertilizer and veterinary medicines) and accessibility to short and medium term credit. The support programme would include improved physical accessibility (feeder roads), human and livestock water supplies, water harvesting and small scale irrigation, social infrastructure and services (health and education).

(c) Joint Ventures: Semi-mechanized farms and Traditional Farming Sector

There is a legal requirement that registered farm (e.g. Semi-mechanized farms) should retain at least 10 percent of their land under forest or plant at least 10 percent of their land to shelter-belt. Currently this is not being enforced. An option recommended by screening study of the fast track watershed management projects is that enforcement of the rule by the State (through fines or taxes) would develop a local community private sector that could provide a full range of shelter-belt services to private farmers and thus supporting livelihoods in the local communities. These services would include nurseries, planting, maintenance, harvesting, etc. The scheme would require FNC authentication and FNC technical support to communities.

4.4 Potential In-country benefits from Watershed Management Interventions in the Abbay-Blue Nile Sub-basin

4.4.1 Benefits from the Reduction in Soil Erosion and Soil Degradation - Ethiopia

(i) Benefits from Reduction of Soil Erosion and Increased Moisture Retention

Currently, soil erosion on cropland in the highlands of the Sub-basin is incurring an annual accumulating loss (through the reduction in soil moisture holding capacity) of an estimated 25,190 tons of grain per year that will reach an accumulated loss of 629,780 tons in 25 years times. In the absence of preventative measures this will continue to accumulate each year thereafter. A 100 percent coverage of cropland with bunds or grass strips that is incurring unsustainable soil loss (estimated to cover 2.03 million ha) would reduce current annual losses of soil and soil moisture holding capacity to 40 percent of current rates achieving a saving of 60 percent of current annual accumulating losses. This would yield an accumulating annual benefit of 15,115 tons of grain per year – in livelihood terms sufficient to sustain 75,575 adults per year, or 1.9 million people by the year 2030.

In addition to preventing loss of soil moisture holding capacity, construction of bunds in moisture deficit areas results in a 7 percent yield increase in crop yield from increased soil moisture retention and thus increased nutrient availability. Thus even bunds on land not suffering from unsustainable soil loss would yield increased benefits. Assuming 30 percent of all cropland with unsustainable soil losses is covered with bunds there would be an annual additional increase in production of 27,400 tons of grain per year - sufficient to feed 137,000 people a year.

(ii) Benefits from the Reduction in Soil Nutrient Losses

Annual gross losses of N are 61,410t/yr and net losses 37,640t/yr (61 percent) after additions and releases from the soil nitrogen pool.

Assuming an estimated annual reduction in nutrient losses through burning of dung and residues of about 3 percent, then an annual reduction of about 805 tons of N can be expected producing an annual saving about 4,830 tons of grain can be expected.

The reduction in nutrient losses through grain removal by the application of organic (manure, compost) or chemical fertilizer is difficult to estimate. Assuming conservatively that an increase in fertilizer uptake of 50 kgs of urea by 20 percent of farmers is possible, this would yield an annual increase in grain production of approximately 138 kgs of grain per farmer or 69,500 tons/yr additional production. The retention of soil nutrients potentially lost through soil erosion by bunds and grass strips assuming 100 percent coverage of cropland with an unsustainable soil loss rate would achieve a saving of about 25,830 tons of grain.

Total benefits accruing from reducing soil nutrient losses amount to 77,360 tons of grain per annum – sufficient to feed 386,800 people.

4.4.2 Sudan

(i) Benefits from arresting Kerib Land formation and Restoration of Existing Kerib Land

There is the potential to reclaim nearly 141,000 ha of kerib land. Assuming a mix of multi-purpose trees and herbaceous forage producing a sustainable yield of 200 kgs of woody biomass and 400 kgs of herbaceous biomass per hectare per year over 60 percent of the area, such a restoration programme could yield nearly 17,020 tons/yr of wood (or 2,550 tons/yr of charcoal) and 34,030 tons/yr forage of (enough to feed nearly 170,150 tropical livestock units[17]).

(ii) Benefits from arresting decline in crop yields on the Semi-Mechanized Farms

Assuming that only 40 percent of the area mapped as large farms is actually cropped in an average year, there is the potential to improve crop production of 2.98 million feddans (1.25 million ha) raising sorghum yields from 360 kgs/ha to 800 kgs. Assuming that 25 percent of the land is rested (in lieu of fertilizer) annually this is reduced to 2.24 million feddans (0.94 million ha). If there is a 60 percent adoption rate this would yield an annual additional production of 413,290 tons/yr of sorghum. The current annual decline in production of 22,300 tons would be halted, although this would be offset by the production foregone of about 112,720 tons/yr of land put under fallow. The net annual incremental production would of the order of 322,870 tons/yr.

(iii) Benefits from a large-scale redistribution of Land to Small-scale Farmers, Agro-pastoralist and Pastoralists

The exact area of alienated land that might revert back to the state will only be known after a comprehensive and detailed survey has been undertaken. How

[17] of 250 kgs liveweight

that land might be redistributed amongst the potential stakeholders (sedentary cultivators, agro-pastoralist and pastoralists) can only be determined through a process to be determined by the newly established Land Commission. Thus, no attempt is made here to assess what may and to whom benefits might accrue to such a re-distribution.

4.5 Other Strategic Interventions

4.5.1 Incentives

(i) Ethiopia

A distinction needs to be made between incentives for on-farm (i.e. private) soil conservation investments and those for community investments. Clarity is required in implementing food for work as an incentive and food for work as direct food relief.

The Federal Rural Development Policy reflects the new ideas and intentions with regard to the role of food aid. It advocates the replacement, where possible, of food for work (FFW) by cash for work (CFW) and, if food is to be used (e.g. for direct relief), it is preferred that food to be procured from local sources.

A different basis needs to be created for motivating and/or compensating farmers to contribute to community work. Some measures for consideration are:

- establish a transparent distinction between on-farm work, voluntary as much as possible, and off-farm development activities that can be compensated by FFW or CFW,
- abandon the application of FFW for on-farm work, and promote the integration of SWC as to become part and parcel of farming practices,
- to harmonise the above measures with ongoing FFW through the WFP-MERET project,
- create alternative, off-farm opportunities for employment and income generation (cash-for-work, farm inputs for work),
- replace "Community Participation" and mass mobilisation campaigns by voluntary work in farmers own village areas on locations selected by farmers themselves,

- ensure that farmers exempted from Community Participation are not loosing opportunities of working in other schemes of employment generation,

- ensure that SWC treated areas will be exempted from land redistribution.

Introduction of such measures requires action at all levels, focussing in the first place on changing attitudes, both of farmers (driven by a food dependency syndrome), authorities (still used to top down planning and implementation) and donors (putting too little emphasis on impact monitoring and cost effectiveness).

The overall objective would be to achieve **genuine community participation** in development activities by empowering, facilitating and assisting local communities in:

- fully integrating SWC activities into farming practices,

- implementing these on a voluntary unpaid basis, and

- allowing farmers to take their own decisions with regard to implementation locations.

(ii) Sudan

Hitherto food aid has been serving as a life-saving instrument in Sudan. With the changing circumstances its role is likely to change. It is generally recognized that it should be linked to improved livelihoods and the broader sectoral interventions such as agriculture, natural resources, education and health. Thus, it could be linked to distribution of agricultural inputs, agro-forestry, water development and pasture rehabilitation. Other activities could include road repairs and construction, food for education and health related interventions.

There is an ongoing debate on the relative merits of providing food versus cash. Both have their advantages and disadvantages in the Sudanese context. The advantages of food transfers are as follows:

- in areas of chronic food shortages providing food increases its availability and brings food prices down;

- they provide a protection against inflation as a transfer in the form of food is self-indexed and the cost of inflation is borne by the provider[18];

[18] FAO/WFP (2006) op. cite.

- giving food is quickest way of improving nutrition;

- providing free or subsidized food is effectively an income transfer as it is possible to trade food for cash or other goods;

- food transfers ensure that the beneficiaries will allocate a higher proportion of an additional unit of food income towards food consumption.

The main disadvantages of large-scale transfers of food are the disincentive effects they have on domestic production and trade. Such transfers could depress market prices leading to serious erosion of profits for domestic producers such that farmers reduce or move out of production.

The main advantage of a cash transfer is that it allows consumers more control over their decisions based on the particular conditions they face. They are a more efficient way of transferring income than pure food transfers. Food can be converted to cash but it involves transfer costs. Cash transfers are generally less distortive to the local economy than large food transfers. In conditions where markets are functioning well cash transfers can augment the development process by creating additional effective demand for goods and services boosting trading and productive activities.

The main disadvantage of cash transfers is that their real value is dependant on the rate of inflation. There is a real possibility of more inflation in food and other prices following a large scale cash transfer programme, particularly where markets are functioning poorly and the economy is relatively closed. Additionally, large cash transfer programmes are the greater risks of fraud theft and administrative leakages, relative to food transfer programmes.

