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
BARO-SOBAT-WHITE NILE
SUB-BASIN
FINAL

January 2007

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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.	Forward 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 Baro-Sobat-White 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 Baro-Sobat-White Nile Sub-basin covers some 468,215 km^2. The main tributaries of the Sobat are the Baro, Gila and Akobo that rise on the Ethiopian Plateau at some 3,300 masl. The Pibor originates on the southeastern clay plains of Eastern Equatoria east of the Bahr el Jebel as a collector channel of a number of ephemeral channels on the clay plains. Below the Pibor-Baro confluence the Sobat forms a defined channel through grassy plains with numerous back swamps. It joins the White Nile just above Malakal. Below Malakal until its junction with the Blue Nile at Khartoum the White Nile falls about 13 meters over a distance of 840 kms.

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. Land Policy in the South is currently based on customary law, and there are considerable inconsistencies in how customary laws are applied in different Regions. It is generally agreed that land laws in the South are not sound because of the lack of tenure security. In addition, the conditions for land utilization are not clear.

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 increasing deforestation, wetland conversion, soil erosion, sediment loads in the rivers. A number of potential negative environmental impacts from existing or proposed developments are recognized including developments in the oil industry; the proposed Baro 1 and 2 dams; the proposed Machar By-pass canals; the sudden influx of returning IDPs and refugees on community natural resources, wildlife conservation in the Gambela and Boma National Parks and water hyacinth infestation in the Baro, Sobat and White Nile.

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.

Chapter 4 examined lesson learnt from watershed management activities in both Sudan and Ethiopia. It goes on to look 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, sediment loads, deforestation and ensuring sustainable wetland development 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

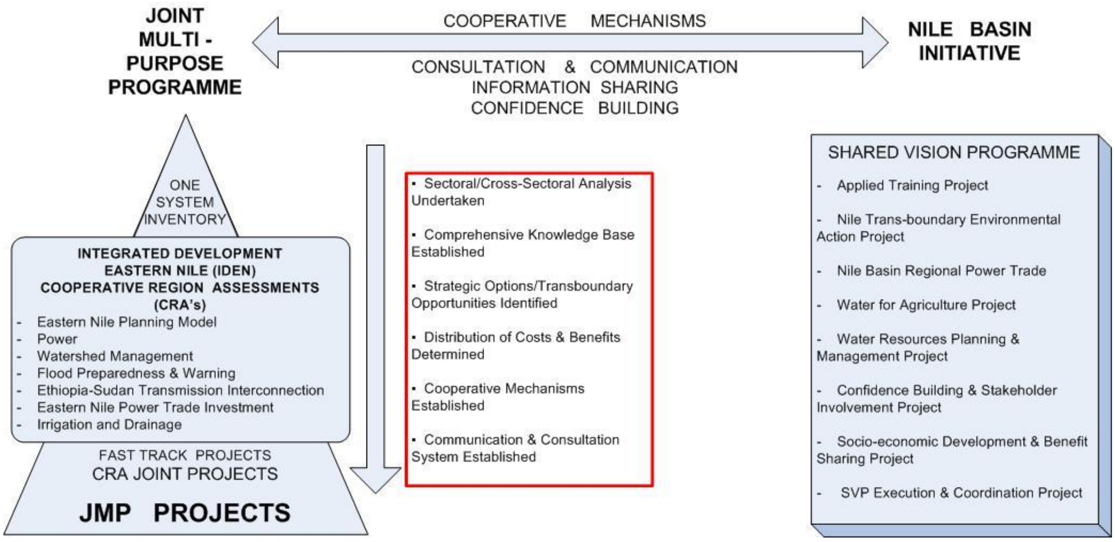
The Eastern Nile Basin Watershed Management Cooperative Regional Assessment (CRA) is in support of the Eastern Nile Subsidiary Action Programme (ENSAP). ENSAP, which includes Egypt, Ethiopia and the Sudan, seeks to initiate a regional, integrated, multi-purpose programme through a first set of investments. 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 trans-boundary 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 trans-boundary benefits and develop long term cooperative arrangements for monitoring land use change, sediment loads and impacts on livelihoods.

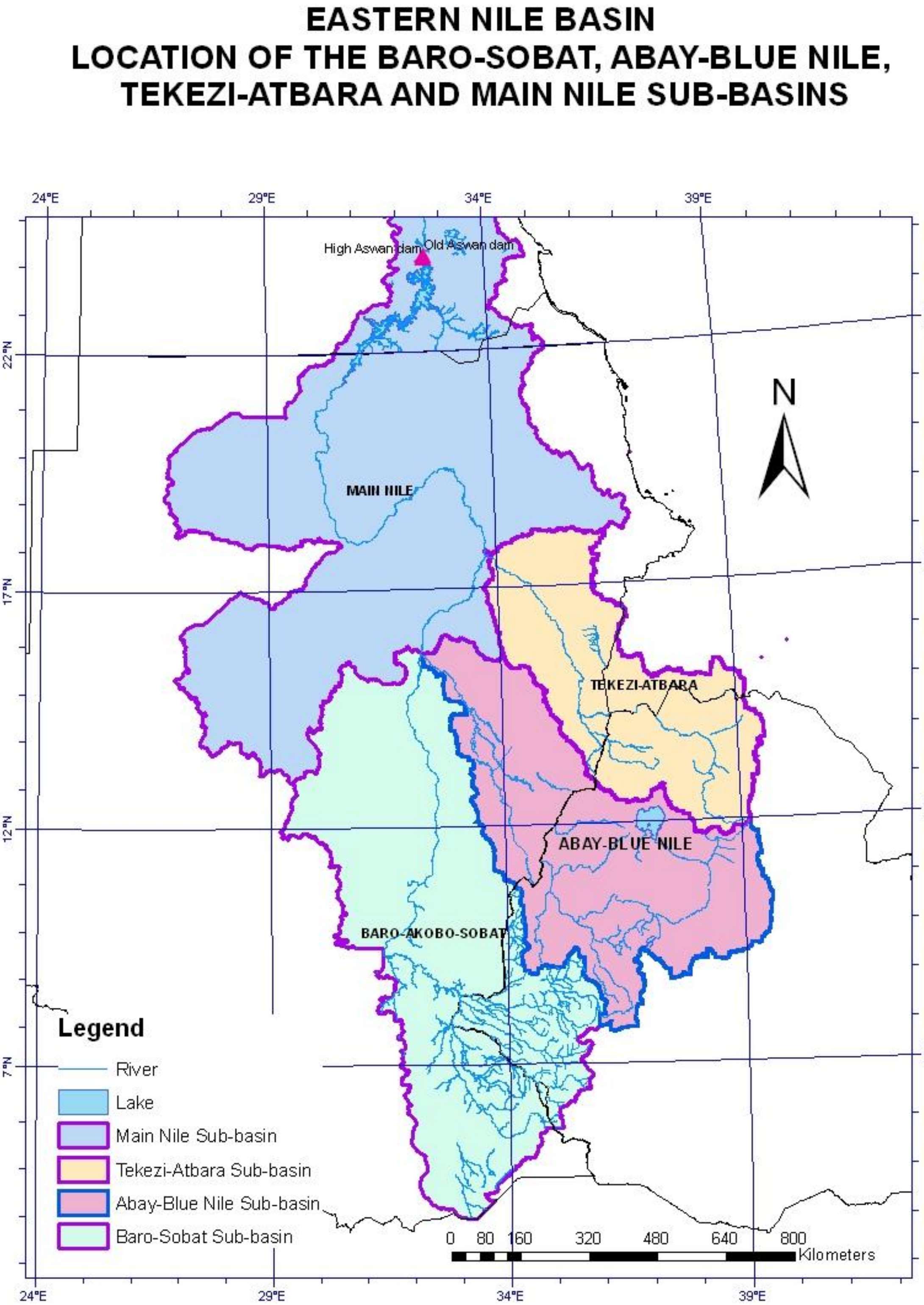
Figure 1. Relationships among and processes of the IDEN CRA's, the Joint Multi-purpose Programme and the Nile Basin Initiative's Shared Vision programme



1.2 Primary Objectives of the Watershed Management CRA

The project focuses on four watersheds: the Abay/Blue Nile, Tekeze/Atbara, the Baro-Sobat-White Nile 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 four 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, Abay/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	Abay-Blue Nile	Very weak

After World Bank (2005a)

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 trans-boundary opportunities to improve livelihoods and achieve poverty reduction. Finally, a Watershed perspective will enable the identification of basin-wide synergies from cooperative trans-boundary interventions.

An 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.

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.

[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.

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 Sub-basin Reports

1.4.1 The Whole Process

The National and Sub-basin Transboundary component and the Distributive Analysis 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;

- 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.

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 Baro-Sobat-White 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 SWHISA 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. SUB-BASIN-WIDE BEHAVIOUR AND LIVELIHOODS: BIO-PHYSICAL AND SOCIO-ECONOMIC SITUATION

2.1 Bio-physical Situation

2.1.1 Watershed and Rivers

The Baro-Sobat-White Nile Sub-basin covers some 468,215 km^2. The main tributaries of the Sobat are the Baro, Gila and Akobo that rise on the Ethiopian Plateau at some 3,300 masl. The Highlands are covered in dense Montane High Forest, although this is rapidly being converted to agriculture. The plains below are covered with a Lowland Baphia Forest that gives way to savanna woodland and then swamp grassland plains. Below Gambela the Baro bifurcates into the Baro and the Adura which rejoin about 70 kms downstream. The Jakau joins the Baro, but below this junction are a number of spills from the Baro into the Machar Marshes (see Map 12 and figure 2 for detailed information).

The Pibor originates on the southeastern clay plains of Eastern Equatoria east of the Bahr el Jebel as a collector channel of a number of ephemeral channels on the clay plains. Although the catchment's southern boundary lies along a number of upland hills and mountains the streams that originate on these rarely if ever cross the plains. Rather they coalesce into a "creeping flood" upto one or two meters deep most of which either evaporates or just reaches the upper collector channels of the Pibor.

Below the Pibor-Baro confluence the Sobat forms a defined channel through grassy plains with numerous back swamps. It joins the White Nile just above Malakal. The Bahr el Jebel and the Bahr el Zeraf strictly become the White Nile at their confluence at Lake No, although the Sobat junction is the point at which most hydrological measurements are made. Below Malakal until its junction with the Blue Nile at Khartoum the White Nile falls about 13 meters over a distance of 840 kms. The inflows from tributaries are small and sporadic. The natural flow regime has been disturbed by the construction of the Jebel Aulia dam 40 kms above the confluence. Irrigation and evaporation have increased losses from the White Nile.

The Sub-basin is divided into nine major catchments. Because of the very flat gradients over most of the Sub-basin division into lower order catchments is virtually impossible with the current digital terrain models. Thus in Sudan the USGS/EROS gtopo30 HYDRO1k data set published by UNEP/DEWA/Grid was not used. Here resource was made to a visual interpretation of the DTM and to the drainage patterns to define the major catchments of the Sub-basin. The areas of the major catchments are shown in table 2.

Table 2. Baro-Sobat-White Nile Sub-basin: Major Catchments - Area (km2) and % of Area

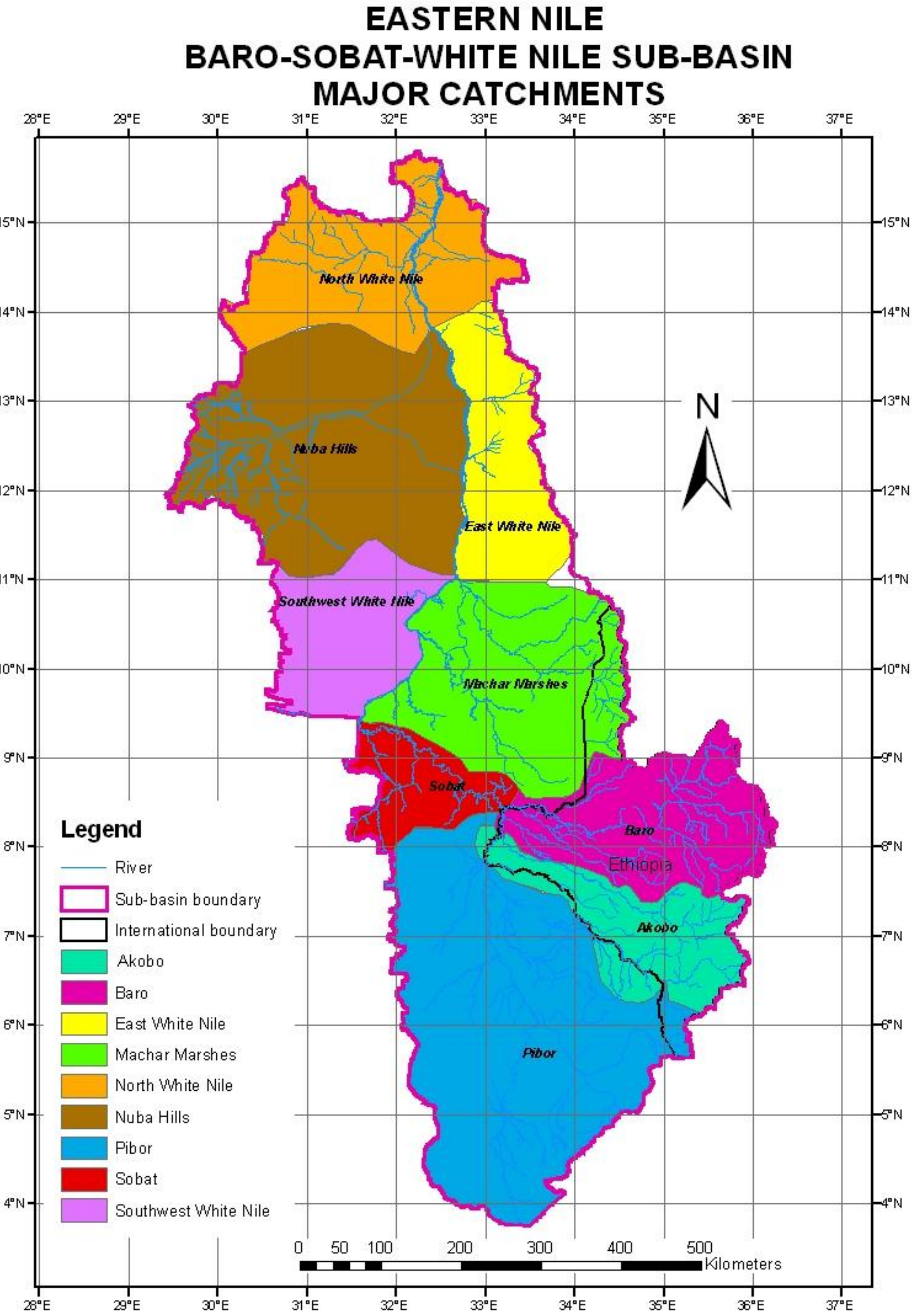
Major Catchment	Area (km2)	% of total Sub-basin area
Pibor	110,873	24%
Nuba Hills	85,293	18%
Machar Marshes	61,682	13%
North White Nile	49,608	11%
Baro	43,838	9%
East White Nile	33,955	7%
Akobo	31,979	7%
Southwest White Nile	31,903	7%
Sobat	19,085	4%
SUB-BASIN	**468,216**	

Source: Basin boundaries: Ethiopia MWR (Addis Ababa) and Sudan: Visual interpretation. .

Despite its much larger catchment the Pibor -with Akobo and Gilo - only supply about 25 percent of the Sobat flow, whilst the Baro supplies 75 percent even after spill to the Machar Marshes.

2.1.2 Relief

In Ethiopia the Baro-Akobo Sub-basin can be divided into two major landscape units of roughly equal size, the western lowlands and the eastern highlands. They are separated by an escarpment and areas of severely dissected highlands. The western half the sub-basin is below 1,000 masl while the highest points in the eastern half of the sub-basin exceed 3,000 masl at Mount Seccia in the east, where the sub-basin watershed is with the Omo-Ghibe River system, and above 3,300 masl at Mount Tulu Welel in Western Wellega.



Map 2. Baro-Sobat-White Nile Sub-basin: Major Watersheds

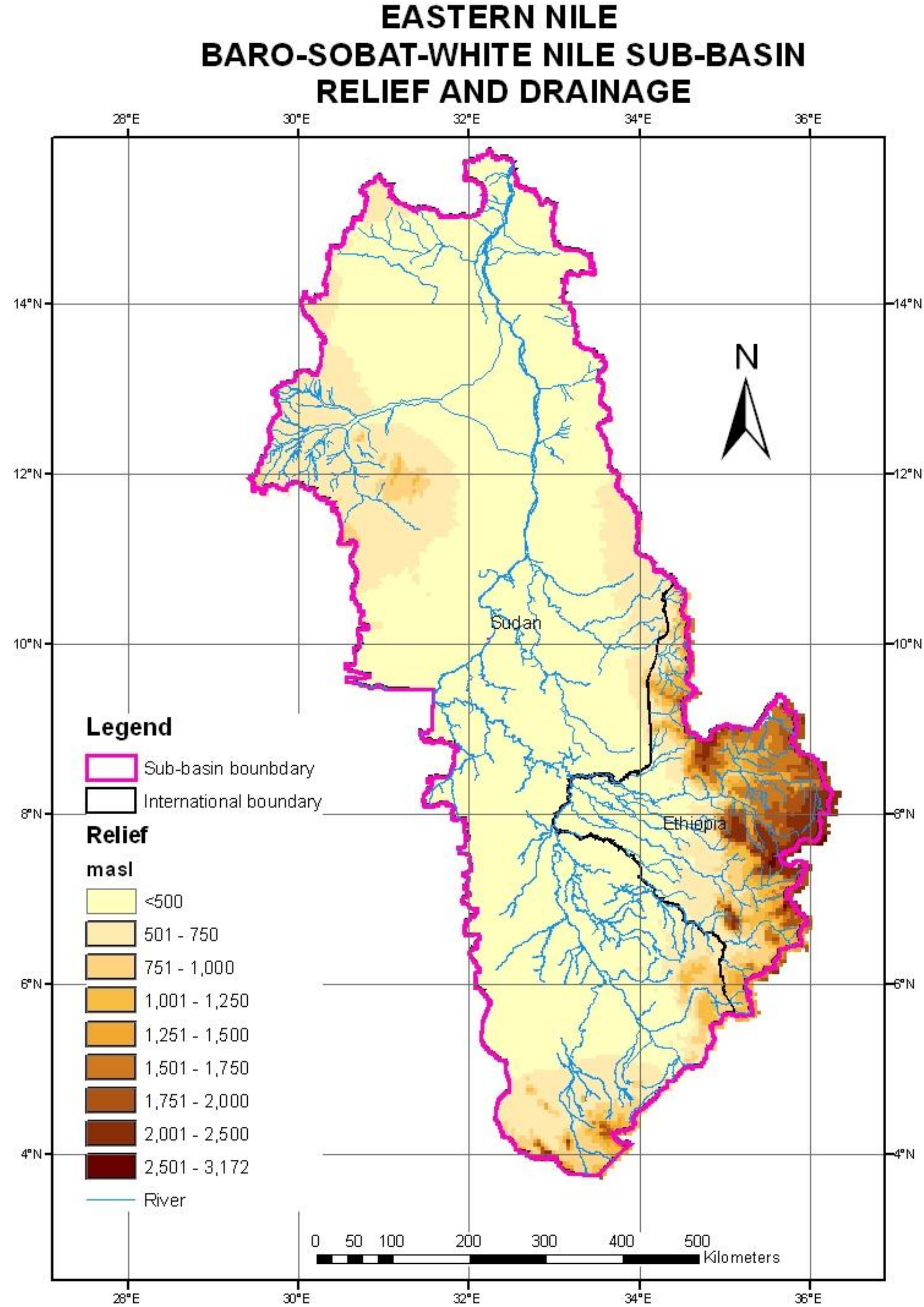
Source: Basin boundaries: Ethiopia MWR (Addis Ababa) and Sudan: Visual interpretation. .

The Gambela salient in the west lies below 700 masl and comprises gently sloping to almost flat plains that continue into the Sudan crossing the border in the west at an altitude of around 400 masl. The plains are abruptly terminated in the east by a well defined, north-south escarpment. North of the salient the foot of the escarpment is less precise and forms a belt of lower altitude broken highlands in BeneShangul-Gumuz RS. A similar area of broken highland terrain is found in the western part of SNNPR around Mizan Teferi and reaching out to Gurafarda, a highland outlier. The highland part of the sub-basin in the east is above 1,500 masl. It is an undulating to rolling plateau, mostly between 1,600 and 2,100 masl, steeply incised by the major rivers with isolated high mountains such as Mount Tulu Welwel and Seccia.

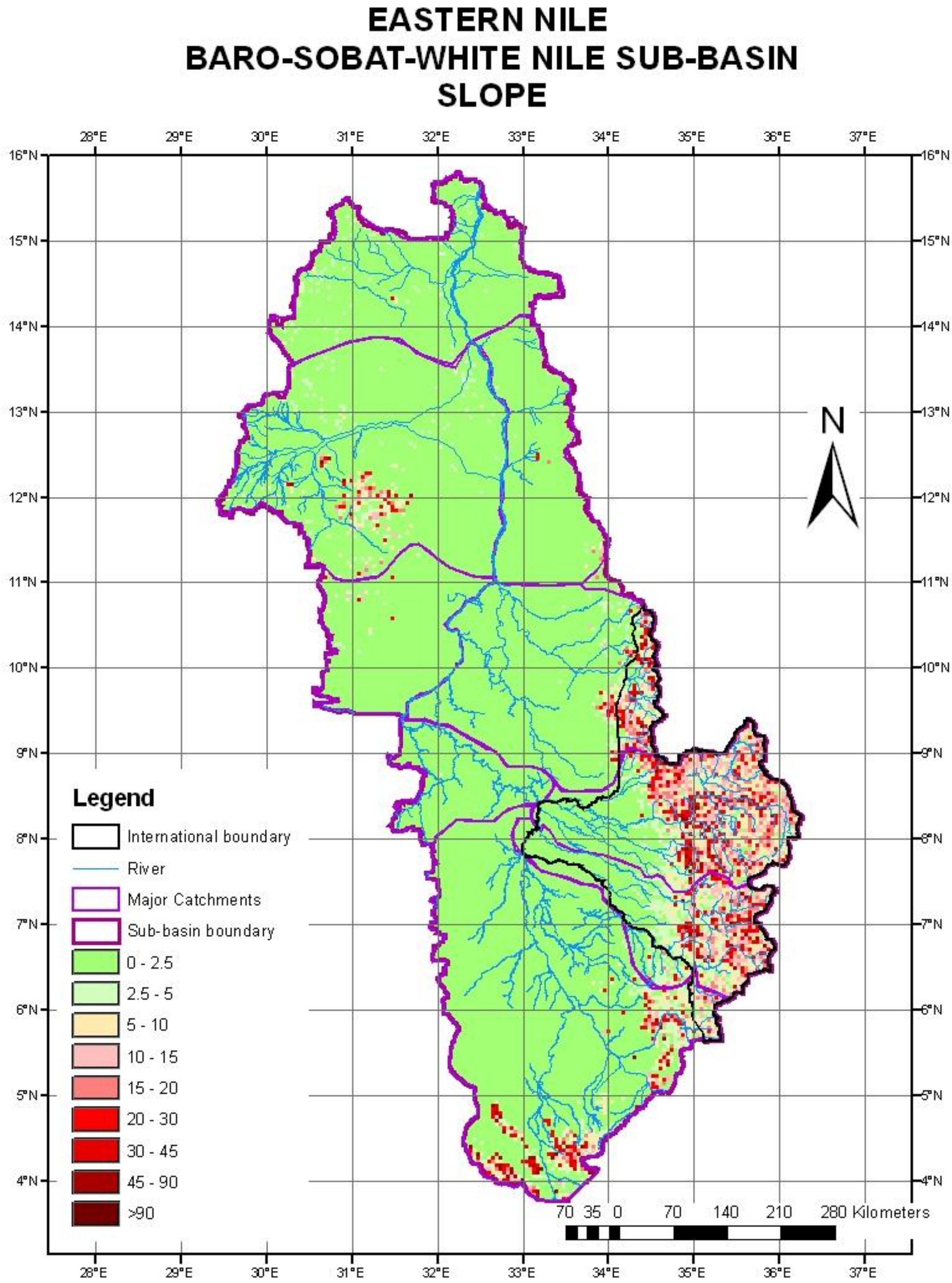
The main relief features in the south of the Pibor-Sobat Sub-basin are a series of steep hills and mountains of basement complex rocks stretching north-eastwards along the Sudan-Uganda-Kenya border reaching up to 3,187 masl on Mount Kinyeti in the Imatong Mountains. Around these is a foothill zone of lower angle slopes that merge into very flat clay plains that stretch northwards to the Sobat River. These plains have very gentle slopes between 0.010 and 0.012 %. The watershed between the Sobat and the Omo-Lake Turkana basin to the east is very low. In the recent geological past water flowed from Lake Turkana into the Nile basin.

On the western side of the southern part of White Nile Sub-basin are the Nuba Mountains rising to about 1,500 masl. To the east are wide clay plains with the Machar Marshes in the south. These plains terminate abruptly in the east against the Ethiopian Highlands. Further north the valley widens with low relief on both sides of the river with a very low watershed between the White and Blue Niles.

Steep slopes clearly mirror the high relief (Map 4). The escarpment at the edge of the Ethiopian Highlands, the Imatong Mountains and associated hills and the Nuba Hills all stand out. Less clear are the steep slopes of the hills on the Boma Plateau.



Map 3. Baro-Sobat-White Nile sub-basin: Relief and drainage
Source: Shuttle Radar Terrain Mission (SRTM 90) digital terrain model.



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

2.1.3 Climate

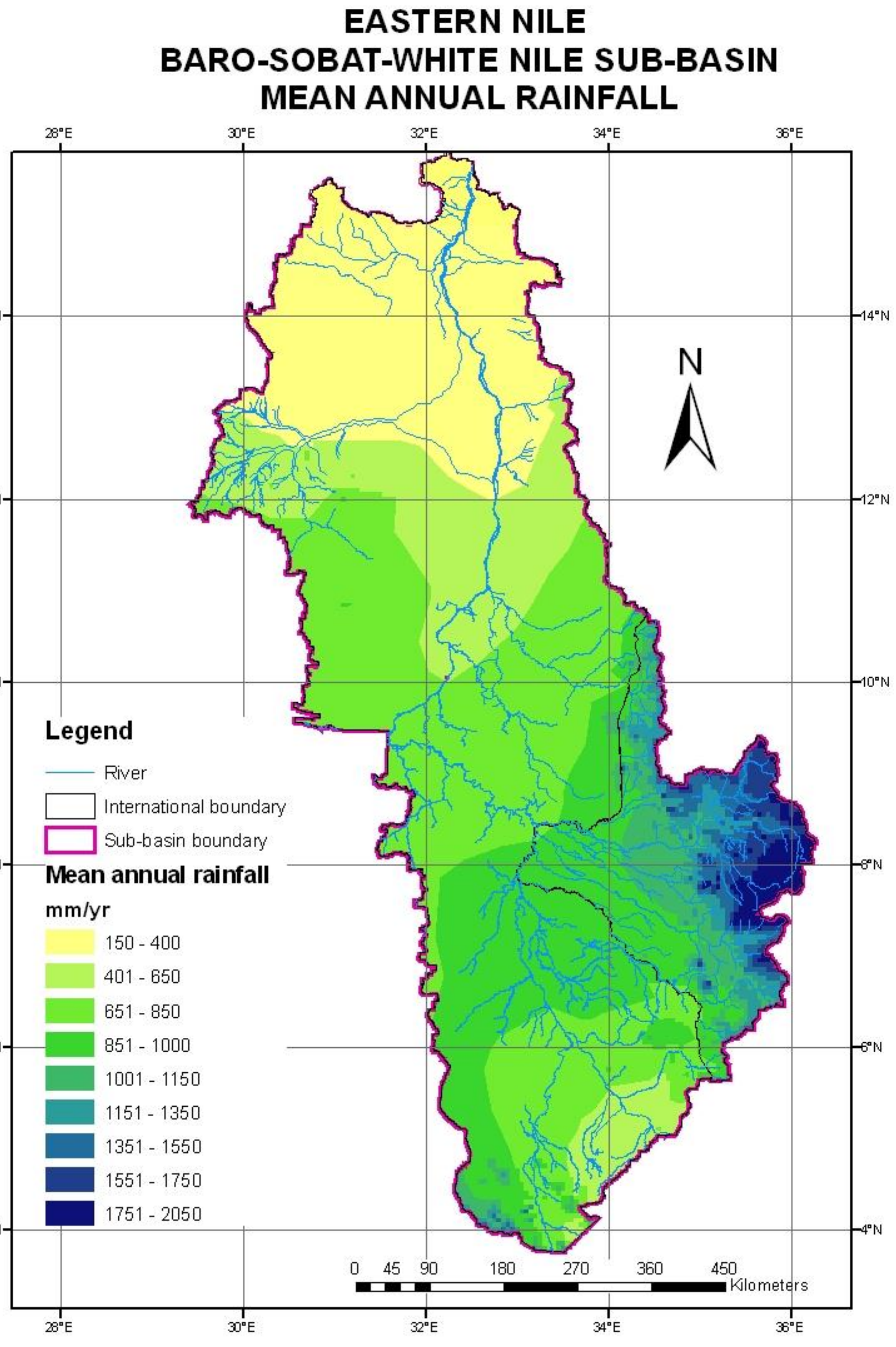
(i) Rainfall

The Baro-Sobat-White Nile Sub-basin within Ethiopia is a particularly well-watered region of the country. However, the spatial variation of the mean annual rainfall is considerable due to the great range of difference in elevation across the basin. Average annual precipitation is as low as 600 mm in the lowlands (less than 500 masl), while it reaches as high as 3,000 mm over the highlands (over 2,000 masl). Most of the upper basin has an annual total of more than 1,800 mm while Gore has an average annual total of over 2,200 mm.

The rainy period is from May to October when 85% of the annual precipitation occurs with a single peak in July. Average rainfall greater than 100 mm occurs from May to October (a six months rainy season). Months with average rainfall greater than 200 mm are June, July, August and September. On average, November, December, January and February are dry months.

On the Gambela plain below 500 meters elevation only about six years in ten have a dependable rainfall of at least four months, which is sufficient to support good yields of most annual crops. Above about 1,000 masl the dependable growing season for annual crops is reliable and failures would occur in only about one year in twenty, and even longer than that above 2,000 masl. In an average season and better, a second rainfed crop should yield well during a dependable growing season of seven and more months in the Highlands.

Within Sudan the highest rainfall is found in the southwest and southeast of the Sub-basin where the mean annual rainfall exceeds 1,000 mm/yr. Over much of the Pibor-Sobat Sub-basin it varies between 750 and 1,000 mm/yr. In the White Nile Sub-basin rainfall decreases northwards from 750 to 250 mm near the junction of the White and Blue Niles. However, everywhere rainfall exhibits both seasonal and year-on-year variability. Variability increases form south to north.



Map 5. Baro-Sobat-White Nile: Mean Annual Rainfall (mm/yr)

Source: ENTRO GIS Database

(ii) Temperature and Evaporation

(a) Temperatures

The temperature range in the Baro–Akobo basin is from about 27.5°C below 500 meters elevation on the flood plain to about 17.5°C at 2,500 meters in the highlands (Map 6). Mean monthly maximum temperatures range from below 22°C, in the highlands around Kombolcha (Wollega) to about 40°C, in the lowlands of Gambela around Akobo.

Maximum temperatures in the highlands rarely exceed 25°C, whereas in the lowlands they generally exceed 36°C during the hotter months of January to April. Mean maximum temperatures greater than 30°C occur from February to April in the Lowlands while July and August have the mean maximum temperature values less than 25°C.

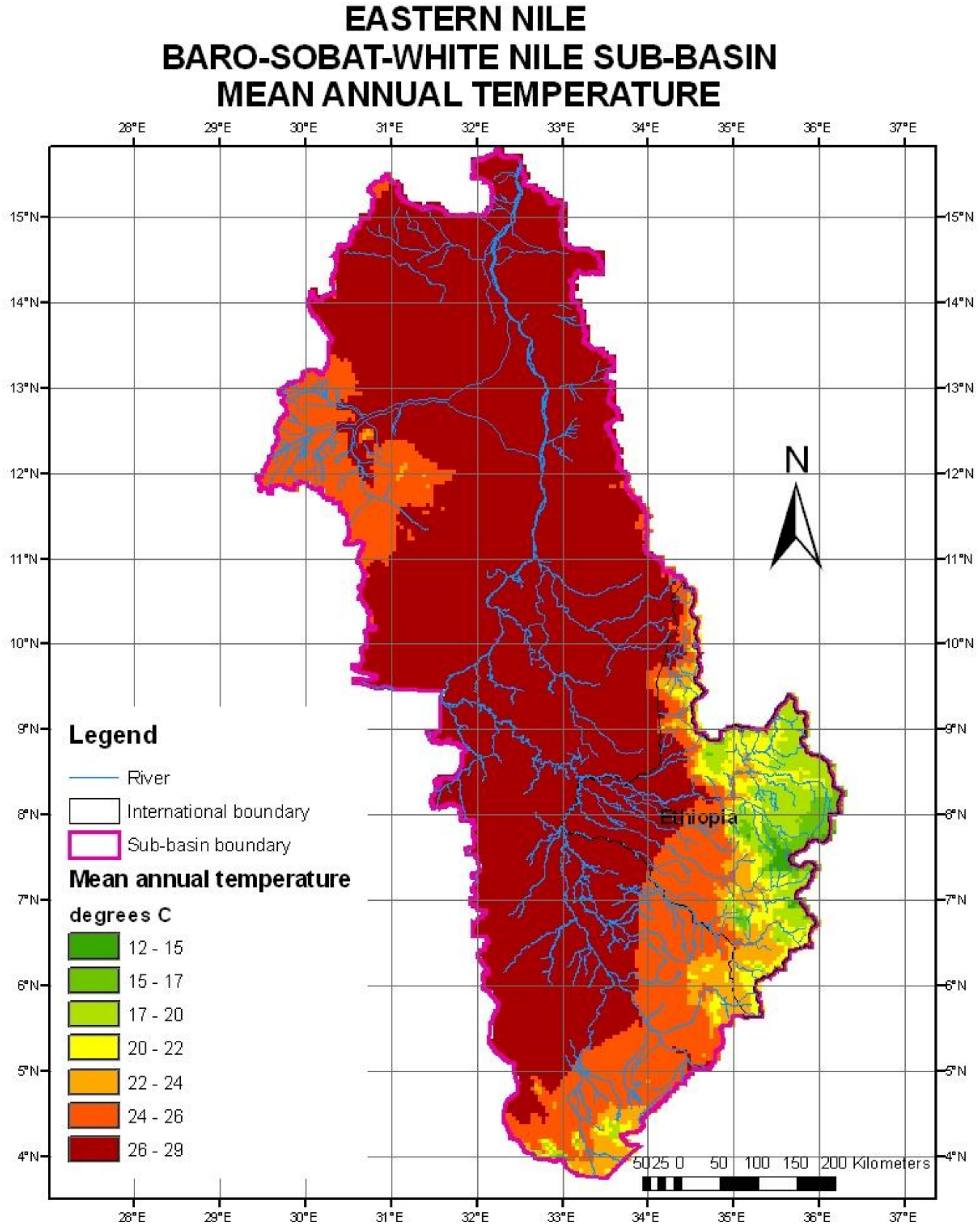
The mean monthly minimum temperatures generally range from 14 – 16°C in the highlands of Illubabor and western Wollega, but they sometimes drop to below 10°C in isolated locations of the highlands during November-February. The mean monthly minimum temperature pattern shows a maximum temperature value in April and a minimum temperature value in December. The mean minimum temperature values greater than 15.5°C occur from January to May while the mean minimum temperature values ranging from 14°C to 15.4°C occur from June to December.

In the Pibor-Sobat Sub-basin mean annual temperatures range from about 17°C in the southern mountains to 26°C at the Sobat-White Nile junction. In the White Nile valley temperatures are generally 25-27°C along the river but decrease with altitude in the Nuba Mountains and towards the Ethiopian highlands.

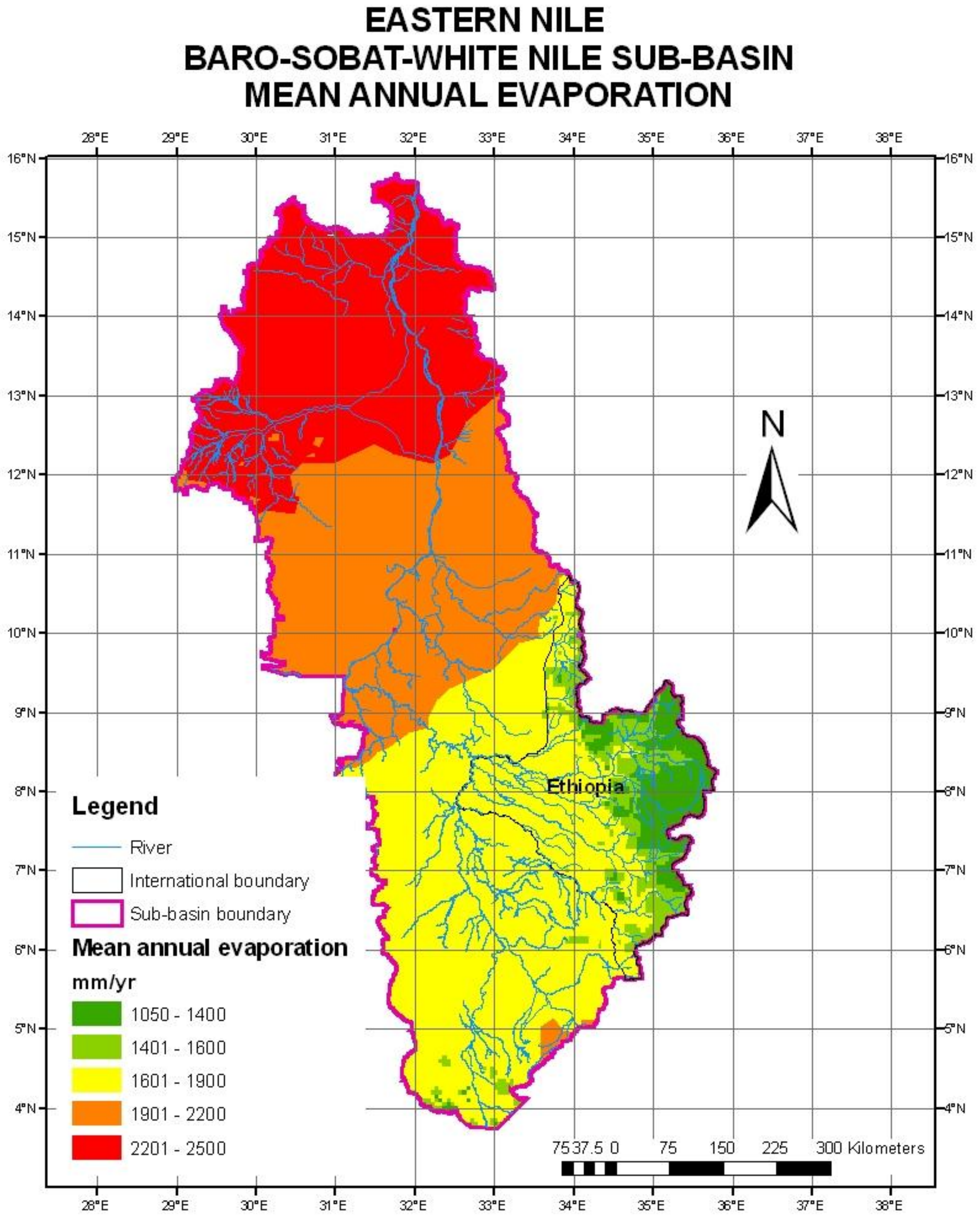
(b) Evaporation

The temporal pattern of the average monthly evaporation of the Baro–Akobo basin (Map 7) correlates well with the monthly mean maximum temperature distribution over the basin. The average monthly maximum evaporation occurs from February to May and the minimum from June to September. As may be expected, potential evapotranspiration is lowest over the highlands and increases progressively towards and onto the Gambela lowlands. For example, Gore (2,130 masl) has a total evapotranspiration of 1,263 mm/yr while Jikawo (410 masl) has a total evapotranspiration of 1,545 mm/yr.