The probable solution for Sudan is to continue with food transfers in locations where food shortages exist due to lack of production or lack of transport infrastructure. Pilot cash programmes should only be considered where the enabling conditions: markets and infrastructure exist and where the scope of food transfers is relatively small and so avoid inflationary pressures.

4.5.2 Resettlement of Population

In Ethiopia in the centuries before 1975 there had been a slow drift of people from the north moving south to less populated areas. Following the Land Reform of 1975 internal movement within rural areas became difficult particularly in the north where land was already short. Peasant Associations [19]Committees allocated land and first preference was always given to dependants of existing families. Nevertheless, there was continued migration into the sparsely forested areas of the southwest.

During the early 1980's a Resettlement Campaign resulted in large numbers of people being moved from the high population density areas to areas in the western Lowlands. Two strategies were followed: (i) movement to large Resettlement Camps, and (ii) a less intense approach where families were "integrated" into existing highland areas mainly in the southwest. There were many documented instances of involuntary resettlement and following the change in Government in 1991 many of the large Resettlement Camps emptied with people returning to their home areas, although in two areas (the Beles Valley and Assossa) many families remained.

A recent study of the negative impacts of land degradation on agricultural production and strategies to alleviate these (Sonnerveld (2002) took as one of its assumptions that population was free to move within and outside the area of ethnic origin of the farmers (migration scenario). Migration within areas of ethnic origin coupled with soil conservation gave an increase in annual agricultural production of 3.28 percent and 3.8 percent with unrestricted migration. With no migration but with soil conservation the annual increase in agricultural production was 0.19 percent.

Since 2003 a new official voluntary resettlement programme is in place (Government of Ethiopia, 2003). Movement of settlers is confined to within-region movement only – no inter-Regional movement of people is envisaged - the "restricted" migration scenario of Sonnerveld (2004). The programme is designed to take into account lessons from resettlement programmes in the past. These include:

- Desperate people will move spontaneously (14 million people face food shortages in Ethiopia),
- Voluntary resettlement is essential for success,
- Resource user rights of host communities must be respected,
- Participants must be fully informed in order to make choices,

[19] Areas with defined boundaries approximately 1,500 ha in extent with about 300 – 400 families.

- Potential conflicts can be reduced by remaining within Regional boundaries[20],
- Risks to environment and environmental factors affecting health must be taken into account,
- The Programme must be designed with rules of access and institutionalised implementation (not as a campaign driven by the present emergency, and
- Incentives must built in at each level of design and seek to achieve sustainability.

The GoE has identified the following areas with the estimated number of population to be resettled as follows:

Abay Basin and part Baro-Akobo Basin

Amahra Region) (N.Gonder, Tegede, Metema, Quara):	1,000,000 people
Oromiya Region: (W & E. Wellega, Illubabor, Jimma):	500,000 people

The Government proposes that amounts of land to be allocated to settlers and to be leased to Commercial Farming must be identified at the same time, and investment and resettlement plans must be harmonized. Initially settlers will be allocated use rights for three years after which if land management is successful full use rights are to be issued for a period to be determined by government.

The programme started in 2003 and is being implemented with domestic funds. A number of potential risks were identified and counter-measures specified in the planning stage. These include:

- Risk of pressure from above for speedy implementation: (built-in triggers in source and target areas with regard to preparedness, suitability and capacity).
- Risk of exposure to malaria and other diseases: (health resources to be made available including clinics, bed-nets provision, etc.)
- Environmental damage (Environmental assessments to be undertaken, potential for forestation and carbon sequestration to be explored).
- Potential conflict over resources, competing claims for land: (land made available to be subject to public consultation, mechanism for adjudication of claims and for compensation to be put in place).

[20] Although as recent events in southern and south-western Ethiopia this is not a guarantee that ethnic conflict over natural resources will not arise.

- Insufficient capacity for implementation: (keep demands on local capacity to a minimum, draw on Capacity Building for Decentralized Service delivery programme).

- Dependency on initial food aid and lack of sustainability: (efforts made to bring attitudinal change in programme design and implementation).

- Budget constraint and delays in funding: (proposed budget considered adequate.)

4.5.3 Improving Rural and Urban Domestic (traditional/biomass) Energy Systems.

(i) Ethiopia

The focus here is on domestic biomass (or "traditional") energy sources. "Modern" energy sources are considered only in respect of their role as substitutions for biomass sources.

The reason for this focus on biomass energy is because of its very large contribution to household energy consumption, even where modern energy sources (electricity, LP gas, kerosene) are available. This is because a large proportion of household energy is used for cooking and the relative total costs of using biomass fuels for cooking is often lower than modern fuels, particularly when the capital costs of modern energy stoves are taken into account. The widespread and increasing total consumption (with rising population) of biomass fuels has obvious implications for vegetation cover and land degradation. The continued use of biomass fuels and emissions of smoke and corrosive gases in enclosed kitchen spaces also have very important implications for the health of women and children.

Many recent studies of rural (and to a much lesser extent urban) energy consumption have revealed an often complex spatial and seasonal patterns to the various biomass fuels consumed (wood, charcoal, crop residues and cattle dung). Generally there is a clear distinction between rural and urban household consumption patterns with the consumption of a higher proportion of modern energy, and within biomass fuels of charcoal.

Within the Sub-basin there are four broad patterns of rural domestic biomass energy systems. In highland Ethiopia a broad distinction can be made between the more humid western and the more arid eastern part related in part to the better natural vegetation cover and also to the much higher number of on-farm planted trees in the higher rainfall areas of the west. The higher number of on-farm trees in the west is also due to the better road system and well developed markets for construction poles. In the western parts wood fuel and crop residues tend to predominate, whilst in the drier east wood, crop residues and dung are used. In the western Lowlands of Ethiopia where population densities are much lower and tree cover still intact, wood is generally the only fuel used.

WBISPP (2005) surveys indicate that women and girls are most involved in collecting biomass (mainly wood) fuels. They spend on average 6 and 3 hours per week respectively collecting biomass fuels, compared with one and half hours per week for men and boys. Women spend an additional 14 hours a week transporting biomass fuels. Boys and girls spend on average 6 hours and men 2 hours per week transporting biomass fuels. The burden of collecting and transporting biomass fuels involves considerable energy - most particularly on children and women. This has negative impacts on nutrition. The considerable time spent on collecting and transporting fuel means less time for other activities (child rearing) and rest. In addition, women and children are exposed to natural hazards and injury.

In the World Bank funded "Access to Energy" Project a number of strategies are currently being pursued. In summary these are:

1. Improved Biomass Energy Utilization Technologies for Rural and Urban Households: Support to private investment in construction and dissemination.

Improved Mitads : The annual reduction in wood use for mitad baking by year 10 would be 7.8 million tons per year.

Lakech Charcoal Stove: publicity campaigns by Regional Bureaus of Rural Energy to maintain the momentum of stove adoption over the ten year period.

Improved ceramic '*gounziye*' Stove with an annual fuelwood saving of 1.8 million tons per annum after ten years.

2. Improved and Sustainable Supplies of Traditional and Improved Biomass Fuels

On-Farm Tree Production: main strategy for supplying fuelwood and poles for rural consumption, and partially meeting urban demand for these products. Sales of fuelwood and poles by farmers to rural and urban markets will support farm income generation and improving rural livelihoods. The programme will also support, and seek to accelerate, the integration of on-farm tree production with crop and livestock production, and sustainable land management.

Sustainable Management of Highland Woodlands and Shrubland Remnants: "hillside closure" to be self-financing by the Communities themselves. Payment of guards and other expenses will be met from fees and charges for cut and carry of hay, fuelwood collection, tree harvesting, etc as may be determined by each individual Community. No external investment funds are required.

Sustainable Management of Highland Forests: develop regional overall land use plans for these forests, and provide support communities to manage High Forests within their jurisdiction.

Sustainable Management of Lowland Woodlands and Bamboo Resources: to ensure the long term sustainable management and utilization of the Ethiopian lowland woodland resources and their associated areas of Lowland Bamboo.

Promotion of Efficient and Sustainable Production of Charcoal: promote the concept of Group Charcoal Burners who would adopt the improved kilns.

Production of Modern Fuels: Ethanol: to be developed and funded by private enterprise with possible concessional funding from the Global Environmental Fund under the "Clean Development Mechanism". Support to comprehensive programme of consumer education.

Briquetting of Agri-residues and Charcoal: Briquetting of agri-residues and charcoal are to be developed and funded by private enterprise.

(ii) Sudan

A similar group of strategies are being adopted in Sudan with perhaps more emphasis on the extension of the use of LPG for household energy (MEPD-HCENR, 2003, UNDP-World Bank, 1988). In Sudan the problem has been approached both from the supply and the demand side. On the supply side a number of strategies have been developed. These include:

- regulation of forest clearing activities under the mechanized farming schemes to retain 10 percent of wood cover;
- improving existing arrangements for the protection and management of woodlands both within and outside forest reserves to improve wood fuel supply;
- increasing wood supplies through tree planting;
- conserving wood supplies through improvements to charcoal production.