In Sudan rates of 1,450 mm/yr occur in the southern mountains and increase northwards to 2,500 mm/yr at the junction of the White and Blue Niles.



Map 6: Baro-Sobat-White Nile Sub-basin: Mean Annual Temperature (degrees C).
Source: ENTRO GIS Database



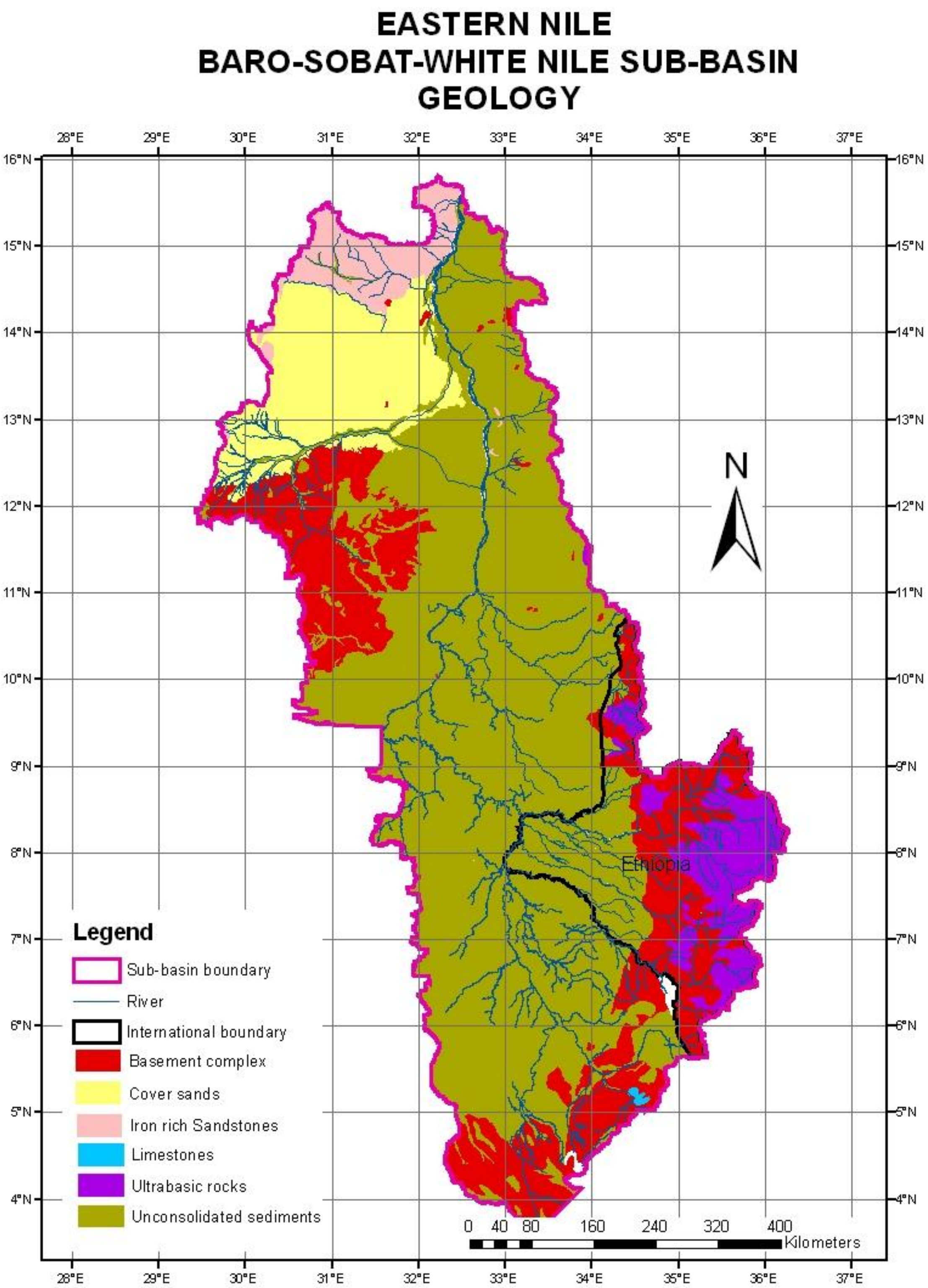
Map 7. Baro-Sobat-White Nile: Mean Annual Evaporation (mm/yr)
Source: ENTRO GIS Database

2.1.4 Geology

The Baro and Akobo catchments consist primarily of Basement crystalline rocks in the eastern uplands with a covering of Tertiary lavas in places and Quaternary sediments in the lowlands to the west.

The surface and near surface geology of the high mountains zone (2,400 to 3,300 masl) is formed by weathered Tertiary basalts capped in places by resistant Quaternary volcanic rocks. West of the high mountainous area lies a high plateau ranging from about 1,300 to 2,400 masl, which is underlain by basalts and granites. Next in westward succession are the crystalline basement complex rocks that form the Masongo Ranges and vary in elevation from about 800 to 1,400 masl. The western-most geomorphic zone in the basin is occupied by the gradually westward slopping surface of the Gambela Plain. This plain is formed and underlain by unconsolidated and undifferentiated Plio-Quaternary sediments that grade westward from about 495 masl at Gambela to 400 masl at the Ethiopia – Sudan border.

Granites and gneisses of the basement Complex outcrop in the mountains and hills of the southern part of the Pibor-Sobat basin. North of these stretching all the way the Blue and White Nile junction are deep deposits of Quaternary and late tertiary Unconsolidated Sediments. To the west of the White Nile Basement Complex gneisses outcrop in the Nuba Mountains.



Map 8. Baro-Sobat-White Nile Sub-basin: Geology
Source: FAO, 1998 "Soil and Terrain Database for Northeast Africa

2.1.5 Soils

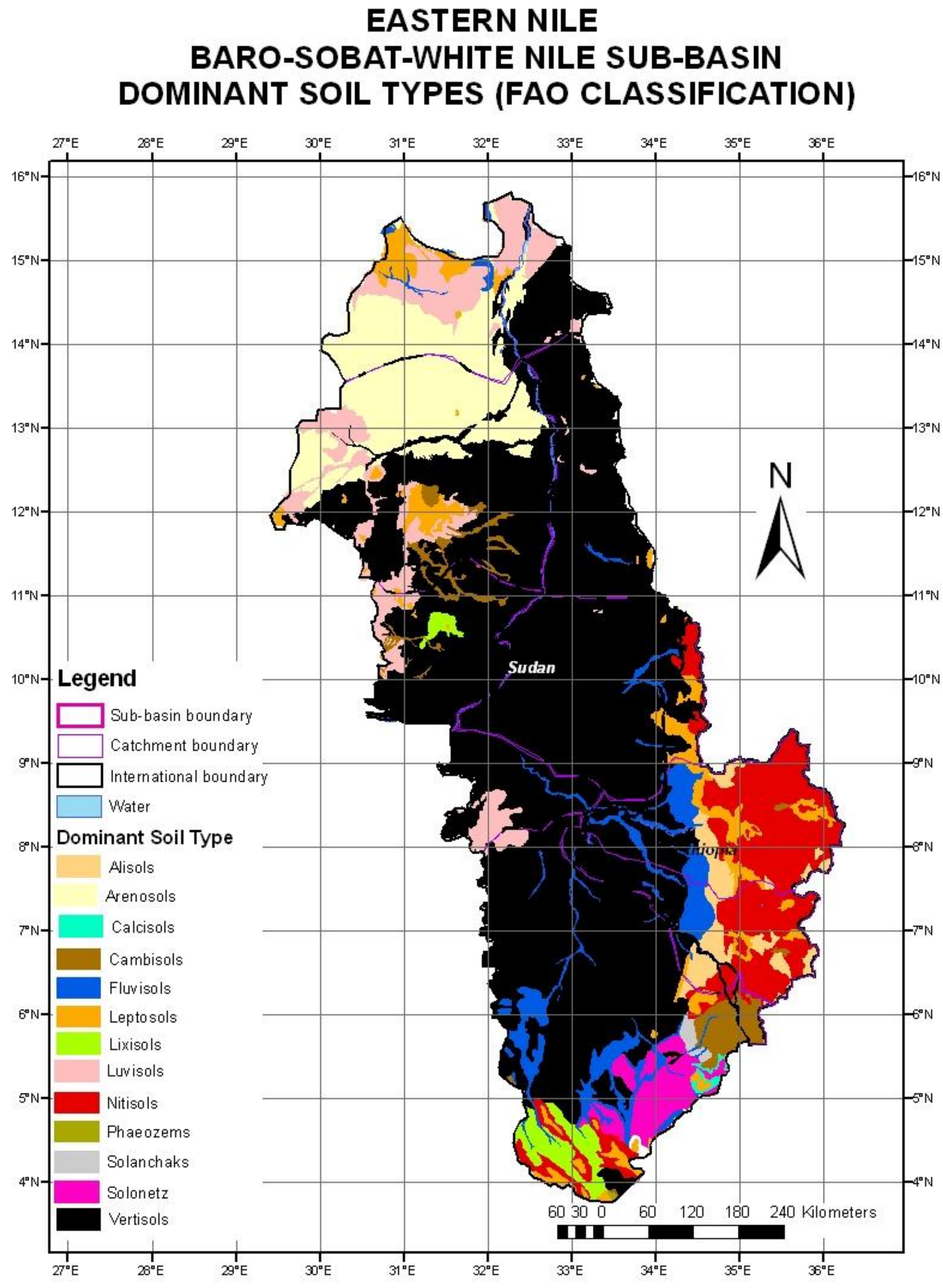
The predominant soils in the highlands are the Nitisols, which usually are deep with smaller areas of Leptosols (table 3). Unconsolidated Sediments that cover all of the Lowlands in Ethiopia and Sudan are overlain by very extensive areas of Vertisols – deep black cracking clays (56 percent of the area). Arenosols derived from wind blown sands are extensive in the north-western part of the Sub-basin (10 percent of the area). Locally Fluvisols occur on coarser textured recent alluvial sediments. A range of soil types occur over the southern Mountains and hills, including Lixisols, Nitisols and Leptosols. On their footslopes and across to the Boma Plateau in the south-east are Cambisols and Solonetz soils.

Deeper Luvisols and shallower Leptosols occur in the Nuba Mountains. Very course textured Arenosols overlay the Cover Sands that merge into Phaeozems and Leptosols over the Nubia Sandstones.

Table 3. Baro-Akobo-White Nile Sub-basin: Dominant Soil Types - % of Area

Soil Type	Area (km^2)	% Area
Vertisols	262,785	56.1%
Arenosols	48,779	10.4%
Nitisols	41,657	8.9%
Luvisols	30,397	6.5%
Fluvisols	23,381	5.0%
Leptosols	20,554	4.4%
Cambisols	10,541	2.3%
Alisols	10,048	2.1%
Solonetz	9,757	2.1%
Lixisols	7,190	1.5%
Water	1,252	0.3%
Solonchaks	1,056	0.2%
Calcisols	710	0.2%
Phaeozems	109	0.0%
	468,216	

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



Map 9. Baro-Sobat-White Nile Sub-basin: Dominant Soil Types (FAO Classification)

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

2.1.6 Vegetation

Information on the vegetation of the Baro-Sobat-White Nile has been obtained from a number of sources. For Sudan these include the Jonglei Investigation Team's study (JIT, 1954), that of the Southern Development Investigation Team (SDIT, 1955), Mann (1977), Obeid Mubarak et al., (1982), Mefit-Babtie (1983), Howell et al., (1988), Howell and Lock (1993), FAO (2005), and Bussmann (2006). For Ethiopia sources included Chaffey (1979), Friis (1993), WBISPP-MARD (2002), Wood and Abbott (2001) and EWLNRS-Bird Life International (1996).

(i) Forest Types

The various forest and woodland types found in the sub-basin are described below:

(a) Aningeria Forests

Aningeria forests lie between 1600 and 2000 m in the Ethiopian Highlands where the annual rainfall is about 1600-2400 mm. The species composition of this type is high due to its wide range of suitable climate conditions. Important species include *Syzygium guineense, Ficus* spp, *Olea welwitschll, Prunus africana, Albizzia gummifera, Polyscias fulva, Morus mesozygia, Ekbergia capensis, Celtus gomphophylla, Cordia Africana*, and *Croton machrostachyus*.

(b) Olea Forests

Olea forests lie between 1,500 and 2,000 masl in both the Ethiopian Highlands and in the Imatong Mountains. Their preference for gentle slopes exposes them to disturbance and exploitation. They comprise a wide range of commercially desirable species: *Olea welwitschii, Bosqueie phoberos, Apodytes dimidiate, Polysicias ferruginea, Olea hochstetteri, Cordia abysinnica* and *Syzygium guineense*.

(c) Evergreen Forests

Evergreen forests occur throughout the highland plateau. Remnants of the forests which once clothed Ethiopia’s uplands, they are now made up of islands of trees whose under-storey has been removed to provide space for coffee; there is no forest regeneration. Nonetheless, the trees continue to provide a low intensity of habitat for birds and other life as well as some slight hydrological benefit.

(d) Lowland Baphia Forests

Baphia forests often merge with riparian forest. It is an open Lowland forest type with associations with the Sudano-Guinea rainforest realm. It is found in the Gambela Lowlands. It contains such species as *Zizyphus pubescens, Diospyrus mesipiliforms, Alstonia boonei, Celtis integrifolia*, and *Chlorophora excelsa*. Woodland species, *Albizzia schimeriana, Croton macrostachyus*, and *Combretum molle*, also occur. Baphia forests are under threat from burning and fuel wood collection.

(e) Tropical rain forest

This is confined to a few small and scattered localities in the south-western part of the Pibor Catchment. The Talanga, Lotti and Laboni forests are found at the base of the Imatong Mountains. In these forests, four stories can be distinguished in the vegetation: the canopy trees, which are 30–50 meters high with long, straight trunks, often buttressed at the base; the second-storey trees, from 15 to 30 meters high, usually not so straight, more copiously branched and with less tendency to form buttresses; the shrub layer, 4–6 meters high, often very dense, with numerous creepers and lianas, and the ground layer of herbs and grasses, usually sparse and often absent. The species occurring in rain forest are similar to those of the drier parts of the forests of West Africa. The most common species are *Chrysophyllum albidum* and *Celtis zenker*i, with *Holoptelea grandis* in Azza forest. A number of valuable timber trees are found, including *Khaya grandifoliola*, *Chlorophora excelsa, Entrandrophragma angolens*e and others.

(f) Podopcarpus Forest of the Imatong Mountains

Between 1,500 and 2,600 masl, the climax vegetation is closed evergreen forest with *Podocarpus milanjianus*, *Olea hochstetteri* and *Syzygium spp.* dominant over a shrubby understorey. Regret of *Acacia xiphocarpa* occupies large areas of old cultivation sites.

Between 2,600 and 3,000 masl *Podocarpus milanjianus* again forms the climax vegetation, but is less mixed with other species, apart from a little *Olea hochstetteri*. This zone includes large areas of mountain meadow dominated by the sedge *Bulbostyles atrosanguineus*. The bamboo *Arundinaria alpina* is also found. Much of the ground is wet or swampy because of the combination of high rainfall and low potential evapo-transpiration. Above 3,000 masl, ferns, *Erica arborea* and *Myrica salicifolia* are dominant. Many species of herbs occur.

(g) Riparian Forests

Riparian forests extend throughout the plateau drainage pattern, dropping down to the flood plains. Like woodlands of the savannah and upland basin, riparian forests are under enormous pressure from local and refugee populations. Important species include *Celtis kraussiana, Ficus sycamorus, Mimusops aethiopum, Tamarindus indica, Maytenus senegalensis, Kigelia aethiopum, Syzgium guinenses* and Acacia spp.

(ii) Highland and Lowland Bamboos

(a) Highland bamboo thicket (Arundaria alpine)

This occurs on gentle slopes above 2,400 masl in the high rainfall areas of both the Ethiopian Highlands and the Imatong Mountains. It is generally in pure stands or occasionally interspersed with trees.

(b) Lowland bamboo (Oxytenanthera abyssinicus)

Within the Baro-Akobo catchment 127,400 ha of lowland bamboo are found in Assossa Zone of BS-G Region and extends into Sudan. It occurs in two main forms: in pure continuous stands with few or no trees or shrubs, and as clumps scattered with woodland and shrubland.

In the dense pure stand bamboo area of Ambessa Chaka Forest, LusoConsult estimated an average of 8,124 live culms per hectare, weighing 19.53 tons per hectare. The density of culms in open “clumped bamboo/woodland-shrubland” is probably about 20 percent of that in the dense pure stands

(iii) Woodland Types

(a) Mixed Deciduous Woodlands

Mixed deciduous woodlands extend along the south-western and north-western edges of the plateau at about 1200m altitude. Their species include *Albizzia schimperiana, Croton macrostachyus, Euphorbia abyssinica, E. candelabrum, Grewia bicolour, Bersama abyssinica,* and *Acacia* spp, among others.

(b) Acacia seyal-Balanites Savanna

Above 570 mm to about 1,500 masl 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* is becoming increasing prevalent because it is fire resistant, does not produce good charcoal and is hard to cut.

(c) Acacia Thornland alternating with Grassland on Clays

Between the 360 mm and 570 mm isohyets on the heavy clays on either side of the White Nile 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 has 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.

(d) Acacia senegal Savanna and *Combretum cordofanum* Savanna on Sands

Between the 360 mm and 570 mm isohyets on the western side of the White Nile on the sandy Arenosols of the cover sands and stabilized sand dunes there occurs Acacia senegal Savanna. The former is most extension and tree species include *Acacia senegal*, *A. tortilis* and *Indigofera oblongifolia*. This area comprises the sandy Gum Arabic belt.

The grass cover is represented by the genera *Cenchris* and *Aristida.* Occasionally the valuable the perennial grass *Andropogun gayanus* is found.

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) Seasonally River-flooded Grasslands

These grasslands are flooded annually to varying depths and periods and form the *toich*, which yields dry season grazing essential to the Nuer and Dinka agro-pastoralists. Two main types can be distinguished: (a) *Oryza longistaminata* dominant, and (b) *Echinochloa pyramidalis* dominant (Howell, 1988).

(a) Oryza longistaminata Dominant Grassland:

The dominant species constitutes 80-90 percent of the standing crop. Oryza does not flower or reach maximum production unless it has been deeply flooded for several months. It yield 1t/ha when not flooded to 7 tons/ha when deeply flooded for a long period. These grasslands are burnt each year early in the dry season. Although a perennial it can produce abundant seed. They provide high quality grazing for much of the year even into the dry season.

(b) Echinochloa pyramidalis Dominant Grassland:

These grasslands are further away from the river and thus flooded less frequently (although a tall variant grows close to the river). It occupies Vertisols with much *gilgai* micro-relief. The species produces growth even during the dry season and is thus a year-round pasture. Associated species include *O. longistaminata*, *Sporobulus pyramidalis*, *Digitaria debilis* and *Echinochloa haploclada*.

(v) Seasonally Rain-flooded Grasslands

Three types are recognized: (a) *Echinoochloa haploclada* grassland, (b) *Sporobolus pyramidalis* grassland, and (c) *Hyperhennia rufa* grassland.

(a) Echinochloa haploclada Grassland:

Between the river-flooded and the rain-flooded grasslands there is often a strip of land with light textured soils and slightly elevated, which is used for settlement and cultivation. As livestock are concentrated here for long periods this grassland is heavily grazed. Nutritionally the grassland is of very high quality during the wet season but quality falls off during the dry season.

(b) Sprobolus pyramidalis Grassland:

This tussock-forming species is not widespread. It is characteristic of heavily grazed areas. It makes no growth during the dry season, is low in protein and during the dry season nutrient levels fall below those needed for maintenance. It is used to make string used in house construction.

(c) Hyperrhenia rufa Grassland:

These grasslands occupy level ground out of reach of river-flooding but are inundated by rain for varying periods. In some northern areas Hyperrhenia may be replaced by *Setaria incrassata*. Although biomass attains 6-7 tons/ha at the end of the wet season, 90 percent of this is stem and contains little of value to livestock. A high proportion of these grasslands are burnt each year. They are generally used at the beginning of the wet season and at the beginning of the dry season after burning. The grass provides a major source of thatching material.

(vi) Swamp vegetation

Three types of swamp vegetation are distinguished: (a) *Cyperus papyrus* swamp, (b) *Typha domingensis* swamp, and (c) *Vossia cuspidata* swamp.

(a) Cyperus papyrus Swamps:

These swamps form a fringe along water courses, pools and other water with deep and constant depth. The plants form a floating mat upon which other species – mainly climbers are found.

(b) Typha domingensis Swamps:

These are most extensive away from the river channels. The vegetation is not floating but rooted into the substrate covered by very shallow water. There are few other plant species. This is probably the extensive swamp type in the Machar Marshes

(c) Vossia cuspidata Swamps:

This vegetation is found next to flowing water. It has creeping, submerged or floating stolons. It is often associated with water hyacinth.

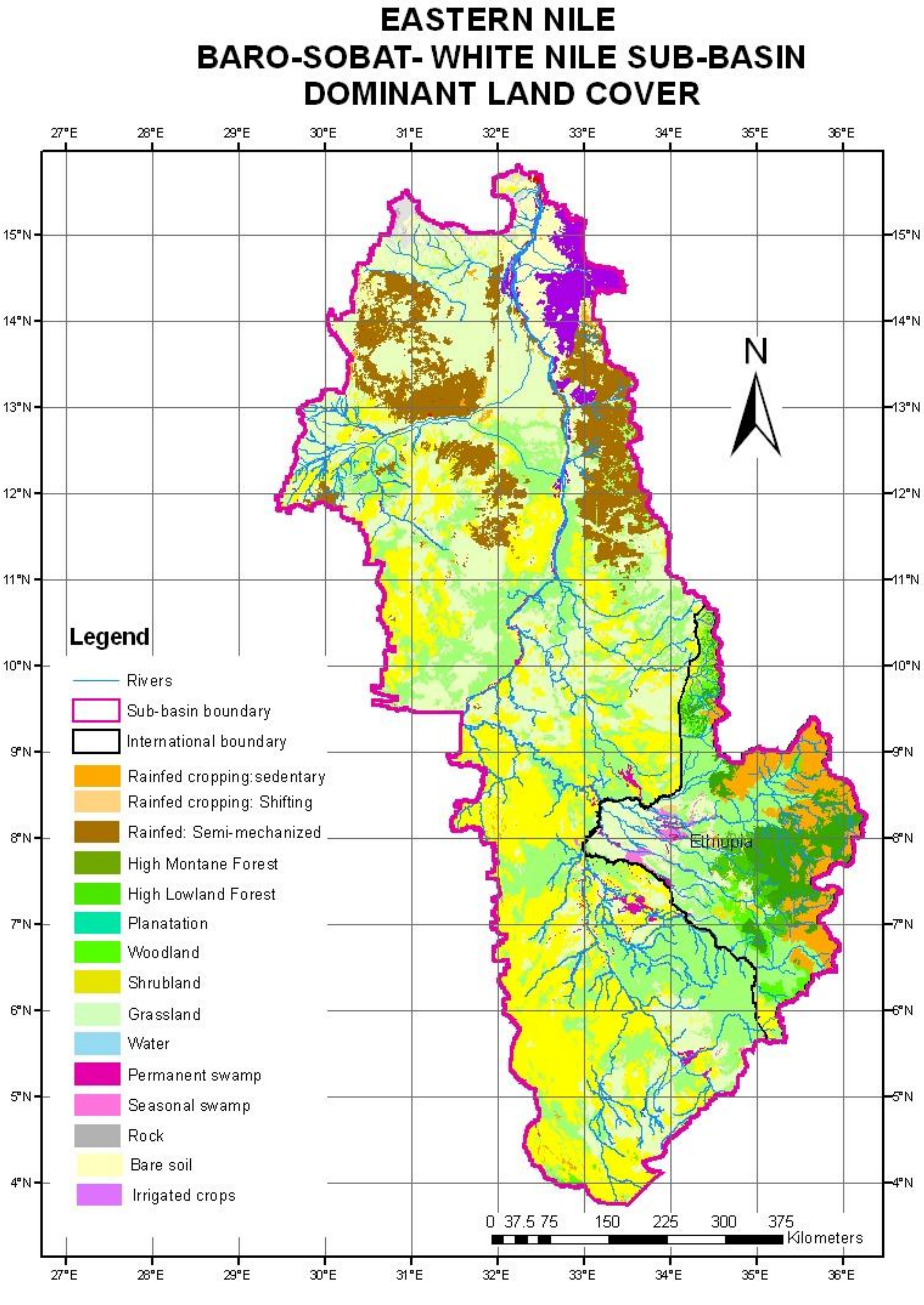
2.1.7 Land Cover

The land cover is dominated by grassland and open woodland and shrubland. Wetlands cover over 7 percent of the Sub-basin. The Semi-mechanized farms cover some 38,187 km^2 and are fourth in terms of area coverage. Montane and Lowland High Forests cover 4 percent of the Sub-basin located almost entire in the Baro-Akobo catchment.

Table 4. Baro-Sobat-White Nile Sub-basin: Dominant Land Cover (km2)

Landcover Type	Area (km2)	% Total
Grassland	136,075	29.1%
Open shrubland	108,993	23.3%
Open woodland	81,486	17.4%
Semi-mechanized Farms	38,187	8.2%
Seasonal swamp	28,974	6.2%
Rainfed crops: Sedentary	16,851	3.6%
Montane forest	14,412	3.1%
Bare land: Sand	14,131	3.0%
Irrigated crops	8,613	1.8%
Dense woodland	6,680	1.4%
Permanent swamp	5,032	1.1%
Lowland Forest	3,581	0.8%
Rainfed crops: Shifting	2,400	0.5%
Water	905	0.2%
Dense shrubland	865	0.2%
Urban	641	0.1%
Bare land: Rock	338	0.1%
Plantation	51	0.0%
	468,216	

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



Map 10. Baro-Sobat-White Nile Sub-basin: Dominant Land Cover

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

2.1.8 Surface Hydrology

(i) Overview

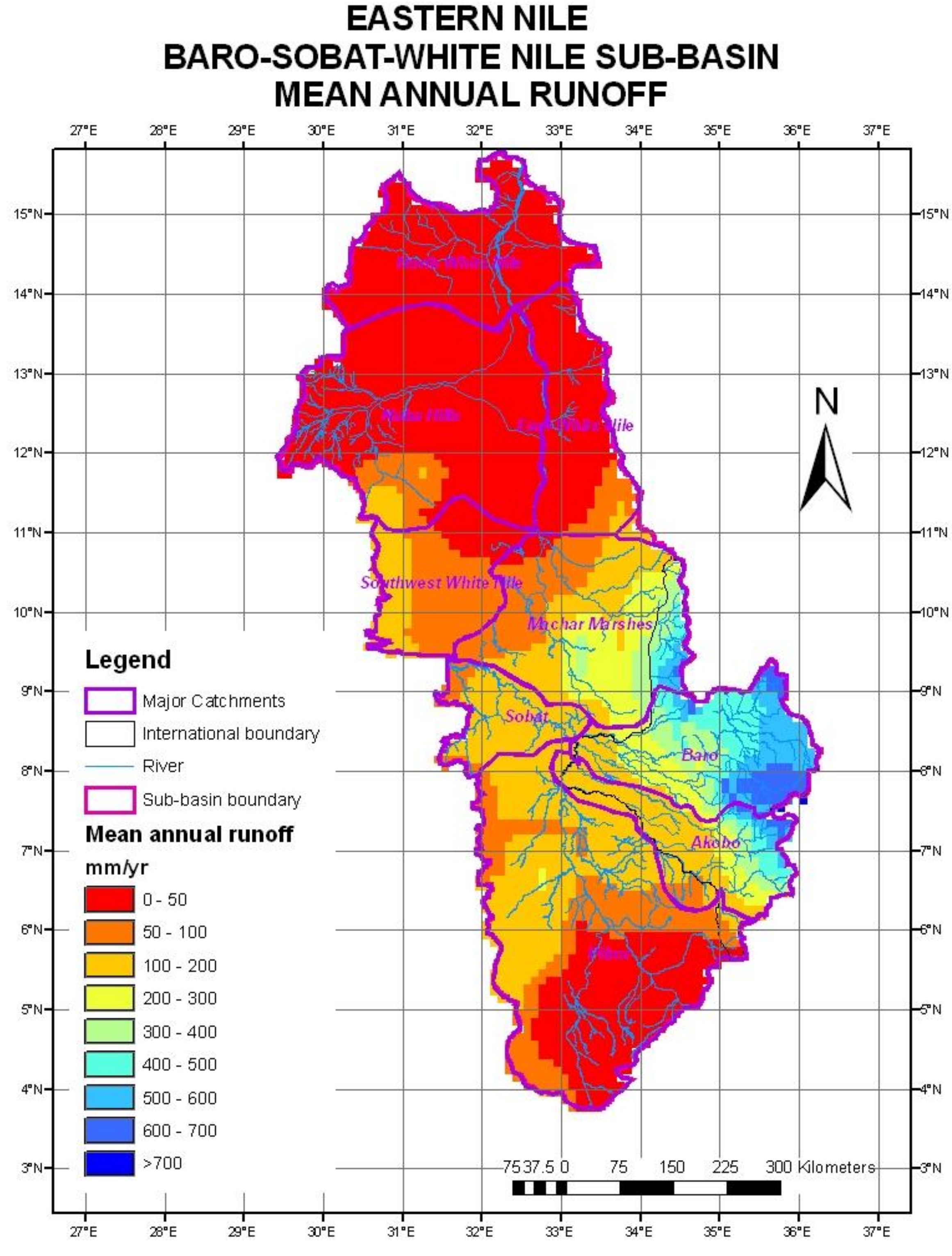
The White Nile emerges from the Sudd swamps at Lake No and is joined by the Sobat just above Malakal. Then it flows north in a shallow valley between the Juba Mountains to the west and the Ethiopian Highlands and then the White Nile-Blue Nile divide to the east.

The Baro and Akobo Rivers rise in the Ethiopian Highlands between altitudes of 1,500 to 3,100 masl. The highlands are covered with dense montane forests although these are rapidly being cleared for small and large scale agriculture and settlement. The rivers pass through an escarpment zone in deep incised valleys before they debouch onto the Gambela Lowlands. Here they pass through wide grassy and swamp plains before reaching the Pibor River and becoming the Sobat River.

The Sobat River rises in the far southeast as the Pibor River on the highlands actually inside Uganda on Mount Moruogole (2,750 masl) although the water from these headstreams only reaches the Pibor in years of very high rainfall. The Pibor joins the Akobo and Baro along the Sudan-Ethiopian border. From the Pibor-Baro junction the river becomes the Sobat. Just before joining the Sobat the Baro has a flood spillway (the Khor Machar) into the Machar Marshes. The water from the Machar Marshes, together with that from khors coming off the Ethiopian Highlands, occasionally reaches the White Nile via the Khor Adar.

(ii) Runoff

The highest runoff rates occur over the Ethiopian Highlands and the western escarpment (Map 11). Very low runoff rates are recorded from the southern clay plains, the north-eastern clay plains and the cover sands of North Kordofan State. Intermediate rates are found to the west of the Ethiopian Escarpment and the northern parts of the Pibor Catchment.



Map 11. Baro-Sobat-White Nile Sub-Basin: Mean Annual Runoff (mm/yr)
Source: USGS/gtopo30/HYDRO30.

(iii) The Baro-Akobo Catchment

The major rivers within the Baro-Akobo basin are Baro and its tributaries (Birbir, Geba, Sor), Alwero, Gilo with its tributaries (Gecheb, Bitun, Beg) and Akobo with its tributary Kashu. The general direction of the rivers is from the east to the west. Streams with steep gradients originate in the eastern highlands (about 2,000 – 3,500 masl) where rainfall is high and debauch onto western plains (Gambela plain around 500 masl) that have relatively low rainfall and moderate to low river gradients, which ultimately join Sobat river which is a tributary of the White Nile.

The peak flows of the major rivers closely match the rainy season, with peak discharge occurring during September. The mean annual runoff of the Baro at Gambela is estimated to be 23.237 km^3.

Table 5. Summary of surface water resources

Name of basin	Catchment area (km^2)	Mean annual runoff (MAR) km^3/yr
Baro Masha	1,653	1.792
Baro 1 site	2,333	2.356
Baro- Kella	4,937	3.473
Baro Gambela	23,461	12.230
Baro: Itang	24,636	10.710
Baro: Jikawo	26,940	11.174
Baro: Border in Ethiopia	30,004	
Baro: Border in Sudan	8,396	
Baro: Total	**38,400**	**9.500**
Akobo-Pibor: in Ethiopia	45,906	
Akobo-Pibor: in Sudan	39,994	
Akobo-Pibor: Total	**85,900**	**3.100**

Source: Feasibility Study of the Baro Multipurpose Project: Volume 1-table 14.2.

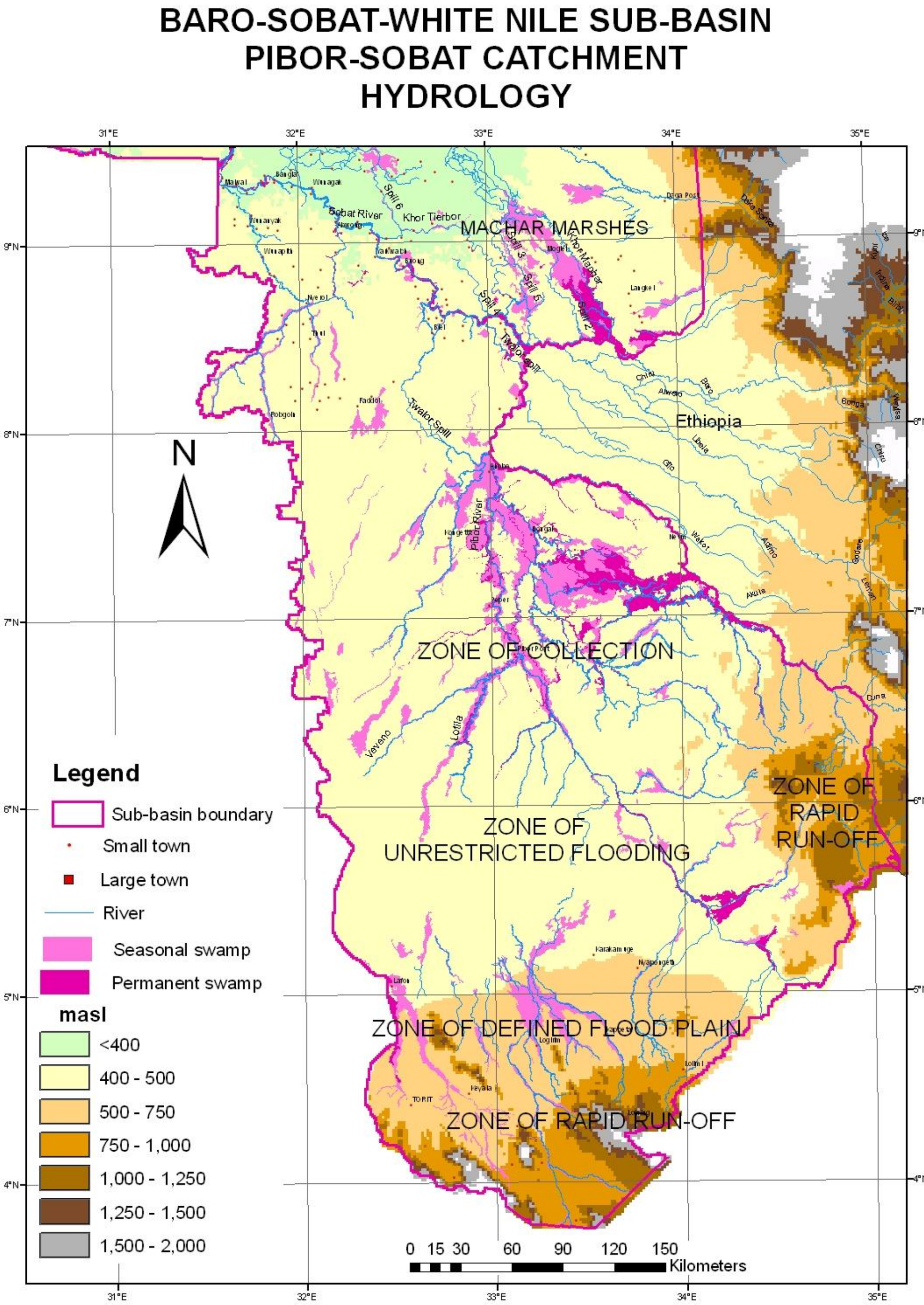
The Akobo appears to spill across to the Pibor through an extensive area of wetland at its junction with the Akula River, although this fact does not appear in any reports from Ethiopia or Sudan. Just above the Jakawu junction the Baro bi-furcates into the Baro to the north and the Adura to the south. They rejoin below the junction with the Khor Machar. The Baro both overflows and spills along the Khor Machar into the Machar marshes. Figure 10 indicates the losses and gains (using 1905-1959 average data) between Gambela and the Baro-Sobat junction (Sutcliffe & Parks, 1999).