On the demand side the key strategies again have been to promote increases in the fuel utilization efficiency:

- institutional strengthening of the National energy Agency (NEA) to enable it to management a fuel utilization efficiency research programme;
- promotion and dissemination of fuel efficient stoves for household cooking;
- identification and dissemination of technology to improve energy utilization efficiency of small wood-based industries.

Increasingly the use of LPG is being promoted for household energy use, particularly in urban areas and more recently in some rural areas.

(iii) Key benefits

In both Sudan and Ethiopia key benefits for these supply and demand side strategies are to increase wood fuel supply on a sustainable basis; to reduce demand for wood fuel and charcoal through increased fuel efficient stoves and through the increase use of LPG. These in turn will reduce the rates of deforestation and increase vegetative cover. Increased stove efficiency and the use of LPG reduces smoke inhalation and reduces the incidence of respiratory diseases particularly to those most exposed: women and children. Thus they will make a substantial impact on peoples' livelihoods, health and well-being.

4.5.4 Improving Rural-urban socio-economic linkages in the context alternative livelihoods.

One of the primary objectives of the Framework for Watershed Management is “to create alternative livelihoods”. The proportion of households dependant on agriculture in Ethiopia is 85 percent although the contribution of agriculture to the country’s GDP is only 45 percent and declining, with the Service and Industrial sectors providing the remaining and increasing proportions. Much of the latter’s activities are taking place in the major urban centres, but also in the small and intermediate centres.

Experience suggests a number of possibilities for small and medium sized urban centres (Barret et al., 2001, World Bank 2004). These include:

- Increasing rural agricultural income by acting as demand and market nodes for agricultural produce from rural hinterlands.

- Reducing costs and improving access to a range of public and private services and goods from within and outside the immediate region by acting as a centre for production, processing and distribution of goods and services to rural hinterlands.

- Becoming centres for growth and consolidation of non-farm economic activities and employment for rural residents through the development of small and medium size enterprises or the relocation of branches of large private or public enterprises.
- Attracting rural migrants through the demand for non-farm labour.

A study on employment and labour mobility in Ethiopia (RESAL-Ethiopia, 1999) concluded that migratory labour is an important source of additional income for poor rural households and likely to play an increasing role as a coping mechanism for households facing food insecurity. It noted that little attention has been devoted to this topic than hitherto. Another study in Ethiopia (Berhanu Nega, 2004) also noted that the development of the non agricultural sector in general and the issue of urbanization in particular should be taken very seriously. The study questioned whether development of the agricultural sector by itself could serve as the engine of growth for industrialization.

A number of key strategies have been identified:

- Develop and improve access to markets through improved road and other forms of communication (e.g. telecommunications);
- Improve access to capital and credit sources;
- Provide basic technical skills (e.g. bricklaying, carpentry, etc) to improve employability;
- Provide support to traders through improved working capital and credit (they provide the link between farmers and non-farm activities and between local, national and international markets).

Together with accessible markets, access to credit and input supplies are main ingredients for rural development. Despite a number of efforts in the past, all three are poorly developed, let alone their appropriate linkage. The Millennium Development Goals Needs Assessment Report (Seme Debela et al., 2004) reports, that “consumption levels of fertilizers and pesticides are one of the lowest in the world, and that there is an enormous potential for agricultural development if inputs are made available timely and at affordable prices and acceptable quality and quantity, supported with favourable policy environment.”

As far as credit and inputs are concerned, it is very difficult to get out of the vicious circle of poor farmers, high interest rates of private credit providers, low reimbursement rates, limited government capacity to provide soft loans, and non-sustainability of incidental soft loan systems through projects/programmes with a limited duration. Bad experiences in the past (failures of blanket-wise input promotion not suited to all conditions) have made farmers even more reluctant to take credits for agricultural investments.

The importance of soft loans is emphasized by many. The evaluation report of Irish Aid activities in Tigray mentioned access to credit as the best secondary project benefit to farmers. The Report suggests using part of the compensation in cash for community work for the creation of revolving funds for credit supply services.

Ready-made solutions to the credit/supply issue do not exist but a number of preconditions need to be considered:

- more site-specific extension messages need to be developed as to replace previous blanket approaches,
- extension and input supply systems should become more problem-oriented and demand-driven,
- both the demand and supply side should develop in line with market-oriented agricultural development,
- supply systems should be developed by the private sector and not by government,
- institutional development at grassroots level should be promoted to better represent farmers' interests (appreciation of extension messages, knowledge of the market, negotiating interest rates).

Successful examples of credit supply (e.g. by Menschen für Menschen in Merhabete, Mida and Dera weredas in the Abbay basin) are based on short term inputs, like providing a starting capital, with appropriate institutional arrangements for long term application. Institutional arrangements need to be based on existing (banking) structures. Revolving funds created and managed by some NGOs within the framework of their ongoing activities are likely to collapse after phasing out of the project.

A number of overall policy issues have been identified as of considerable importance in relation to local economic development in small and intermediate urban centres (Satterthwaite and Tacoli, 2003). These support and reinforce some of the issues previous identified. They include:

- Transport and communications infrastructure are very important although of themselves will not guarantee local economic development.

- Decentralization has great potential in terms of efficiency and accountability but there are a number of cost and other considerations. In particular there is a need to address: (i) access to adequate financial resources, (ii) a favourable climate for local institutions (e.g. land tenure systems, institutional structure of markets, a broader national development strategy that is export orientated).
- Better integration of local, regional and national planning.
- Capacity building of local institutions especially where decentralization is recent.
- Strengthening of local democracy and civil society to make it easier for poor groups to have their needs taken into consideration.

4.6 Potential Transboundary benefits: Overall Downstream Impact on Sedimentation in the Abbay-Blue Nile River System from Upstream Watershed Management and Dam Operation Activities

Overall an achievable watershed management programme involving grass strips, bunds, area closures and conserved and sustainably managed woodlands and shrublands and some 250 micro dams constructed could achieve nearly a 43 percent reduction in suspended sediment in the Abbay river system. The suspended load of the Abbay at the border could be reduced from 140.0 million tons to about 79.2 million tons per annum.

The total reduction of sediment entering the Roseires Reservoir would be of the order of about 42.4 million tons per annum. The amount currently entering the Geizera/Managil Irrigation Schemes could be reduced by 31 percent: from 7.88 million tons to 5.45 million tons (a reduction of 2.43 million tons). The reductions of sediment entering the Rahad Irrigation system would be of similar orders of magnitude.

There are two potential negative impacts of this substantial reduction in sediment load and these both occurred in the main Nile below the Aswan High Dam following closure of the dam and a 90 percent reduction in sediment load. The first involves erosion of the river bed and transportation of this downstream given the higher energy potential of the river following sediment reduction. Within the Highland parts of the sub-basin bed sediment is likely to be relatively thin given the steep gradients of the main streams and rivers and the relatively high efficiency in transporting sediment through the sediment (the overall high sediment delivery ratio).

Erosion is likely to be concentrated in the Sudan reach of the Blue and Main Niles. It is likely to be greatest where the sediment from the kerib land has lodged in the valley bottom. This may have implications for sedimentation in the Senner Dam with eroded bed sediment replacing suspended sediment for a time. Experience from the Nile below the AHD was that erosion occurs in steeper reaches and deposition occurs in less steep reaches until some form of equilibrium is reached.

A second potential negative impact is an increase in river bank erosion. Both the Blue and the Main Nile currently suffer from accelerated bank erosion due to a number of causes. This is likely to increase in the medium turn.

As the bed sediment is normally of larger particle sizes than suspended sediment the eroded bed sediment is unlikely to substantially contribute to the suspended load, and will move downstream in relatively short annual movements with flood peaks.

4.7 Potential Regional/Global Impacts

4.7.1 Carbon Sequestration

Under the Kyoto Protocol there is provision for carbon trading between developed and developing countries. Currently these are only eligible for re-forestation rather than reductions in woody biomass consumption (e.g. through the use of improved stoves) or avoiding deforestation (e.g. through intensified agriculture). Nevertheless as Niles et al (2002) state future changes to the Kyoto Protocol may include these criteria or that parallel carbon markets outside the Kyoto Protocol may develop.

By way of example, currently in the Amhara Region the unsustainable proportion of wood consumption as fuel is releasing the following greenhouse gases (WBISPP/MARD, 2005):

Carbon (C)	4.6 million tons
Carbon dioxide (CO2)	17.1 million tons

Whilst the present system of national accounting depreciates manmade capital no account is made for the depletion or degradation of natural resources: they are viewed as a "free gifts of nature (Ahmed Yusuf et al., 1989). Similarly no account is made for increases in natural capital (e.g. through new discoveries of minerals, improved surveys, tree planting, major land improvements, changes in prices and thus of values on natural resource stocks). According to current national accounting practice changes in man-made capital (i.e. investment) are recorded and form part of the GDP/GNP, It has been suggested that increases or decreases in "natural capital" be similarly treated.