(iv) The Pibor-Sobat System

The hydrology of the Pibor-Sobat system is complex and still imperfectly understood. A hydrological distinction may be made between the Pibor Catchment, the Baro-Akobo Catchment almost entirely in Ethiopia and the Sobat-Machar Marches. Here only the Pibor Catchment and the Sobat-Machar Marshes Catchment are considered.

(a) Pibor Catchment

Four patterns of streams have been recognized in the Pibor Catchment that occur successively northwards in approximately west-east zones (Jonglei Investigation Team, 1954). The first zone is the area of rapid runoff where stream debouch off the Basement Complex Hills and Mountains. Flows are seasonal and highly variable, sediment loads are high and gradients very steep. Below these streams on the foot-slopes gradients rapidly decrease and coarse sediment is deposited forming well defined valley floodplains.



Map 12. Sudan: Pibor-Sobat Sub-basin: Hydrology
Source: Landsat TM 36-05 & Howell et al (1983)

Figure 2. The Pibor-Sobat Catchments: the hydrology of the Sobat and its tributaries (Source: Sutcliffe & Parks, 1999).

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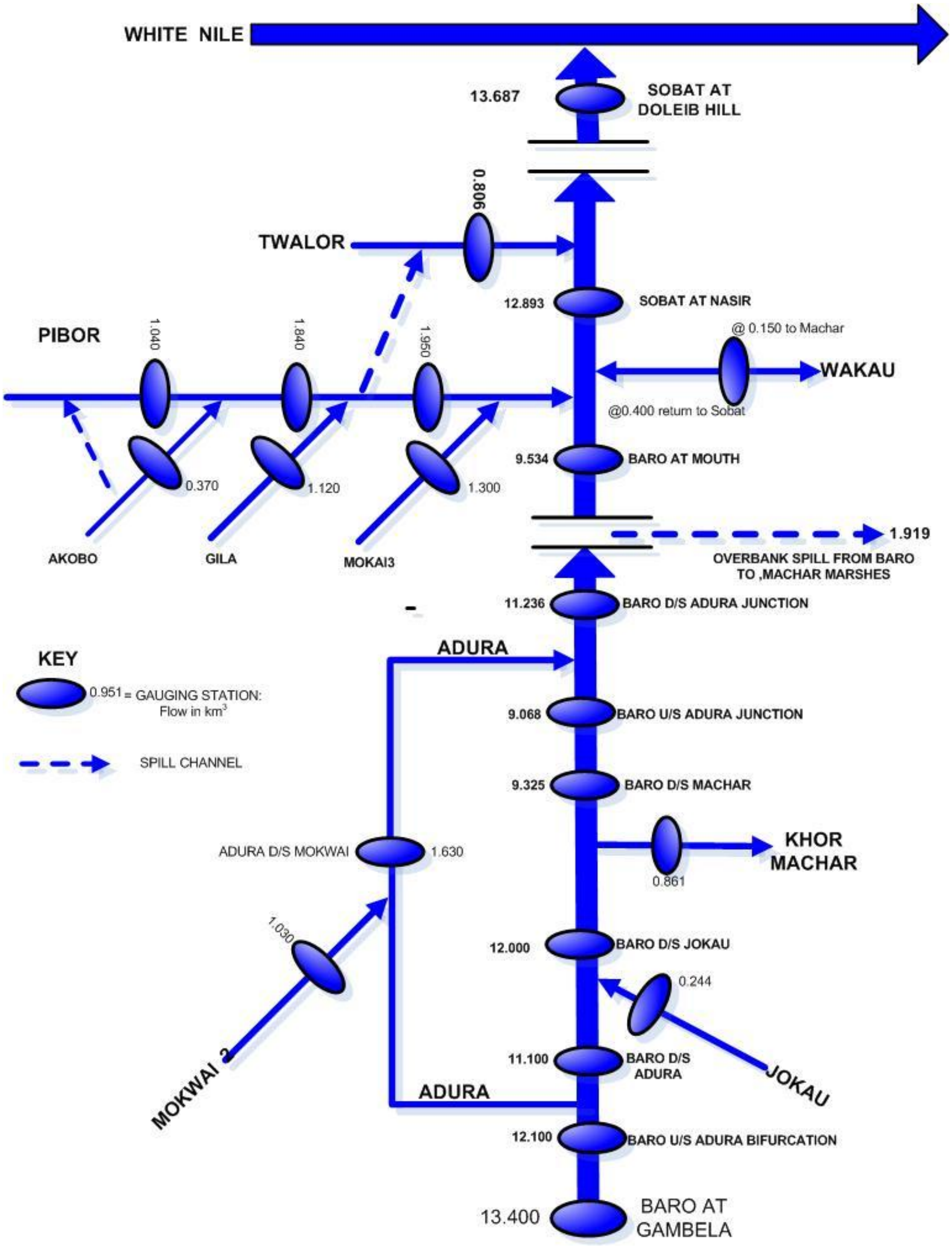


The third zone comprises the very flat impermeable clay plains with high grasses. The streams spill out into inter-connected channels, eventually defined channels disappear. In the wet season rainfall combined with water from the streams forms a "creeping flow" of water up to a meter deep that moves slowly across the plains often into the dry season. Most water is lost through evaporation.

Finally, defined but wide channels begin to form again as water collects the creeping flow. Alluvial banks begin to form and well defined rivers such as the Pibor, Akobo, Baro and the Sobat can now be recognized. Here rivers may braid into two or more channels during the high floods. Occasion spillways occur where water during the high flood spills out of the main river. Some water spills onto the wide floodplains eventually to return to the main river as the flood subsides. Some water flows across low watersheds into other channels.

It is in this Zone that there is an area of wetlands even more extensive than those of the Machar Marshes, where a spill appears to occur between the Akobo and the Pibor Rivers to the northeast of Pibor Post.

Three main "collector" streams: the Viveno, Lotila and Kengen join at Pibor Post to form the Pibor River. Downstream the Pibor is joined on the west by the Geni and from the Ethiopian Highlands by the Akobo. Further downstream the Pibor is joined successively by the Gilo, Mokai and Baro from Ethiopia. At Baro-Pibor confluence the river becomes the Sobat. During high flows just below the Akobo confluence the Pibor spills westwards to the Twalor (Nyanding) a south bank tributary of the Sobat (see figure 2).

(b) The Machar Marshes

Permanent and Seasonal Swamp:

The Machar Marshes are the least known of the southern Sudan wetlands. There is neither direct ground evidence for the distribution of permanent and seasonal swamp nor direct evidence of the swamp and grassland vegetation types. The JIT study estimated an annually flooded area (swamp and grassland) of between 6,000 and 20,000 km^2. The area was mapped by El-Hemry and Eagleson (1980) using Landsat imagery. They estimated the area of permanent swamp as 8,700 km^2 (of which 60 percent was grass and forest). The area has also been mapped by the FAO Africover Project. Their survey mapped 967 km2 of permanently flooded swamp and 1,947 km^2 of seasonally flooded swamp – a total of 2,913 km^2 of flooded land. They also map 5,392 km^2 of grassland with no trees or shrubs. It is possible that part of these grasslands could also be seasonally flooded.

Sutcliffe and Parks (1999) using a water balance model estimated the area of inundated land as varying between 1,500 and 6,000 km2 over a 5 year period (1950-55). An examination of a December 1986 thermal infra red image suggested an approximate "evaporating" or flooded area of 3,000 km^2, close to the Africover figure.

Thus the area of "seasonally" flooded vegetation that is actually mapped depends very much on the year the satellite imagery was taken. In a high rainfall year more flooded vegetation will be mapped than in a dry year. Also it important to note that interpreting vegetation (particularly seasonally flooded land) using satellite imagery in this area is extremely difficult as many areas are burnt. (Because of the problems of cloud cover satellite imagery is only available for the dry season.)

In conclusion, it is possible that the area of permanent Papyrus, Phragmites and Typha swamp may be relatively small and given the extreme variability of permanent water levels the area of Papyrus and Vossia swamp (which prefers constant and deep water) may be very small indeed. Given the variability of the spilling and seasonality of rainfall the area of seasonally flooded land can vary widely from year-to-year. Thus, the Machar Marshes are very different from those of the Sudd in terms of the small area of permanent swamp and the extremely variable area of seasonal swamp.

Drainage through the Machar Marshes

The drainage pattern within the area has been mapped by this Project using 2005 Landsat imagery (Map 11). The general pattern accords with that of the JIT survey (JIT, 1954).

Water passes through the swamps by three main routes. Firstly, water from the eastern Baro passes through the Khor Machar and other spills that join to form the Khor Adar, which eventually joins the White Nile. This khor has a channel some 100 m wide and 2.5 m deep separated by alluvial banks from a flood plain 800m wide. However, the channel is normally choked with grass, and except in extraordinary high rainfall years little water reaches the White Nile. The average outflow is estimated at 0.150 km^3.

Secondly, water from the eastern torrents (the Tombak, Yabus, Daga and other small streams) link up on the Khor Daga that in turn links up with the Khor Adar.

Thirdly, there is a tributary of the Khor Machar that flows parallel to the Sobat becoming the Khor Tiebor that in turn becomes the Khor Wol. The Khor Wol eventually joins the White Nile at Kodok. The average outflow of the Khor Wol is 0.100 km^3 although exceptionally it can reach 1.0 km^3.

Water balance of the Machar Marshes:

A number of studies including Hurst (1950), JIT (1955), MIT (El-Hemry & Eagleson, 1980) and Sutcliffe and Parks (1999) and most recently by Waterwatch (2006) for the JMP Scoping Study have been undertaken on their water balance. Except for the Waterwatch study these have been summarized by Sutcliffe and Parks (1999). There are four components of the water balance: (i) northward spills from the Baro, (ii) the eastern khors from the

Ethiopian escarpment, (iii) rainfall over the marshes, and (iv) evaporation/evapotranspiration. The Waterwatch Study focussed only on the balance between rainfall and evaporation and used a different method to estimate the loss by evaporation of the two inflow components.

Spills from the Baro occur to both sides of the river during the flood peak when flows exceed 1.5 km^3 between July and October, with spills from the upper Baro earlier than those from the lower Baro. Total spill as estimated by the JIT Study varies between 1.0 to 6.0 km^3 with a mean spill of 3.60 km^3. Approximately 2.82 km^3 (including the Khor Machar) flows north to the Machar Marshes through the Khor Machar, Khor Wakau, other spill channels and by over-bank flooding. Some 0.4 km3 returns to the Sobat via the Khor Wakau on the receding flood. The MIT Study made an estimate of 3.54 km^3 but included spill during low flows of the Baro-Sobat. If these are excluded their estimate is 2.873 km^3. Sutcliffe and Parks using the 1950-55 (years with below average rainfall) flow data estimated northward spill as 2.328 km^3.

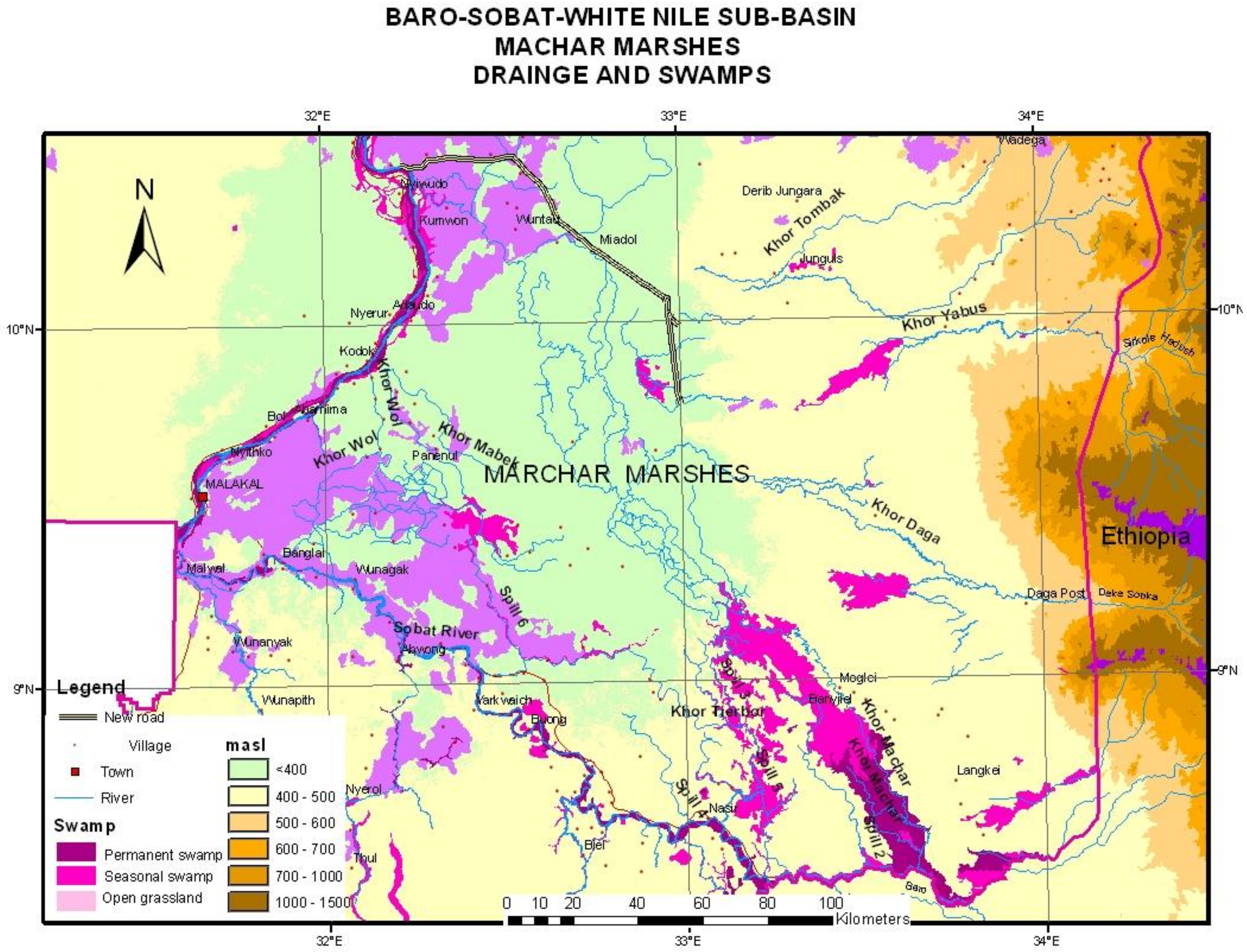
The "Eastern Torrents"[2] originate on the Ethiopia Escarpment and drain an area of approximately 10,300 km2. The two main khors are the Yabus and Daga. Based on the mean annual rainfall and a gauged runoff coefficient of 15 percent, total mean annual runoff was estimated by the JIT to be 1.744 km^3. The MIT study estimated total runoff from the Eastern Torrents 4.2 km3 and a further runoff from the clay plains of 1.41 km3. Sutcliffe and Parks consider these to be severely over-estimated and used the JIT estimate.

The JIT study estimated that direct annual rainfall on the Marshes was 800 mm giving a total annual supply of 15 km^3 (over an area of 20,000 km^2). The MIT Study used a mean annual rainfall of 933 mm over an area of 8,700 km2 giving an annual supply of 8.12 km^3. Sutcliffe and Parks estimated the average annual rainfall 1950-1955 to be 933 mm over a mean flooded area of 3,350 km2 giving an annual supply of 3.125 km^3. Waterwatch estimated the annual rainfall for the year 2001 using the Tropical Rainfall Measuring Mission (TRMM) satellite sensor as 784 mm.

Losses from the area include (i) drainage to the White Nile, and (ii) evaporation. Drainage to the White Nile is through Khors Adar and Wol. Mean annual loss through the Ada was estimated to be 0.150 and that through the Wol at 0.100 km3.

The MIT used an annual open water evaporation rate of 1,340 mm/yr whilst Sutcliffe and Parks estimated the annual evaporation rate to be 2,150 mm. No allowance for soil re-charge was made as it was assumed the soil moisture had already been recharged when the khors and spills begin to flow. The Waterwatch study estimated annual evaporation as 972 mm using the SEBAL energy balance model on MODIS Satellite 1 km data. Map 7 in this report indicates annual evaporation rates over the Machar Marshes as between 1,666– 1,900 mm. There are clearly considerable differences between these estimates.

[2] Terminology used by the Jonglei Investigation Team.



Map 13. **Sobat-Machar Marshes Catchments: Drainage and Swamps (Source Africover & CRA Interpretation)**

(v) White Nile

Between Sobat Mouth and its junction with the Blue Nile, the White Nile falls about 13 m in 840 kms. The inflows from tributaries are low and sporadic. The natural regime has been affected by the Jebel Aulia dam that was constructed in 1934-37. The average (1905 – 1983) annual outflow from the Sudd is 16.091 km^3. There is little seasonal variation with mean monthly flows varying from 1.188 km^3 in June to 1.515 km^3 in January. It is the Sobat inflow that provides some seasonality to the White Nile flow. The mean (1905-83) annual flow of the Sobat at Doleib Hill is 13.530 km^3, with a mean monthly variation of 0.273 km^3 in March to 1.992 km3 in October. The Sobat flood is attenuated by the spill both to the Machar Marshes and to the southern plains.

Between Malakal and Mogren (Khartoum) the White Nile mean (1961-95) annual flow reduces from 32.85 km^3 to 28.13 km^3 (a mean reduction of 4.72 km^3) due to abstraction and evaporation. However, these reductions have been increasing from a low reduction of about 3.0 km^3 in 1978 to about 6.00 km^3 in 1995 (Sutcliffe & Parks, 1999: fig. 8.4), although the rise is not explained. A part of this increase would be due to the start-up of the Kenana Sugar Scheme in the late 1970's. A Waterwatch Study for the ENSAP JMP on the evaporation from the Jebel Aulia Dam estimated the (2001) evaporation to be 1.766 km^3 although Abdel A. Ahamed (2006) reported evaporation losses from the reservoir 2.5 km3. The Waterwatch study estimated gross evaporation loss from the Kenana Sugar Scheme as 0.612 km^3.

2.1.9 Groundwater

The NBI One System Inventory of Water Resources in Sudan (Ahmed, 2006) points that the quantitative estimates of groundwater in the Sudan are "rather approximate" and that considerable efforts are needed to arrive at more accurate figures.

The Baro-Akobo Catchment has two basic types of aquifer (MWR: Baro-Akobo Master Plan, 2001). One is associated with fracture and crush zones in the Basement Complex rocks and the other in the Pliocene to Quaternary alluvium, an unconsolidated sedimentary porous medium. Basement Complex aquifers characteristics vary with the degree of fracturing and area continuity that exists in otherwise impermeable bodies of metamorphic and/or igneous rock. Rock type and mode of emplacement usually have little relationship to Basement Complex permeability. The available information indicates production rates to be generally less than one litre per second (1 lt/s).

The alluvium constituting the aquifers in the Baro and Pibor Plains is usually fine sand to silt. Water yields from wells constructed in these aquifers range from about 0.01 l/s to 1.0 l/s. Static water levels of wells in these aquifers usually vary from ground surface to about 7.0 meters below ground surface.

In areas of the Unconsolidated Sediments that stretch from the Sobat Basin and then down the Main Nile and across to the Blue Nile the hydro-geological system comprises two aquifers: an upper and a lower (Farah et al., 1997). The upper aquifer includes mainly the Upper Gezira Formation and the upper part of the Lower Gezira formation in the area between the Blue and White 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.

West of the White Nile in the south Basement Complex rock outcrop to form the Nuba Mountains and are likely to be similar to the basement Complex aquifers in the Blue Nile and Atbara Sub-basins. There the presence of groundwater varies with the degree of fracturing and is limited to deep cracks in otherwise impermeable bodies of metamorphic and/or igneous rock. North of the Basement Complex rocks cover sands initially overly the Nubian Sandstone aquifer until its outcrops in the north-western part of the Sub-basin. Everywhere groundwater depths are 241 to 310 meters. Estimated water yield of the Umm Ruaba Basin is 1.7 km3 and that from the Nahud Basin 0.1 km3 (MEPD-HCENR, 2003).

2.2 Socio-economic Characteristics

2.2.1 Administration

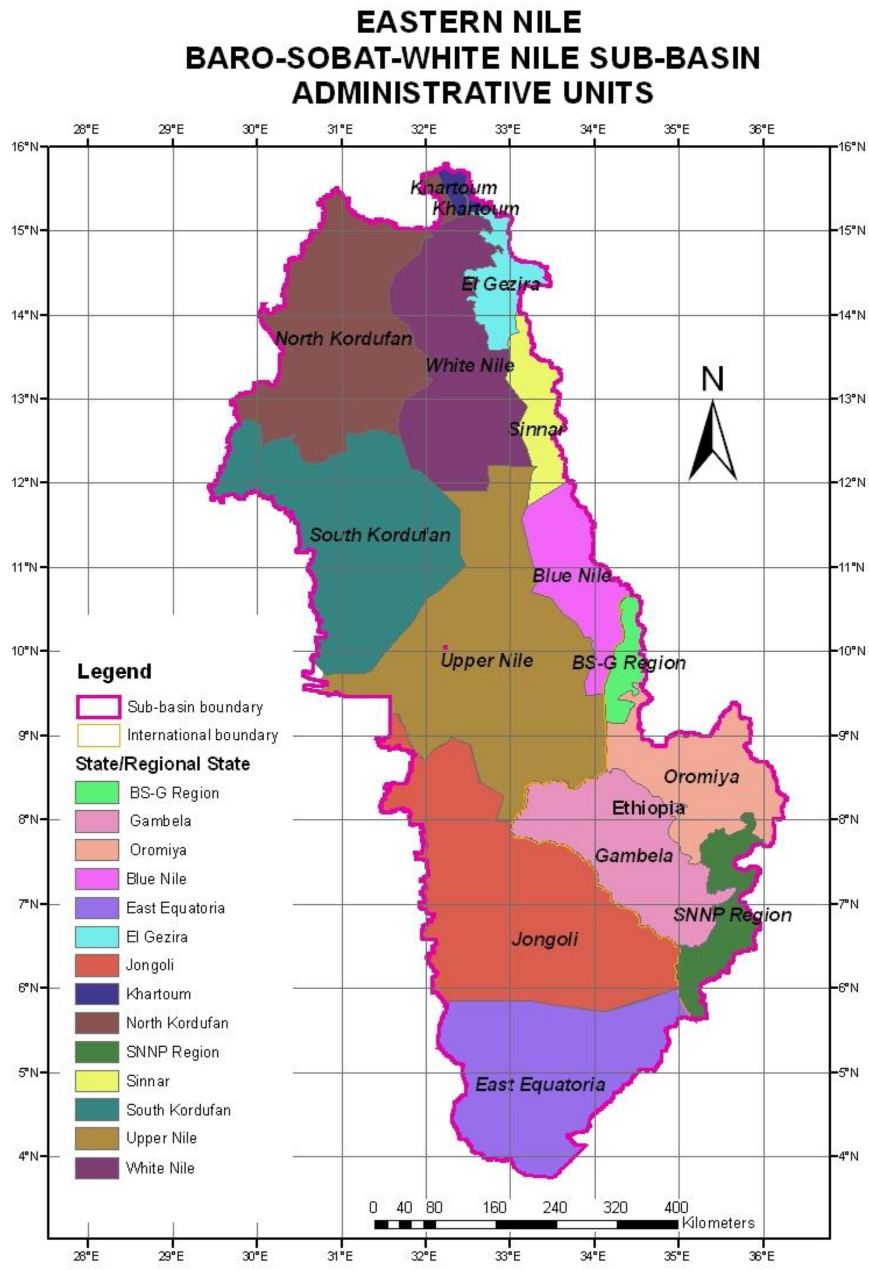
Within the Sub-basin in the Sudan there are ten states and in Ethiopia FOUR Regional States partially located within the Sub-basin: 84 percent of the Sub-basin area is in Sudan and 16 percent in Ethiopia (table 6).

Table 6. Baro-Sobat-White Nile Administrative States/Regional States and their areas (km2)

State/Regional State	Area (km2)	% of Sub-basin
SUDAN		
Upper Nile	77,339	**16.5%**
Jongoli	74,207	**15.8%**
South Kordufan	57,110	**12.2%**
North Kordufan	53,419	**11.4%**
East Equatoria	49,517	**10.6%**
White Nile	40,438	**8.6%**
Blue Nile	18,191	**3.9%**
Sinnar	10,339	**2.2%**
El Gezira	8,708	**1.9%**
Khartoum	2,206	**0.5%**
	391,474	**84%**
ETHIOPIA		

Gambela	32,235	**6.9%**
Oromiya	25,996	**5.6%**
SNNP Region	13,045	**2.8%**
Beni-Shangul Gumuz	5,466	**1.2%**
	76,742	**16%**
	468,216	

Source: Sudan: ENTRO GIS data base: Ethiopia WBISPP GIS Database



Map 14. Baro-Sobat-White 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 1 km 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[3]. National census estimates of the rural-urban distribution were used to provide estimates of total rural and urban populations. These are shown in table 7.

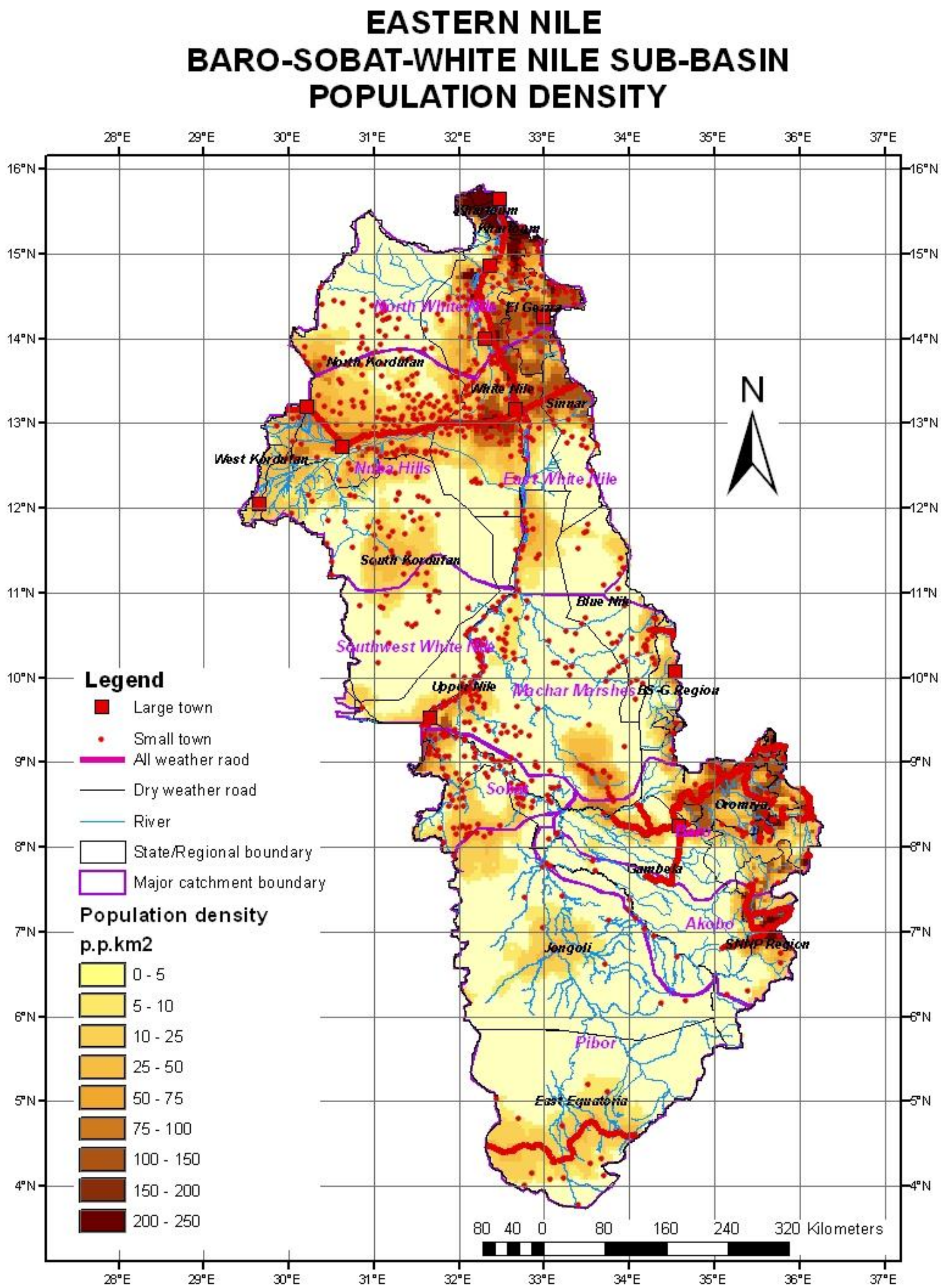
Table 7. Baro-Sobat-White Nile Sub-basin: Total, Rural and Urban population estimates by State/Regional State for 2002.

State/Regional State	Total pop.	Rural pop.	Urban pop.	Rural %	% of Sub-basin total	Pop density ppkm2
Blue Nile	411,895	308,097	103,798	75%	3%	23
East Equatoria	398,782	294,301	104,481	74%	3%	8
El Gezira	1,131,140	877,765	253,375	78%	9%	130
Jongoli	392,065	307,379	84,686	78%	3%	5
Khartoum	2,148,190	285,709	1,862,481	13%	17%	974
North Kordufan	1,366,520	941,532	424,988	69%	11%	26
Sinnar	451,829	323,961	127,868	72%	4%	44
South Kordufan	811,353	622,308	189,045	77%	6%	14
Upper Nile	615,417	482,487	132,930	78%	5%	8
White Nile	2,162,050	1,318,851	843,200	61%	17%	53
	9,889,241	**5,762,390**	**4,126,851**		**78%**	
BS-G Region	89,903	74,711	15,192	83%	1%	16
Oromiya	1,816,430	1,507,577	308,846	83%	14%	70
Gambela	338,233	303,283	34,950	90%	3%	10
SNNP Region	556,571	502,528	54,044	90%	4%	43
	2,801,137	**2,388,099**	**413,032**		**22%**	
	12,690,378	**8,150,489**	**4,539,883**			

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

Nearly 80 percent of the population lives in the Sudan. Densities vary from 974 p.p.km2 in Khartoum State to only 5 p.p.km2 in Jongli State. Excepting Khartoum rural rates are generally high between 61 percent in White Nile State in Sudan and 90 percent in the SNNP Regional State in Ethiopia. The patterns of population densities are shown in Map 15. The central part of the Ethiopian plateau has the highest density exceeding 122 people per km^2 in some parts.

[3] Note: These are not the full State populations: many of the States are "clipped" by the Sub-basin boundary.



Map 15. Baro-Sobat-White Nile Sub-basin: Population densities and distribution.

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)

The densities in the deep valleys and the escarpment are very low. In the lower basin densities are low and generally confined to the Baro River. In Sudan the highest population densities are found in Khartoum, El Gezira, White Nile States and along the main road in Senner and North Kordofan States. Areas of medium population density include the Nuba Mountains in South Kordofan State, along the White Nile and along the Khor Machar in Upper Nile State, and along the main road from Kenya to Juba in the southern part of East Equatoria State. Elsewhere population densities are very low.

(ii) Demographic Characteristics

Population growth rates and other demographic characteristics are shown in table 8.

Table 8. Baro-Sobat-White 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 ****
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**
Blue Nile	3.00	25.2	42.7	3.7	108.3	38.5	12.3	137	**122**
North Kordofan	1.80	31.1	47.4	4.9	91.8	40.1	12.2	125	**106**
South Kordofan	1.40	23.2	47.5	3.4	94.3	39.3	124	138	**119**
White Nile	2.80	39.0	45.5	3.9	95.7	40.4	10.0	109	**100**
NORTH SUDAN	**2.80**	**37.3**	**42.8**	**4.1**	**100.4**	**37.8**	**11.0**	**116**	**98**
Upper Nile	0.90	21.6	45.9	3.3	101.7	38.5	16.2	100	**92**
Jonglei	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	**n.d.**
Equatoria	1.00	26.2	43.8	2.6	109.0	33.8	11.6	177	**156**
SOUTH SUDAN	1.80	19.6	43.5	2.9	104.4	38.0	13.9	152	**130**
ETHIOPIA*									
BS-G Region	2.43	16.9	44.5	4.7	101.4	37.2	12.6	104***	
Oromiya	2.56	17.0	45.0	5.5	99.6	38.3	10.9	86***	
Gambela	2.71	10.3	41.1	2.5	103.6	32.7	11.8	68***	
SNNP Region	2.98	9.7	45.2	4.0	98.9	38.6	11.4	95***	

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

(iii) Literacy and Education

The literacy and primary school enrolment rates for the States/Regional States in the Sub-basin are shown in table 9.

Table 9. Baro-Sobat-White 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 enrol.	% enrol.
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
Blue Nile	31.3	41.8	20.4	143,305	48,914	34.1
North Kordofan	39.1	52.0	29.4	364,719	170,023	46.6
South Kordofan	44.4	56.2	34.4	290,819	100,663	34.6
White Nile	54.4	64.5	44.3	335,040	255,152	76.2
NORTH SUDAN	**54.5**	**66.6**	**42.4**	**5,455,266**	**3,187,705**	**58.4%**
Upper Nile	62.4	75.8	50.3	259,318	48,002	18.5
Jonglei						
Equatoria	47.4	60.6	34.3	292,646	42,728	14.6
SOUTH SUDAN	**52.6**	**65.4**	**39.3**	**1,037,964**	**120,682**	**11.6**
ETHIOPIA*						
BS-G Region	17.7	24.9	**10.5**	180,971	493,599	95%
Oromiya	22.4	29.3	**15.6**	2,240,471	3,600,777	64%
Gambela	29.3	38.6	**19.5**	1,098,511	335,222	76%
SNNP Region	24.4	33.9	**15.2**	609,321	207,169	85%
				4,129,274	**4,636,767**	**89%**

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

(iv) Water and Sanitation

The percent population with access to drinking water and sanitation facilities are shown in table 10.

Table 10. Baro-Sobat-White Nile Sub-basin: States/Regional States – (a) Percent Population Access to Drinking Water, (b) Sanitation Facilities

(a) Drinking Water by Source

State	Main source of water							
	Piped into dwelling	Public tap	Deep Well/pump	Dug Well/ bucket	River/canal	Rainwater	Others	Not stated
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	0.4
Blue Nile	12.3	2.1	9.3	2.1	33.2	27.9	13	0
North Kordofan	16.3	5.3	20.5	25.4	2.2	13.2	17.1	--

South Kordofan	0.9	1.7	76.6	7.1	0.1	4.9	8.6	--
White Nile	23.1	5.5	10.3	12.4	28.5	7.7	11.8	0.8
NORTH SUDAN	**50.8**	**4.3**	**15.8**	**9.8**	**12.8**	**--**	**6.4**	**0.1**
Upper Nile								
Jonglei								
Equatoria								
Malakal	**3.6**	**1.8**		**0.2**	**94.1**		**0.3**	
ETHIOPIA*	**Tap**		**Protected well/spring**	**Unprotected well/spring**	**River, Lake, pond**			**Not stated**
BS-G Region	12.5		5.7	0.1	63.1			18.6
Oromiya	11.2		11.2	34.2	43.1			0.3
Gambela	16.7		9.8	16.5	56.2			0.8
SNNP	7.6		11.2	30.5	50.1			0.2

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

Khartoum, El Gezira and Sinner States have rates of piped water and deep wells well above those of Blue Nile, and North and South Kordofan State. Data for other South Sudan States are missing although the town of Malakal has 94 percent of the population using rivers or canals, which may be indicative of the rates in Southern Sudan.

In Ethiopia rates of protected water supplies vary between 18 and 27 percent indicating a more even distribution.

Table 10 (b) Sanitation facility by type

State	**Flush to Sewage System**	**Flush to septic tank**	**Traditional pit latrine**	**Soak away pit**	**Others**	**Missing**	**No facilities**
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
Blue Nile	--	3.5	56.0	3.2	0.4	0.8	36.0
North Kordofan	--	2.9	31.4	1.9	1	0.1	62.6
South Kordofan	--	2.4	48.7	0.3	1.4	0.9	46.4
White Nile	--	4.8	45.7	3.7	2.2	0.5	43.2
NORTH SUDAN	--	7.7	69.2	1.6	1.6	--	19.9
Upper Nile							
Jonglei							
Equatoria							
Malakal		2.1	22.4	4.5	0.6	0.3	70.1
ETHIOPIA*	**Flush -**	**Flush -**	**Pit – private**	**Pit - shared**		**Not**	**No facilities**

	private	shared				stated	
BS-G Region	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
Gambela	3.0	3.1	13.1	11.7		2.1	67.0
SNNP Region	1.2	0.9	38.1	22.8		1.2	36.0

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

The pattern in the variation in rates of the population without sanitary facilities is not the same as that of protected water supplies. Blue Nile, White Nile and South Kordofan States have the relatively lower rates similar to ElGezira and Sinner, In Ethiopia the rates of population with no facilities are lower in Oromiya and SNNP Regions than in the lowland regions of Gambela and BS-G regions.

2.2.3 Livelihood Characteristics

Within the Sub-basin the political boundary between Sudan and Ethiopia is mirrored by socio-cultural and 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 another 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 peoples with sheep, cattle and camels. The southern group, the Badiya 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 has 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 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.

West of the White Nile are the Nuba group of peoples who live in the Nuba Mountains but who also cultivate on the plains. They make up 90 percent of the population in the Nuba Mountains. They are in fact a group that have more than 50 languages and dialect clusters falling into 10 groups (Mohamed Suliman, 1999). They practice a range of productive activities including the mainstay of their economy crop production, as well as animal husbandry, hunting and foraging.

The Baggara are an Arab speaking pastoral people, a large proportion of whom belong to the Hawazma group, their home area being west of the White Nile in and below the Nuba Mountains. They are said to have started to enter the mountains at the beginning of the 19^{th} century. They use the mountains, the clay plains west of the White Nile and cross over in the dry season and also graze to the north of the Machar Swamps. They only enter the southern Funj area in the dry season.

Further south are the group of Nilotes peoples: the Nuer, Dinka, Shilluk, Anuak and the Murle. The Nuer, Dinka and Murle are pastoralists or more properly agro-pastoralists whilst the Shilluk and Anuak are mainly sedentary cultivators.

The Dinka within the Sobat-White Nile Sub-basin occupy the area just to the east of the White Nile. They comprise four "tribes": the Ngok (to the south of the Sobat), the Dunjol, the Paloich and the Abialongto the north. The Nuer occupying the Sub-basin are found to the east of the Dinka and eastwards to the Gambella region of Ethiopia. They belong to the Eastern Jikaing and the Lau tribes: two of the 11 major grouping. The Lau occupy the area to the south of the Sobat whilst the Jikaing are to the north.

The Shilluk occupy a narrow strip along the banks of the White Nile between the Sobat-White Nile confluence northwards to Kodok. Unlike the Nuer and Dinka the Shilluk are sedentary. Around the villages rainfed cultivation of sorghum, maize, groundnuts, beans and tobacco occurs. Unlike the Nuer and Dinka the Shilluk posses far fewer cattle and depend less on cattle products. Thus they are not obliged to migrate with the seasons. Additionally the intermediate and "toich" grasslands are close by the villages. Fishing is an extremely important component of their economy.

The Anuak are also cultivators but have no cattle or small stock. They are found in Ethiopia and just to the south of the Gambella salient. They occupy the high levees along the Sobat River and its eastern tributaries. They cultivate sorghum and maize on the flood retreat soils below the levee. Fishing is an important element of their livelihoods.

The Murle occupy the Boma Plateau as far north as Pibor Post in Pibor Locality of Eastern Equatoria. They are divided into two groups: the plains Murle (Lotilla) and the Hills Murle (Ngalan) who occupy the Boma Plateau. The Plains Murle are essentially Agro-pastoralists. However, although cattle are their main source of livelihood they do cultivate some maize and sorghum. The Hill Murle are essentially agriculturalists with some cattle. The cultivate maize, sorghum, sesame, tobacco and coffee.

The Toposa live in Kapoeta Locality of Eastern Equatoria, which experiences a lower rainfall than elsewhere in the Region. They are mainly pastoralists keeping cattle, camels, goats and sheep, but also cultivate some maize and sorghum.

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

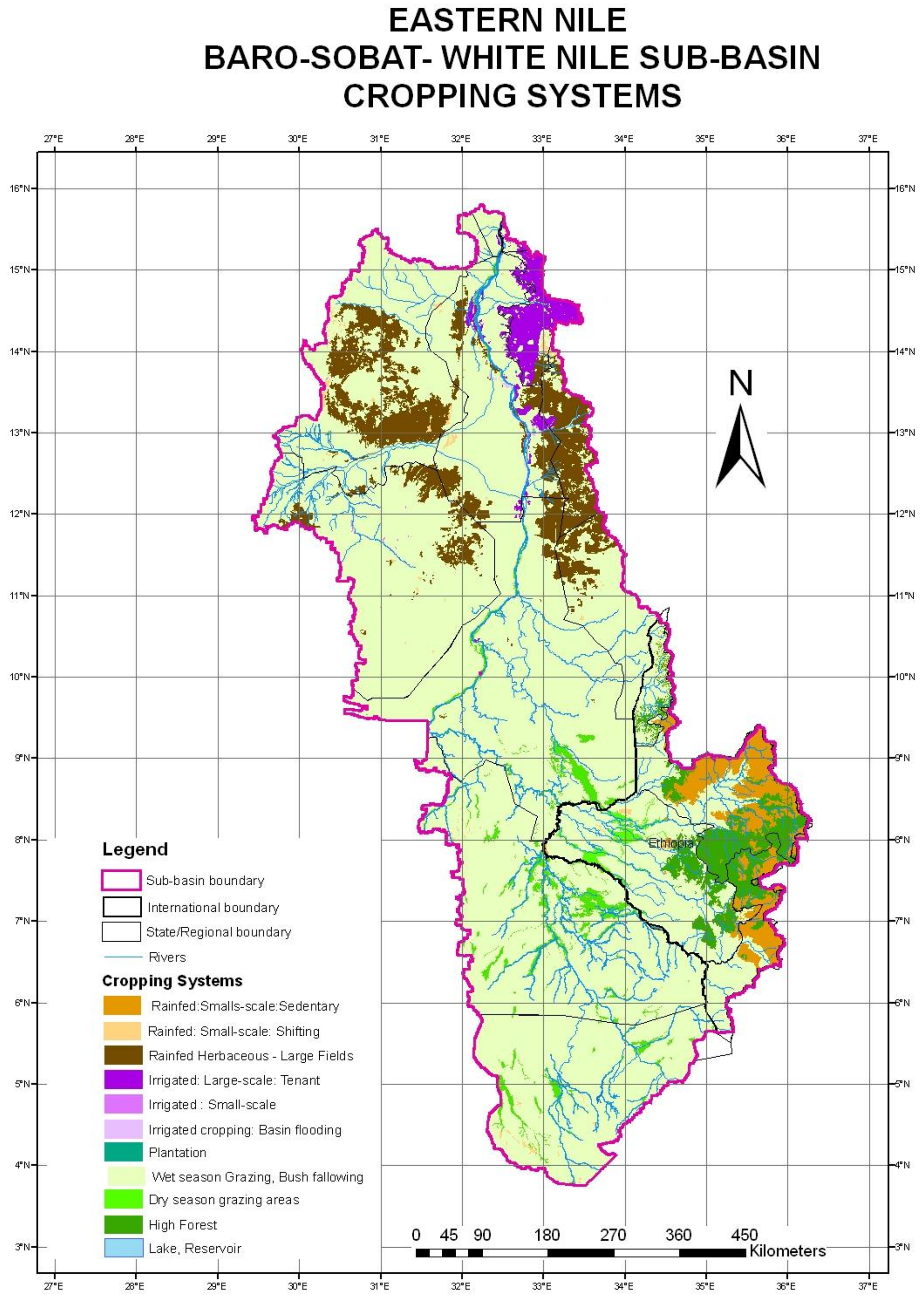
(i) Overview

The main agricultural land use systems in the Baro-Sobat-White Nile Sub-basin in Sudan and Ethiopia are relatively distinct except along the international border where the cultural affinities 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 11.

Table 11. Main Agricultural Systems in the Baro-Sobat-White 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) Cropping (Enset, roots, cereals, pulses) Small Livestock holdings (Communal grazing, crop residues)	Ethiopia: Highlands
	Small-scale traditional; shifting	State land: Individual and Communal use rights	Cropping (cereals, pulses): No livestock holdings (Tsetse infestation)	Ethiopia & Sudan: Lowlands
	Small-scale: traditional: flood retreat	State land: Individual and Communal use rights	Cropping (cereals, pulses) Small Livestock holdings (Communal grazing	Ethiopia & Sudan: (Anuak, Shilluk)
	Large-scale: Semi-mechanized	State land: Medium-term Leases	Cropping (Sorghum, cotton, sesame)	Sudan: Lowlands
IRRIGATED CROPPING	Small schemes in valley bottoms: Small-scale operations (< 1.0 ha) Gravity: Controlled water-tables	State Land: Individual use rights: additional to rainfed land	Cropping (cereals, vegetables)	Ethiopian Highlands
	Small-scale:(<20 ha) Pump	Individual Freehold State land: Lease	Cropping: Sorghum, wheat, Alfalfa	White Nile
	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: Long lease	Cropping: Sugar	Sudan: Kenana Schemes
LIVESTOCK	Small-scale: Extensive Pastoral Transhumant	Communal use (grazing, water) rights	Cattle, small-ruminants	Sudan (Toposa)
	Small-scale: Extensive Agro-pastoral Transhumant-sedentary	State land: Communal use (grazing, water) rights	Cattle, small-ruminants Small-scale cropping	Sudan (Nuer, Shilluk, Murle)

Rainfed cropping operates at the traditional small-scale and the large and semi-mechanized scale (Map 16). 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.



Map 16. Baro-Sobat-White Nile Sub-basin: Cropping Systems
Source: FAO Africover Sudan (2002) & WBISPP-MARD (2001 -2003)

(ii) Traditional Small-scale Rainfed Systems of Agriculture

The Highland traditional rainfed systems can be divided into cereal based and enset-root based. The enset-root based system is represented by the Mocha (Sheka) people, living mainly in the highest parts of the Ethiopian Highlands, cultivating Enset as a co-staple crop with cereals and tubers. The system is based on two types of field: a permanent garden around the homestead and the open and rotating fields beyond. The garden crops include enset, root crops (yam, taro and sweet potato), pulses, vegetables, spices and coffee. The open field crops are mainly cereals: teff, maize and sorghum.

The Highland cereal based systems are found in the Ethiopian Highlands, the Nuba Mountains and the Imatong Mountains. In the Ethiopian Highlands they are represented by sorghum-maize-coffee system. The dominant crops are maize and teff and some sorghum. Below 2,000 masl coffee is an important cash crop. Some root crops (sweet potato and Oromo potato) are grown in homestead gardens, occasionally with a small enset plot. Livestock include cattle, sheep and goats. Cattle are important for draught power, milk and as a store of wealth. Livestock feed supply comprises open grazing, crop residues and grass hay. Because open grazing is still available (although decreasing rapidly), cropping, livestock production and tree growing are not closely integrated.

West of the White Nile are the Nuba group of peoples who live in the Nuba Mountains but who also cultivate on the plains. They practice a range of productive activities including the mainstay of their economy crop production, as well as animal husbandry, hunting and foraging. Farmland is divided spatially and in terms of crop production into three units: the homestead, the hillside and the far farms. Homestead farms produce early maize, bulrush millet and finger millet and are the responsibility of the women. The terraced hillside farms are planted with later maturing grains. The far farms are located on the clay plains and are used for sorghum. The hillside and plain farms are under a form of shifting cultivation and bush fallowing. Whilst necessitating much labour, the spread of farms among three types tends to spread risk and harvesting times are different thus spreading scarce labour.

In the agricultural systems of the Boya, Lakuka and Dindinga peoples who inhabit the Imatong Mountains there are two cropping seasons (April-July, and September-December (Muchomba and Sharp, 2006). Crops in the first and second season include sorghum, cowpeas, groundnuts and sesame. Cassava is a crop that bridges the two seasons. Livestock are important but household assets have been severely depleted during the Civil War.

In the Lowlands and on the escarpment there are two main types of agricultural systems: (i) rainfed cropping based on bush fallowing and shifting cultivation practiced by the Berta, Komo, Mao and Meban peoples in the lowlands and the Majangir on the Escarpment and (ii) cropping based on rainfall and residual moisture (flood retreat) practiced by the Anuak along the Baro-Akobo and the Shilluk along the White Nile.

In the shifting cultivation systems the main crops are sorghum, maize and beans. The Majangir people practice a sophisticated system of weed mulching and forest fallowing. The use of the weed mulch to suppress weed growth extends the period of cultivation by some two to four years. Thus, the Majangir appear to have partially solved the problem of weed infestation, which is probably the cause of final abandonment of shifting cultivated fields elsewhere. Livestock holdings in this land use system are very low. Less than 7 percent of households have cattle, but 47 percent have goats. Most of the system lies within areas of high tsetse challenge, and are thus exposed to trypanosomiasis. Bee-keeping is a speciality of the Majangir.

The Anuwak, Opo and Komo peoples cultivate the banks and levees of the Baro, Akobo and Sobat rivers rather than the woodlands on the interfluves. Two crops of maize and beans and one crop of sorghum are obtained. The average cropped area of each maize crop is 1-2 ha with 1 ha of long season sorghum. The first maize and bean crops are grown on the wetter soils where there is residual moisture. The second crop is grown during the rain season on the high and better-drained levee soils with the sorghum and bean crops. Because of the high tsetse challenge in the woodlands and lowland forests no livestock except chickens are kept. Fishing is an important source of food.

The Shilluk occupy a narrow strip along the banks of the White Nile between the Sobat-White Nile confluence northwards to Kodok. Around the villages rainfed cultivation of sorghum, maize, groundnuts, beans and tobacco occurs. The Shilluk posses far fewer cattle and depend less on cattle products than the Baggara, Dinka and Nuer Agro-pastoralists. Thus they are not obliged to migrate with the seasons. Additionally the intermediate and "toich" grasslands are close by the villages. Fishing is an extremely important component of their economy.

(iii) Large-scale Semi-Mechanized farms

The large-scale semi-mechanized systems are identical to those in the Abbay-Blue Nile Sub-basin. They 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. Sorghum is the main crop with some sesame. In the Sub-basin rainfall is relatively higher and more reliable than in the Tekeze-Atbara and the Abbay-Blue Nile Sub-basins.

There are approximately 9.1 million feddans (3.8 million ha) of land covered by large-scale semi-mechanized farms. This figure will include land that may have been abandoned as it is almost impossible to distinguish this from fallow land or land with crop residues on the surface.

(iv) Small-scale Irrigated Cropping: Highland Valley-bottoms

Traditionally these wetlands have been avoided due to the presence of diseases such as typhus fever for humans and liverfluke for cattle. Limited wetland edge cultivation of maize is known to have been practiced in the area going back to the mid 19th century (McCann, 1995) but this expanded during the 20th century (Wood and Dixon, 2001). In some areas, where upslope erosion has been particularly severe, as in the Ghimbi to Nejo area, wetlands have become the major source of food accounting for up to 70% of the grain produced by these communities. More commonly this figure is around 10 to 20%, but the timing of these harvests, as the hungry season approaches, makes the wetland food particularly valuable.

In addition, to the drainage based cultivation of wetlands in the northern and eastern parts of the upper Baro-Akobo sub-basin, there is also long established cultivation of *taro* (*Colocasia esculenta*) in wetlands in Bench Maji Zone around Mizan Teferi, and in Sheka Zone around Tepi. Traditionally this does not usually involve any water management as this crop is tolerant of flooding. However, water management is occurring in some places farmers because farmers have realized that yields can be increased in this manner with flooded areas extended and water availability improved before and after the rains.

(v) Small-scale Pump Schemes: White Nile

Along the banks of the White Nile are a significant number of small-scale irrigators using a variety of irrigation methods. These are estimated to cover some 494,000 feddans (207,480 ha) (Knott & Hewett, 1994). Pumped irrigation straight from the river is common. Cereals and vegetables are the main crops grown by small-scale irrigators. Maize and sorghum are produced in summer and wheat in winter. Large areas of broad beans and vegetables are also grown under irrigation during the winter

(vi) Large Irrigation Schemes: Small-scale Operations

The two major schemes are the Gezira and Managil. Here 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.

(vii) Large Scheme: Large-scale Production of Sugar Cane

This is the Kenana Sugar Scheme which is part State and part commercially financed. Water is pumped from the White Nile. It has some 146,000 feddans (61.320 ha) of irrigated land (Knott & Hewett, 1994) under sugar cane. The Mill has a crushing capacity of 17,000 tons/day over a 218 day cycle.

(viii) Agro-Pastoral Systems of Production

There are a number of groups of agro-pastoralists who practice various forms of transhumant herding across the Sub-basin. In the northwest and northeast in the valley of the White Nile are groups that follow a north-south movement: moving northwards in the wet season and returning to their homelands at the end of the rains. In the south across the vast clay flood plains of the Baro and Pibor rivers groups move between their villages on slightly higher ground in the wet season and follow the retreating floods in the dry season to take advantage of the fresh pastures on the residual moisture.

In the far north-west in North Kordofan are the Zagawa, Kawahia and Kababish who move north in the wet season to take advantage of the annual grasses that flourish at this time, moving back again at the end of the rains. Their herds are mixed: cattle, sheep and camels. To the south of them, east of the Nuba Mountains and west of the White Nile are the Baggara who essentially cattle herders. During the dry season they move with their herds south and east across the White Nile to the north of the Machar Marshes returning to their home areas in the dry season.

East of the White Nile are two groups: the Rufa'a al-Hoi and the Fulani who herd their livestock from their base to the north of the Machar Marshes in the dry season, moving north in the wet season to the Geizira-Mangil Scheme and the large-scale semi-mechanized farms to take advantage of the new pastures and to escape the scourge of biting flies in their home area. The Rufa’a al-Hoi are an Arab speaking Muslim nomadic peoples with sheep, cattle and a few camels. The Fulani are in fact a mixture of many ethnic groups from West Africa who have the West African long horned cattle that are fast walkers but poor milkers.

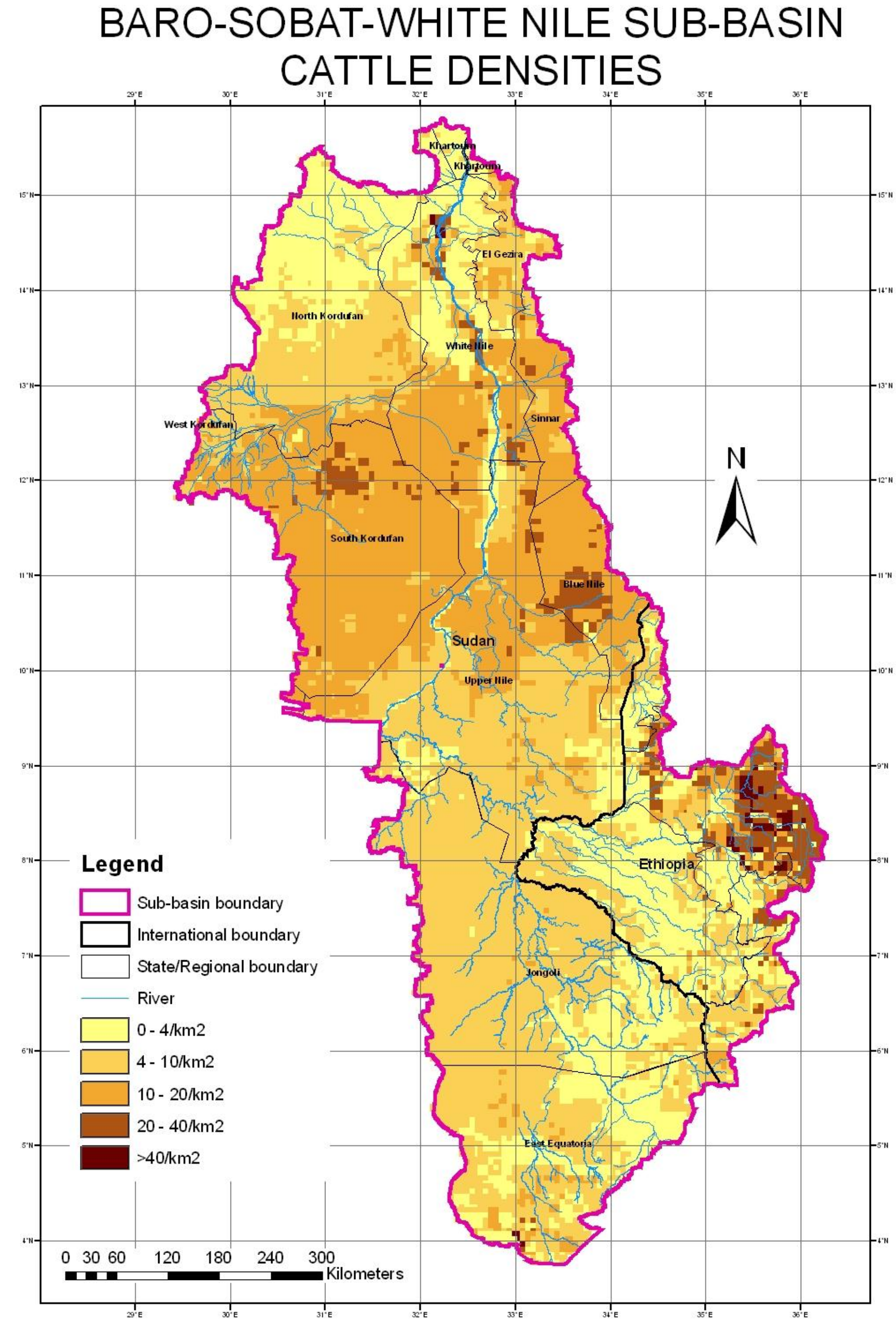
These northern groups engage in the very substantial livestock and well established marketing system of Northern Sudan. This marketing system is involved in a substantial domestic market and well as the export market to Middle Eastern countries. Their livestock are sold at the most northerly points of their herding movements when they are in prime condition.

The southern pastoral systems are practiced by the Dinka, Nuer, Murle and Toposa. They are primarily pastoral people but also practice a form of shifting cultivation growing millet, maize and occasionally cotton. In addition, fish is an important part of their diet. Settlements are located on higher ground. They are occupied during the rains from May to November. During the rains the cattle are close to the settlement. At the cessation of the rains the cattle are moved to extensive grass plains until about January when both grass and water are finished. Then with the crops harvested all the people and livestock move to the "*toich*" (seasonally flooded) grasslands along the rivers. Here the grazing and fishing is excellent. At the beginning of the rains in May women and children move back to the villages to clear the land for cultivation, whilst the cattle slowly follow.

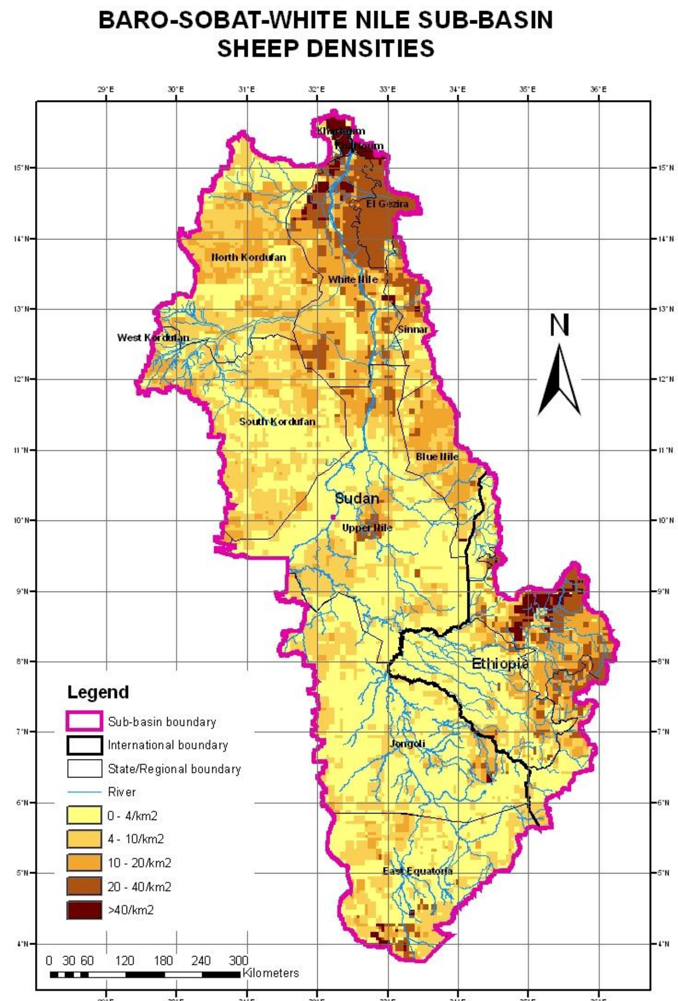
These groups engage in both the northern livestock marketing system and also a southern marketing system. The southern system caters for a relatively small domestic market centred on Juba, but export markets to the south in Kenya, Uganda and the Democratic Republic of Congo. There is also a substantial local market for breeding stock catering for young returning migrants establishing their own herds.

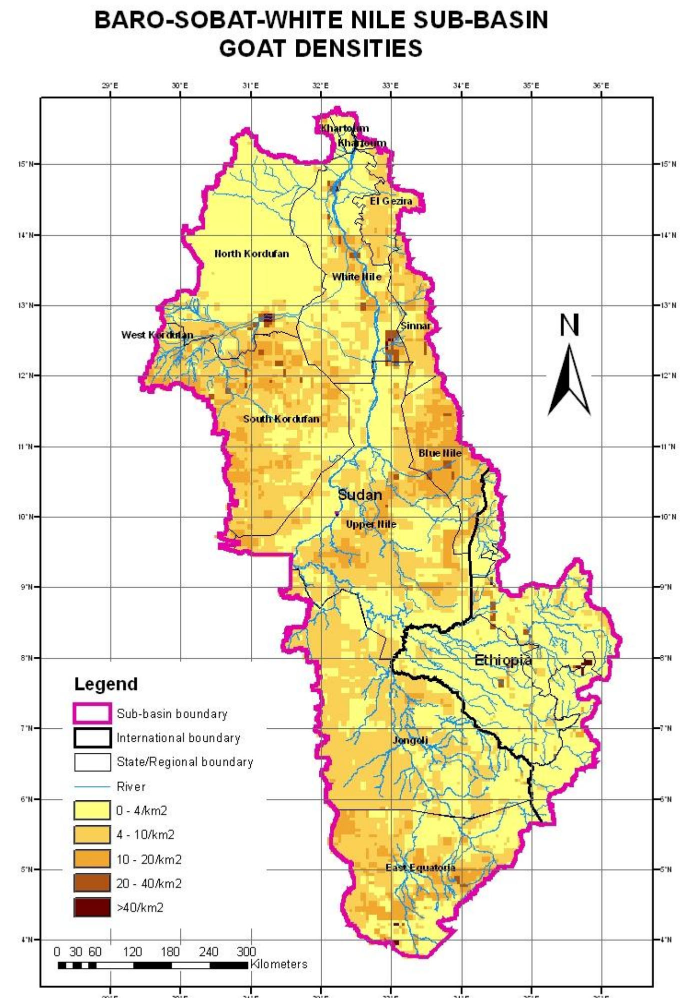
Data from the FAO Livestock Atlas for Africa are used to derived Map 17 and 18 to show the distribution of cattle, sheep and goats. Cattle densities are high in the Ethiopian Highlands, the Nuba Mountains and in the area just to the north of the Machar marshes. There moderately high in the central area across the White Nile catchment, the area occupied by the groups that are engaged in the south-north grazing movements. The southern areas have relatively low densities, in particular the area of intermittent drainage across the Pibor catchment.

Overall densities of sheep are nearly everywhere higher than goats. Highest sheep densities are located in the Ethiopian Highlands, the Nuba Mountains and in and around the Gezira-Managil Irrigation Scheme. Moderate densities are found across the central part of the White Nile Valley. Goat densities are lowest over the Ethiopian Highlands and in North Kordofan with only moderate densities elsewhere.



Map 17. Baro-Sobat-White Nile Sub-basin: Cattle densities
Source: FAO (2003)





Map 18. Baro-Sobat-White 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. 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. Farmers sell to the small merchants or assemblers in the market towns. In the Sub-basin given the very high transport costs due to the very poor road network cereal crop marketing is very limited. Crop marketing in the Highlands is mainly concentrated on the marketing of coffee. In the Lowlands there is some very local; trading of cereals into Gambela town.

In Sudan a distinction must be made between the northern part of the Sub-basin (essentially the White Nile Valley from Malakal to Khartoum) and the south. In the south some 20 years of Civil War have seriously disrupted all economic activity including crop and livestock marketing. Much of what follows refers to conditions in the north.

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 the south the peoples of the area are attempting to re-establish their livelihood strategies. The economy and infrastructure has seen destruction on a much wider scale than before. However, the economic environment is starting to see a gradual re-establishment of markets and trade: both local and export-import to the north as road and river communications become improved. This is particularly so in Eastern Equatoria where hostilities ceased some years ago (Cately, Leyland & Bishop, 2005).

(ii) Livestock Marketing

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). In the Sub-basin, as with cereal crop trading livestock marketing is limited to sales to local centres.

In northern 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. Within the Sub-basin terminal markets are also located at Kosti.

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 Southern Sudan the marketing system south of Malakal is generally linked into the markets in Kenya, Uganda and the DRC. These are only now being re-established. There is an active local market for breeding stock driven by the demand from young returning migrants wanting to establish their own herds.

2.4 Forestry and Agro-forestry

2.4.1 Forestry Contribution to the Economy

In Sudan in the Sub-basin approximately 8.8 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. An unknown quantity of charcoal is exported from the central parts of the Sub-basin to Khartoum. Woodlands provide all building materials in rural areas. They constitute 33 percent of the 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 situation in Ethiopia is not dissimilar to that in Sudan. In Ethiopia in the Baro-Akobo Sub-basin some 7.95 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. 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 Baro-Sobat-White Nile Sub-basin comprises the major part of the low rainfall woodland savannah zone extending from the border with Ethiopia to North Kordofan on clay soils east of the White Nile and sandy soils to the west.

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 (2004). 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 coffee growing under shade. Some on-farm Eucalyptus planting is taking place in the Kaficho-Shakiso Zone where the forest has largely been cleared. In other Highland areas considerable numbers of indigenous trees remain in and around cropland.

2.5 Biodiversity and Wildlife Conservation

2.5.1 Introduction

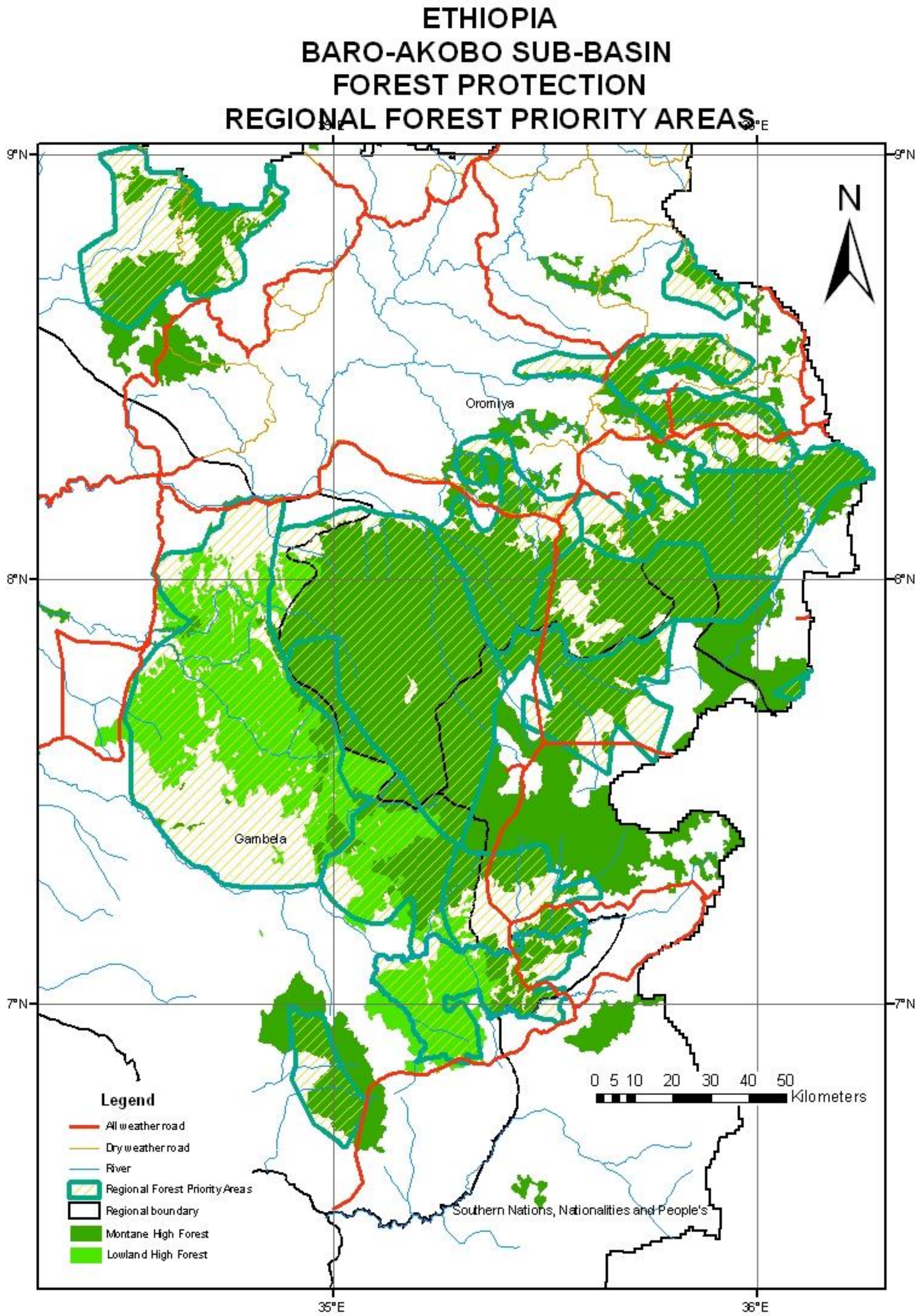
The Sub-basin has an extremely wide range of species and habitat biodiversity. In terms of habitat two of the most important of the Lowland-Highland High Forests of the Ethiopian Highland and the Imatong Mountains, and the wetland-flooded grassland mosaic of the Ethiopian and Sudan Lowlands.

2.5.2 Lowland-Highland Forests

As described in detail in paragraph 2.1.8 the forests of the Sub-basin exhibit a wide variety with 8 types of forest (including Highland Bamboo). In Ethiopia the transect from the Gambela plains to the highest parts of the Sub-basin contains in nearly one continuous a wide range of forest subtypes from the Guinea-Congolian forest through transitional sub-types to a numbers of the Afro-Montane Sub-types identified by Friis (1992). Many of these sub-types have never been fully studied and may contain Guinea-Congolian species not yet recorded in Ethiopia. The forests are home to wild coffee and are an important genetic resource with a natural resistance to coffee berry disease. Tree ferns are known from only this part of Ethiopia and cover dense stands over large areas. Pure stands of Highland Bamboo (*Arundaria alpina*) also occur over substantial areas between 2,800 to 3,100 masl. .

These forests are recognized as being less rich in avifaunal diversity than the woodland-shrubland habitats, possibly because of their long isolation from the forests of Kenya and Uganda (EWNRS, 1996). Other wildlife includes Colobus and Vervet Monkeys, Tree Squirrel, Lion, leopard, antelopes, buffalo, Elephant, Porcupine, Aardvark, Wart Hog and Forest Pig.

In Ethiopia the high forests are covered by 15 Regional Forest priority Areas. (RFPA's). However, only 6 of these have been demarcated on the ground. It can be noted from Map 19 that many areas of the RFPA's are without forest cover, and there are some areas of forest outside the RFPA boundaries.



Map 19. Baro-Sobat-White Nile Sub-basin: Ethiopia Forest Areas and Regional Forest Priority Areas

In Sudan the forest areas on the Imatong and adjoining Mountains also rise out of semi-arid plains and likewise exhibit marked altitudinal zoning (Bussman, 2006). In terms of avifaunal the forests contain some 62 of the 68 species of the Guinea-Congo Forest biome, some 33 of the 49 species of the Afrotropical Highlands Biome and 33 of the 49 species of the Somali-Masai Biome.

The forests were gazetted as a forest reserve in 1952 but have lacked conservation status despite its special biodiversity importance (Makakis, 1998). No Management Plan has been prepared for the forests (FAO, 2005).

2.5.3 Wetlands-Flooded Grasslands Mosaic

The plant ecology of the wetlands-Flooded grassland mosaic located on the clay plains of the Baro and Sobat Catchments have been described in detail in para. 2.1.8. In addition to their importance in the livelihood strategies of the agro-pastoral peoples who live on the plains, they provide habitat and species biodiversity of some considerable importance. Most famously they are home to the White-eared Kob (*Kobus kob subspp. leucotis*) and to the Nile Lechwe (*Kobus megaceros*). The white eared kob undertake a massive migration of some 1,500 kms. Both listed by IUCN as threatened species. In addition the area is an important habitat for 100 mammal species and 400 avifaunal species.

2.5.4 Biodiversity Conservation

There are two national parks in the Sub-basin: the Gambela National Park in Ethiopia and the Boma National Park in Sudan (see map 24) . In addition there is the Kidepo Game Reserve, which adjoins the Kidepo National Park in Uganda,

The Baro-Akobo Sub-basin contains only one of Ethiopia's 9 National/Regional Parks and three of the 17 Controlled Hunting Areas. The Gambella Regional Park is 506,100 ha in extent and is located between the Akobo and Ghilo rivers, east of the road between Gambella and Gog. The Park encompasses a wide range of habitats including wetlands, seasonally flooded grasslands and savanna grasslands and woodlands. It has not been gazetted and conservation resources in terms of staff and facilities are extremely meagre. Following the change of government in 1991 control of the Park passed to the Gambela Regional Administration. The area is visited by the White Eared Kob and elephant have visited the area in the past.

The Boma National Park encompasses an area of some 2.28 million ha of the clay plains and a mosaic of wetlands, seasonally flooded grasslands and open wooded savanna grassland in the north-western part. The south-eastern part of the Park includes part of the Boma Plateau and the escarpment that separates the plateau from the plains. It was declared a National, Park in 1977 but has not been gazetted. Oil has been discovered in the Park in commercial quantities. The area is extremely inaccessible, most particularly during the wet season. The main routes have been mined and minor routes un-maintained. The Park is now managed by the New Sudan Wildlife Organisation (NSWO) and a regional headquarters has been established at Boma town. There are 22 Staff including 5 Senior Staff but facilities and equipment are lacking (Morjan et al., 2001). A first study of the Park for nearly two decades was made in 2001 and preliminary wet season wildlife inventory and human livelihoods survey was made.

The Kidepo Game Reserve is located in the upper Kidepo Valley and adjoins the Kidepo National park in Uganda and covers some 120,000 ha. It was declared a Game Reserve in 1975. No information is available on either the state of the Reserve or maps of its boundaries (Babiker A. Ibrahim, 2000).

2.6 Transport and Communications

There are no major road linkages between Ethiopia and Sudan within the Baro-Sobat-White Nile Sub-basin. A dry weather track crosses the border at one point: Kurmuk. Two secondary roads: one in Sudan from Malakal and one in Ethiopia from Gambela town come very close and may meet at Jikauo on the north bank of the Baro River, which at this point forms the border. Secondary roads in Ethiopia touch or come very close to the border at Akobo and Dioma. (Map 20).

Within Sudan there are three primary and three secondary roads.

(a) Primary Roads
The three primary roads are:

Senner to Kosti and El Obeid
Khartoum – Kosti
Kenya border – Juba: This road has been opened from the Kenya border as far as Torit. The Torit to Juba section remains impassable as at December 2005 (FAO/WFP, 2006). The road linking Juba to Malakal is still not operational.