The burning of woody biomass stocks for fuel and for clearing for agriculture and settlement permanently reduces the Nation's woody biomass "capital". One component of the environmental value of woody biomass is its value for sequestering carbon and so contributing to a reduction on global warming. Under the Kyoto Protocol a "market" for sequestered carbon now exists. If the discounted value of US$7.63 per ton of carbon is used, then the current annual release of 4.6 million tons of carbon from burning woody biomass stocks in the Amhara Region incurs a potential loss of income of US$35.1 million (EBirr305 million).

The Net National Income (NNI), which is the GDP less the depreciation of capital is the nearest measure of the nation's sustainable income. However, as currently measured it does not take into account "depreciation" or depletion or permanent degradation of the nation's "natural capital", i.e. soil, water, forests, etc. The estimated value of woody biomass stocks destroyed in Amhara Region estimated at EBirr 305 million. This figure represents the depreciation of the Region's wealth and is the amount by which the NNI should be reduced to reflect true sustainable income.

Conversely, and based on recent carbon trading values if just 25 percent of the carbon released from burning woody biomass stocks in Tigray could be sequestered through a 10 year programme of community managed woodlands and forest this could yield a potential income of US$8.8 million over the same period.

4.7.2 Biodiversity

Pagiola (1997) reports that there are positive benefits to biodiversity from practicing sustainable land management practices. These include an increase in below ground biodiversity including organisms such as insects and other invertebrates that play a vital role in maintaining soil fertility. However the greatest impacts on biodiversity are indirect. By increasing the lands productivity this reduces the need to clear more agricultural land and thus reducing deforestation and preserving biodiversity. Increased livestock pressure on rangelands initially changes the species composition and cover. The proposals to reduce pressure on rangelands in Sudan will have a positive impact on increasing biodiversity.

The Ethiopian Highlands are one of the six Vavilov centres of crop endemism. Of particular importance is the gene pool of the cereal crop barley, included within which are strains resistant to rust. An Ethiopian variety of barley crossed with other varieties helped save the United States barley crop from being devastated by rust and so saved the united States millions of US$. In situ conservation of the barley, teff and wheat gene pools are of global significance.

5. BASIN-WIDE OPPORTUNITIES FOR HIGH IMPACT COOPERATIVE WATERSHED MANAGEMENT ACTIVITIES

This chapter looks forward to the second component, the Distributive Analysis and to the third component the "Cooperative Mechanisms" which will examine the differing levels of cooperation, the fourth component which is the development of a Long-term Watershed Management CRA and the fifth component the identification of the next round of potential Watershed Management projects. The chapter thus represents a current stage of thinking and analysis.

5.1 Framework for Analysis

5.1.1 Types of Cooperative Benefits

A framework for analysing types of benefits from cooperative action with respect to international rivers has been prepared by Sadoff and Grey (2005). It identifies four types of benefits that can be achieved. These benefits can be economic, social, environmental and political. The framework assumes no hierarchy with regard to the magnitude of potential benefits. This will depend on the particular circumstances, the type of cooperative actions and costs involved. Neither does the framework assume a particular sequencing in which the cooperative actions should be followed although cooperative activities could be linked. Starting with ecological cooperative activities could lead to political cooperation. Conversely a setback in political cooperation could be a constraint to ecological or socio-economic cooperation.

Increasing benefits to the river (Ecological and subsequently Socio-economic cooperation)

Cooperation can enable better management of river-related ecosystems, providing benefits to the river and underpinning all other benefits that can be derived from the river. These include benefits such as better water quality and river flow characteristics across a basin which come from activities such as headwater management and wetland maintenance.

There are a number of examples of potential benefits to the river in the Abbay-Blue Nile Sub-basin given the coincidence of highland/lowland and transboundary elements of the basin, from catchments in the Ethiopian highland to those in Sudanese lowlands. The clearest example of this type of benefit is the potential reduction in sediment load in the Abbay-Blue Nile River resulting from the Watershed Management Programme in the Ethiopian Highlands. This will have clear impacts in reducing sedimentation by approximately 30 percent in the Roseires Reservoir (reduction of 36.04 million tons/yr) and Senner reservoir (reduction of 34.92 million tons/yr). There would be similar proportional reductions in sedimentation in the Rahad (0.68 million tons/yr) and the Gezira-Managil (2.43 million tons/yr) Irrigation Schemes.

These reductions in sediment in the Reservoir will have positive impacts on power generation with less expenditure on clearing intakes. The reduced sediment in the irrigation canals of the irrigation schemes will lead to high water delivery efficiencies and increase crop production. There would also be benefits to the many pump irrigations in reduced damage to pumps as well as reductions in water purification requirements for domestic and industrial water supplies.

Increasing benefits from the river (Primarily Economic)

These types of benefits derive from efficient and cooperative management and development of shared rivers to increase benefits which are obtained from the river, usually in terms of production benefits, such as agricultural output and hydro power development. They may also include flood / drought management, navigation and environmental conservation, and water quality improvement for abstraction and recreation. These benefits may emerge through the coordination of dam and irrigation management throughout the river basin system.

There is considerable potential for these Type 2 benefits in the Abbay-Blue Nile system. For example the Karadobi Dam on the Abbay River could generate electricity which can be exported to the Sudan and Egypt. Flow moderation from this dam can impact upon the seasonal availability of water through the system, thereby facilitating downstream irrigation in the Rahad and Gezira-Managil Schemes in the dry season. However, upstream flow moderation can have negative impacts where there is reduction of high flows which are important for ecological reasons with the loss of silt or water flow into specific areas.

Reducing costs because of the river (Politico-economic)

A third type of benefit derives from lessening tensions through cooperation, so that less costs are incurred on military expenditure and surveillance needed due to tensions caused by a shared river resource.

Benefits: Increasing benefits beyond the river (Economic and Social)

With high levels of cooperation, it may be possible for economic integration to occur between states along an international river with regional infrastructure developed, and economic activities planned along the river course, not on the basis of national self-sufficiency, but in response to economic comparative advantage and efficiency, so as to maximize benefits from the basin as a whole rather than within each country separately.

The potential for these benefits in the Abbay-Blue Nile Sub-basin is beginning to appear with increased collaboration between Ethiopia, Egypt and the Sudan in hydropower production and trade. Such benefits will also appear as a regional market develops along the Northwest Ethiopia-Metema-Khartoum corridor.

5.1.2 Benefit Sharing: The Distribution of Costs and Benefits

For regional river basin planning to occur across the two countries there will be a need for assessment of the costs and benefits to each country of the proposed land uses and investments, and if necessary for benefit sharing arrangements to be developed under an appropriate coordination mechanism.

To get to the stage where benefits from "beyond the river" are achieved through basin-wide assessment of comparative advantage and optimal use of the resources requires a high level of trust and confidence between states, as well as an overall mechanism which can undertake planning and development, as well as manage associated benefit sharing arrangements. Benefit sharing could be particularly important in the case where one country, such as Ethiopia as a headwater country, forgoes agricultural development of its western Lowlands and maintains a vegetated landscape in that area in order to reduce sediment loads, help moderate flows in the Abbay-Blue Nile river system and so reduce the need for dams to control river flows.

If beneficial developments are forgone in Ethiopia, (such as agricultural resettlement opportunities in the lowlands), the country could expect some payment from the downstream beneficiaries to make its own actions worthwhile. (How such funds are distributed between the Federal and Regional governments in Ethiopia would be another issue requiring sensitive investigation and resolution.) A similar within-country situation could be encountered, especially in Ethiopia with the different regional governments in the upper sub-basin and the lower sub-basin.

Integrated basin-wide development and water resource management is the goal for ensuring sustainability and productivity of rivers, while unilateral action for maximising local and national benefits irrespective of negative impacts elsewhere in the system, is least desirable. In moving towards coordinated and collaborative action in the basin, the benefits have to be worth the costs for all parties involved or some benefit sharing and compensating arrangement has to be put in place. To move in this direction it is necessary to improve perception of the potential benefits, from the obvious to the less obvious, and to understand the distribution of benefits and costs in order to achieve an arrangement which stakeholders see as fair.

5.1.3 Modes of Cooperation

Sadoff and Grey (2005) envisage a continuum of modes of cooperation from unilateral action (i.e. with no cooperation) to activities involving coordination (communication and sharing of information on national plans), to collaboration (adaptation of national plans for mutual benefits) and finally to joint actions (joints plans, joint investment).

Unilateral action in a sub-basin means no cooperation; foregoing opportunities for mutual benefits and through uncoordinated activities increasing the possibility of reduced flows or increased sediment loads.

Coordination can be achieved, for example, by cooperative collection and or exchange of hydrological information that could lead to such benefits as improved flow forecasting for floods or droughts. Exchanging information on national sub-basin development plans could assist national planners in avoiding conflicting projects. Extending the boundaries of cost-benefit analysis of catchment developments to include an assessment of transboundary downstream impacts is another example. Cooperative Regional Assessments (CRA's) permit a sharing of information and provide a basis for equal acquisition of information. Coordination may enable countries to secure some type 1 and type 2 benefits.

Collaborative activities could include adapting national sub-basin plans to either secure regional gains or avoid harm to other riparian users. This mode of cooperative activity could secure type 1 and 2 benefits. Where countries are able to share these benefits this could lead to type 3 or even type 4 benefits. For this to occur then there needs to be some form of agreed benefits sharing mechanisms.

Finally, joint action occurs when the sub-countries countries jointly design, invest and implement shared river development. In the present case the Joint Multi Purpose (JMP) programme is a prime example.

Sadoff and Grey make the point that the continuum is non-directive, dynamic and iterative. By non-directive it is not intended to infer that more cooperation is necessarily better. It is dynamic because various points along the continuum will more appropriate for different activities at different times. Finally, the continuum is iterative because successful initial cooperative activities may spawn new opportunities for cooperative action.

5.2 Cooperative Activities involving Coordination: Basin-wide Information Exchange

5.2.1 Hydrology and Sedimentation

Given the large seasonal variation and very rapid response times in stream flows of the Abbay-Blue Nile River the sharing of flow, sediment and meteorological data collection has a number of advantages to Sudan and Egypt.

Sutcliffe and Lazenby (1994) have pointed out that the one major gap in the investigation of the hydrological regimes of the Nile Basin is the measurement and analysis of erosion and sediment load: particularly for the Abbay-Blue Nile and Tekeze-Atbara Sub-basins. Monitoring of suspended sediment loads throughout the Sub-basin at the outlets of micro-catchments, sub-catchments and catchments of varying size would provide a more complete understanding of the linkages between catchment size, geomorphology, soils and land use and the sediment dynamics within the sub-basin.

With the possibility of significant reductions in suspended sediment from catchments in the upper Sub-basin as a result of the ongoing Watershed Management interventions (soil and water conservation structures, water harvesting and small dams) it will be important to monitor any changes in bed sediments and bank erosion in the downstream catchment. The proposed integrated erosion-sediment monitoring programme that has been proposed in Ethiopia could be combined with the bed and bank monitoring programme downstream to provide a complete system-wide understanding of erosion, sediment delivery, suspended sediment, and bed aggradation and degradation.

A Sub-basin wide sharing of flow and meteorological data combined with satellite imagery and the analysis cold cloud temperatures would enable timely and accurate forecasting of flood flows. For example, it was shown during the 1988 Blue Nile floods that cold cloud data could provide useful in formation on rainfall amounts from which flow forecasts could be made.

The three main components of such a system are (Hardy et al., 1989): the collection of cold cloud duration data and their conversion to rainfall estimates in real time; the conversion of rainfall estimates to river flow estimates at key sites;

and the modelling of the flood flow down the main channels to forecast levels and flows at key points. The combination of rainfall estimation and the rainfall-runoff model allows river flows to be forecast up to three days ahead on the Blue Nile and so increases the forecast lead at Khartoum from three to six days. Forecasts for the Dinder and Rahad are based on regression. This has advantages to both Ethiopia and Sudan in terms of an early warning system and for efficient dam operation.

Although the above system is geared to forecasting flood flows, Sutcliffe and Lazenby aver that it can be used to forecast the start of run off on the various Abbay-Blue Nile tributaries. Within the limits set by inflows, storage capacity and the abstract limits set by the Sudan-Egypt Water Agreement, the aim of the Sudan authorities is to maximise irrigation, hydropower and water supply, at the same time seeking to minimizing sedimentation in the Roseires and Senner dams (Sutcliffe and Widgery, 1997). The operating rules are complex because the energy demand and does not coincide with irrigation releases. In some years flows rise in March-May because of rains over the southern tributaries in Oromiya and Beneshangul-Gumuz Regions. A forecast of these flows might be used to plan the area of irrigated crops to be planted and also plan the operation of the reservoirs. A model has been developed (Hamad, 1993) that utilizes such data and has shown that there could be a significant improvements in hydro-power generation.

5.2.2 Land Use/Land Cover

The objective of establishing a land use /land cover monitoring system is to capture the dynamics of landcover and land use in terms of location. Knowledge of the rates of conversion of forest, woodland and shrubland to agriculture and on the specific locations and extents of these conversions would also be a great value in evaluating and reformulating policies and plans on watershed management and in rainfall-runoff modelling. In addition the results could be used for monitoring:

- agricultural and rural development;
- domestic bio-energy supply;
- forestry and woodland management and conservation:
- resettlement planning, implementation and monitoring;
- disaster preparedness planning and monitoring;
- water development;
- many other facets of natural resources management and conservation.

For this reason, and given the scarce resources and expenses required to undertake mapping landcover changes, consideration should be given for a wider role for mapping landcover changes (i.e. not only landcover monitoring for watershed management).

Two alternative (though not necessarily mutually exclusive) approaches to monitoring landcover are possible.

The first alternative is to attempt to monitor changes in land cover over the whole Sub-basin. Any monitoring system must have information on the baseline situation at one point in time (whether past or present) from which changes in the future can be measured. The Abbay-Blue Nile Sub-basin covers some 31.2 million hectares and monitoring landcover changes across the whole Sub-basin at relatively frequent intervals (say five years) would be extremely demanding in resources. Although, it must be said that within the northern lower basin land cover changes are likely to be small. If the whole Sub-basin is to be monitored then some form of sampling may have to be considered as an alternative to complete re-mapping with all the implications for obtaining statistically reliable data that sampling entails.

Rather than whole-Sub-basin monitoring a reduction in the resources required could be achieved if a more focused assessment was made of landcover changes in key thematic or Sub-catchment priority areas. These might include but be not limited to:

- Assessing landcover changes in the upper catchments of key river basins (e.g. the Didessa Catchment) as an input to analyzing sedimentation rates and changes in flood frequency and the need for developing catchment management plans and activities;

- Assessing changes in vegetation cover in woodland areas on the frontiers of agricultural expansion;

- Assessing landcover and woody biomass changes in reception areas where voluntary resettlement is being undertaken (e.g. Lower Didessa-Anger Valleys);

- Assessing woody biomass changes in areas of high-intensity agriculture to monitor on and off farm tree and shrub cover;

- Assessing landcover and woody biomass changes in areas of active expansion of Commercial agriculture (e.g. the western Lowlands of Beneshangul-Gumuz Region).

5.3 Cooperative Activities involving Coordinated Watershed Management Planning (Effective/Optimal Basin-wide Utilization of Resources)

5.3.1 Abay-Blue Nile Catchment

Considerable watershed management developments are taking place in the upper catchment. Studies are being conducted into the feasibility of the Karadobi Multi-purpose Dam. This involves the construction of a storage reservoir with an initial capacity of 26.48 km^3. Given the various ongoing and planned watershed management and other development activities, it would be advantageous to undertake a cooperative Sub-basin study. This could examine the ongoing and future watershed management programme in the upper catchment, the operation of the Fincha'a, Karadobi, Rosieres, Senner and Meroe Dams, the planned irrigation, rainfed and rangeland development activities of the lower catchment. The objective would be to determine the optimal basin-wide utilization of resources. The various problems of erosion, kerib formation, reservoir and irrigation canal sedimentation, decline in soil fertility and rangeland productivity, and could be addressed in an integrated way.

5.3.2 The Dinder-Rahad Catchment

Currently, the Dinder-Rahad Catchment within Ethiopia is relatively undeveloped. Although only supplying 4 km^3 compared with the 50 km^3 of the Blue Nile as its leaves Ethiopia the sediment loads are high (although no data is available at present). The Catchment experiences frequent and extensive flooding on the Sudan side of the border. Excess sedimentation is occurring in the maya'a wetlands in the Dinder Park and outside.

On the Sudan side of the border is a considerable belt of woodland and shrubland that is in the Dinder National Park. On the Ethiopian side of the border is the proposed Alatish National Park. However, the wooded clay plains on the Ethiopian side offer considerable potential for rainfed cropping and livestock production and parts are now being developed for sesame production. A key problem of the area is water supplies as the rivers generally do not flow for part of the dry season. Groundwater resources are known from the alluvial aquifers but the main Nubian sandstone aquifer lies below the basalt and requires considerable technical expertise to locate.

The cooperative development of a Catchment Watershed Management Plan could ensure that the sediment loads in the two main rivers continue to remain low. Expertise that has been developed in the Sudan in avoiding problems of rainfed cropping on the clay soils would be of considerable use to land developers in Ethiopia. A joint groundwater survey of the Lowlands could reduce costs and increase accuracy. There are thus a number of mutually beneficially cooperative activities.

5.3.3 An International Trans-boundary Park: The Dinder-Alatish Park

There is considerable scope to develop an international trans-boundary park by combining the Dinder and the proposed Alatish National Parks. The Dinder Park is well established, gazetted and internationally recognized. In contrast, the Alatish Park currently has only Regional government recognition although the Federal Ethiopian Wildlife Development and Conservation Department (EWDCD) has recommended that it be nationally gazetted and also made the recommendation for the establishment of a Transboundary Park (Cherie Enawgaw et al., (2006).