(b) Secondary Roads

There are three secondary roads that may not be passable during the rainy season:

Ad Damazin - Paloich
Rabak – Malakal

Pocalla-Boma-Lokichoggio (Kenya)

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

(c) Railway

There is one railway:

Sennar – El Obeid

(d) River Transport

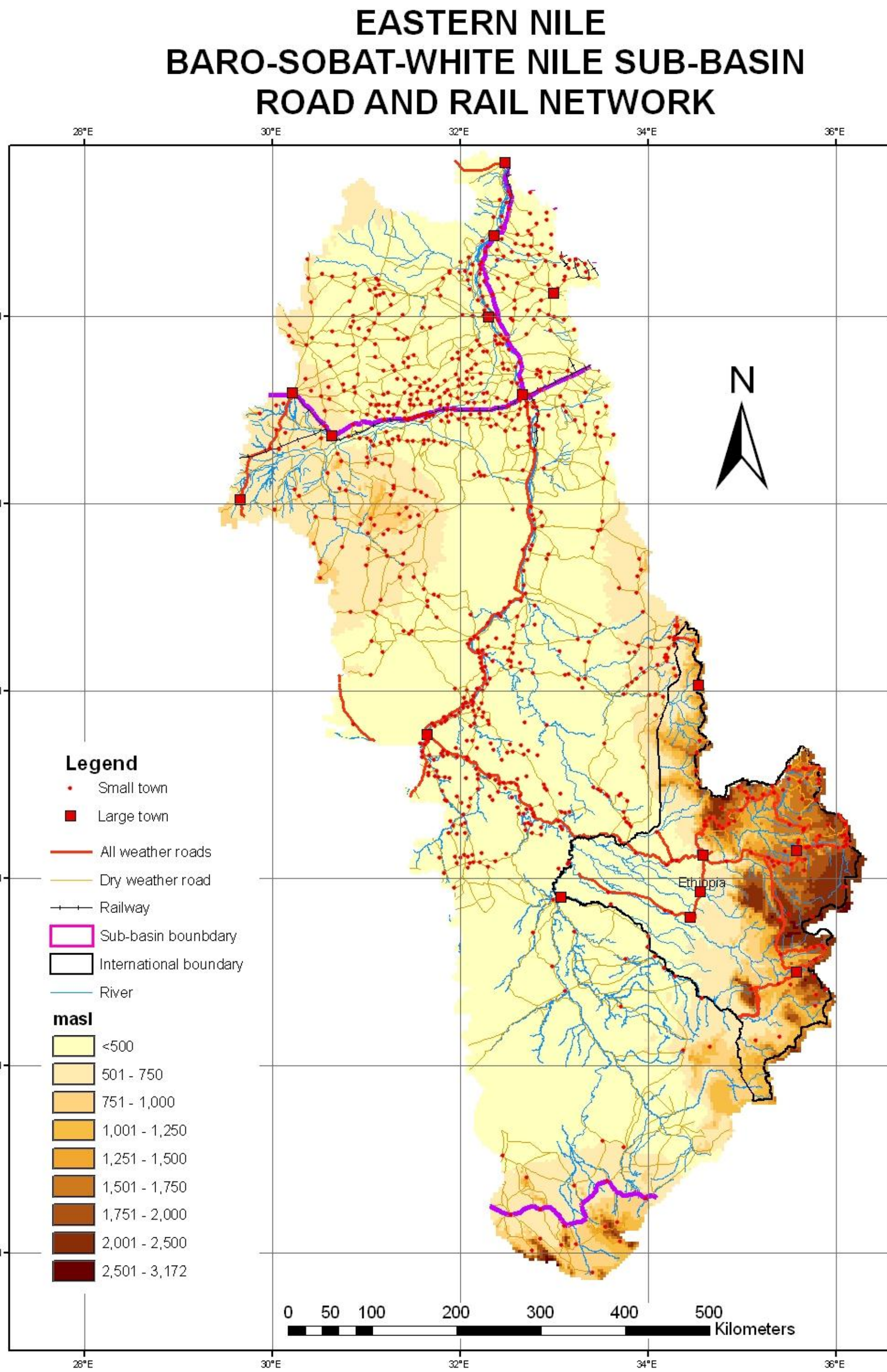
River transport between Kosti-Alkali-Juba is now functioning and the number of barges increasing.

Within Ethiopia, the basin is traversed by a network of all-weather roads of some 1,058 km, though the road density is low compared to many African countries. The roads Addis – Gambela, Addis – Assisi, Jimma – Mizan Teferi, and Gore – Tepi are well maintained all-weather roads. The Gambela – Dembidolo road is also all-weather road, but in need of maintenance. Numerous smaller roads or dry-weather road links, accessible only

In general, the western part of the basin is the least served by roads. Further improvements to roads in the basin are expected to take place consistent with the priorities of the Road Sector Development Plan of the Ethiopian Road Authority.

In terms of accessibility to all-weather roads some 52 percent of the area of the Sub-basin is more than 15 kms. This compares with 45 percent for the Abay Sub-basin and 39 percent for the Tekeze Sub-basin. The main areas are the still forested plateau and escarpment, and the south-western lowlands. (Map 46).

There are six operational airports in the Baro-Akobo basin connected to Addis Ababa by schedule air services. Gambela is the largest and the only airport with paved runway and navigation aids. It handles about 5,000 passengers (arrivals and departures) per year, while the other five handle 15,000 between them.



Map 20. Baro-Sobat-White Nile Sub-basin: Road and Rail Network
Source: Afriroad & EMA (Addis Ababa)

3. SUB-BASIN-WIDE WATERSHED MANAGEMENT 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 Baro-Sobat-White 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. 3). 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).

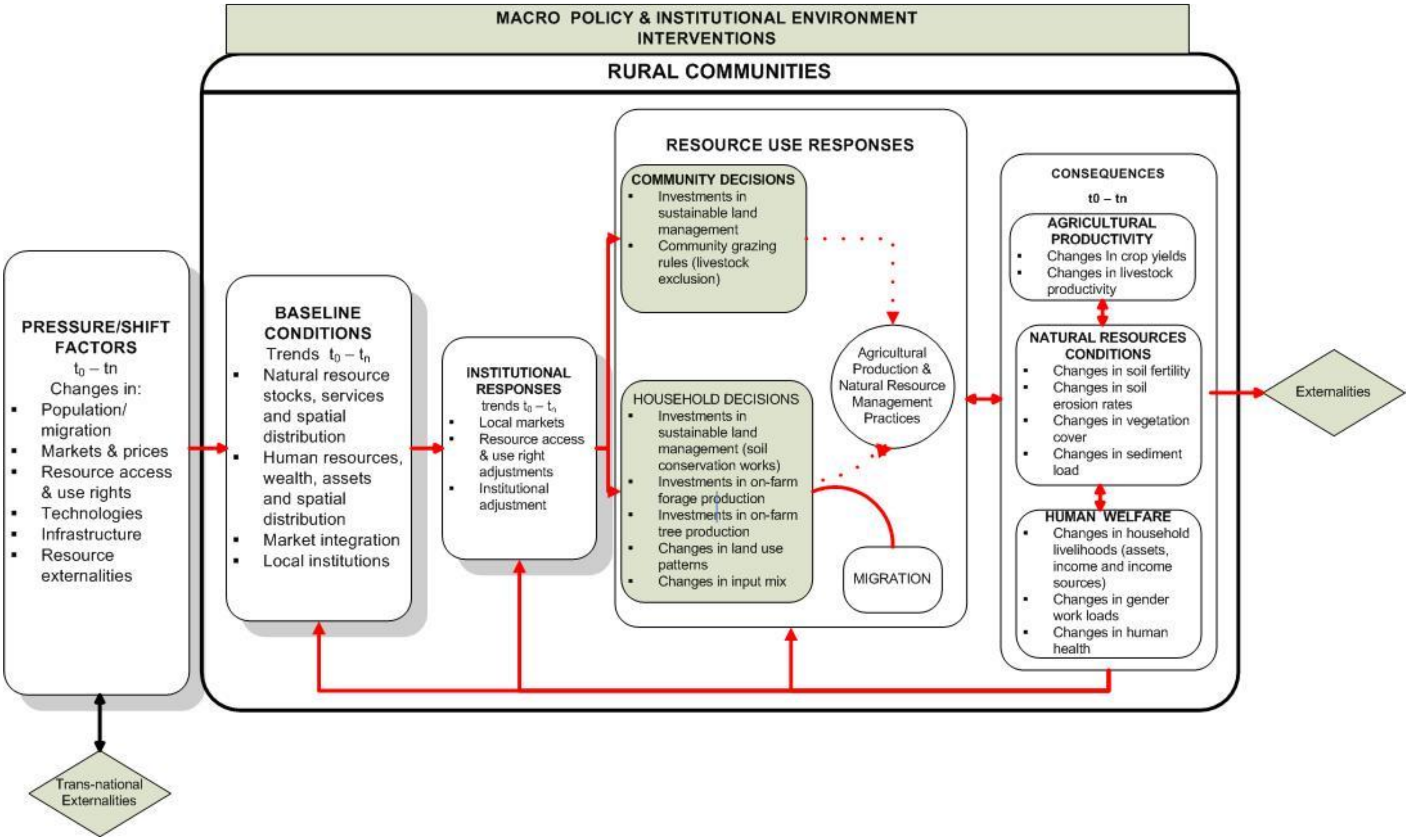


Figure 3. Framework of Analysis for Natural Resource Degradation in the Sudan.
Source: Scherr, S.J. et al., 1996

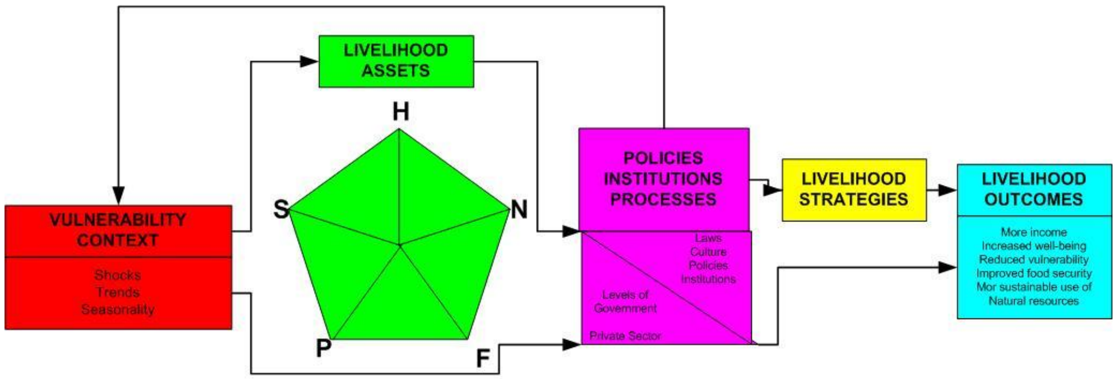
These shifts can in turn induce responses at the community and household level. Of particular importance and of relevance to the present analysis are the community and household decisions with regard to investments (or non investments) in agriculture, soil conservation, and small-scale irrigation. Other 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 10 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 4). 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 4. A Framework for Household and Community Livelihoods Analysis in a Poverty-Natural Resources Context.



KEY:
H = Human Capital
S = Social Capital
N = Natural Capital
P = Physical Capital
F = Financial Capital

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[4]. The percentages of population below the official poverty line are shown in Map 21.

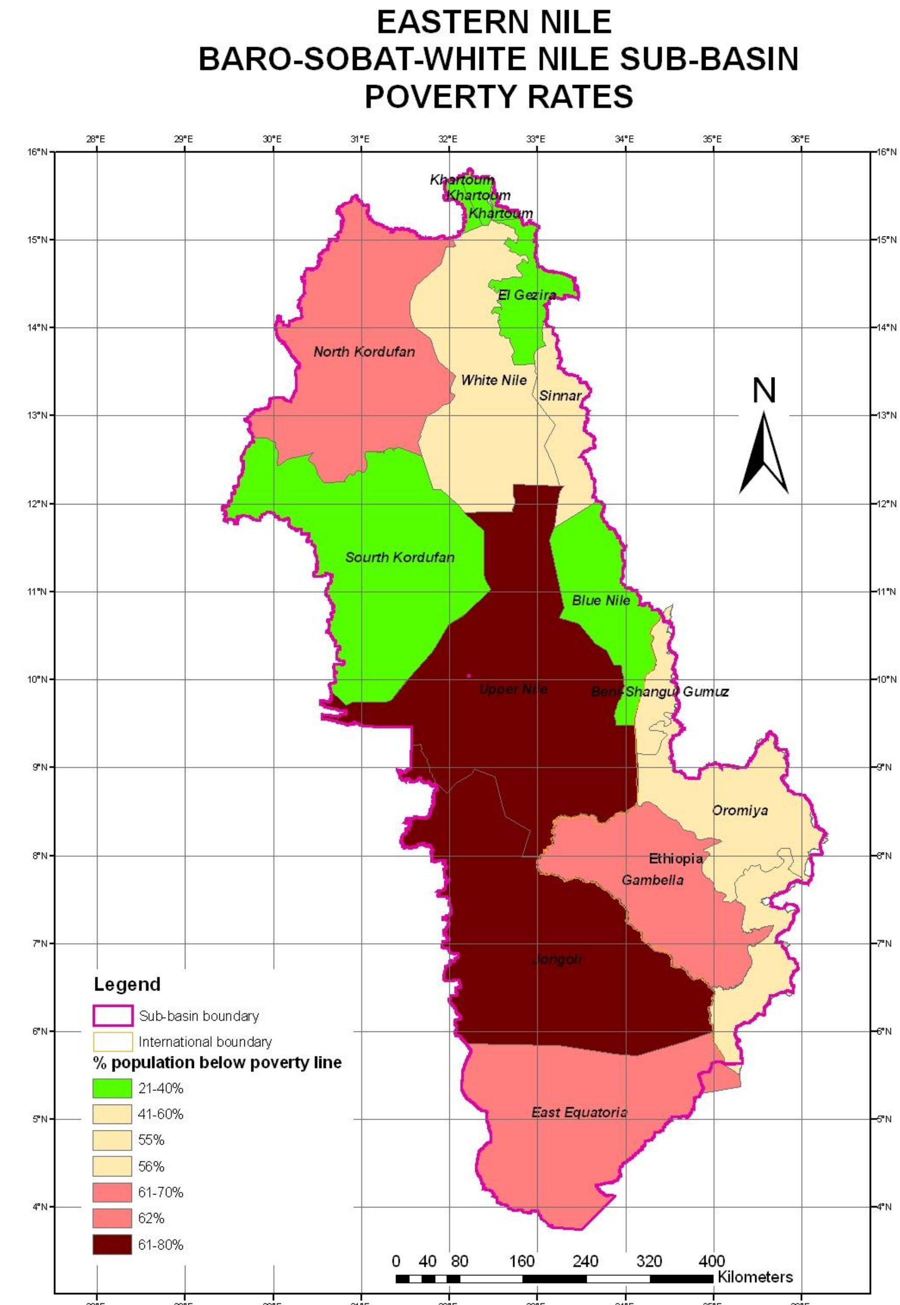
(i) Poverty

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. In all Regional States except Oromiya rural rates had increased since 1995 as had all urban rates.

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

[4] 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.

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). 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 21. 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).

The spatial distribution of the percentage of the population (total in Sudan, Rural in Ethiopia) is shown in map 16. High poverty rates are most prevalent in Southern Sudan and North Kordufan State. Rates in Ethiopia are not as variable: from 55 percent for SNNP Region and Oromiya to 62 percent in Gambela.

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) 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,
- 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 Policy Issues in the Sudan

(i) Land Policy Issues Northern 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, 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.

(ii) Land Policy Issues in Southern Sudan

Land Policy in the South is currently based on customary law, and there are considerable inconsistencies in how customary laws are applied in different Regions. One common principle is that "land belongs to the people" which is different from the North where nearly all land has been declared government land. It is generally agreed that land laws in the South are not sound because of the lack of tenure security. In addition, the conditions for land utilization are not clear. This lack of tenure security and lack of clarity on land utilization conditions weaken incentives to invest. The JAM considers that a land law review is required. There is an upcoming Land Commission for Southern Sudan that will consider future land policy in detail for the South. It is anticipated that land policy in the future constitution will be based on the conclusions and recommendations of the Land Commission.

(iii) Natural Resource Development and Management Policy in Southern Sudan

A USAID assessment of environmental threats and opportunities in Southern Sudan (Catterson et al., 2003) noted with concern the views expressed by the Technical Committee on Natural Resources Management and Utilization that the wetlands in Southern Sudan "*represent prime agricultural lands in Southern Sudan. Although these wetlands can also be used for livestock watering and grazing, sanctuaries to thousands of bird species etc., their main function should be for the production of cereal crops such as maize, sorghum, rice, etc.*"

Howell et al. (1988) refer to a number of studies into the possibility of utilizing the seasonally flooded clay plains and in particular to the ILACO field trials into large-scale irrigated cropping. They enumerate the many technical problems encountered. At the end of a 9 year study (1976-1984) they concluded "...*any new programme of development must begin where others were forced to leave off and must preceded by a thorough examination of the experience gained in this interlude in the violent and damaging history of the area in the last 33 years.*"

The USAID study states that whilst these development aspirations are understandable it hopes that they will be tempered by effective environmental review and any plans for development be formulated in close and well-informed consultation with affected communities.

3.2.3 Institutional Issues

(i) Complexity of the Institutional Framework

The Baro-Sobat-White 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 four Regional State administrations and with Sudan ten State administrations with five located within the administration of Southern Sudan.

In Ethiopia, whilst a Master Plan study has been undertaken for the Baro-Akobo Catchment 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 Baro-Akobo Catchment is one of the 12 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.

(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 (ARD, 2004). 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

(World Bank, 2005b). 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. The USAID Environmental Assessment Report (Catterson et al., 2003) referring to agricultural and land use policy directions of the Southern Sudan administration considered that they would like to return to the "*status quo ante*" typified by a "command and control" approach as their central theme of agricultural and natural resource policy. The Report concluded that great care will be needed in agricultural and rural development to avoid policies, actions and decisions that erode peoples' actual or perceived land and resource tenure rights.

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.

(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.

In Ethiopia, whilst a Master Plan study has been undertaken for the Baro-Akobo 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:

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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. Under the ENSAP programme four CRA's are being undertaken in the Baro-Sobat-White Nile and the other Sub-basins within the Eastern Nile Basin and providing opportunities for cooperative assessments and planning.

(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

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. 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 in North Kordufan State and thus not as high a risk environmental. Conversely, in the traditional rainfed cropping areas in Kordufan State and also in the eastern part of Jongli State (e.g. the Boma Plateau) and the south-eastern parts of East Equatoria 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 drought and conflict.

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.

3.3.2 Livelihood Assets

The Ethiopian SDPRP Report (FDRE-MOFED, 2002) outlines a number of other determinants of poverty. It is interesting that a number of these also occur in the analysis (World Bank, 2003) 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 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.

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. In this way it 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 areas with poor access farmers 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 and pastoral 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, 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 proportion of households dependant on agriculture in Ethiopia and Sudan are 85 percent and 70 percent. However, the contribution of agriculture to each country's GDP is only 45 percent and 37 percent respectively and declining in both 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 (ARD, 2005) 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 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 Over-view

The main area of sheet erosion is within the Ethiopian Highlands. On the large Semi-mechanized and small traditional farms the key soil degradation problem is nutrient mining. They are located on the clay plains in the north-east and north-west parts of the Sub-basin. The alienation of large areas of traditional cropland and rangeland has given rise to severe natural resource conflicts, which in some areas has been exacerbated by ethnic tensions. Sedimentation is not currently a major problem in the Sub-basin.

A key problem is the un-controlled deforestation in the Ethiopian Highlands due to expansion of smallholder and large scale agriculture, and the potential consequences they may have on increased erosion and suspended sediment loads, and change in seasonal flow regimes. Another key problem is the uncontrolled utilization of the highland valley-bottom swamps and the destruction of their environmental services and products.

There are a number of potential problems facing sustainable watershed management in the Sub-basin. These may be summarized as follows:

- the sudden influx of very large numbers of IDP's and refugees returning to their homelands and the consequent pressures this may have on the natural resource base;

- the destruction and neglect of the physical and social infrastructure after 20 years of war and insecurity;

- the rupture and breakdown of the intricate socio-cultural networks within and among the many and various ethnic groups because of the war;

- the large scale operations of and associated with oil exploration and production (waste water disposal, road construction, oil spills) and their impacts on the fragile hydro-ecosystems and their biodiversity, and on the dependant livelihoods of the local inhabitants;

- the possible negative impacts of river control structures in the upper catchments of the Baro-Akobo on the extensive lowland wetlands and their biodiversity, and on the associated livelihood systems of the local inhabitants in the Baro-Akobo-Pibor catchments;

- the possible negative impacts on the Machar Marsh wetland systems and the associated livelihood systems if the construction of the Machar By-pass Canal were to go ahead;

- the uncontrolled development of the Montane Forests of the Imatong Mountains, the planting of exotic trees and the general destruction of the biodiversity.

3.5.2 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, 1985) within the Geographic Information System (see Annex 1 for the full description of the methodology). Little work has been done in Ethiopia on gully densities and erosion rates. In the Baro-Akobo gully erosion is local and mainly confined to inappropriately located culverts. In this high rainfall area natural vegetation quickly invades and helps stabilize gullies.

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, soil nutrient mining (Semi-mechanized Farms), wetlands and High Forest areas within the Baro-Sobat-White Nile Sub-basin are shown in Map 22.

(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. However, given the steep slopes prevailing in parts of the Nuba and the Imatong Mountains and where the forest and woodland cover has been cleared for agriculture sheet erosion is likely to be taking place in these locations.

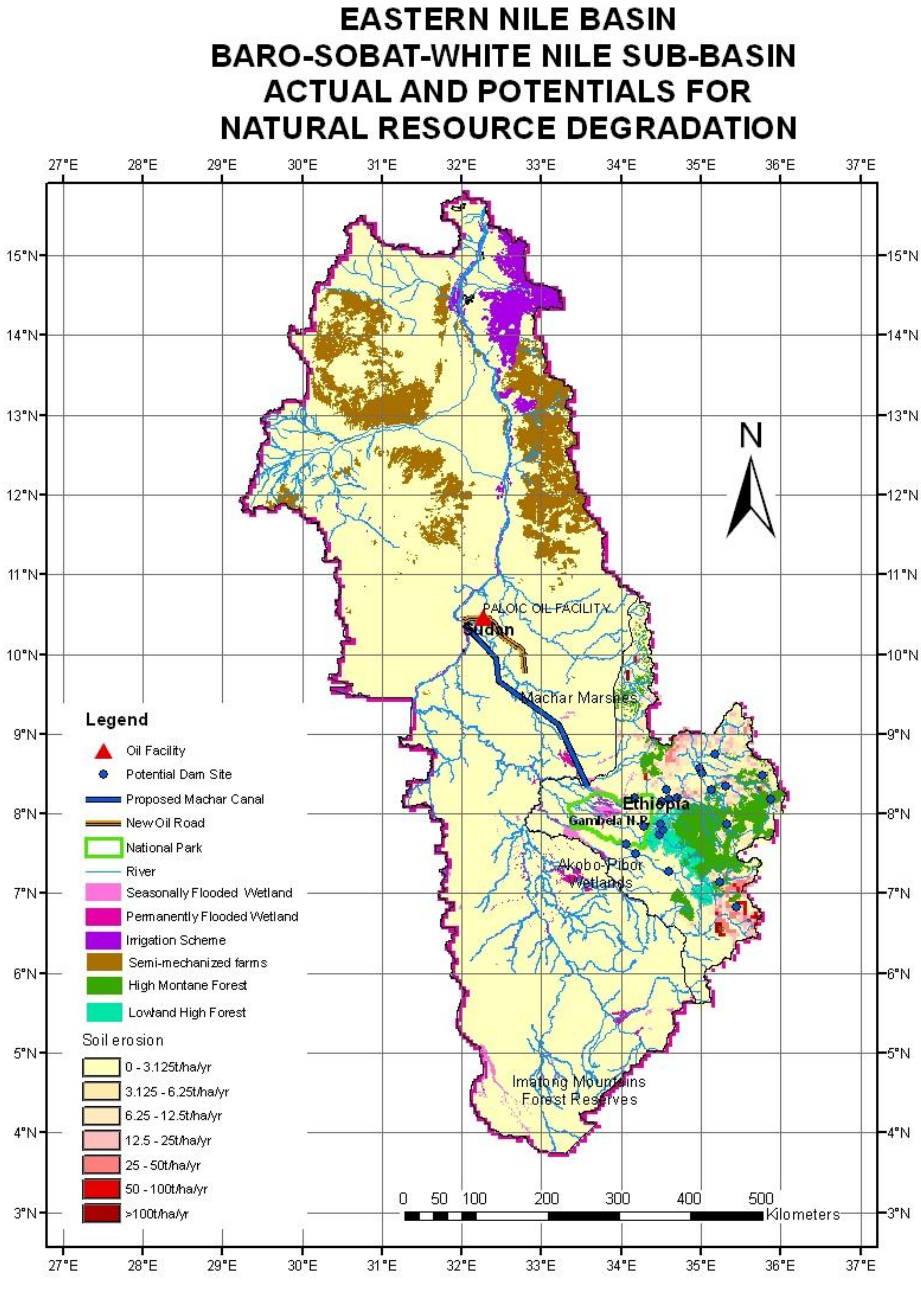
Three main areas of high sheet erosion are found in the Baro-Akobo basin. The first is located on the escarpment in BSG Region. The second area is north and south of the Baro River Valley, whilst the third area is found in SNNP region in the catchments of the Upper Gilo and Duna.

The total soil eroded in the Baro-Akobo Catchment is estimated to be 43.7 million tons per annum and that from cultivated land 21.5 million tons per annum. This is a much higher proportion than in either the Tekeze or Abay Sub-basins, a reflection of the much higher vegetative cover in the communal lands of this high rainfall area.

(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 (NCS) (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 12.



Map 22. Baro-Sobat-White Nile Sub-basin: Actual and Potentials for Natural Resource Degradation.

Table 12. 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	**1.6%**

Source: Sutcliffe (1993)

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 Baro-Sobat-White Nile Sub-basin is shown in Table 13, together with accumulated losses for 5, 10 and 25 years.

Table 13. 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)
Baro-Akobo	**2,591**	**12,957**	**25,914**	**64,875**

Source: Calculated from Soil Loss and Land Cover Maps (WBISPP, 2001)

The current annual crop grain production for the Baro-Sobat-White Nile Sub-basin is 0.514 million tons. The annual loss due to soil erosion as a proportion of total production is 0.5 percent in the Sub-basin. However, after 10 years this rises to 5 percent and after 25 years to 13 percent of annual crop production.

(iii) Gully erosion

The Ethiopian highlands of the Sub-basin are relatively free of gulley erosion given the good vegetative cover in this high rainfall environment. Locally some gully erosion can be observed, almost invariably due to the poor location of a road culvert, and along cattle tracks between villages and water sources.

In Sudan gully erosion in the Nuba Mountains is more likely given the long period of settlement and the low vegetative cover.

(iv) River bank Erosion

Given the relatively dense vegetative cover along the Baro, Akobo, Pibor, Sobat and White Nile Rivers, river bank erosion is not the problem that it is in the Blue Nile, Atbara and Main Nile Rivers. The slow current and almost flat banks of the White Nile could also be an additional factor.

(v) Suspended Sediment in the Baro-Sobat-White Nile River System

Sediment transport data have been collected at eleven gauging stations in the Baro-Akobo basin. The oldest records started in 1988 on the Keto River near Chanka, followed by the records on other six stations started in 1988. All records on these stations stopped in 1990. However, indicative annual sediment load has been estimated for six stations (see Table 14a) using the limited amount of data available.

The Baro 1 and 2 Dam Feasibility Study has examined additional data taken by MWR up to 1996 and additional data collected by the Study (table 14b). Data is available for 7 additional stations. The data for these stations are shown in Table 56b. Sediment yields vary from 35 to 324t/km^2/yr with an average of 125t/km^2/yr. These rates are considerably lower than those of the Tekeze and Abay Sub-basins, reflecting the greater ground cover in this forested high rainfall regions.

Table 14a. Average Annual Sediment Yield (Master Plan)

River	Drainage Area (km²)	Mean Annual Flow (m³/s)	Annual Sediment Load (t/yr/km²)
Keto	1,006	17.60	324
Gumero	106	2.05	35
Ouwa	288	5.80	284
Sor	1,620	53.60	124
Gecheh	79	1.90	63
Begwaha	125	3.30	85

Source: B-A Master Plan Study

Table 14b. Average Annual Sediment Yield (Master Plan)

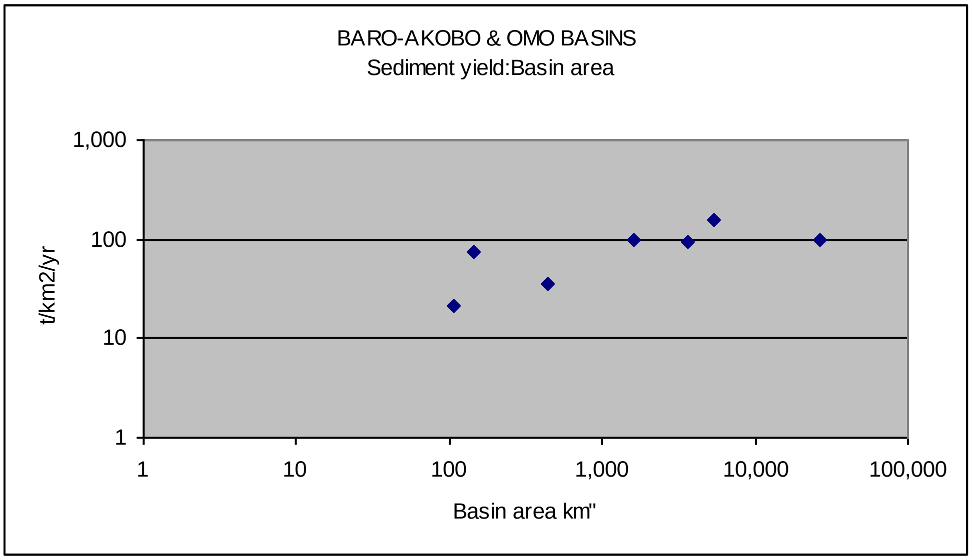
River	Drainage Area (km²)	Mean Annual Flow (m³/s)	Annual Sediment Load (t/yr/km²)
Sor nr. Metu	1,622	50.1	169.0
Geba nr. Chora	1,582	49.3	137.0
Geba nr. Suppi	3,894	54.8	75.2
Uka at Uka	53	1.3	49.5
Gummero nr Gore	106	1.9	31.6
Baro nr. Masha	1,653	56.8	155.0
Genji nr. Gecha	115	4.6	87.8

Baro1-2 Feasibility Study (2006)

			Annual Sediment Load (t/yr/km²)
Mean			**124.6**

Figure 5 shows the scatter plot of tables 60a and 60b. As with the Tekeze and Abay Sub-basins annual sediment yields had a slight tendency to increase with catchment area, although the relationship is not significant.

Figure 5. Ethiopia – Baro-Akobo Sub-basin: Catchment area and sediment yield relationships.



Source: Norplan et al., (2006)

There is no significant difference between the sediment yields of small and large catchments. This would appear to indicate there is little or no storage of sediment within the Baro-Akobo river system within the Highlands, a factor normally attributed to declining sediment yields with increasing catchment areas. However, in this case, this is to be expected given the steep gradients in both tributary and main rivers. Given the relatively high sediment delivery ratios and very similar sediment yields it would appear that within the Highlands the river system is relatively efficient in delivering and removing eroded sediment from the landscape. The inference of this is that interventions to reduce in-field erosion are likely to have a relatively immediate impact on sediment loading in the river system.

With an estimated annual mean suspended sediment load in the Baro and Akobo Rivers of 8.15 million tons and an estimated 43.7 million tons of soil eroded, this gives an estimated sediment delivery ratio (SDR) for the whole Sub-basin of only 19 percent, considerable less than the Tekeze (about 60 percent) and the Abay (about 49 percent). This is a clear reflection of the very substantial vegetation cover in the upper catchments of the Baro and Akobo Rivers. Thus some 81 percent of soil eroded remains within the landscape.

(vi) Dam and Reservoir Siltation

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 only dam in the Baro-Akobo catchment is the Alwero Dam. It has a catchment of approximately 2,738 km^2. Using the average sediment yield estimate for the Baro-Akobo catchment (124t/km^2/yr) the annual suspended sediment load of the Alwero River would be approximately 341,155 tons/yr or 332,720 m^3/yr. Given that the catchment is heavily forested with little cultivation this is likely to be an overestimate. Assuming a sediment retention rate of 86 percent this would result in an estimated accumulation of 284,616m^3 of sediment per annum.

The proposed Baro1 Dam on the Baro River has an estimated sediment inflow of 0.42 million tons/yr and a sediment retention rate of 98 percent. Thus the dam would retain 0.41 million tons/yr and allow 0.1 million tons/yr to Baro 2 Dam below. Assuming the same sediment retention rate the Baro River below Baro 2 would have only 0.009 million tons/yr of suspended sediment. After 50 years it was estimated that 0.24 percent of Baro 1 Dam's live storage would be depleted and that of Baro 2 would be 0.62 percent.

3.5.3 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

The WBISPP (2003) estimated that within the Baro-Akobo Basin only 1,730 tons/yr of dung is used as fuel. However, some 212,600 tons/yr of crop residues are burnt as household fuel. This resulted in a loss of some 1,003 tons of N and 102 tons of P.

An estimated 514,616 tons of grain is removed from cropland annually. This would account for an additional 14,770 tons of N and 2,950 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 enrichment ratios of 2 for 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 1,886 tons with 329 tons of available P on 1.6 million ha of cultivated land and 43.7 million tons of annual soil loss.

The estimated total annual losses of soil nutrients to cultivated land are summarized in table 15.

Table 15. Ethiopia – Baro-Akobo Basin: Estimated losses of N and P soil nutrients from three sources.

Source of loss	tons N	tons P
Dung/residues as fuel	1,003	102
Grain removed	14,770	2,950
Soil erosion	1,886	329
TOTAL	**17,659**	**3,381**

Source: CRA Calculation

Against these N losses are annual increments of N from rainfall and asymbiotic and symbiotic fixation. For Ethiopia these are estimated to be 15 kgs per ha per annum (Sanchez, 1976). From mineralization and external sources there is an annual increment of 24,195 tons of N. Although some of this would be lost through leaching, it would appear that overall there is a net gain of N of about 6,536 tons. This is in contrast to the net losses incurred in the Tekeze and the Abay Sub-basins.

This is almost certainly not the case in those weredas located on acidic and infertile granite-derived soils in Western Wellega. The sub-soil is extremely deficient in nutrients. The nitrogen pool in these soils is thus likely to be extremely deficient. In these soils most nutrient mineralization rates are probably one third the rate of those on basaltic soils. Farmers use a "moving night kraal" system over their fields in an effort to restore soil fertility. It can be assumed therefore that in these areas the nutrient loss is net.

(iii) Sudan

Within the Baro-Sobat-White Nile Sub-basin in Sudan there are approximately 9.09 million feddans (3.82 million ha) of large to medium semi-mechanized farms (SMF)[5]. However, a proportion of this land has gone out of production and in some cases has been abandoned. The FAO/WFP crop survey for 2004 estimated cereal production from the SMF Sector for Senner and Blue Nile

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

States as 337,000 tons. Average yields are 0.36 tons per ha, which suggests that approximately 2.23 million feddans (0.936 million hectares) were under crops in these States. This suggests that in 2004 (an average rainfall year) only 38 percent of the SMF land within these States were cropped.

Land is rented from the government at about £S1 per feddan (0.42ha). Sorghum occupies about 80 percent of the area, with sesame and some cotton occupying the remainder. According to an ILO report in 1976 the advantages were seen to be:

- Employment generation,
- Contributing to expanded food supply for domestic consumption and for export.
- Have a low demand for public services and support compared with peasant agriculture or large irrigation schemes.
- Mobilizes private investment.

However, the complete removal of vegetation and the consequent removal of natural predators (snakes and cats) have 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.

The soils of the Gezira and White Nile Plains require that at least 25 percent of the land should be fallowed at any one time. Soil analyses indicate the absence of a reserve of weatherable minerals capable of releasing plant nutrients and a low level of total available plant nutrients. Traditional farmers aver that land should not be cultivated continuously for 5 years without being left to rest for a further six to ten years.

In the Gederef area the available evidence shows that yield potential on newly cleared land declines from 1,000 kgs per feddan to about 100-200 kgs per feddan after 6 to 10 years of continuous cropping (Kreab, 1996). Continuous mono-cropping of sorghum mines soil nutrients. It is reported that the SMF's cultivate continuously without using fertilizer for 6 – 8 years then abandon the land and open up new land illegally in un-demarcated areas. Traditional farmers extend the period of cultivation by rotational cropping sorghum with sesame.

Continuous cultivated results in a loss of soil structure and an increase in sand fraction. This is further exacerbated by soil compact from the use of heavy machinery. All lead to a reduction in soil moisture holding capacity. As crop residues are cleared from fields (to facilitate mechanical cultivation) soil organic matter also declines further reducing soil moisture holding capacities. Given the low and variable rainfall in the Atbara and Blue Nile Sub-basins this has a significant negative impact on crop yields.

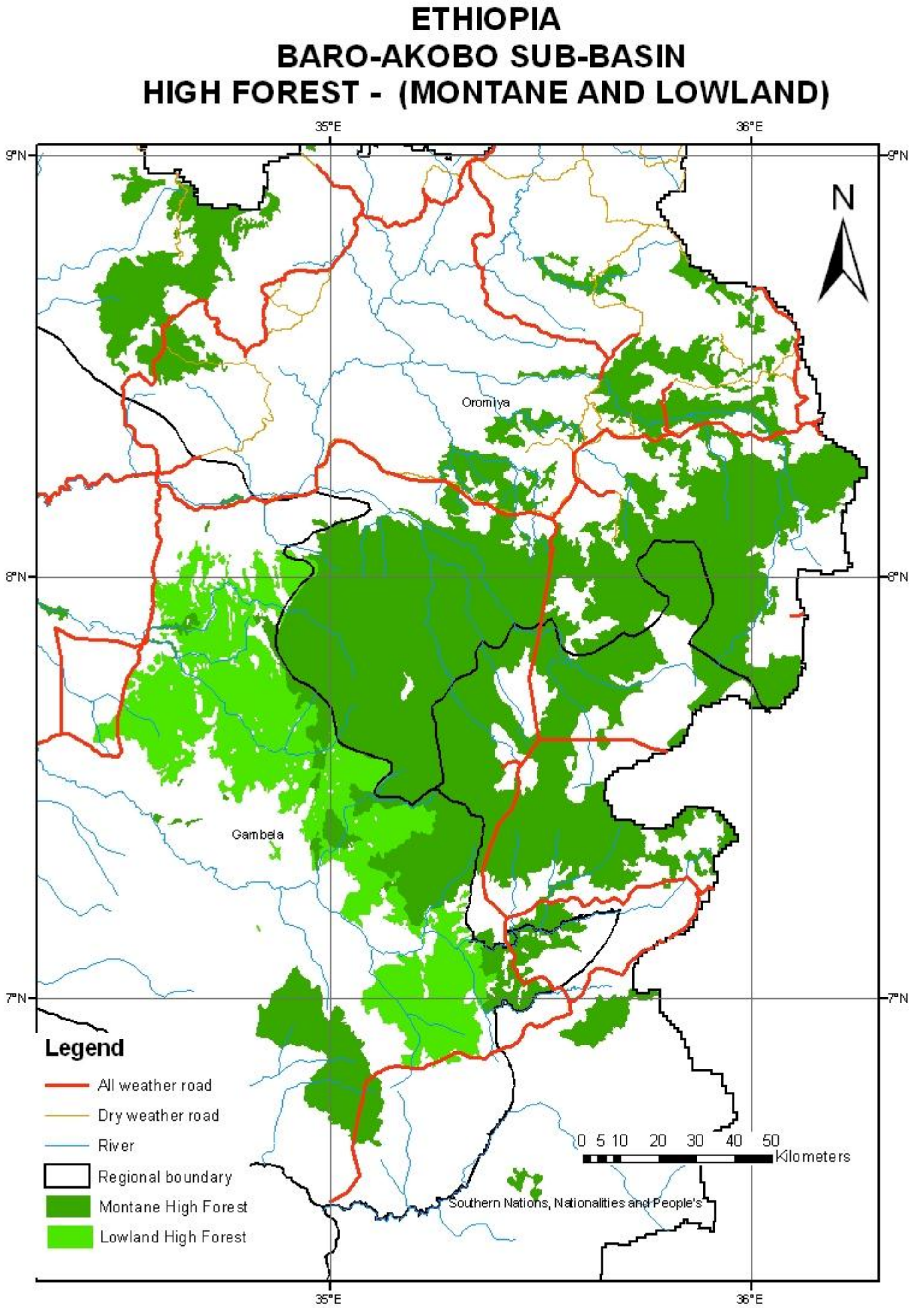
During the 1990's the area harvested on the SMF's contracted by 2.4 percent per annum whilst yields declined even further by 5.1 percent per annum (World Bank, 2005). This resulted in a decline of GDP from SMF Sector of 6.7 percent. These declines are due to a decline in soil fertility in the absence of 25 percent fallowing, a build-up of weeds (including striga) and to an expansion onto marginal land.

Using the above area decline figures for the Baro-Sobat-White Nile Sub-basins would indicate that some 218,225 feddans (91,654 ha) a year are being abandoned. Assuming an average yield of 0.36 tons per ha, there is an annual (cumulative) reduction in production due to declining yields of 26,625 tons of sorghum.

3.5.4 Issues related to Deforestation and Loss of Vegetative Cover in the Upper Baro-Akobo

(i) Trends and Impacts in Ethiopia

The dominant environmental change in the Baro-Akobo sub-basin is the loss of forest cover which is most marked in the southern and eastern part of the upper sub-basin where the main areas of forest remain (Map 23). The most recent analysis of forest clearance in the south-west highlands, both within the sub-basin and to the east, was made by Reusing (1999) using data from the WBISPP. He identified extensive thinning of the forest and the break-up of the major block of forest in the south-west due to clearance in particular salients, especially along newly constructed roads. His figures show that between 1971 and 1997 approximately 60% of the high forest showed signs of some negative human impact, with 17% having such severe impact that there was complete deforestation. In this period he identified a loss of approximately 4,940 sq km out of a total monitored are of 18,000 sq km (Reusing, 1999, pp.29-32).



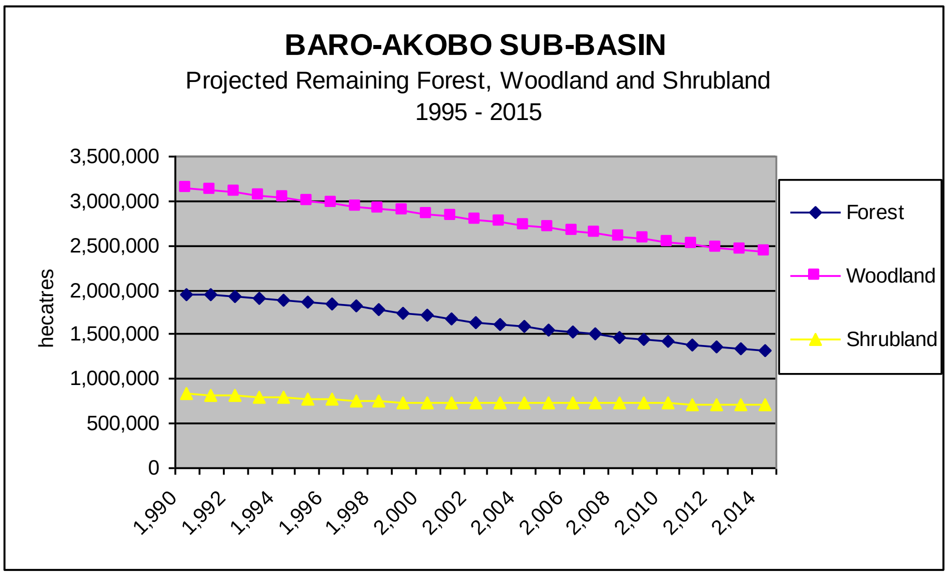
Map 23. Baro-Akobo Sub-basin: Montane and Lowland High Forest Areas.

The forecast amount of forest, woodland and shrubland cleared between 1990 and 2015 within the Baro-Akobo Sub-basin are as follows:

Forest:	642,445 ha (33% of 1990 area)
Woodland:	724,367 ha (23% of 1990)
Shrubland	126,448 ha (155 of 1990 area)

The reason for the lower area of shrubland cleared is because much shrubland occurs on slopes greater than 30 percent and is not used for cultivation. Figure 6 shows the forecasted amount of forest, woodland and shrubland remaining 1995 – 2015.

Figure 6. Ethiopia- Baro-Akobo Sub-basin: Projected remaining Forest, Woodland and Shrubland after Clearing for Small-scale Agriculture and Settlement.



Source: WBISPP 20005

The conversion of forest land to crop land and then grazing land has implications for hydrology. Although there is much debate at present about the role of forest land in affecting the volume of flow, due to evapotranspiration by trees, there are clear implications of forest loss upon the moderation of stream flow, especially the storage of water from the rainy season into the dry season. Hence, linked to the loss of forest are trends towards higher floods and lower dry season flows.

There is some evidence of this already occurring in the sub-basin, with the Sor hydro-power plant (near Metu) becoming more seasonal in its power generation and the Baro River at Gambela having more frequent high floods which are affecting long-established villages and low flows which allow the river to be forded in the dry season. Further, as forest in the upper sub-basin is replaced by farm land sediment loads are reported to be increasing with their implications for dam development in the upper sub-basin and for river bed levels and channel overflow in the lower sub-basin.

(ii) Driving Forces

The main driving forces are:

Farming system dynamics: The main cause of forest loss is agricultural clearance. This is driven by two main factors, the decline in yields on cultivated land with the subsequent abandonment of that land from cultivation, and rural population growth.

Population Growth and Resettlement: A related driver of forest clearance is population growth which is in the order of 2.8% in the rural areas of the upper sub-basin. This growth is mostly due to natural increase, but there has been a long history, when permitted, of spontaneous migration of people in search of land or economic opportunities associated with the coffee economy, as well as planned resettlement from famine affected areas.

Forest Land Alienation to State Farms and Investors:

The process of forest land allocation for parastatal estate farming accelerated during the Derg government (1974-1991) as the road infrastructure in this area was improved. This saw the establishment of the 8,000 ha coffee estate at Bebeka, to the west of Mizan Teferi and the established of another state farm for coffee near Tepi covering around 5,000 ha. In the lower basin the state farm at Abobo was also established partly in woodland.

Since the change of government in 1991, and the introduction of the free market, forest land has been allocated to investors on long leases for estate agriculture. This has mostly been done in SNNPRS where a rather favourable attitude to investors exists, compared to that in Oromiya where more stringent EIA procedures have been applied. The new estates are mostly in Sheka Zone, near Masha, along the road from Tepi to Gore, but also west of Mizan Teferi. In all cases the estates have been established in areas of high forest and experience shows that when options exist for using secondary / thinned forest within the allocated area, investors prefer the high forest.

Coffee Prices and Forest Loss: A further irregular driver of forest clearance is the periodic fall in coffee prices and the subsequent decision by farmers to convert coffee forest, already thinned in terms of tree density, into farmland. The most recent experience of this was in the early years of the 21st century. The impact of low coffee prices is exacerbated by the impact of a long and complex trading chain which means that the village price for coffee is often only some 30% to 45% of the international price. Conversely, forest thinning for coffee increases during times when the coffee prices are strong relative to other crops.

Sawmills and Forest Access: **T**here is little legal logging going on today, although small-scale pit sawing remains. The major aspect of large-scale logging that was undertaken during the derg regime has been the way in which it opens up areas of forest for spontaneous agricultural settlement.

Land Tenure and Land Registration: Where land tenure related issues have had an impact upon forest clearance is during the last two years (2004-2006) since the process of land registration has been publicized – but not implemented. Land registration rights will be given to individuals on the basis of the land they are using and so the rule has led to those with access to forest areas clearing it and undertaking minimal farming so that they can claim they are using this land. This seems to involve all elements of the community, rich and poor, as well as settlers.

3.5.5 Vegetation Loss in the Lowlands of the Baro-Akobo Catchment

(i) Trends:

(a) Forest Loss:

Analysis by the WBISPP in the high forest areas of Dima, Godere, Gog, Akobo and Gambela weredas has estimated the rates of deforestation caused by expanding population (2.23% per annum) and its need for agricultural crop land. Annual destruction of the woody biomass from the high forest areas for agricultural expansion was estimated at about 4,287 ha per annum in 1995. This will increase exponentially and it is estimated that Gambela Regional State could lose 32% of its high forest resources between 1990 and 2020. Some 68 percent of the loss will occur in Godere and Dima weredas. These weredas are also exhibiting the fastest rate of decrease of forest.

Table 16. Predicted Areas of Forest & Forest Loss in Gambela Regional State, by Zone 1990-2020

ZONE	1990	2000	2010	2020	Loss 1990-2020	Loss % of 1990	Loss % of total
Itang	536	0	0	0	536	100 %	0%
Gambela	24,443	21,990	18,937	15,132	9,311	38%	6%
Abobo	142,460	135,795	127,501	117,160	25,300	18%	15%
Gog	45,039	40,286	34,373	27,000	18,038	40%	11%
Godere	152,511	135,687	114,752	88,652	63,859	42%	39%
Dima	165,415	152,586	136,624	116,723	48,692	29%	29%
TOTAL	**364,989**	**333,757**	**295,563**	**247,944**	**117,045**	**32%**	**100%**

It should be noted that the above analysis does not take into account forest that is cleared or seriously disturbed for coffee cultivation in the limited higher altitude areas of this state, nor does the rate of population increase take into account migration to forested areas by populations from outside the wereda.

The impact of forest loss is likely to be much less serious for soil erosion than in the escarpment zone due to the lower gradients. Nonetheless, there are serious biodiversity implications of the loss of this forest and the habitat it provides for wildlife.

(b) Woodland Destruction:

The main threats to the lowland woodlands come from clearing for large scale irrigated agriculture, state farms and resettlement schemes, fuel wood collection around the large refugees camps, fuelwood collection for the towns, and the burning activities associated with hunting by the Anuak and Majangir. The impact of these fires on tree mortality of both the lowland forest and the Combretum-Terminalia woodland is not known but must be positive.

3.5.6 Deforestation and Desertification in the Khor Abu Habel of the White Nile Catchment

The Khor Abu Habel is one of the tributaries of the White Nile between Malakal and Khartoum on the western side of the River. This tributary drains the Nuba Mountains (Southern Kordofan) and parts of Northern Kordofan and White Nile States into the White Nile downstream of Tendelti town. Throughout these States desertification is accelerating and continued large increase in rural and urban population are likely to worst the situation in future. The exploitation of woodland resource round towns is leading to increase in soil erosion and sand dune encroachment. The rapidly growing demand for charcoal among urban population is leading to severe desertification in these areas.

The incidence of desertification is also resulting from fuel wood requirements, and in association with subsistence and commercial farming which is spreading throughout these sub-catchments. The impact of drought together with steadily increasing population pressure on arable land, has led subsistence farmers to move out of marginal or depleted lands to extend cultivation into forested areas. The encroachment of cultivation on these vulnerable lands has led to loss of biodiversity. This practice accelerated the soil erosion making the people of these areas even more vulnerable to future droughts which may result in environmental refugees and displaced Citizens. The droughts of the last decades have more severe impact on the land and the people of these areas than on those of the eastern side of White Nile (from comments of the Sudan Steering Committee).

3.5.7 Issues related to Deforestation and Loss of Vegetative Cover in the Upper Pibor catchment

The Africover project mapped some 88,000 ha of montane Podocarpus forest in the Imatong Mountains and nearby hill masses, with some 46,174 ha within the Pibor Catchment.

The forests were gazetted as a forest reserve in 1952 but have lacked conservation status despite its special biodiversity importance (Markakis, 1998). During the 1970's the Reserve was exploited by the regional forestry department, the Taklanga Tea project and the Imatong Mountains Development Authority. There was a research station at Soba and the trend then was to replace indigenous species with Eucalyptus. No Management Plan has been prepared for the forests (FAO, 2005).

A survey undertaken in 2005 using satellite imagery identified 12 plant communities primarily of mountain forest types (Prins & Friis, 2005). The Mountains hold 30 of the 33 bird species of the Afrotropical Highlands Biome and 62 of the 68 species of the Guinea-Congo Forests Biome (African Bird Club, accessed 2006).

The current status of the forests is not clear. However, these forests are unique in Sudan and there is an urgent need to determine their status and afford them protection. With the expanding Eco-tourism industry, the Mountains could prove a significant attraction.

3.5.8 Wetland Loss in the highlands

(i) Trends

Within the plateau area of the upper sub-basin there are many small permanent and semi-permanent wetlands, mostly occupied by *Cyperus latifolius*. These are mostly found in the upper reaches of the Sor, and Gabba rivers. These account for approximately 2% of the land area but they are becoming increasingly important as land pressures in the cleared area outside the forest increase.

Traditionally the wetlands have been avoided due to the presence of diseases such as typhus fever for humans and liverfluke for cattle. However, these areas have long been used as source of domestic water, from the springs which occur along their edges, and as sources of sedges (*Cyperus latifolius*) for thatching. Limited wetland edge cultivation of maize is known to have been practiced in the area going back to the mid 19th century (McCann, 1995) but this expanded during the 20th century (Wood and Dixon, 2001).

In some areas, where upslope erosion has been particularly severe, as in the Ghimbi to Nejo area, wetlands have become the major source of food accounting for up to 70% of the grain produced by these communities (WA / WI study). More commonly this figure is around 10 to 20%, but the timing of these harvests, as the hungry season approaches, makes the wetland food particularly valuable.

In addition, to the drainage based cultivation of wetlands in the northern and eastern parts of the upper Baro-Akobo sub-basin, there is also long established cultivation of *taro* (*Colocasia esculenta*) in wetlands in Bench Maji Zone around Mizan Teferi, and in Sheka Zone around Tepi. Traditionally this does not usually involve any water management as this crop is tolerant of flooding. However, water management is occurring in some places farmers because farmers have realized that yields can be increased in this manner with flooded areas extended and water availability improved before and after the rains.

Management of wetlands for sustainable cultivation, when drainage is involved, is not easy and there has been extensive and, in some areas, complete, loss of wetlands in the southwest highlands of Ethiopia. The impacts of the loss of wetlands or their transformation for farming are considerable and are also distributed in different ways across the communities. Women and the poor are especially seriously affected when wetland cultivation leads to the loss of safe spring water for domestic use and the loss of plant materials for craft and domestic use. Similar losses are linked to wetland degradation, but in addition the typically richer cultivators loose out.

(ii) Driving Forces for Upland Wetland Drainage Cultivation

(a) Food Shortages

The major driving forces for wetland cultivation are seasonal food shortages caused by grain storage problems and the small areas of uplands cultivated due to guarding problems and shortages of plough oxen. Other constraints on upland farming have included the expansion of coffee land by landlords in the past. Hence a combination of environmental and socio-economic issues, as well as technical failings are driving wetland use.

(b) Market Opportunities

More recently and also more location specific, there has been a growing demand from urban areas for green maize, *tef* and vegetables which are grown in wetlands. Urban growth has been associated with the growth of the coffee-based economy and there has been some response by farmers close to urban centres to grow crops in response to these market opportunities.

(c) Land Tenure Change

A key driving force which led to an expansion in wetland cultivation in the late 1970s was the land reform of 1975. This led to the equal redistribution of all types of farm land, including wetlands, but excluding forest land, amongst the households of each Peasant Association. In order to keep access to each type of land farmers had to show that they were using it and so wetland cultivation increased.

(d) Resettlement

The resettlement after the 1984 famine also led to the increased use of wetlands in some areas of Illubabor where the integrated resettlement approach was used. Local communities asked to host resettlers allocated them land which was not in use or not of prime quality, and in some cases this included wetlands. Settlers were also encouraged to cultivate wetlands for an early maize harvest as they did not have root crops which help local farmers fill the hungry season food gap.

(e) Menschen fur Menschen (MFM) Eco Programme

In the mid / late1980s, the NGO MFM developed a programme, in Illubabor, which sought to reduce the pressure for forest clearance by developing rural livelihoods in the areas outside the forest. One element in this was wetland drainage for vegetable cultivation. Although this element of the programme was closed by the late 1990s, it showed communities some of the possibilities, as well as some of the problems, that could be encountered in wetlands and provided a stimulus to further wetland drainage.

(f) Wetland Task Force

Since the early 1990s there has been Wetland Task Forces in the south-west highlands, including parts of the upper Baro-Akobo sub-basin. In years when food shortages are severe in other parts of the country, the Task Forces set communities targets for additional wetland drainage and cultivation and regularly visit communities to ensure these are achieved. In some cases they are also requiring farmers to extend the drainage period and undertake double cropping in the wetlands.

(iii) Facilitating Factors

(a) Technological Innovation:

In response to the need to cultivate wetlands in the early 20th century a system of dendritic drainage was developed and this spread widely in Wellega and Illubabor. This meant that instead of just the margins of swamps being drained by channels going into the central swamp, whole swamps could be drained for cultivation. In some cases this technology was followed by methods of channel blocking to reduce over-drainage, but this was not always the case.

(b) New Crop Varieties:

Over the last 30 years there has been research undertaken in Ethiopia to develop short-season or early maturing varieties of crops. These have been sought to help the country overcome food insecurity caused by irregular rainfall and short growing seasons. One indirect impact of this has been to improve the success of wetland farming with short-season maize (from Kenya) maturing before the rain causes the valley bottoms to become waterlogged.

Partly linked to this, but also due to the growing recognition of the importance of valley bottom wetlands for food production in Wellega, the Ethiopian Agricultural Research Organization (Bako Research Centre) has been undertaking research into wetland or *"bone"* cultivation methods in an attempt to improve yields.

3.5.9 Loss of Biodiversity: Gambela Regional Park and Boma National Park

These two Parks are considered together given their close proximity and the ecological linkages between them. Their status has been described in para. 2.5.4.

The Gambela Park was proposed because of the numerous large wildlife species, particularly Nile Lechwe, White eared Kob and the Whale-headed Stork. The White Eared Kob migrates every year between the Sudd in Sudan and the Gambela Marshes. A survey by Lavrenchenko et al. (1989) inventories some 88 mammal species of 9 Orders and 28 Families. In addition to White-eared Kob they include elephant, Nile Lechwe, Topi and Road Antelope. In smaller numbers Lion, Leopard, Lelwel Hartebeeste and Buffalo are also found. There are extensive areas of swamp habitat. Some 43 species of mammals and an IBA team recorded 230 species of birds (EWNHS/Bird Life International (1996). There are two near threatened bird species: the Shoebill (last recorded in 1961) and the Basra Reed Warbler (last recorded in 1976). Golubtsov et al (1989) recorded the presence of 92 fish species belong to 51 genera and 23 families.

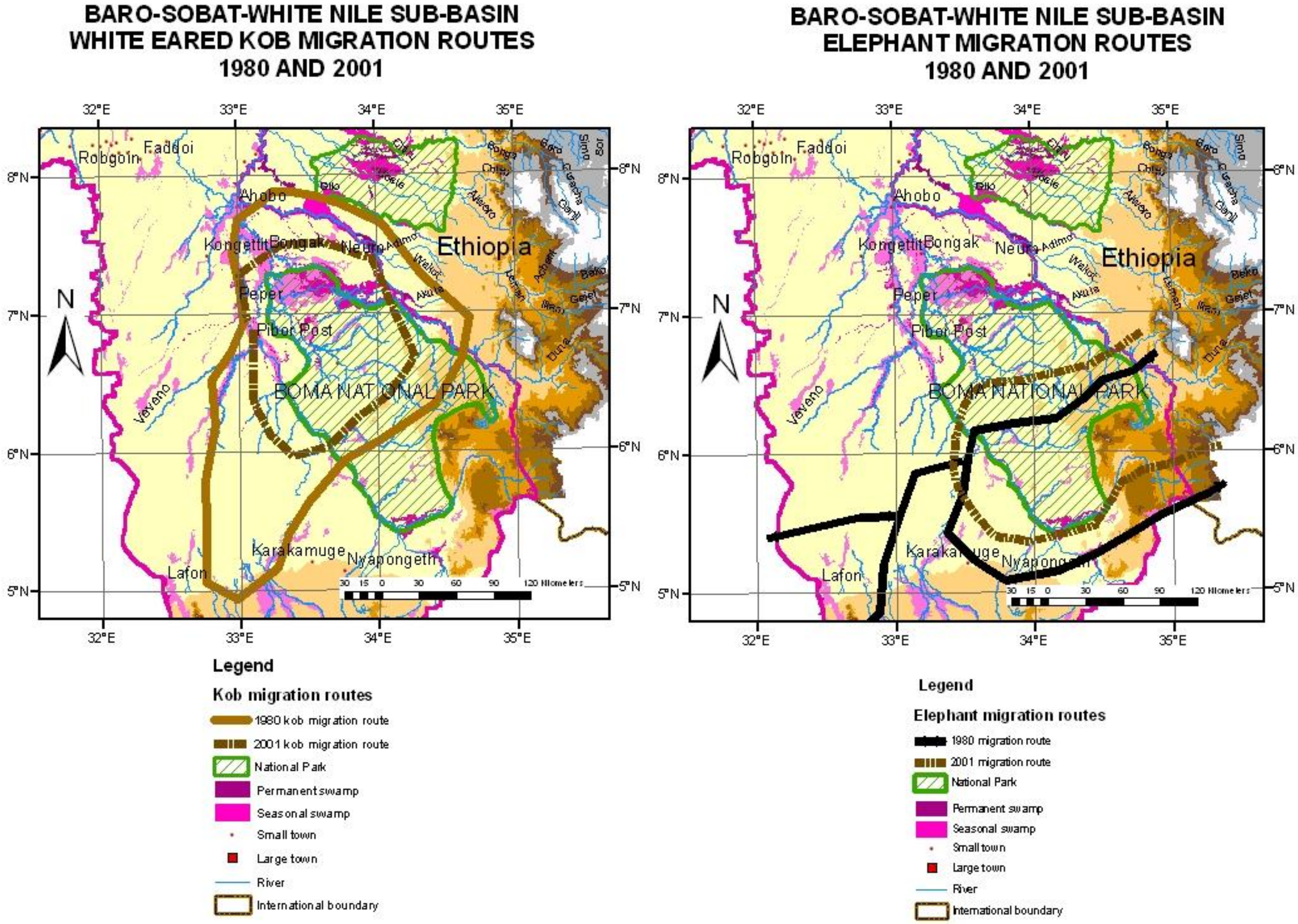
The Park is not legally gazetted and no Management plan has been prepared. There are no visitor facilities. The two vehicles and Park stores were destroyed during the government change over in 1991. The Park contains the Akobo large-scale farm and Alwero Dam, and irrigation developments is currently underway in the centre of the Park. There is a critical problem of illegal hunting, with a large number of arms made available because of the Sudanese Civil War. The Phugnido Refugee Camp is located adjacent to the Park. The last major study of the area was made in 1986 by the Russian Institute of Evolutionary Morphology and Animal Ecology under the UNESCO Man and the Biosphere programme. (Sokolov, 1989) although a bird survey was undertaken in 1995-96 by the Ethiopian Wildlife and Natural History Society (EWNHS-Bird Life Int., 1996).

The local inhabitants include the Anuak to the east, who cultivated along the Baro and Akobo Rivers and the agro-pastoral Nuer to the west and into Sudan (see para. 2.3.1 for details of the livelihood strategies).

The Boma National Park lies close to the Ethiopian border and just 70 kms southwest of the Gambela National Park. It is located between the River Kagen in the west and the Oboth in the east, and from the River Kurin in the south to the Guom swamps in the Akobo-Pibor Spillway. Although the Park was established in 1977 it has been neglected as indeed has the area generally. This is in part due to its remoteness and in part to the fact that during the Civil War the area was contested between the government and the SPLA.

Some five ethnic groups inhabit the park and its environs: the Murle (Boma plateau agriculturists), Murle (plains pastoralists), Jie, Anuak, Suri (Kichepo). The plains Murle, Suri and the Jie are predominantly pastoralists whilst the Anuak and plateau Murle are predominantly agriculturalists. The pastoralists used to have very large herds of cattle, sheep and goats but have lost substantial numbers during the conflict and now own 25 to 30 percent of their previous holdings.

In the wet season of 2001 a Team supported by USAID and in collaboration with the University of Missouri, USA, undertook a survey to assess the impact of conflict on the Boma National Park looking in particular at the status of food security livestock and wildlife (Deng, 2001). Generally the pastoralists saw internal tribal conflict as the major source of livelihood vulnerability the agriculturalists saw drought as the main external shock to their livelihoods. Hunting and wild food collecting was a coping mechanism adopted by all peoples as an alternative livelihoods strategy, although the degree to which this strategy was adopted varied among the different groups.



Map 24. Baro-Sobat-White Nile Sub-basin: Migratory Routes of White-eared Kob and Elephant: 1980 and 2001
Source: Deng, 2001)

A major wildlife inventory had been undertaken in 1980 (Fryxell, 1983) and provided a baseline for the 2001 study. With the exception of population estimates for Reedbuck, Ostrich and Eland populations the 2001 estimates suggest that there has been a massive decline in nearly all animal species. The most affected were the White-eared Kob and the Mongalla Gazelle. A summary is provided in table 17. The big increase in hunting has caused the migratory routes of White-eared Kob and Elephant to change over 20 years (Map 24).

Table 17. Comparison between Wildlife Population estimates in the years 1980 and 2001.

Species	2001 count Wet season	1980 count Wet season	1980 count Dry season
White-eared Kob	176,120	680,716	849,365
Lesser Eland	21,000	2,612	7,839
Oribi	3,920	2,939	2,264
Reedbuck	28,840	2,000	3,000
Road Antelope	1,960	2,059	3,085
Mangalla Gazelle	280	5,933	21,678
Warthog	280	293	4,868
Ostrich	3,640	1,306	2,151
Tiang	N.S.	24,078	29,460
Lelwel Hartebeest	5,600	8,556	47,148
Zebra	N.S.	24,078	29,460
Buffalo	N.S.	2,965	11,179
Giraffe	N.S.	4,605	9,028
Waterbuck	N.S.	620	2,462
Steinbuck	N.S.	292	1,981
Grants Gazelle	N.S.	1,222	1,811
Elephant	N.S.	1,763	2,179

Source: Deng, 2001.
N.S. – Not seen

The vegetation survey revealed an increase in tree densities an indication of habitat improvement and stability.

3.5.10 An Overview of the Issues relating to Potential Negative Impacts on Natural Resources in the Lowland Baro-Akobo, Sobat and Southern White Nile Catchments

These issues relate to "**potential**" rather than "current" negative impacts on the natural resources and the associated livelihoods of the peoples occupying these three catchments within the Baro-Sobat-White Nile Sub-basin.

These catchments are in stark contrast to those in the other three Sub-basins in that much of its natural vegetation and environmental is intact. However, there are a number of ongoing negative impacts of development activities and a number of potential threats emerging to the natural resources and environment of the Sub-basin. They also differ in the degree to which hydrology, ecology and livelihoods are closely linked in extremely dynamic systems. Much of the area has been affected by the 20 years of Civil War (on both sides of the international border) and its attendant destruction of physical and social infrastructure, and the breakdown in socio-cultural networks and relations.

It is important to note there are very close linkages between hydrology and ecology, and between the ecology and livelihood systems. Whilst much is known in general regarding these relationships there is a lack of detailed knowledge most particularly of the hydrology. It is known, for example that the hydrology of the Sobat and its wetlands (such as the Gambela Wetlands, the Machar Marshes and the Akobo-Sobat Marches) are subject to considerably more variability than for example that of the Bahr el Jebel and the Sudd Wetlands. The extreme seasonal and year-on-year variability have important implications for the livelihood systems and the way that they have adapted to these.

The rich diversity of hydrological and ecological conditions has given rise to a rich diversity of livelihood and socio-economic systems. These have over time developed a close response the seasonal changes in hydrology and ecology. Thus, any proposals for interventions in the hydrology require a detailed and sensitive understanding of these relationships.

The complex ecological conditions make for rich and varied patterns of habitats and species and genetic bio-diversity. The wetlands in particular support very distinctive flora and fauna that is uniquely adapted to conditions in the swamps. As with the hydrology there is a dearth of information on the ecology and biodiversity status of the Sub-basin.

Much of the variability in the hydrology is because some 70 percent of the water in the Baro and Sobat catchments originates in the high rainfall areas of the Ethiopian Highlands. Formerly these highlands comprised vast areas of sparsely populated High Forest. These provided for relatively stable hydrological conditions. Under an exponentially increasing population pressure supplemented in part by in-migration, large areas are being converted to small and large scale agriculture. Additionally, there are plans to tap the hydro-power and irrigation potential of the main rivers. These changes will have significant impacts on flow regimes and sediment loads.

The Sub-basin has seen some 30 years of civil war. As a result, the complex livelihood systems and the social networks that supported them have been seriously disrupted. Considerable movements of people have taken place and only now are many of the displaced people beginning to return. The Sub-basin is thus in a state of considerable human flux. Additionally, much of the social and economic development that was taking place just prior to onset of the Civil War has been destroyed, severely damaged or lost.

There are long-standing plans to change the hydrology of the Bahr el Jebel and the Sobat Sub-basins. In the Bahr el Jebel Sub-basin the Jonglei Canal is proposed. The full implementation of this project will have important implications and impacts on the livelihood systems of the Sobat-White Nile Sub-basin. Some 268 kms of the canal were constructed before the on-set of the Civil War and its future is still undecided. There are also long-standing plans to change the hydrology of the Sobat River with a diversion canal to collect spill from the Sobat that currently sustains the Machar Marshes and transmit this directly to the White Nile.

Significant developments are taking place in the Sub-basin with regard to oil exploration and extraction. Both exploration (cutting of seismic traces, test drilling, access road construction) and drilling and extraction (road construction, new towns, pipelines, oil wells) have already had severe environmental and social impacts.

There are immense problems in the Sub-basin of initiating and sustaining all aspects of rural and urban development, reducing poverty, developing sustainable livelihoods and restoring economic and social networks. The CPA and JAM have set in considerable detail the modalities and conditionalities required to achieve these. However, in terms of watershed management and seeking to achieve sustainable livelihoods the key problems can be summarized as follows:

- The need to obtain a detailed knowledge of the complex hydrology-ecology systems in the whole of the Sobat-White Nile Sub-basin (in both Ethiopia and Sudan). Whilst the Bahr el Jebel was thoroughly studied as part of the Jonglei Canal investigations, the Sobat-White Nile Sub-basin was not studied in detail. This will involve establishing an effective and consistent hydrological and climatic monitoring network.

- The need to obtain a detailed knowledge of the relationships between the hydrology-ecology and livelihood systems and their dynamics, as a basis for effective and sustainable development planning and implementation. Already by the early 1980's socio-economic conditions in the Sub-basin (and that of the Bahr el Jebel) were changing rapidly from those studied in the 1950's and 60's (Howell et al., 1988). Twenty years of civil war will have caused further changes.

- The need to determine the potential impacts of upstream hydrological developments (dams, hydro-power, irrigation) on the sensitive hydrological-ecological and livelihood systems downstream in both Ethiopia and Sudan.

- The need to make a full inventory and status assessment of the habitat and species bio-diversity as a basis for effective and sustainable conservation planning.

- The need to determine the potential impacts on the hydrology, ecology and livelihoods of the continued development of the oil sector in the Sub-basin and develop an effective monitoring system

Given the complexity of the social and economic issues and the paucity of technical data, this report can only make a very provisional assessment of the potential impacts that some of the current and proposed developments may have on the Sub-basin specifically in watershed management terms.

3.5.11 Sensitive Hydrological-Ecological System of the Machar Marshes

(i) Potential Impacts in Changes in the Flow Regime of the Baro River

Spills from the Baro occur when the monthly flow exceeds about 1.500 km^3 per month and are concentrated between the Khor Jakau and Baro Mouth. The JIT estimated the total mean annual spill is about 2.820 km^3 but varies widely between 1.00 and 5.00 to 6.00 km^3. Sutcliffe and Parks (1999) estimated the 1950 – 1955 (low rainfall years) spill at 2.328 km^3. Using the flow data (1967 – 2003) from the Baro Multi-purpose Project Feasibility Study[6] and using the 1.500 km3 per month, indicates a spill of about 2.465 km^3.

Whilst a number of dams have been proposed in the Baro-Akobo catchment those designated Baro 1 and Baro 2 have been studied to feasibility level. That Report states that "it is not anticipated that the change in river flow will cause any significant changes in the ecology along the Baro, Sobat, White and main Nile."

An examination of the current and projected discharges of the Baro River at Gambella (Table 18) indicate that the reduction in high flows will reduce the amount of spill by about 20 percent from 2.465 km^3 to 1.965 km^3, some 0.500 km^3. The main impact of this will be the degree and extent of flooding of the "toich" grasslands. Assuming the same flood coefficient as the Sudd (Sutcliffe and Parks, 1999) of 1 meter depth and taking into account rainfall and

[6] Norplan, Norconsult and Lahmeyer Int. for Ethiopian MoWR (2006) "Feasibility Study of the Baro Multi-purpose project", Draft Final Report, May 2006.

evaporation, this would indicate a reduction of flooding of about 410 km^2. Using Sutcliffe and Parks estimate of 3,350 km^2 of flooded area this is a decrease of about 12 percent. As this represents valuable dry season grazing for pastoralist groups that use the area during the dry season, it is suggested that this cannot be considered an "insignificant" impact.

Table 18. Projected Change in Baro Discharge at Gambella from the Baro Multipurpose Project: Potential Impact on Baro Spills to the Machar Marshes.

	Jan	Feb	mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	**Dec**
Current (m3/s)	86	58	50	56	136	360	647	873	1008	665	271	**129**
Current (Million m3/mth)	230	140	134	145	364	933	1,733	2,338	2,613	1,781	702	**346**
>1,500 million m3/mth (To Machar)							233	838	1,113	281	**=2,465**	
Projected (m3/s)	131	106	91	91	145	324	584	794	970	657	292	**166**
Projected (million m3/mth)	351	256	244	236	388	840	1,564	2,127	2,514	1,760	757	**445**
>1,500 million m3/mth							64	627	1,014	260	**=1,965**	

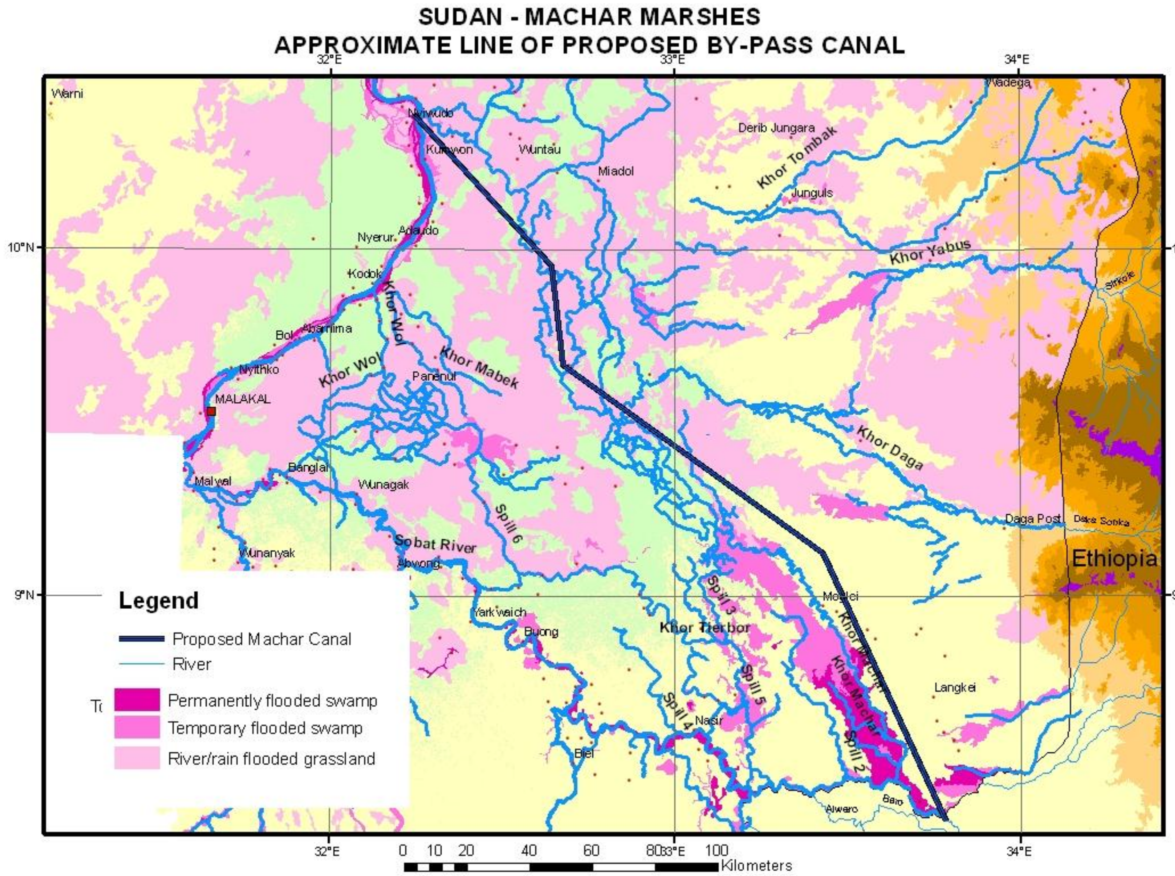
Source: Norplan et al (2006)

(ii) Potential Impact of a Machar Marshes Canal

One of the plans for increasing the flow of the White Nile and providing "new water" for downstream users is the "Machar Mashes Scheme". The plans envisage a canal from the Baro downstream from Jokawu, just within Sudan to an outlet above Melut on the White Nile, a distance of some 300 km (Map 25).

The annual benefits were estimated by the JIT to be 4.4 km^3. The MIT study estimated a potential gain of 8.0 km^3, although Sutcliffe and Parks (1999) have seriously questioned this estimate. Hurst et al (1947) pointed out a key disadvantage of the scheme was that in low years the losses are much reduced and that water in the canal "could also be reduced to the point of vanishing altogether". The most recent study (using MODIS satellite data for 2001) undertaken for the JMP (Waterwatch, 2006) estimates a potential gain of only 0.96 km^3.