There is now considerable experience in Sudan of a community-based approach to Park management in the Dinder National Park. Both Parks experience seasonal grazing from Felata pastoralists and are subject to pressures from people living around the Park. A cooperative or joint management of a Trans-boundary Park would have a number of advantages:

- shared experiences in community-based Park management
- cost-effective joint management of the Park as one eco-system, and
- strong possibility of international recognition and ability to secure both Government and external funding.

5.4 Achieving Synergy from outputs from The Watershed Management CRA and from Coordinating Watershed Management Activities with other Programmes

5.4.1 Introduction

There are two aspects: firstly achieving synergy between the analysis and outputs of the ongoing CRA's, the ENSAP Joint Multi-purpose Programme (JMP) planning and the NBI Shared Vision Programme (SVP), and secondly between Watershed Management activities and activities related to the other CRA subject matter (e.g. irrigation development, flood control and management). The opportunities for the first are relative are of a relatively short time span, whilst the latter belong to the long term.

5.4.2 IDEN CRA's, the JMP and the SVP Programme

The IDEN CRA's include:

- Eastern Nile Planning Model,
- Flood Preparedness and Early Warning,
- Ethiopia-Sudan Transmission Interconnection,
- Eastern Nile Power Trade Investment
- Irrigation and Drainage

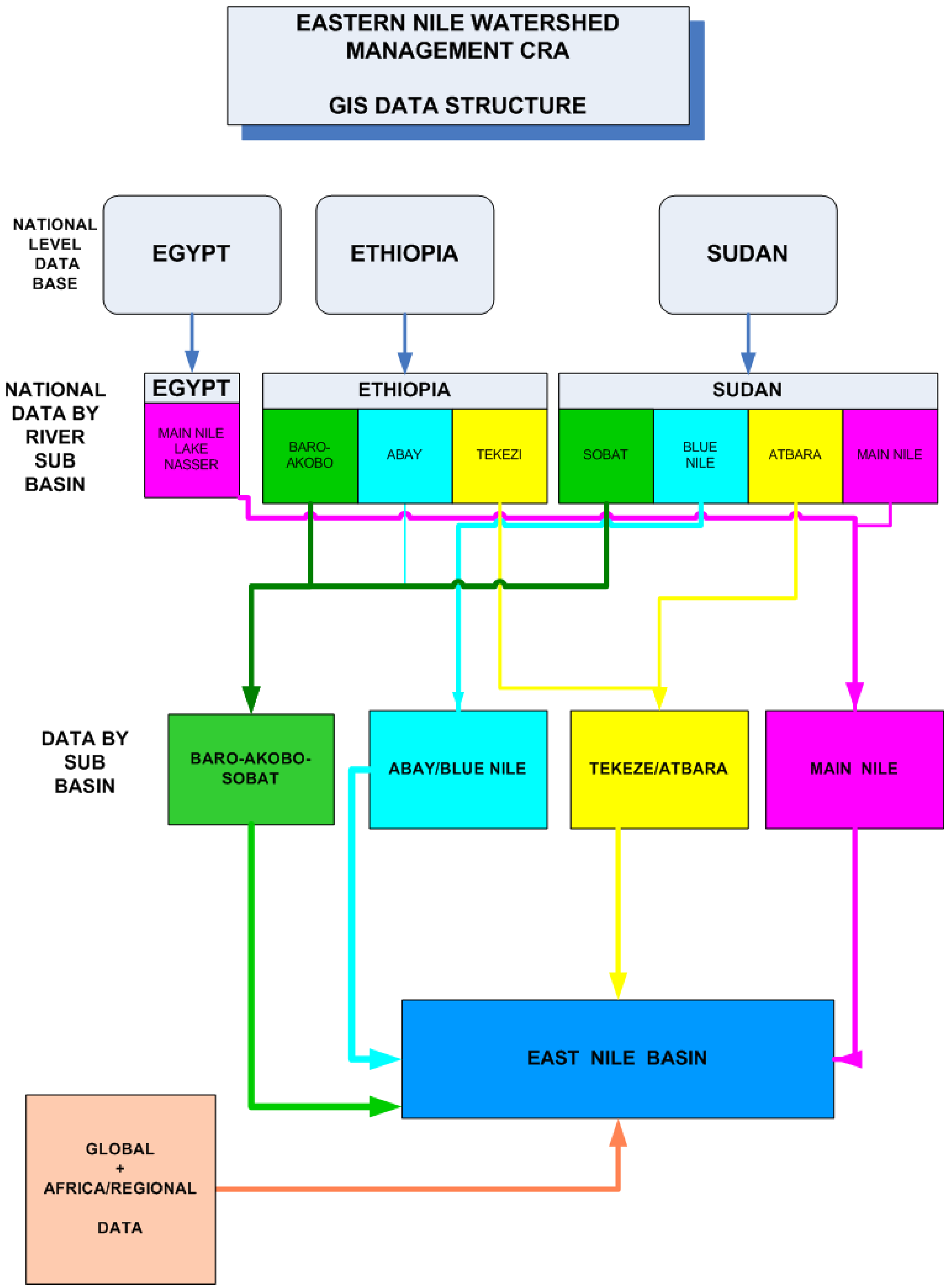
The outputs of the Watershed Management CRA are of immediate and direct relevance to the Joint Multi-purpose programme, the Eastern Nile Planning Model and the Irrigation and Flood Preparedness CRA's in terms of data and information relating to erosion and sedimentation, to on-going livelihood strategies and to the identification of some of the underlying causes of natural resource degradation and the levels and patterns of poverty. Given the limited resources available to ENTRO it is important that data and information collection efforts should not be duplicated.

The Watershed Management CRA has developed a substantial Geographic Information System that will be considerable use to the Eastern Nile Planning Model, as well as to the Irrigation and Flood Preparedness CRA's.

Additionally, synergy could be achieved in the collaborative development by the CRA Teams of the Cooperative Mechanisms. Some of these mechanisms will cater for activities in more than one CRA area. Some Cooperative Mechanisms that serve Watershed Management activities can also serve those for Irrigation and for Flood Preparedness. This is particularly so in the case of coordination of information sharing, but possibly less so in cases of joint actions (e.g. joint planning exercises).

With respect to CRA outcomes and in the case of the CRA's covering Transmission Inter-connection and Power Trade Investment the possible linkages are less obvious. Outcomes from the Watershed Management CRA of information on constraints to and potentials of agricultural production; on livelihood strategies; and levels and distribution of poverty will be of use in the development of power trade investment interventions. This information would be useful in developing potential demand scenarios for likely patterns of domestic power demand.

Figure 12. Watershed Management CRA: GIS Database Structure



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The SVP has eight projects designed to build a strong foundation for cooperative action. They are essentially capacity building projects. Although each has a separate focus they build on each to form a coordinated programme. The projects of most relevance to the Watershed Management CRA are as follows:

- The Applied Training Project for integrated water resources management (IWRM);
- Water for Agriculture Project to provide a basis for increased availability and efficient use of water for agriculture;
- Nile Transboundary Environmental Action Project (NTEAP) to promote cooperation in environmental management;
- Water Resources Planning and Management Project to build skills in the analysis of hydrology and the characteristics of the Nile basin system;
- Socio-economic Development and benefit Sharing Project is building network of professionals to explore alternative Nile Basin development scenarios and benefit sharing schemes.

The outputs of the Watershed Management CRA touch on all these Projects and provide valuable information on the core areas of each the programmes. The Watershed Management CRA GIS database will provide useful data for Water Resources Planning project. Some the analysis that is being undertaken in the Distributive Analysis of the Watershed Management CRA will be of practical use to the Socio-economic Development and Benefit Sharing project. Similarly, outputs from the NTEAP activities in the Dinder National Park have informed this

CRA on lessons learnt in developing a community-based approach to biodiversity and natural resource conservation.

5.4.3 Other International Programmes

There are a number of national and international programmes where cooperation and collaboration could yield mutual benefits. At the basic level this could take place through sharing information, experiences and lessons learnt. At a more higher and elaborate level this could take the form of joint activities in research, technical support and joint projects.

One example of a current joint programme is the "Hydrology for the Environment, Life and Policy" (HELP) programme that involves scientists from Sudan, Ethiopia and Egypt in a collaborative applied research programme under the auspices of the UNESCO Chair in Water Resources (UCWR). The Gash, Atbara and Blue Nile have been nominated as HELP basins. The results from the this four year programme will provide a valuable input to the joint Watershed Management planning exercises for the Tekeze-Atbara Sub-basin.

A second initiative of relevance to cooperative watershed management activities is the Nile Basin Capacity Building Network for River Engineering (NBCBN-RE), which covers the whole of the Nile Basin. Based at the Delta Barrages in Cairo, Egypt the Network has the following objectives:

- to make optimal use of existing capacities and institutes inn the field of river hydraulic engineering and connecting specialized institutions and experts;
- to enhance communication between experts and institutions;
- to improve access to education and training within the region;
- to facilitate research on river engineering;
- raise awareness concerning the central role of the River Basin as the management unit of international waters among politicians and professionals;
- to develop a Regional information centre and database accessible to members of the network.

The Network undertakes a considerable training and research programme. The research programme is organized around six research clusters: river morphology, hydropower, GIS and modelling, river structures, environmental aspects and flood management.