Clearly the impact of this Scheme would be considerable if it captured all the spill and inflow from the eastern Torrents. The Machar Marshes would effectively dry out apart from some localized flooding from rainfall (Howell & Lock, 1983). In addition the canal would cut across livestock trekking routes between dry and wet season pastures.



Map 25. Sudan – Sobat-White Nile Sub-basin: Approximate Alignment of the Proposed Machar Canal.

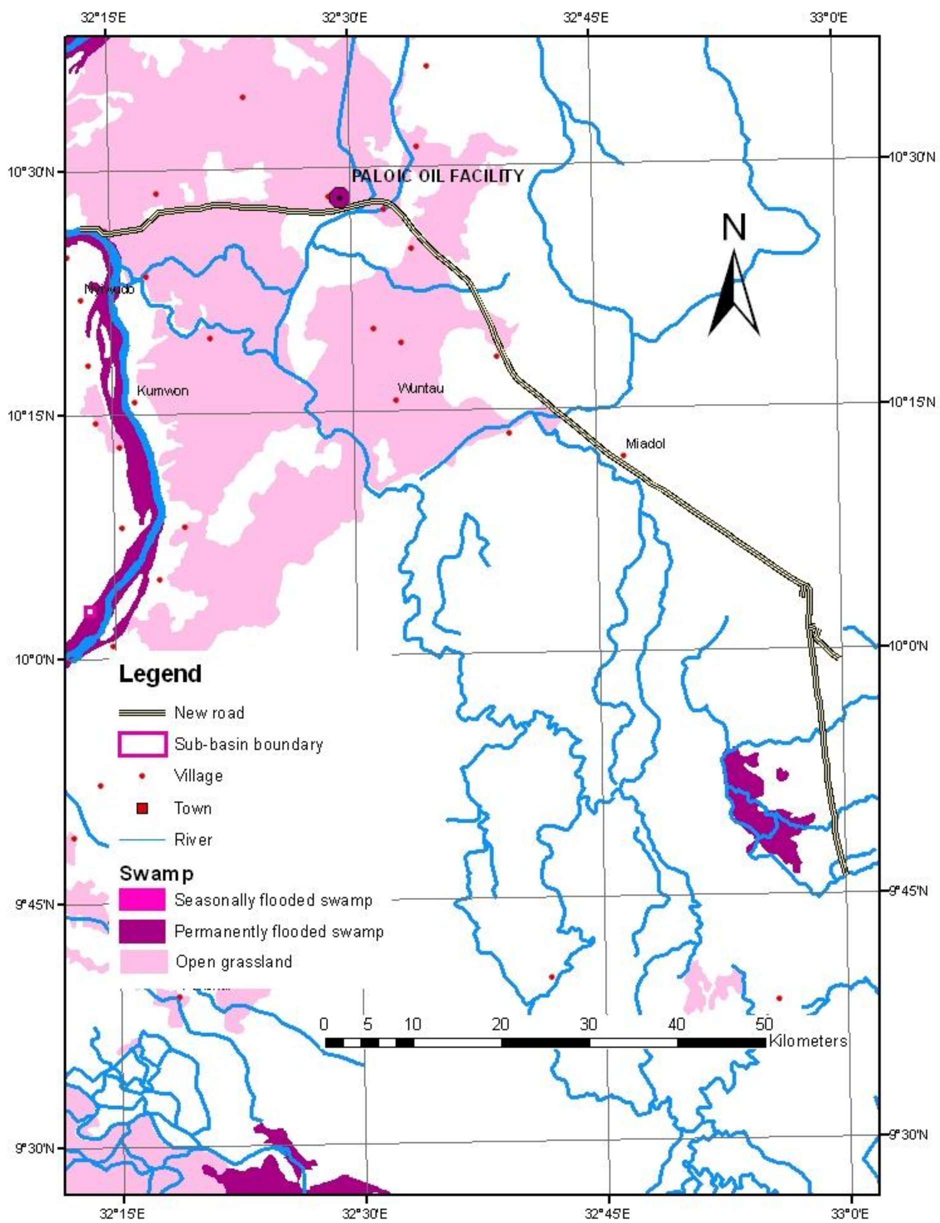
(iii) Potential Environmental Impacts of Oil Exploration and Extraction

The most immediate impacts of oil development activities within the Machar Marshes relate to activities associated with (a) exploration, and (b) extraction. The former tend to be temporary but extensive, the latter permanent but more concentrated (UNEP, 2006).

There are two potential problems related to oil extraction and transport within the Machar Marshes. The first is that the oil is pumped together with water and the two have to be separated. At this point the water is heavily contaminated and must be treated before disposal. If this is not done effectively then severe pollution problems will occur. Given the importance of the marshes in terms of water supplies and fishing this would have a serious impact on the livelihoods of the local inhabitants.

A second potential problem is the construction of all-weather roads without effective drainage and adequate culverts (Map 26). In these cases the road acts as a dam and can cause serious flooding on the upstream side and lack of water on the downstream side. Given the very complex drainage systems within the Marshes any disruption in water flow can have very serious impacts on the distribution of the important "toich" grazing areas.

SUDAN - SOBAT - WHITE NILE SUB-BASIN
OIL EXTRACTION AND NEW ROAD DEVELOPMENT

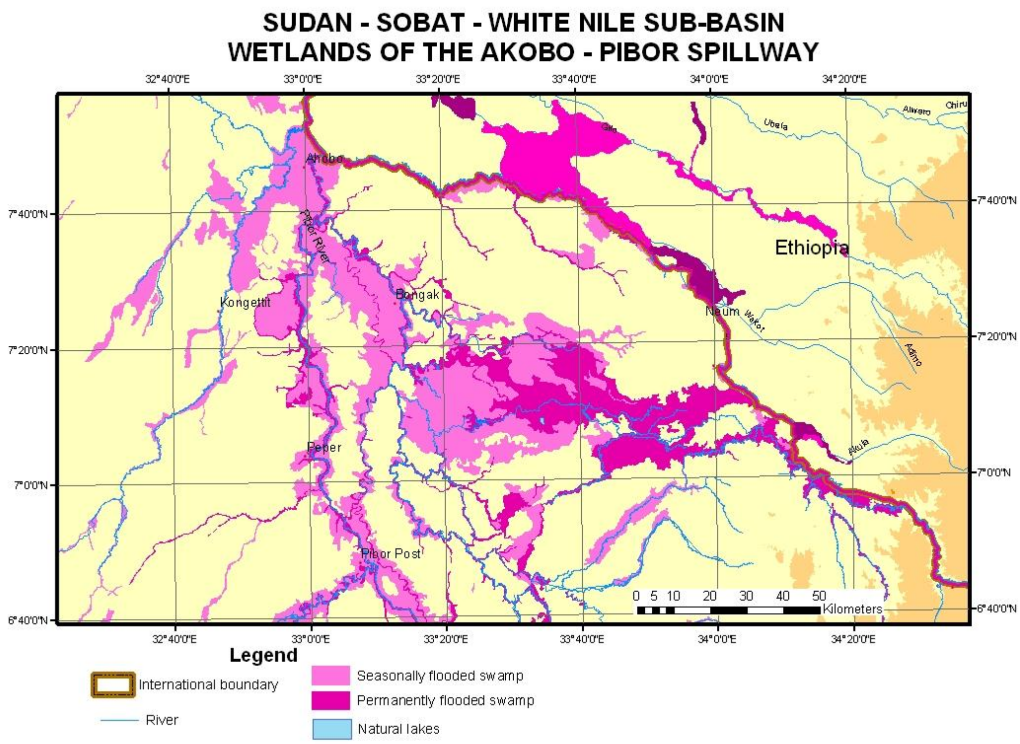


Map 26. Sudan – Sobat – White Nile Sub-basin: Oil and Road development in the Machar Marshes.

3.5.12 Wetlands of the Akobo – Pibor Spillway

There is no mention in the Nile Basin Study by Hurst nor in Jonglei Investigation Study Report of the spillway between the Akobo and the Pibor, which lies to the east of Pibor Post. Associated with this spillway is an extensive area of wetland of both seasonal and permanent swamps. There are approximately 230,000 ha of permanently flooded swamp and 250,000 ha of seasonally flooded swamp (Map 27). This is several orders higher than the permanent and seasonally flooded swamp in the Machar Marshes and represents a vast area of importance for biodiversity conservation. It is known that vast herds of White Eared kob (*Kobus kob leucotis*) use this area as part of their migratory routes. There is also a population of Nile Lechwe (*Kobus megaceros*).

As with the Machar Marshes these wetlands depend to a large extent on spill water from one river to another. Thus any dams on the Akobo that would change the nature of the high peak flood flows would have a significant impact on the amount of spill. This could have serious impacts on the ecology and thus the livelihoods of the Murle people who use this area for grazing. It is not known whether oil exploration is being conducted in this area.



Map 27. Sudan – Sobat – White Nile Sub-basin: Wetlands of the Akobo-Pibor Spillway

3.5.13 Potential Environmental Impacts of Returning Refugees and Displaced Peoples

The ceasefire and the CPA have already resulted in the return of 500,000 IDPs and refugees into the south and transitional area with limited or no resources. In a situation where even under normal conditions there is competition over natural resources, there is a danger of conflict flaring up if the delicate local ecology is disturbed (JAM, 2003, Catterson et al., 2003).

As people return there will be a need to clear land for farming, which will involve considerable cutting of trees and burning. It will be important that as far as is possible that they do not occupy marginal land. It will be important the most fertile of traditional crop areas are not alienated for agro-industrial schemes.

3.5.14 Infestation of the White Nile with Water Hyacinth

Water hyacinth (*Eichhornia crassipes*) appeared in the White Nile in 1957 in the area of the Sudd. It has since spread north and southwards (Abdalla Abdelsalem Ahmed, 2006). It is also reported to have appeared in the Baro in Ethiopia about 1976 (EWNHS, 1996) and is also in the Sobat system. The weed has a number of serious negative impacts. The presence of the weed in the river system leads to an increased loss of water from evapotranspiration. It also reduces the areas of open water available for fishing, which is an important livelihood strategy for the people of the Sub-basin. It also acts as impedance to river navigation along the White Nile a factor of considerable economic importance.

Experiments in Sudan revealed that the water loss was 1.5 gm/cm^2 /day for water hyacinth covered water surface as compared to 0.85 gm/cm^2 /day for a free water surface (Dissogi, 1974). Computing the total loss from the 3,000 km^2, being the estimated infested area in the 1970s, the water loss in the infested area is 16.425 km3 compared to 9.308 km^3 being lost from an equal free water surface. Obeid (1975) calculated the total loss due to the presence of water hyacinth as 7.12 km^3, which is one tenth of the average of the normal yield of the Nile based on (1912 – 1965) records.

Current reports indicate that the water hyacinth problem is not as serious as it was in the seventies and eighties of the last century and consequently, the water loss would be less than the previous figures. Nevertheless, there would still be water lost due to the presence of water hyacinth in the White Nile stretches, and hence an updated investigation is required inasmuch as ecological and climatological changes might trigger a second, even more severe, episode of infestation (from Sudan Steering Committee comments)

A study in the Nile system in Egypt (Batanoumy & El-Fiky, 1975) showed how rapid its growth can be. A plantlet with a 450 cm^2 basal area, 40g fresh weight and 7.4 leaves attained a basal area 1.0827m2, a fresh weight of 1,244 kgs and had 208 leaves in 50 days in a drainage ditch. During that period a plant would produce 43 new offsets on average. Such a plant after 200 days during the growing season would produce 3,418,800 new offsets with an area of 1.493 km^2. In middle Egypt during winter the plant growth is very slow due to low temperatures: a factor not likely to occur in the Soba-White Nile Sub-basin.

3.6 Trends in Soil Degradation in the Baro-Sobat-White Nile Sub-basin with no Watershed Management Programme

3.6.1 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[7] 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 Baro-Akobo Sub-basin are:

Baro-Akobo: weredas in West Wellega, Jimma, Illubabor, Sheka and Bench Maji Zones

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

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.

3.6.2 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[8] was used to define four categories of wereda:

- Category 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.
- Category 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.
- Category 3: weredas that would reach their support capacity within 10 years at current population growth rates using current levels of farm technology.
- Category 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 up to 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 cropland without restriction up to the 10th year and those in the 4th category would expand for the full 20 years.

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

3.6.3 Subjective Assessment of Population Movements

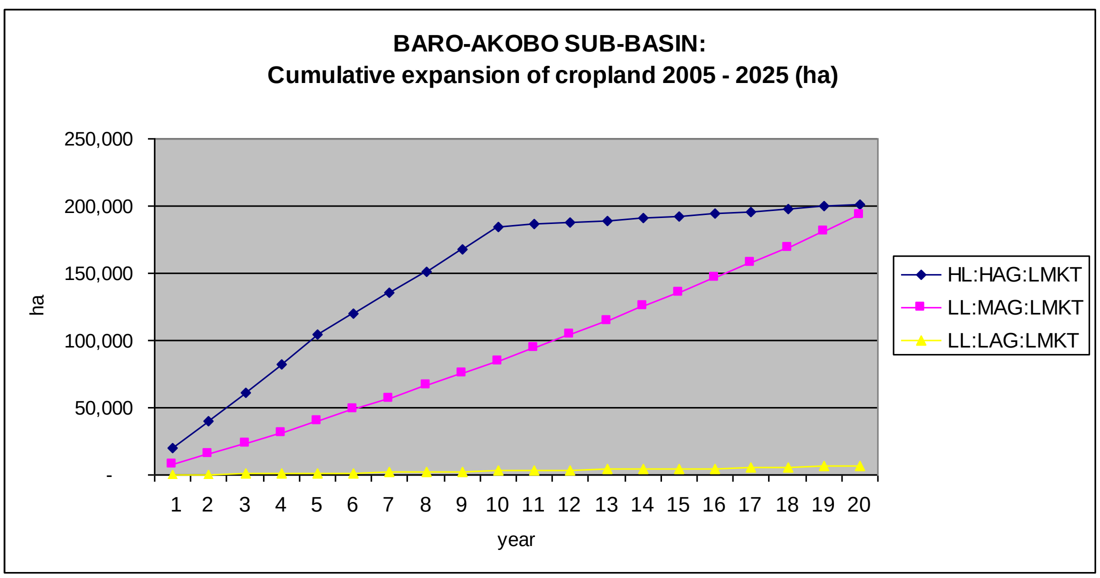
The main areas of agricultural expansion in the Baro-Akobo sub-basin are most marked in the southern and eastern part of the upper sub-basin where the main areas of forest remain. The most recent analysis of forest clearance in the south-west highlands, both within the sub-basin and to the east, was made by Reusing (1999) using data from the WBISPP. He identified extensive thinning of the forest and the break-up of the major block of forest in the south-west due to clearance in particular salients, especially along newly constructed roads. These included the Gore to Mizen Teferi Road through Yeki, and the Bonga to Macha road.

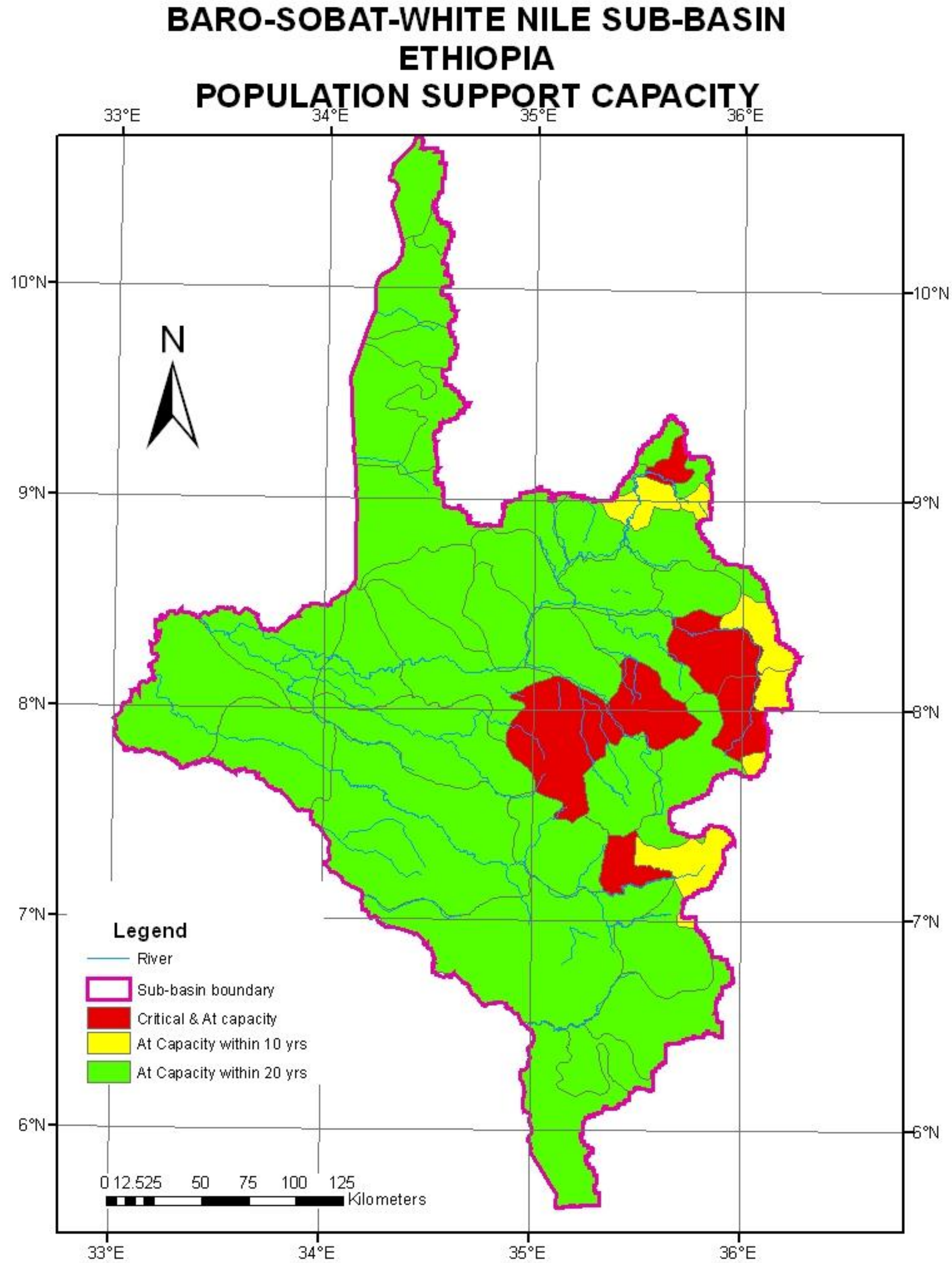
His figures show that between 1971 and 1997 approximately 60% of the high forest showed signs of some negative human impact, with 17% having such severe impact that there was complete deforestation. In this period he identified a loss of approximately 4940 sq km out of a total monitored are of 18,000 sq km (Reusing, 1999, pp.29 -32).

3.6.4 Assessment of Cropland Expansion using the PSC Categories

The spatial distribution of the three categories of weredas is shown in Map 28. In the Baro-Akobo Sub-basin the main expansion of cropland takes place in the Highland domain. However except for weredas in the high Forest areas most reach capacity within 10 years and expansion slows down. (Figure 7).

Figure 7. Baro-Akobo Sub-basin: Expansion of Cropland by Development Domain 2005 – 2025 (ha)



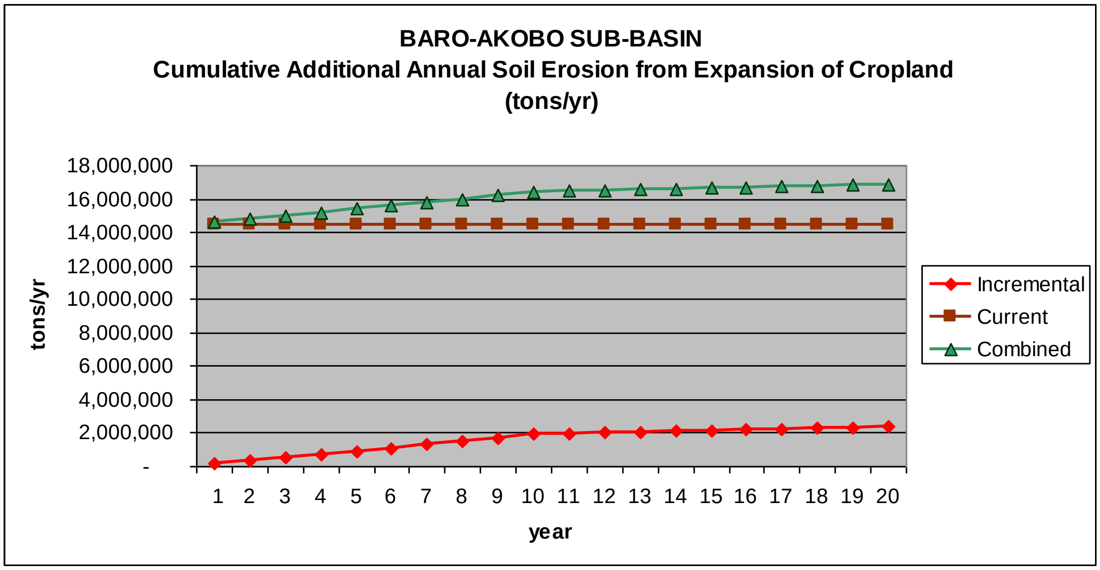


Map 28. Ethiopia: Eastern Nile Basin: Distribution of weredas of the three Population Support Categories

Source: WBISPP/MA

The additional soil erosion after 20 years from cropland is estimated to be 17.9 million tons/yr or approximately 17 percent of current erosion on cropland (Figure 8).

Figure 8. Baro-Akobo Sub-basin: Incremental annual soil erosion (tons/yr) from the expansion of cropland (2005 – 2025.)



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 of 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 in Northern Sudan

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 exercises rights of land distribution through sheikhs. Each village possesses 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 (which gave to 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 (ADS) 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 (RGBP). 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 (GDAS) 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 <u>existing</u> 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 Baro-Sobat-White 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[9]/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 should range beyond soil and water conservation technologies and include inter-linked technologies related to crop, animal and tree husbandry.

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

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.

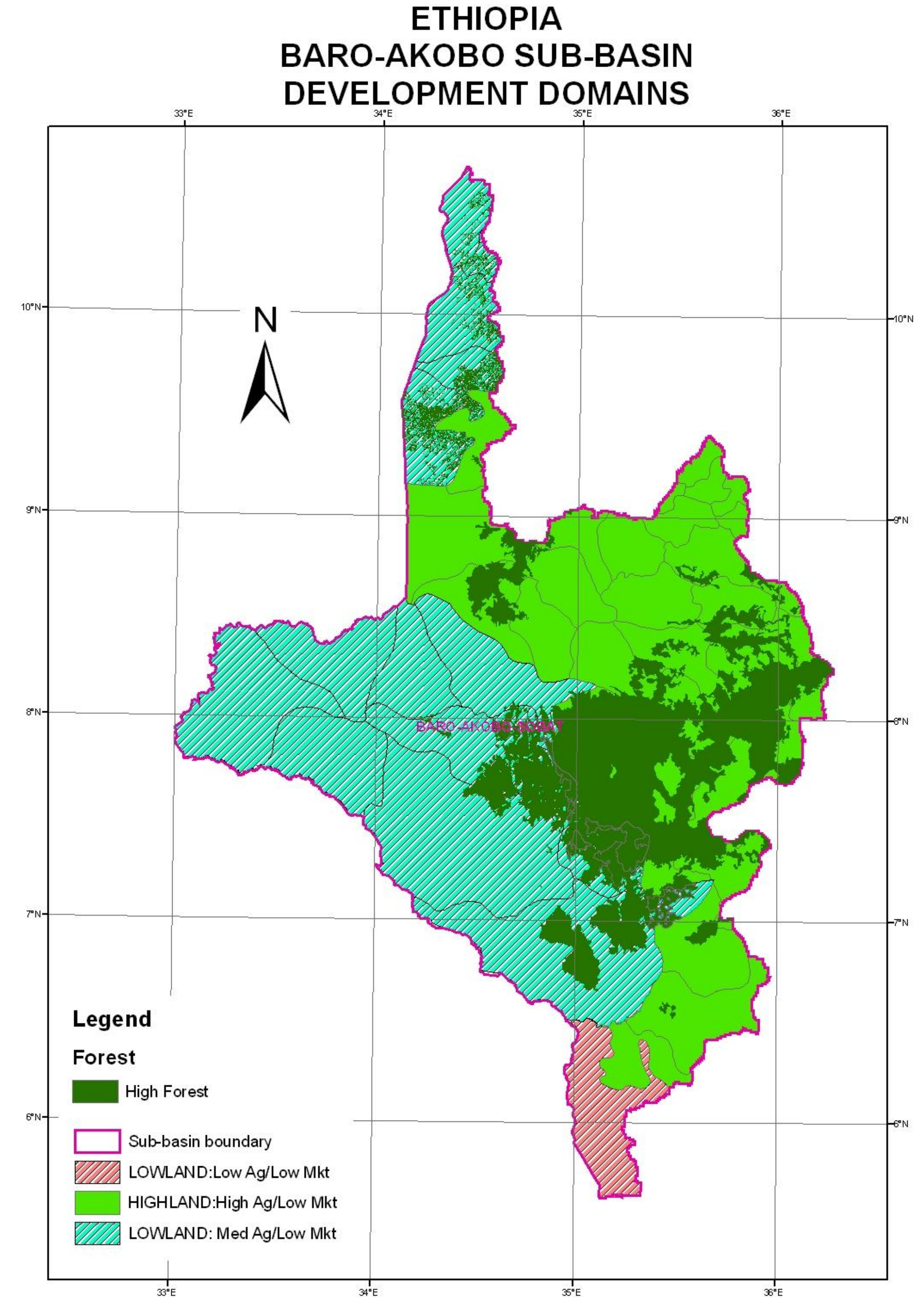
Within each Development Domain are a number of Farming Systems that have been described in the Sub-basin Socio-economic descriptions. The distribution of In terms of targeting specific land management technologies the available evidence suggests that there is a clear distinction between frequently moisture stressed and areas that are infrequently stressed. In the Highlands there is only one high agricultural potential Development Domain given the high and reliable rainfall patterns. The Lowland Domains with low agricultural potential occur in the west and southwest because of flooding (in the west) and low and variable rainfall in the southwest (Map 29).

A matrix showing the occurrence of the Farming Systems within each Domain is shown in table 19.

Table 19. Ethiopia – Baro-Akobo Sub-basin: Occurrence of Farming Systems within Development Domains.

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

T1 (LOWLAND) = SHIFTING SORGHUM+MAIZE
T2 (LOWLAND) = RIVERBANK CULTIVATION OF ANUAK
T3 (LOWLAND) = AGRO-PASTORAL NUER
T4 (HIGHLAND) = MAIZE+TEFF+SORGHUM +COFFEE
T5 (HIGHLAND) = SORGHUM+MAIZE+COFFEE



Map 29. 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).

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.

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.

(ii) HIGHLAND: High to Medium Agricultural Potential (Very low to low moisture stress risk) with Poor Market Access:

(a) Overall Strategies:

The opportunities for marketable annual crops products 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 (e.g. coffee, tea, honey, butter, Kororema). Currently tea is grown as an estate crop but there is considerable potential for it to be grown as a small-holder crop as in Kenya. The latest expansion in the estate (tea and coffee) sector has drawn considerable local opposition.

As pressure on land resources increases valley bottom swamp land development is likely to increase. It will be important to establish best agronomic and water control practices and local swamp management institutions.

The strategy for own-consumption agricultural production should be to ensure food security with an expansion of smallholder "organically" grown coffee and tea as cash crops. . 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 milking cow and small ruminant productivity.

Valley Bottom Swamp Development: should be implemented in a sustainable and equitable way as outlined in para. 4.3.8 (iv) below.

On-farm Tree development: Given the lack of timber 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 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.

(d) Other Strategies

Small-holder Tea Production: In many areas of the Sub-basin the environmental conditions for tea production are excellent. Hitherto tea production has been an estate enterprise, but there is considerable potential to develop this as a smallholder crop. Initially this could be done as an outgrower scheme around the existing factory and later expanded on the Kenya model with Farmer Cooperatives owning the tea factories.

Corrorima Production (*Aframomum corrorima*): There is limited potential to increase the harvesting and marketing of this indigenous spice crop. In most parts of the upper Sub-basin it is not cultivated and is a collected NTFP. Cooperative marketing would probably provide the necessary stimulus to increase the rate of harvesting.

Honey production: The technology is well known in the area but there is a need to improved quality control and marketing. A number of NGO's are currently involved in providing this support.

(v) LOWLAND: Medium to High Agricultural Potential (Moderate to low moisture stress risk) with Poor Market Access:

(a) Overall Strategies:

Soil fertility rather than soil moisture is the key constraint to crop production. Tsetse fly infestation and trypanosomiasis is the key constraint to livestock production except in the grassland areas of western Gambela where with the lack of tree cover it is absent. Malaria is the key constraint to human settlement across the whole area.

For crop production three potential development strategies are available in these areas. (i) Intensification of existing bush-fallowing cultivation; (ii) limited development of medium to large scale commercial agriculture, and (iii) limited large-scale irrigation. For the Pastoral System of production two key strategies are: (i) improved animal health and (ii) limited improvement to livestock marketing.

(b) 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 by the Majangir people and would be appropriate in this Development Domain. 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.

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

The area for such development in the Baro-Akobo Catchment is very limited. Some expansion in the area of the existing State farm on the alluvial soils near

Abobo is possible but this would have to be at the expense of the Baphia Lowland Forest.

(d) Large-scale Irrigation

There is one major irrigation scheme proposed from the Alwero Dam. This is located within the Gambela National Park. Given the uncertain security situation in the area it is not certain how this scheme will proceed.

(e) Improved Animal Health

The village animal health worker system that was developed in Southern Sudan during the Civil War and those currently being developed in the Afar and Somali Regions provide a model for improving animal health of the Nuer pastoralists.

(f) Improved Livestock marketing

The biggest constraint to improving livestock marketing is the long distance and poor communications to the main Ethiopia or export markets. A potential solution would be for Nuer pastoralists to join into the Sudanese livestock marketing system, either to the north or south to the Kenya and Uganda markets.

(v) LOWLAND: Low Agricultural Potential (high moisture stress risk) with Poor Market Access: Dima Lowlands.

Soil fertility and soil moisture deficits are both constraint to crop production. Tsetse fly is present and a constraint to livestock production. Malaria is the key constraint to human settlement across the whole area. Because of these constraints the area is very sparsely populated. Attempts during the Derg era to resettle pope into this area ended in total failure because of the high moisture stress and the lack of surface water.

4.3.6 Potential Impacts in Reducing Soil Erosion and Sedimentation

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

In these high rainfall areas the up-take of soil conservation structures has been much slower than in the Abay or Tekeze Sub-basins. It is now recognized that vegetative measures such as grass strips are more likely to be adopted in these areas (Wood - personal communication) with soil bunds used for the steeper slopes: above 15 percent slope with soil loss rates approximately 20 t/ha.

However, these measures are only likely to be adopted in areas that have always been (e.g. in Oromiya Region) or have evolved (e.g. in SNNP Region) into a system which is dominated by cereal cropping with no fallowing. In other areas where there is still considerable soil depth and high organic matter levels farmers are unlikely to change from their traditional methods (e.g. contour trash lines). In these areas enset and root crops are important components of the farming system. Although no research has been done of the efficiency of these soil conservation methods and so their soil retention rates are not known but must be positive. The GIS soil erosion hazard analysis indicates that the weredas where these systems are still operating also have relatively low proportions of their cultivated area with a moderate to high soil erosion hazard.

The areas with higher proportions of cultivated land with a moderate to high erosion hazard occur in two areas in the Sub-basin: both where cereals tend to dominate and fallowing has generally ceased. The first is in the south-east in the upper Akobo Sub-catchment in SNNP Region (4 weredas), and the second is located on the steeper slopes of the Upper Baro catchment in Oromiya (17 weredas). It is estimated that 325,920 ha or 22 percent of the cropped area should be treated.

In the high rainfall area of the Amhara Region, research showed that after land taken up by the structures had been 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. Vetiver grass has long been used in the Bebeka Coffee Estate to demarcate blocks of coffee trees and grows vigorously in the area. 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.

With 22 percent of cultivated land covered with grass strips and soil bunds and assuming an average of 65% trapping efficiency, soil movement on cropland could be reduced from 14.5 million to 12.43 million tons and sediment delivery to the river from 3.15 million t/yr to 2.70 million t/yr.

(ii) Soil Erosion of Non-cropland

It is estimated that some 28.64 million tons of soil per annum are moved from non-cropland. "Non-cropland" is essentially communal lands that are used for grazing and fuelwood collection and include the under-utilized degraded lands. In the Baro-Akobo Sub-basin it also includes 1.77 million ha of high Montane and Lowland Forest. Generally, in this high rainfall environment vegetation cover is dense.

It is considered that the opportunities for significantly reducing erosion on non-cropland are much less in the Baro-Akobo than the Tekeze and Abay Sub-basins. The two main production objectives for area closure are fodder and fuelwood/poles. The opportunities for area closures are restricted to the north-eastern highlands in West and East Wellega where grazing and fuelwood are becoming in short supply (6 weredas). In the remaining areas fuelwood is not short supply, livestock feed is generally not in short supply or livestock are not kept. In these areas the demand for area closure would be low to nothing.

Research in Tigray (Descheemaeker et al., 2005) indicates that enclosures have a trapping efficiency of 90 to 100 percent with an average sediment catchment area to enclosure area of 3.0. Thus an enclosure of 10 ha retains 90 percent of the sediment from a catchment area of 30 ha.

Total soil loss in the target weredas is 1.18 million tons/yr. Assuming 30 percent of the non-cultivated land is enclosed with a trapping efficiency of 90 percent, a catchment to enclosure ratio of 3.0 and a sediment delivery ratio of 22 percent, then 49,520 tons/yr will be delivered to the river system, a reduction of 211,122 tons/yr or 81 percent of the sediment load before treatment.

(iii) Overall Impact on Sedimentation in the Baro-Akobo River System

Overall an achievable watershed management programme involving grass strips, area closures and conserved and sustainably managed woodlands and shrublands could achieve nearly a 30 percent reduction in suspended sediment in the Baro-Akobo river system. The suspended load of the Baro-Akobo Rivers at the border could be reduced from 8.15 million tons to about 7.36 million tons per annum.

(iv) Potential Reduction in Sediment Load due to Retention in Baro 1 and 2 Dams

Current suspended sediment load at the dam site is estimated to be 0.415 million tons per year. To simulate forest removal an increased sediment load of 1.339 million tons per year was used. A trapping efficiency of 100 percent was assumed in the calculations of the life of the dead storage.

Comparing the location of the dams and the land cover map indicates that approximately 60 percent of the soil loss in the Baro Catchment

4.3.7 Opportunities to Reduce Soil Degradation and Loss of Agricultural productivity in the Baro-Sobat-White Nile Sub-basin

(i) Soil Nutrient Losses in the Highlands

(a) Burning Dung and Residues

Overall there is a net gain of nitrogen due mineralization. However, in those weredas whose soils are derived from acidic basement complex rocks (gneisses, granites) the mineralization rates are likely to be one fifth of those on basalts. The nutrient losses from burning dung and residues in these weredas would be almost total. Nutrient losses from these weredas are estimated at 292 tons of N and 29 tons of P.

(b) Grain removal

The analysis assumes that net losses only occur in weredas with basement complex soils. Total losses of nutrients are estimated at 990 tons of N and 198 tons of P. 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. The current losses of N in the target weredas would require 2,152 tons of Urea.

(c) Soil Erosion

Assuming the same weredas as before, the retention of soil nutrients potentially lost through soil erosion by grass strips 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 1,194 tons of the present loss of 1,989 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 Baro-Sobat-White 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, A.A. (1997) demonstrated that sub-soiling (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.

It has been 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.
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 (500kgs/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).

4.3.8 Opportunities to Reduce to the rate of Deforestation in the Baro-Sobat-White Nile Sub-basin.

(i) Background

The two main areas of montane forest are in the Ethiopian Highlands of the Baro-Akobo Catchment and the Imatong Mountains and associated Hills in the southern part of the Pibor Catchment. In Ethiopia there are some 1,409,000 ha of montane forest and 362,000 ha of lowland high forest. In Sudan there are 46,174 ha of montane forest. In Ethiopia some 15 Regional Forest priority Areas have been nominated but only 6 have been demarcated on the ground. It has been estimated that at the current rate of deforestation due to land clearing by small farmers 33 percent of the montane forest will be lost by 2015. More recently conversion of forest for large scale plantations has accelerated this rate of loss.

The Imatong Forest was gazetted more 50 years ago but it is known that 20 years ago the forests were being converted to tea estate, in-planted with exotics and being subject to logging. It is not known what has happened in the interim.

In the Lowlands there are large areas of Acacia-Balanites woodland on the better drained soils. In the northern part of the Sub-basin clearing for large scale rainfed farming has already cleared vast areas of woodland. Those remaining to the south are now a major source of charcoal for urban centres and Khartoum.

(ii) An Alternative Approach to Conserving Natural Resources and Developing Sustainable Livelihoods in the Baro-Sobat-White Nile Sub-basin

An alternative to the top-down approaches adopted in the past suggests that it is important to recognize the needs of all the local communities living in the sub-basin, as well as the wider beneficiaries in the Nile Basin and the global community. This means that a rights-based approach should be applied to the sub-basin’s development, one which is both environmentally and socio-economically sensitive, as well as being economically viable and contributing to regional and national development.

Some guiding principles which this approach should include are:

- Recognition of the rights of the indigenous people living in the sub-basin, both their rights to the lands they have traditionally used and the resources therein, as well as their rights to sustainable development,

- Recognitions of the linkages within the sub-basin between environmental conditions and livelihoods and from the sub-basin to downstream communities in the Sudan and eventually Egypt, but also upwind to those parts of Ethiopia where rainfall may in part be due to the evapotranspiration of the forests of the upper sub-basin, and

- Recognition of the global significance of the biodiversity in the sub-basin because of the presence of wild coffee genetic resources in the forests which should be conserved in situ and other biodiversity which is as yet unprotected, as well as the fauna and flora in the National and Regional Parks and Regional Forest Priority Areas and Forest Reserves.

(iii) A Framework for Sustainable Resource Use

Any approach to watershed management requires coordination of actions at the basin and sub-basin level with appropriate institutional development, policy coordination and methods for applying the agreed approaches at different levels. This section elaborates some of the essential aspects of this coordination at different scales.

(a) Institutional Development for Coordination and Policy Coherence:

Given the inclusion within the sub-basin of land belonging to four Ethiopian Regional States and ten Sudan States, it is important that a mechanism for coordination is developed. This must address upstream – downstream linkages as well as the management of trans-regional land uses, especially forests.