On a different note there is the "Improving Livestock Water Productivity in the Nile Basin", a project of the CGIAR Challenge program on Water and Food. The aim of the project is to help to produce more food with less water through water-friendly livestock production. The programme is of particular importance to sustainable watershed management activities. The project is researching ways of using crop residues more efficiently and thus increasing the overall productivity of transpired water. Improved livestock feeding systems such as cut and carry combined with conservation tillage reduces grazing pressure on communal pastures, reduces water runoff and erosion and increases infiltration. The project is looking at ways in which livestock can be successfully integrated into large irrigation schemes such as the Gezira, where livestock currently provide nearly a third of farmers' income.

The World Bank funded TerrAfrica Project is also of relevance to the Distributive Analysis component of the Watershed Management CRA and vice versa. The TerrAfrica Project a multi-stakeholder partnership which seeks to enable the scaling-up of mainstreaming and financing of Sustainable Land Management (SLM). The project is developing a set of analytical tools to strengthen the knowledge of land degradation and of its effects, with the objective of mainstreaming SLM in the development agenda of Sub-Saharan Africa. Among these tools, TerrAfrica is supporting the development of a framework to assess the impact of land degradation and the benefits of SLM: the *“Cost-Benefit Framework for pro-SLM decision-making in Sub-Saharan Africa”*. The framework is intended to present the extent, severity and impact of land degradation, in order to provide information on the costs of degradation, benefits of SLM practices, and trade-offs involved in policy choices that could guide decision-making, with the aim of supporting the mainstreaming of SLM.

This multi-country project will be implemented in two pilot countries - Ethiopia and Ghana - and aim at further strengthening the country dialogue and enabling environment for SLM scale up through a combination of in depth analytical work and capacity building, particularly on the economics of land degradation. This is viewed as one of the important underpinnings in support of the mainstreaming of sustainable land management (SLM) into decision-making and investment operations. More specifically, this project would aim at (1) increasing capacity for analytical assessment of economic and environmental costing, and (2) enhancing and improving stakeholder dialoguing, information exchange and cooperation towards SLM. The results and the lessons learnt from this multi-country project will be shared and possibly replicated regionally through the TerrAfrica platform.

Clearly the analytical work that forms the basis of the Distributive Analysis component is of direct relevance to the TerrAfrica Framework. Both projects have established and are continuing contacts, and are sharing information and concepts.

5.5 Transboundary Trade and Economic Development within the Abbay-Blue Nile Sub-basin

Currently there is little or no cross-border trade within the Abbay-Blue Nile Sub-basin between Sudan and Ethiopia nor has there been a history of such trade. Sudan's agricultural sector within the basin is based on irrigated cotton for export, irrigated and rainfed cereal cropping for home consumption self-sufficiency and a livestock sector for both home consumption and export. In Ethiopia the agricultural sector is primarily based on cereal and livestock production for own consumption. The Sub-basin's agriculture has no export component. Sudan has a comparative advantage in terms of petroleum products.

Currently there is no primary or secondary road connection between the two countries, the nearest secondary road linkage being through Metema in the Tekze-Atabara Sub-basin. The main roads in Ethiopia terminate at Guba (north of the River) and Assossa (south of the river). On the Sudan side of the border the closest main road to the border terminates at Ad Damazin (Map 16). The Alatatish Park on the Ethiopian side and the Dinder National Park on the Sudan side will (it is intended) prevent agricultural development occurring over a substantial part of the western Lowlands.

Nevertheless, the western Lowlands of the Abbay-Blue Nile Sub-basin within Ethiopia have only recently begun to see development of their natural resource potential. Vertisols cover some 965,930 ha in the Lowlands. Just across the border in Sudan are 1.25 million ha of semi-mechanized rainfed cropping, with a marketing structure relatively well developed. In Sudan to the north of the river the area is connected to Khartoum and to Port Sudan by a major highway and railway. In Ethiopia there is just across the watershed boundary a new all-weather road from Gonder just to the north of Lake Tana to Metema, which then links to the Gederef-Khartoum Highway. A rail link to western Ethiopia from Sudan has also been mooted.

The Tana-Beles Project is now being implemented will see substantial hydro power and irrigation development. Together with the development of the western Lowlands of Ethiopia for rainfed agricultural and given the ease of access westwards (as distinct to those of the Addis Ababa metropolitan area), coupled with possible markets in Sudan it is possible trans-boundary trade could develop between the two countries. Additionally, Port Sudan offers an alternative entry port for Ethiopia to Djibouti for these western areas.

However, significant economic growth will only occur with the development of value-added activities within the sub-basin that are related to the agricultural development. As both countries grow essentially the same crops neither country has a specific comparative advantage that could engender trans-boundary economic development. The possibility exists for a joint strategic food grain reserve that could provide a measure of food security for both countries.

The potential for trans-boundary tourism is weak. Ethiopia's tourism sector is geared to the northern "cultural" circuit and the Simien National Park, whilst that of Sudan is geared to the "cultural" route along the Nile and to a very small extent licensed hunting. The one possibility is a trans-boundary National Park based on the Alatish and Dinder Parks. An enlarged Park would increase the possibility of conserving and increasing wildlife, essential for any wildlife tourism.

On balance it is difficult to see any major trans-boundary trade and economic development taking place within the Abbay-Blue Nile Sub-basin. A second major road from Gojam via Guba to Al Damzin would be in competition with the Gonder–Metema-Gederef road as a corridor of development. Nevertheless, with improved access and a freer of movement of people (e.g. visas and work permits) and given the rapidly expanding industrial and construction sector, Sudan could provide a source of alternative livelihoods through short or long-term non-farm work.

5.6 Potential Positive Interaction among Interventions

There are a number of ongoing and potential watershed management interventions with the Abbay-Blue Nile Sub-basin that are essentially "in-country" rather than trans-boundary and to a large extent are being undertaken independently of each other.

Upstream the major on-going activities that are relatively independent of each other are the soil and water conservation programme, the small dams programme, the livestock forage development component of the National Livestock project and the proposed construction of the Karadobi Dam.

Potentially, there would be considerable advantages in integrating the small dams programme with that of soil and water conservation and this is under active consideration. The lack of integration between these two programmes has seen the rapid silting-up of most of the dams constructed to date and to the placing of a moratorium on the programme. The soil and water conservation programme has in recent years broadened considerably in scope and now integrates many agricultural activities (crop and livestock development) at the micro watershed level. The advantages of integration and the often positive inter-action among various components have generally been recognized although the detailed modus of implementation has often still to be adapted to particular local circumstances.

The positive interactions among such interventions as stone bunds, livestock closure areas, stream bank protection, water harvesting and small woodlots on degraded hillsides in reducing soil erosion, promoting increased crop and pasture productivity have been clearly demonstrated in the research work being undertaken under the auspices of Mekele University and documented in the Ethiopia Country Report. The case of gully reclamation being accelerated by the location of enclosed areas in the gully catchment areas have demonstrated how positive interaction between interventions can occur. The case of the Eucalyptus woodlot located in a valley bottom and the subsequent drying out of small swamp and the formation of a valley bottom gully also demonstrate some of the negative interactions that can occur.

Taken together the watershed management programme in the Abbay Catchment and the proposed Karadobi Dam have the potential in combination to effect a significant reduction in suspended load of the Abbay River (para. 4.4.1). The positive impacts this reduction will have on the operation of the Roseires and Senner reservoirs and the Gezira-Managil, Rahad and the Pump Irrigation Scheme have also been outlined.

Downstream in the clay plains of Sudan are a number of ongoing and potential interventions that have potentially positive interactions. The sustainable reclamation of the kerib land along the Blue Nile and Dinder will not only prevent further loss of valuable cropland belong to small farmers, but also provide an opportunity to produce fuelwood and fodder on individual plots.

An integrated programme of land redistribution based on land capability and local participation, supported by legal guarantees for tenure security and by technical assistance and logistical support for crop, livestock and tree production has enormous potential for positive interactions in terms of increasing soil fertility and increasing crop production, reducing pressure on rangeland and increasing livestock production, reducing pressure on woodlands and developing community development funds and overall reducing the potential for conflict between groups of people.

5.7 Cumulative Impacts of Watershed Management Interventions in Broad terms

This Section anticipates the results of the "Distributive Analysis" that will examine the cumulative impacts on livelihoods, economy and environmental. This analysis will examine the locations of interventions and the distribution of costs and benefits at the Sub-basin level and within and between Countries. This brief section thus can not report in full the scale, relative magnitude and distribution of the cumulative impacts. It is only intended to report the cumulative impacts in broad terms. The detailed specifics will be contained in the Distributive analysis Report.

5.7.1 Positive Impacts

There are two main positive measurable impacts of the proposed watershed management interventions: (i) increased crop, fodder, livestock and wood production (and reduced losses), and (ii) reduced sediment load in the Abbay-Blue Nile River system. The assumptions and details of these have been outlined in chapter 4. Table 19 and end figures 13, 14 and 15 provide a summary.