Coordination of sub-basin management by the four regional states in Ethiopia and the ten States in Sudan will require the development of an institution in each country, which is able to influence, and where necessary control, the actions of agencies within the regional governments. This is currently taking place in Ethiopia, with the imminent publication of the "River Basins organizations Proclamation".

In Sudan the Southern Sudan administration is only just establishing itself and it may be some time before River Basin Authorities become a priority. However, the JAM Report (2003) recommends as a priority, the establishment of a Southern Commission on Natural Resources Management. The Commission would take responsibility for preparing an inventory of natural resources, designing a strategy for their rehabilitation and long-term sustainable management. Additionally the Commission would clarify the powers and responsibilities of the National Government, the Government of Southern Sudan, state and communities with respect to rights pertaining to and management of natural resources.

(b) Policy Coherence

While one of the key responsibilities of the sub-basin agency will be the formulation of a framework development plan for the basin and the coordination of its implementation by the regional states, this must be based on a coordinated and coherent set of policies. In Ethiopia and Sudan policies developed at the regional level are based on federal government policies. In Ethiopia where perhaps decentralisation of authority has gone further, there has been some room for differing interpretations of federal policies and there are already examples of differing interpretation of investment policies and EIA procedures. In Sudan this is now beginning to occur and most of the Sub-basin will come under the immediate authority of the Southern Sudan administration. Nevertheless, achieving policy coherence in either country is not going to be easy.

There is also the need to develop additional policies or policy practice where there are gaps in the working out of the Ethiopian constitution and in Sudan with the principles set out in the CPA and the modalities set out in the JAM. This is particularly so where key issues which are vital to river basin development have not been addressed. Areas of concern might include:

- Forest policy,
- Biodiversity considerations in development planning, and
- Protection of the rights of minority or neglected ethnic groups, of whom the sub-basin includes many.

(c) Strategic Land Use Zoning:

A key element of any coordinated sub-basin development will be a strategic land use framework, or zoning of land use, to ensure that different land uses occur in appropriate parts of the basin for them in order to maximize overall benefits. This strategic land use zoning has to be coordinated at a sub-basin scale across the four Regions and the ten States concerned. This must involve a process of land evaluation to identify the suitability of the land for a range of uses, but it must also include consideration of biodiversity conservation concerns, methods to ameliorate the impact of climate change, and downstream hydrological issues, three areas which are often given little attention.

Critical land use zoning issues to be addressed at this scale include:

- protected areas for genetic resources – especially coffee and forest resources – e.g. Kontir Berhan and Yayu coffee forests, and lowland – highland forests e.g. the Imatong Forest Reserve, the total number of tree species and level of endemicity;
- protected areas for wildlife – e.g. Gambela Regional Park in Ethiopia,
- maintenance of wetlands integrity;
- protected areas for catchment management in terms of steep terrain and need to control erosion, but also catchments for planned reservoirs, e.g. the Baro hydro-power scheme,
- sites for irrigated farming, and
- appropriate cropping systems for different areas.

Strategic land use zoning will not only assess where forest must be retained for sound functioning of the sub-basin in terms of hydrological stability and minimal sediment levels, but also where controlled expansion of agriculture can be allowed, and where sustainable logging can also be permitted.

(d) Community Empowerment

One specific area where policy development is desirable and coordination within the sub-basin essential, is in the role of communities in basin development. In particular, it has been noted above that the state is not very effective in managing protected areas, and the same is likely to apply to any strategic land use zoning. However, there are some NGO initiatives in both Sudan and Ethiopia, which are showing how community involvement can lead to forest protection and improved land use management. Hence a coordinated policy through the basin which recognizes the role of communities, and bring them into the discussions and implementation of the basin development plan would seem to be appropriate.

(e) Community based Land Use Planning

At the local level sustainable watershed management should be achieved through technical measures, such as farming system development and appropriate soil and water conservation measures. However, this should be implemented within the framework of a community land use plan which ensures that land use is matched to land capability based on planning by communities. At the community level some involvement of rural households in planning land use across their area, especially with respect to common access grazing areas, forest resources and conservation measures should be possible with some technical support.

(iv) Technical Measures for Sustainable Resource Use and Livelihood Development

(a) Forest Management for Livelihood Development.

The debate about forest use and conservation often takes place with little public participation or consideration of the needs of these communities. There are however some approaches to forest management which are now more participatory and even involve handing over responsibility for forests to local communities in order to ensure their effective protection.

It should be recognized that with forests there are two potentially conflicting scenarios based around conservation for their environmental functions and transformation to fulfil economic functions. The environmental functions of the high forests in the sub-basin include:

(i) acting as a repository of genetic resources,

(ii) providing habitats for faunal and floral species,

(iii) providing hydrological functions, including moderation of the discharge of water to streams and rivers, and minimization of sediment content,

(iv) protecting soils from erosion and ensuring slope stability, and

(v) being a sink for CO^2.

Economic functions include providing:

(i) timber,

(ii) non-timber forest products (NTFPs) (e.g. honey, coffee and spices),

(b) Development of NTFP's.

The development of NTFPs is seen as one way in which the value of the forests can be increased and thereby communities encouraged to develop participatory forest management groups which will protect and maintain the forests. In this way both the environmental and economic functions are supported, rather than these being in conflict.

Marketing is a key element in this NTFP development. Honey producers have formed marketing groups in order to be able to negotiate with traders and a contract has been established between seven of these and a specialist honey trader who can process the high water content honey from this area. As a result of this linkage honey prices have increased threefold over a three year period. Organic certification of coffee in the area has also been achieved through two cooperative unions and marketing of this coffee with a premium is being undertaken through an international network linked to the certifier.

(c) Farming Systems Development

The driving force to land use change, especially deforestation, in most of the sub-basin is population growth and the demands for increased farm land as the number of farm families has increased and crop yields have fallen. The way to address this has traditionally been forest clearance, and more recently the use of chemical fertilizers to maintain yields.

More recently the government research and extension service have sought other ways to improve yields and maintain soil fertility. Initially this led to the introduction of composting technologies, while there has also been renewed attention to other biological methods, such as agroforestry and biological soil and water conservation methods. There has certainly been some positive experience with such methods with one NGO in the Metu area reporting increases of over 30% in crop yields following agronomic soil and water conservation activities alone.

Such on-farm research has to be undertaken in the different farming systems and also for households with different resource endowments in each farming system. The past problems with blanket extension messages must be avoided. Farming system development must also be linked to market development in order to encourage farmers to invest in maintaining the structure and fertility of their land.

(d) Sustaining the Upper Sub-Basin Wetlands

Research and field development activities by a local NGO, Ethio Wetlands and Natural Resources Association (EWNRA), over a ten year period in the upper sub-basin near Metu in Illubabor Zone has shown that cultivation and some hydrological storage and water supply functions can be sustained almost indefinitely if a set of practices are followed. In one case where these were used over 80 year of wetland cultivation and use were reported. However, in most communities only some, or none, of these are practiced and so wetlands are in general prone to degradation once cultivation commences. The key practices which are recognized by the local communities as a result of their own experiments and which are now part of their local knowledge include:

- Achieving a multiple use regime with only parts of the wetland in cultivation in any year,
- Restricting the drainage period and avoiding double cropping which involves a 10 month drainage period,
- Maintaining a swamp area at the wetland outlet to prevent down-cutting and lowering of the water table,
- Maintaining a swamp area at the head of the wetland as a water reservoir,
- Avoiding drainage within 5 metres of springs around the wetland edge,
- Minimizing the depth of the drains and using ditch blocking techniques to prevent over-drainage,
- Using ditch-blocking to ensure the wetland floods in the wet season to replicate the natural flooding regime, and
- Keeping the slopes coming down to the edges of the wetlands under natural vegetation to reduce sediment deposition.

Based on this experience a model of sustainable multiple use in wetlands has been developed which is being used in extension discussions by EWNRA with wetland using communities in the area (see Figure 9).

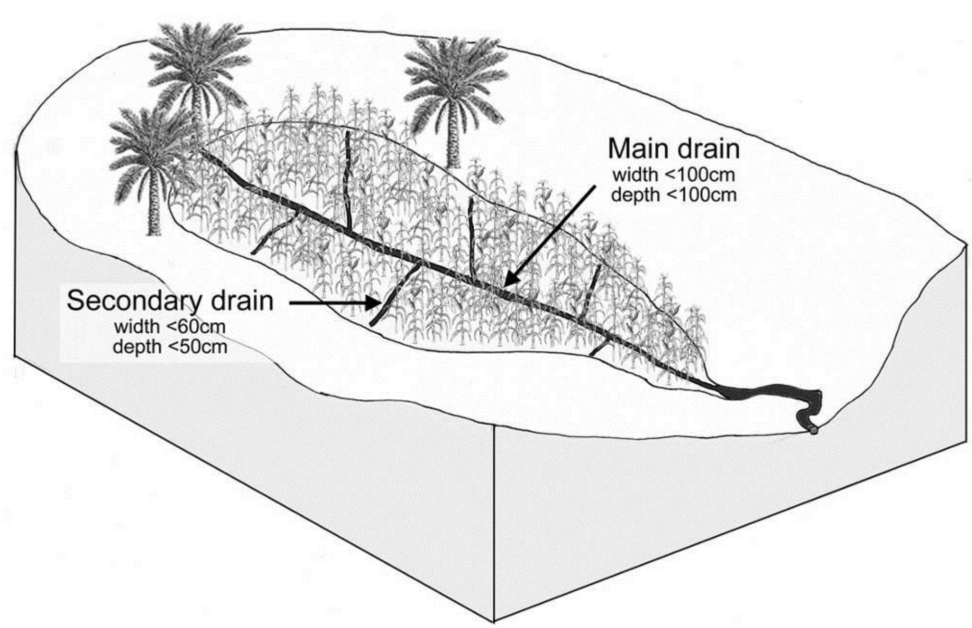


Figure 9. Baro-Akobo Sub-basin: Valley-bottom Swamp Development
Source: Wood and Abbot (2001)

Wetlands also benefit from sound catchment management as much of the water flow into them is at the subsoil level from the interfluves. As a result, soil and water conservation measures in these areas, as well as the maintenance of natural vegetation and coffee forest on the catchment slopes has been found to help maintain wetland water supplies. Hence sustainable wetland use will also benefit from community based participatory land use planning.

However, it is to be noted that in the most sustainably managed wetlands there tend to be locally developed, or traditional, community institutions which undertake some wetland management activities. Some are also involved with choosing wetland for cultivation, protecting swamp areas within wetlands, coordinating cultivation and the preparation of the land. However, in most cases these committees have a rather narrow focus and ignore the full range of benefits which are obtained from the wetlands. A key point is their neglect, in some cases, of the impact of drainage and cultivation on springs, and hence the workload of women when springs dry up. Another area of neglect is the limited attention they give to catchment management issues.

As part of its wetland work the local NGO has come into conflict with the efforts of the government's Wetland Task Forces which seek to expand wetland drainage rapidly and intensify it. Intensification through double cropping is an easy route to wetland degradation, while rapid expansion of wetland cultivation is often undertaken with little attention to the points outlined above as the communities selected by the Task Force usually have no such knowledge and there is no appropriate government extension advice. Where the Task Force tries to impose intensification on communities with a sound understanding of wetland management, there has been resistance to the government orders. Slowly it seems that sustainable wetland management, with a balance between economic benefits and environmental functions, is not only becoming better understood by the communities, but also by the government agencies at the wereda and zonal level.

4.3.9 Opportunities to Support Pastoral and Agro-pastoral Developments in the Sub-basin

(i) A Clearer Understanding of the Hydro-ecological Dynamics of River and Rain Flooded Grasslands and Pastoral/Agro-pastoral Livelihood Systems

(a) A Complex pattern of Peoples, Hydrology, Ecology and Livelihood Strategies

The complex hydrology and its relationships to the rain and river flooded grasslands and the wetlands of the Baro and Pibor catchments have been outline in sections 2.2 and 2.3. Within this complex environment a number of groups of agro-pastoralists and cultivators have developed complex livelihood systems involving crop and livestock production and fishing. An essential component of these livelihood systems was the network of social ties, cross-cutting obligations and mutual support (social capital in the DIFID Livelihoods model).

Information on these livelihood systems in the western part of the Pibor catchment were collected by the Jonglei Investigation Team (JIT, 1954) and the Southern Development Investigation Team (SDIT, 1955) late 1940's early 1950's and in the late 1970's and early 1980's in the rangeland ecology survey by Mefit-Babtie (1983) and the agricultural studies by ILACO/BADA (1981). These were well summarised by Howell et al (1988).

(b) Changes in Livelihood Strategies up to 1983

Howell has described some of the changes in livelihoods that had taken place between the 1950's and 1983. Four main processes were recognised: (i) the growth of the cattle trade, (ii) the development of the grain trade, (iii) the gradual emergence of the use of cash as a medium of exchange and (iv) the expansion of migrant labour.

The cattle trade gradually developed in the 1950's with Dinka and Nuer bidding for prime cattle at government auctions, using sales of sheep and goats and aged oxen, as well wages earned of government construction projects. In addition the trade in hides expanded considerably. With the cattle export trade came the trade in grain. Initially, grain was used as barter but gradually cash became the medium of exchange. The trade in cattle became an incentive for young men to gain cash either through the local labour market, but increasingly by seasonal migration to the large mechanized and irrigated farms to the north.

In the late 1960's early 1970's severe flooding from the Bahr el Jebel across the area made created tremendous hardships as crop land was flooded and livestock died in large numbers. This was made worse by the 1966-72 Civil War, between 1972 and 1983 conditions slowly improved. But cattle numbers were severely reduced, people had been dispersed because of the war and social networks had broken down.

Malakal and the smaller towns became active administrative centres. By 1981 Malakal had a population of 50,000 compared with 12,000 in 1954. Markets were re-established and trading networks grew. Rural-urban linkages were strengthened through local trade in grain and livestock. Migration for work increased rapidly. Trading in dried fish – first unsalted but later salted - expanded rapidly after 1972. Around Malakal a limited trade in fresh fish existed. The increase in migrant labour increased furthering the demand for cattle, and as a result the cattle trade expanded considerably.

A contraction in the range of effective kinship ties was noted as young men earned cash to purchase cattle. Among the Nuer there were disputes as to who had rights to cattle acquired in this way. Reciprocal distributions of cattle at marriage started to break down and there was weakening of mutual obligations. Permanent migration to towns further contributed to the weakening of agnatic ties.

(c) The Need to Understand Current Livelihood Strategies

Some twenty years of civil war have taken place since Howell's assessment of the situation in 1983. Once more the peoples of the area are attempting to re-establish their livelihood strategies. The economy and infrastructure has seen destruction on a much wider scale than before. However, as before the economic environment is starting to see a gradual re-establishment of markets and trade: both local and export-import to the north as road and river communications become improved. This is particularly so in Eastern Equatoria where hostilities ceased some years ago (Cately, Leyland & Bishop, 2005).

The scale of disruption of social networks in the latest civil has been far more extensive and protracted than the first. Ethnic groups have been pitted against each other on a scale not seen before. Millions of displaced people are returning to their homelands.

It will be important that a full understanding of peoples' various livelihood strategies informs and guides the formulation of development programmes. A full understanding of the complex hydro-ecological natural resources framework within which these strategies are implemented will also be important in the development process. Any watershed management study of the Sub-basin must address these complexities to provide an effective foundation for the long-term recovery of the Sub-basin.

(d) Opportunities to Support Livestock Production and marketing

Most grassland in the Pibor catchments are rain flooded and thus only have a seasonal pattern of use. They are of high quality early in the rains but later dry out and become unpalatable. A second opportunity for grazing these pastures comes at the beginning of the dry season when burning can initiate a flush of new growth on the residual moisture. At both time drinking water may be the main factor that limits exploitation of these pastures.

The plains are drained by a network of very shallow water courses running northwards. The range Ecology Survey recommends that low bunds could be constructed across these to produce better and longer lasting pasture. The ditch in front of the bund would act as a hafir. The value of these bunds would be enhanced if they would coupled with a more systematic approach to burning. Burning should take place earlier to take advantage of soil moisture but not too early to destroy the economically important supplies of thatching grass.

Cately et al (2005) have described the extremely successful large-scale community-based animal health worker system that was established during hostilities and its important role in the eradication of rinderpest. The system is now in place for more routine animal health support.

Key constraints to increasing livestock production and marketing are the lack of recognised and serviced stock routes with watering points and the lack of holding grounds or quarantine arrangements with Uganda, Kenya and the Democratic republic of Congo. To the north markets in the Middle East are now well established and offer considerable opportunities for increasing livestock trade throughout the Sub-basin.

(iii) Support to Communities Receiving Returning IDPs and Refugees

There is a need to mitigate the negative environmental impacts that returning refugees and IDPs will have on the natural resource base through increased deforestation and destructive agricultural practices for instance. While the re-establishment and diversification of agricultural, livestock and fishing activities will be absolutely vital to ensure the livelihoods of returning refugees and displaced people, it is also crucial that this is done in an environmentally sensitive way so as to ensure their long-term viability and avoid recurring conflicts and tensions over natural resources allocation and utilization.

During the civil war there was an absence of any formal management of Southern Sudan's natural resources and the destruction of many valuable natural resources. There is now an urgent need to develop a strategy for the rehabilitation and sustainable management of the natural resources based on comprehensive inventory and a clear definition of the powers and responsibilities of the various levels of government and local communities. These arrangements must also link to the livelihood needs of the returning communities and ensure that sustainable incomes can be generated.

In the short term much will depend on local community initiatives in the allocation of land for cultivation and grazing, woody biomass resources for fuel and house construction. Communities will need to undertake careful and agreed local land use planning and resource allocation to avoid conflict between existing and returning peoples and between resource uses. Community development efforts can be done through the promotion of agro-forestry, household woodlots, improved energy efficient stoves, regulation of charcoal production and the development of local institutions for community-based management of natural resources.

4.3.10 Opportunities to Avoid Potential Negative Impacts of Water, Oil and other Infrastructural Developments

(i) Water Developments

The two main potential water developments in the Sub-basin that could have potential negative impacts are: (i) the Baro 1 and 2 dams, (ii) development of irrigated land inside the Gambela Regional Park from the Alwero dam, and (iii) construction of the Machar By-pass canal.

The indications are that the Baro 1 and 2 Dams will have a positive impact in reducing the sediment load in the Baro River. However, the operation of the dam will reduce the height of the flood peak. It is estimated that this will reduce the area of flooding in the Machar marshes by approximately 41,000 ha or 12 percent of the mean flooded area of 335,000 ha. This represents a loss of valuable *toich* grazing land for the Eastern Nuer pastoralists and Dinka agro-pastoralists.

It has to be noted that whilst the floods provide valuable *toich* grazing land for the pastoralists, they are increasingly negatively affecting the Anuak cultivators. Mengistu Woube (1999) following hydrological and field studies reported that the abnormally high floods occurred in 1986, 1988, 1991, 1994 and 1996. These he attributes to human interference in the catchment in the absence of proper land use planning. With the increasing population of the Anuak flood free sites are becoming increasingly difficult to locate and food production is adversely affected.

The biodiversity value of the Gambela regional Park has been outlined in Chapter 3. The Alwero dam is located in the eastern side of the park and the downstream irrigated area (currently not developed) will occupy the central part.

There is a need to undertake a full environmental, social and economic impact assessment of the three potential developments on a Basin-wide basis. The Baro 1 and 2 Feasibility Study confines itself to "ecological" impacts in isolation from the livelihood strategies of the local peoples that have been developed in the framework of the hydro-ecological characteristics of the area.

The hydrology of the Pibor-Baro-Akobo system in the lowlands is not fully understood and there needs to be an integrated hydrological, ecological and livelihoods analysis. The economic assessment of these developments should quantify wherever possible the social and ecological implications of the each development. Thus, a full cost-benefit analysis should be undertaken that includes environmental, social and economic impacts within the whole Eastern Nile basin. Social and environmental impacts that are not possible to monetize should highlighted in quantitative and qualitative terms.

(ii) Oil Exploration and Development

The JAM states in its economic cluster section, that it will be important that the industrial, manufacturing and investment sectors integrate environmental concerns into their development processes. It is important that environmental impact assessments are conducted and best practices and environmental standards should be introduced. The World Bank's Country Economic Report (World Bank, 2003) makes the point that the petroleum industry poses serious environmental threats such as oil spillages and the laying oil pipelines that the government has yet to address.

The Sudan Environmental Policy Act (2001) is the most recent environmental legislation, but still lacks by-laws and law enforcement capabilities (El-Moghraby, 2006). The Energy and Investment Sectors supersede this by drafting their own separate regulations. Despite the active role played by Secretariat of the HCENR, which is the focal point for all environmentally related conventions, the HCENR has not been able to perform all its mandated tasks. This is mainly due to the following constraints:

- Most of the state's councils have not been established and this has resulted in weak representation of the HCENR at the state level.

- The council members (ministers of relevant institutions) have never met since the establishment of the HCENR. This reflects the low priority and commitments of the governments towards environmental issues in Sudan. This situation could be explained by the fact that that the country has been weighed down by long years of war and many urgent pressures and that politicians could not allocate the necessary time or resources to cater for environment.

However, this situation is expected to change now after the CPA and the need to follow and adopt a sustainable course of development.

At the field level it was reported that there a lack of horizontal and vertical coordination between and among responsible agencies, organizations and ministries.

4.4 Other Strategic Interventions

4.4.1 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[10];
- 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

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

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.

4.4.2 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 [11]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

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

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,
- Potential conflicts can be reduced by remaining within Regional boundaries[12],
- 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.

[12] Although as recent events in southern and south-western Ethiopia have shown, this is not a guarantee that ethnic conflict over natural resources will not arise.

The GoE has identified the following areas as follows:

Baro-Akobo Sub-basin: weredas in West Wellega, Jimma, Illubabor, Sheka and Bench Maji Zones

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).

- 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.)

4.4.3 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 reduce smoke inhalation and reduce 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.

4.4.4 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.

4.5 Potential In-Country Benefits from Watershed Management Interventions

4.5.1 Ethiopia

(i) Benefits from reduction of Soil Erosion and Increased Soil 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 2,590 tons of grain per year that will reach an accumulated loss of 64,875 tons in 25 years times. In the absence of preventative measures this will continue to accumulate each year thereafter. Some 24 percent coverage of cropland with bunds or grass strips that is incurring unsustainable soil loss (estimated to cover 1.514 million ha) would reduce current annual losses of soil and soil moisture holding capacity to 35 percent of current rates achieving a saving of 65 percent of current annual accumulating losses. This would yield an accumulating annual benefit of 404 tons of grain per year – in livelihood terms sufficient to sustain 2,020 adults per year, or 50,525 people by the year 2030.

(ii) Benefits from the Reduction in Soil Nutrient Losses

Annual net losses of N in the weredas with soils derived from basement complex rocks are 1,807 t/yr. Assuming an estimated annual reduction in nutrient losses through burning of dung and residues of about 3 percent, then an annual reduction of about Nutrient losses from these weredas are estimated at 292 tons of N and 29 tons of P. Assuming that residues and dung are replaced by wood fuel at a rate of 3 percent per annum then the annual cumulative gain in N would be 9 tons or 54 tons of grain.

The reduction in nutrient losses through grain removal in the target weredas 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 34,652 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 2,050 tons of grain.

Total benefits accruing from reducing soil nutrient losses amount to 41,756 tons of grain per annum – sufficient to feed 208,780 people.

4.5.2 Sudan

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

Assuming that only 38 percent of the area mapped as large farms is actually cropped in an average year, there is the potential to improve crop production of 3.636 million feddans (1.527 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 2.727 million feddans (1.145 million ha). If there is a 60 percent adoption rate this would yield an annual additional production of 1.448 million tons/yr of sorghum. The current annual decline in production of 28,000 tons would be halted, although this would be offset by the production foregone of about 137,440 tons/yr of land put under fallow. The net annual incremental production would of the order of 1.310 million tons/yr.

(ii) 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 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.

4.6 Potential Transboundary benefits: Overall Downstream Impact on Sedimentation in the Baro-Sobat-White Nile River System from Upstream Watershed Management and Dam Operation Activities

Overall an achievable watershed management programme involving grass strips, area closures and conserved and sustainably managed woodlands and shrublands could achieve a 30 percent reduction in suspended sediment in the Baro-Akobo river system. The suspended load of the Baro and Akobo Rivers at the border could be reduced from 9.48 million tons to about 6.6 million tons per annum.

The current sediment load at Baro 1 and 2 dam sites is 420,000 tons/yr. The feasibility study estimates that both dams would have a retention rate of 86 percent. Thus they would retain 406,000 tons of sediment annually.

Table 20. Estimated Reduction in sediment loads of the Akobo and Baro Rivers from Upstream Watershed Management and Dam Operations

	Akobo (tons/yr)	Baro (tons/yr)	SUB-BASIN (tons/yr)
Old sediment load	**3,997,375**	**5,479,750**	**9,477,125**
Reduction - t/yr: Grass strips	1,165,037	1,498,251	**2,663,288**
Reduction - t/yr: Enclosures	89,050	122,073	**211,122**
Total reduction t/yr	1,254,087	1,620,323	**2,874,410**
New sediment load	**2,743,288**	**3,859,427**	**6,602,715**
With Baro 1 & 2 dams			
Reduction in sediment loads		406,000	
New sediment load	**2,743,288**	**3,453,427**	**6,206,715**

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).

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. Currently bank erosion is not reported to be a problem in the Baro, Akobo, Pibor or Sobat rivers.

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-afforestation 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 SNNP Region the unsustainable proportion of wood consumption as fuel is releasing the following greenhouse gases (WBISPP, 2005):

Carbon (C)	1.41 million tons
Carbon dioxide (CO2)	5.20 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. 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 1.41 million tons of carbon from burning woody biomass stocks in the SNNP Region incurs a potential loss of income of US$10.8 million (EBirr 94.8 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 SNNP Region estimated at EBirr 94.8 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 SNNP region could be sequestered through a 10 year programme of community managed woodlands and forest this could yield a potential income of US$2.69 million over the same period.

4.7.2 Biodiversity

Pagiola (1997) reported 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. This impact would be particularly important in the Baro-Sobat-White Nile Sub-basin given its global importance in biodiversity in wildlife, forest and wetland resources.

The Ethiopian Highland forests contain the world's Arabica coffee gene pool, included in which are strains of coffee resistant to coffee berry disease that nearly devastated the Kenya coffee sector. Sustainable management of these forests and the *in situ* conservation of the coffee gene pool are of considerable global importance.

5. BASIN-WIDE OPPORTUNITIES FOR HIGH IMPACT COOPERATIVE WATERSHED MANAGEMENT ACTIVITIES

5.1 Framework for Analysis

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. Thus the chapter represents a current stage of thinking and 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 these benefits in the Baro-Sobat-White Nile Sub-basin given the coincidence of highland/lowland and trans-boundary elements of the basin, from catchments in the Ethiopian highland to those in Sudanese lowlands. Important examples include the reduction in sediment from improved land management practices, the reduction in rates of deforestation and its potential impact on frequency and degree of flooding and the potential for cooperation in wildlife and ecosystems management in preserving species and habitat biodiversity. These in turn will have important benefits from the river (economic benefits).

Increasing benefits from the river (Primarily Economic)

Many of these types of benefits derive from the environmental benefits outlined above and also 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 benefits in the Baro-Sobat-White Nile system. For example the Baro 1 and 2 hydro-power dams on the Baro River can generate electricity which can be exported to the Sudan. 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 water spills into wetlands.

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.

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 Baro-Sobat-White Nile Sub-basin is beginning to appear with increased collaboration between Ethiopia and the Sudan in hydropower production and trade.

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 Economic and Social benefits 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 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 trans-boundary 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 Baro and Akobo Rivers 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. 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. This is particularly important in the Baro-Akobo Catchment where there are substantial changes in land cover taking place. The replacement of high Montane forest (with very high evapotranspiration rates) for cereal cropping (with much lower rates) can have significant impacts on water yield and seasonal flows, as well as on sediment yield.

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. This has advantages to both Ethiopia and Sudan in terms of an early warning system and for efficient dam operation.

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 Baro-Sobat-White Nile Sub-basin covers some 46.8 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 Baro and Akobo Catchments) 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 (e.g. in Blue Nile State);

- Assessing landcover and woody biomass changes in reception areas where large numbers of IDPs and refugees are returning;
- 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.

Opportunities for joint trans-border park management are not as favourable as in the Dinder-Alatish case. The Boma and Gambela parks are more remote areas and they are not contiguous. The Akobo river floodplain is located in between and is more intensively used by pastoral communities. Joint activities would first have to focus on wildlife population assessments. The option of linking up (by the Ethiopian side) with the US funded wildlife assessment project for the Boma park, could be explored to this regard.

When more advanced management and conservation plans are developed for these two parks, harmonization of buffer zone management and development should be considered.

5.3 Cooperative Activities involving Coordinated Watershed Management Planning (Effective/Optimal Basin-wide Utilization of Resources)

5.3.1 Joint Sub-basin Planning

The current watershed management developments taking place in the upper catchment are on a much smaller scale than the Tekeze-Atbara and Abay-Blue Nile Sub-basins. Nevertheless, there is substantial deforestation of the high forest taking place in both the Baro and Akobo Catchments. Studies are being conducted into the feasibility of the Baro 1 and 2 Multi-purpose Dams. This involves the construction of one storage reservoir (Baro 1) with an initial live storage in Baro 1 of 0.993 km^3 and one intake reservoir just below (Baro 2).

Given the substantial changes taking place in land cover, 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 Baro 1 and 2, the Jebel Aulia and Meroe Dams, the planned irrigation from the Baro and White Nile Rivers, rainfed and rangeland development activities of the lower catchments. The objective would be to determine the optimal basin-wide utilization of resources. The various problems of erosion, deforestation, decline in soil fertility and rangeland productivity, and could be addressed in an integrated way.

5.3.2 Wetlands, Sustainable Livelihoods and Biodiversity Conservation

There are some 3.4 million ha of permanent and seasonal swamp and perhaps some 10 million ha of river and rain flooded grasslands. These have immense importance to the livelihoods or the inhabitants of these areas, as well as great importance in terms of habit and species biodiversity.

There is a need to undertake a full environmental, social and economic impact assessment of the three potential developments on a Basin-wide basis. The Baro 1 and 2 Feasibility Study confines itself to "ecological" impacts in isolation from the livelihood strategies of the local peoples that have been developed in the framework of the hydro-ecological characteristics of the area.

The hydrology of the Pibor-Baro-Akobo system in the lowlands is not fully understood and there needs to be an integrated hydrological, ecological and livelihoods analysis. The economic assessment of these developments should quantify wherever possible the social and ecological implications of the each development. Thus, a full cost-benefit analysis should be undertaken that includes environmental, social and economic impacts within the whole Eastern Nile basin. Social and environmental impacts that are not possible to monetize should highlighted in quantitative and qualitative terms.

5.3.3 Transboundary Cooperation in Wildlife Conservation

Opportunities for joint trans-border park management are not as favourable as in the Dinder-Alatish case. The Boma and Gambela Parks are more remote areas and they are not contiguous. The Akobo river floodplain is located in between and is more intensively used by agricultural and pastoral communities. Joint activities would first have to focus on wildlife population assessments. The option of linking up (by the Ethiopian side) with the USAID funded wildlife assessment project for the Boma Park and a US Forestry Department Project to undertake an elephant survey in and around the Boma Park should be explored to this regard. IUCN have already developed a proposal (IUCN, 2006) to undertake a transbounary assessment of wildlife and habitat status and could provide an international forum to coordinate such a survey.

When more advanced management and conservation plans are developed for these two parks, harmonization of buffer zone management and development should be considered.

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 (figure 10) 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.

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);

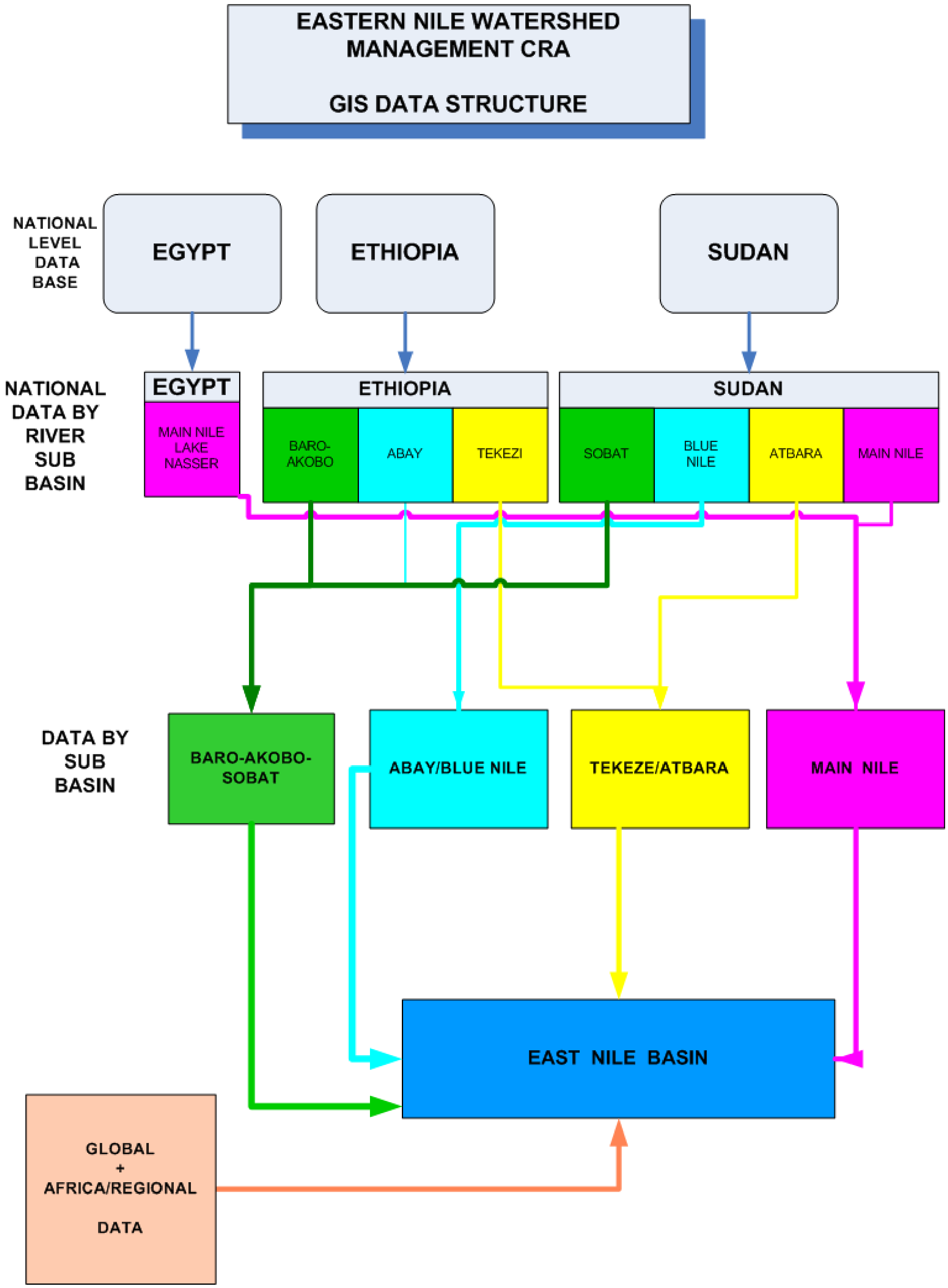
- Water for Agriculture Project to provide a basis for increased availability and efficient use of water for agriculture;

- 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.

Figure 10. Watershed Management CRA: GIS Database Structure



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-Managil, 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

The Baro-Akobo Lowlands have both rainfed and irrigation potential and are part of the pastoral and agro-pastoral livestock production systems in Sudan. During the 19th and early 20th century the economy of these lowlands looked westwards towards the White Nile. Gambela was the outlet port for coffee and other agricultural produce for all of southwest Ethiopia (Johnson, 1999).

With their development for agriculture and given the ease of access westwards (as distinct to those of the Addis Ababa metropolitan area), coupled with the markets in Sudan it is likely that trans-boundary trade will develop between the two countries. There is already some informal trade in livestock and gold. With road access to the Juba - Lokichokio road then the upper Sub-basin would have easy access to Uganda and Kenya. Similar, with road access to Malakal then there would be accessible to markets northern Sudan.

The possibility exists for a joint strategic food grain reserve that could provide a measure of food security for both countries. 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.

5.6 Potential Positive Interaction among Interventions

There are a number of ongoing and potential watershed management interventions with the Baro-Akobo-White 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 community forest management, non-timber forest products (NTFP) promotion, wetland development, a modest soil and water conservation programme, the irrigation development on the Baro floodplain, and the proposed construction of the Baro Dam.

Potentially, there would be considerable advantages in integrating the wetlands development with that of soil and water conservation and community forest management and NTFP activities. 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.

Taken together the watershed management programme in the Baro and Akobo catchments and the proposed Baro Multi-purpose Dam have the potential in combination to effect a significant reduction in suspended load of the Baro and Akobo Rivers (para. 4.4.1).

Downstream in the clay plains of Sudan are a number of ongoing and potential interventions that have potentially positive interactions. 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.

In the southern part of the Sub-basin a comprehensive natural resources inventory coupled with a livelihoods study supported by land tenure reform should provide the basis for strategic and community level land use planning. These proposed activities, coupled with rangeland and water development, support of livestock marketing and improved trading networks would and facilitate the re-integration of the large number of IDP's and returning refugees into their local communities and enable them to re-establish their livelihoods.

5.7 Cumulative Impacts of Watershed Management Interventions in Broad terms

This Section in particular 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 and wood production (and reduced losses), and (ii) reduced sediment load in the Baro-Sobat-White River system. The assumptions and details of these have been outlined in chapter 4. Table 21 and end figures 11, 12 and 13 provides a summary.

Table 21. Summary of Cumulative Benefits to Watershed Management Interventions.

Impact	Amount
Reduction of crop production foregone:	
- burning dung & residues	54 tons/yr grain
- grain removal: use of fertilizer	36,652 tons/yr grain
- nutrient lost in soil erosion	2,050 tons/yr grain
- lost soil moisture holding capacity: 1st year - lost soil moisture holding capacity: 25th year	404 tons/yr grain 10,100 tons/yr grain
Increase in crop production (SMF's):	1,310,000 tons/yr grain

In terms of sediment reduction the cumulative impact of all the watershed management interventions would be to reduce the current sediment load in the Baro and Akobo Rivers by 2.874 million tons from 9.477 million tons to 6.602 millions tons.

With the completion of the Baro 1 and 2 Dams and assuming the full impact of the Watershed Management Interventions annual sediment load would further reduced by between 0.407 and 1.313 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.

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