Table 19. Summary of Cumulative Benefits to Watershed Management Interventions.

Impact	Amount
Reduction of crop production foregone:	
- burning dung & residues	4,830 tons/yr grain
- grain removal: use of fertilizer	69,500 tons/yr grain
- nutrient lost in soil erosion	25,830 tons/yr grain
- lost soil moisture holding capacity: 1st year	17,751 tons/yr grain
- lost soil moisture holding capacity: 25th year	443,775 tons/yr grain
Increase in crop production (SMF's):	
Kerib reclamation	
- Prevention of land lost	not known
- Fuelwood production	17,620 tons/yr (adw)
Charcoal equivalent	2,550 tons
- Forage production	34,030 tons/yr
Tropical Livestock Units	170,150 TLU's

Clearly, these will have very positive impacts on peoples' livelihoods through increased production, reduced vulnerability, increased livelihood assets and a wider range of livelihood strategies.

In terms of sediment reduction the cumulative impact of all the watershed management interventions would be to reduce the current sediment load in the Abbay by 63 million tons from 140 million tons to 77 millions tons. Sediment entering the Roseires and Senner Dams and the Gezira-Managil and Rahad Irrigation schemes would be reduced by similar proportions.

With the completion of the Karadobi Dam and assuming the full impact of the Watershed Management Interventions annual sediment load would further reduced by between 9.4 to 15.5 million tons.

5.7.2 Negative Cumulative Impacts

It must be recorded that these substantial reductions in sediment load will have potentially negative impacts on erosion of sediment of river beds and a potential increase in river bank erosion.

REFERENCES

Ahmed Musa Siyam et al (2005) "Assessment of the Current State of the Nile Basin Reservoir Sedimentation Problems", UNESCO-

Ahmad, Yusuf J and Salh El Serafy and Ernest Lutz (1989) "Environmental Accounting for Sustainable Development" edited by. A UNEP-World Bank Symposium, World Bank.

ArabMAB (2006) "Biosphere Reserves in Arab Countries: Dinder Biosphere Reserve".

ARD for USAID (2004) "Ethiopia: Land Policy and Administrative Assessment".

Barber, R (1984) "An assessment of the dominant soil degradation processes in the Ethiopian Highlands: Their impacts and hazards", EHRS WP 23.

Bewket, W (2003) "Household level tree planting and its implications for environmental management in the north-western highlands of Ethiopia: a case study in the Chemoga watershed, Blue Nile Basin" Land Degradation & Development 14: 377-388.

Bewket, W & G. Sterk (2005) "Dynamics in land cover and its effects on stream flow in the Chemoga Watershed, Blue Nile Basin, Ethiopia", Hydrological processes 19: 445-458.

Billii & F.Dramis (2003) "Geomorphological investigation of gully erosion in the Rift Valley and the northern Highlands of Ethiopia", Catena Vol. 50, 2-4, pp. 353-368.

Cherie Enawgaw et al (2006) "Report on the Assessment of Alatish Park in Amhara regional State", EWCO, Addis Ababa, May 2006.

Desta et al (2001) Land degradation in the highlands of the Amhara region and strategies for sustainable land management. ILRI Livestock Policy Analysis programme, Working Paper 32, Addis Ababa.

Ersado, L (2005) "Small-scale Irrigation Dams, Agricultural production, and Health: Theory and evidence from Ethiopia", World Bank Research Working Paper 3494, Jan. 2005, World Bank, Washington DC.

Ersado, L G.S.Archer & J. Alwang (2001) "Economic analysis of development projects with health side effects: Evidence from northern Ethiopia", IFPRI, Washington DC.

FAO (1986) “Early Agro-Meteorological Crop Yield Assessment”, FAO, Rome.

FAO (2006) "The New Generation of Watershed Management Programmes and projects. FAO Forestry paper 150", FAO Rome.

Farah, E.A. et al (1997) "Groundwater Resources in a Semi-arid Area: A Case Study from Central Sudan", J. of African Earth Sciences Vol 25, Issue 3, pp.543-466.

Friis, I (1992) "Forests and Forest Trees of Northeast Tropical Africa", HMSO, London.

Hamad, O. E. "Optimal operation of a reservoir system during the dray season", Ph.D. thesis Univ. Newcastle on Tyne, cited in Sutcliffe and Lazenby (1999).

Hardy et al (1989) "The use of satellite derived rainfall estimates as inputs to flow prediction in the river Senegal", IAHS Pub. 181 (New Directions for Surface Water Modelling: Ed. M.L. Kavas)

Hassan M. Fadun et al (1999) "Use of Remote Sensing to map gully erosion along the Atbara River, Sudan", JAG Vol. 13/4 cited in NTEAP (2005) "Soil Erosion Mitigation in the Nile Basin in Sudan", NTEAP, Khartoum.

Hurni, H (1985) "Erosion, Productivity and Conservation Systems in Ethiopia". Paper for IV Int. Conf. on Soil Conserv. , Venezuela.

JAM (2005) "Volume III: pg. 283 Key Policy and Institutional Challenges".
Joint Assessment Mission (2005) Volume III: Section 4. Productive Sectors, paragraph23.

Mekki Abdel Latif (2005) "Soil Erosion in the Nile Basin of Sudan", NTEAP, Khartoum.

MWR (1998) “Tekezi Medium Hydro Study”, Addis Ababa.

Niles, J.O. et al (2002) "Potential carbon mitigation and income in developing countries from changes in use and management of agriculture and forest lands", in Eds. I.R.Swingland Capturing Carbon and Conserving Biodiversity: The Market Approach, Earthscan Publications, London.

Norplan-Norconsult-Laymeyer (2006) Pre-feasibility Study of the Karadobi Multi Purpose Project", for Ethiopian MWR, May 2006.

Nyssen, J et al (2005) "Assessment of gully erosion rates through interviews and measurements: a case study from northern Ethiopia", accepted for publication in Earth Surf. Process. Landforms 30, (2005).
Sadoff, C.W. & D. Grey (2002) “Beyond the river: the benefits of cooperation on international rivers”, Water Policy 4: 389-403.

Sadoff, C.W. & D. Grey (2005) “Cooperation on International Rivers: A Continuum for Securing and Sharing benefits”, Water International 30: No. 4: 1-8.

Salih, A.A. (1997) "Relationships of Tillage Systems to Soil Properties, Cotton Root Growth and Yield in the Geizera Scheme".

Shibru Daba et al (2003) Assessment of gully erosion in eastern Ethiopia using photogrammetric techniques", Catena Vol. 50, 2-4, pp. 273-291.

Stocking, M (1996), ”Soil Erosion: Breaking New Ground", in Eds. M.Leach & R. Mearns "The Lie of the land", IAI, London.

Stocking, M.A. & A. Pain (1983) “Soil Life and the Minimum Soil Depth for productive Yields: Developing a New Concept”, Discussion paper No. 150, Univ. of East Anglia, November 1983.

Sutcliffe, J.P. (1993) “Economic assessment of land degradation in the Ethiopia Highlands: a case study”, NCS Secretariat, MoPED, TGE, Addis Ababa.

Sutcliffe, J.V. & J. Lazenby (1994) Hydrological Data Requirements for Planning Nile Management", in P.P.Howell & J.J.Allan "The Nile: Sharing a Scarce Resource", CUP

Sutcliffe, J.V. & N.J. Widgery (1999) "The problems of sustainable water resources management in Sudan" IAHS Publication (Sustainability of Water Resources under increasing uncertainty", Ed. D. Rosbjerg et al).

Walling,D.E. (1983) “The Sediment Delivery Problem", J. of Hydrology vol. 68, pp. 209-237.

Waterbury, J. (2002) “The Nile Basin: National Determinants of Collective Action”, Yale University Press.

WBISPP/MoARD (2001) "Strategic Plan for the Sustainable Management of the Woody Biomass Resources of the Amhara Regional State".

WBISPP/MoARD (2003) Separate Reports on Natural Grazing Lands and Livestock Feed Resources for Tigray, Amhara, BSG, Oromiya, SPNN and Gambela regional States.

WBISPP/MoARD (2005) "Ethiopia: A National Strategic Plan for the Biomass Energy Sector".

Wood, A (2000) "The Role and Importance of Wetlands in Ethiopia", EWRP Policy briefing Note 1, Ethiopian Wetlands Research programme, Addis Ababa.

World Bank (2000) “Sudan: Options for the Sustainable Development of the Gezira Scheme”, Report No. 20398-SU, World bank, Washington DC.

World Bank (2004) Four Ethiopias: A Regional Characterisation Assessing Ethiopia's Growth Potential and Development Obstacles. Draft background report to Country Economic memorandum, Addis Ababa.

World Bank (2005) "Rural Land Policy in Ethiopia: Aide Memoir",

World Bank (2005) "Sudan: Stabilization and Reconstruction: Country Economic memorandum", Vol1. Main Text, Worlds Bank, Washington DC.

Wood, A (2000) "The Role and Importance of Wetlands in Ethiopia", EWRP Policy briefing Note 1, Ethiopian Wetlands Research programme, Addis Ababa.