NILE BASIN INITIATIVE
Initiative du Bassin du Nil

Watershed Management in the Eastern Nile Basin

Constraints and opportunities

Eastern Nile Technical Regional Office

WATERSHED MANAGEMENT IN THE EASTERN NILE BASIN

Challenges and Opportunities

Eastern Nile Technical Regional Office
Addis Ababa, Ethiopia
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ABBREVIATIONS AND ACRONYMS

SDPRP	Sustainable Development and Poverty Reduction Program
AHD	Aswan High Dam
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
C	Carbon
CCDF	Community Carbon Development Fund
CDA	Community Development Association
CDM	Clean Development Mechanism
CMWP	Cooperative Management Watershed Program
CRA	Cooperative Regional Assessment
CSO	Central Statistical Authority
ENCOM	Eastern Nile Council of Ministers
ENSAP	Eastern Nile Subsidiary Action Program
ENSAPT	Eastern Nile Subsidiary Action Program Team
ENTRO	Eastern Nile Technical Regional Office
ENWMP	Eastern Nile Watershed Management Program
ESC	Ethiopian Steering Committee
ET	Emission Trading
ETB	Ethiopian Birr
EWNHS	Ethiopian Wildlife and Natural History Society
EWRP	Ethiopian Wetlands Research Program,
FAO	Food and Agricultural Organization
FFW	Food for Work
GWh	Giga Watt Hour
GWP	Global Water Partnership
HCENR	Higher Council for Environment and Natural Resources
HDLDA	High Dam Lake Development Authority
IDEN	Integrated Development of the Eastern Nile
IDP	Internally Displaced Peoples
IDRC	International Development and Research Committee
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IRR	Internal Rate of Return
IWRM	Integrated Water Resource Management
JAM	Joint Appraisal Mission
JI	Joint Implementation
JMP	Joint Multi-purpose Program
LDC	Less Developed Country
LULUCF	Land Use, Land Use Change and Forestry
MALR	Ministry of Agriculture and Land Reclamation
MARD	Ministry of Agriculture and Rural Development
MDG	Millennium Development Goals
MEPD	Ministry of Environment and Physical Development
MIGA	Multilateral Investment Guarantee Agency
MOH	Ministry of Health
MWh	Mega Watt Hour
N	Nitrogen
NBI	Nile Basin Initiative
NBTF	Nile Basin Trust Fund
NELCOM	Nile Equatorial Lakes Council of Ministers
NELSAP	Nile Equatorial Lakes Subsidiary Action Program
NELTAC	Nile Equatorial Lakes Technical Advisory Committee
NFP	National Focal Point
NGO	Non-government Organization
Nile-COM	Nile Council of Ministers
Nile-SEC	Nile Secretariat
NPC	National Program Coordinators
NPC	National Project Coordinator
NPV	Net Present Value
NSDC	National Social Development Coordinator
NTFP	Non-timber Forest Products
OECD	Organization for Economic Cooperation and Development
OP	Operational Paper
PASDEP	Plan for Accelerated and Sustainable Development to End Poverty
PCF	Prototype Carbon Fund
SAP	Subsidiary Action Program
SDD	Sudanese Dinar Dollar
SDPRP	Sustainable Development and Poverty Reduction Program
SDR	Sediment Delivery Ratio
SLM	Sustainable Land Management
SMF	Semi-mechanized Farm
SNNP	Southern Nations, Nationalities, and Peoples (region in Ethiopia)
SPLA	Sudanese People's Liberation Army
SSC	Sudan Steering Committee
SSEIA	Strategic Social and Environmental Impact Assessment
SVP	Shared Vision Program
SWC	Soil and Water Conservation
TAC	Technical Advisory Committee
TRBI	Trans-boundary River Basin Initiative
UNDP	United Nations Development Program
UNFCCC	United Nations Framework Convention on Climate Change
US EPA	United States Environmental Protection Agency
WBISPP	Woody Biomass Inventory and Strategic Planning Project
WFP	World Food Program
WSM	Watershed Management

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This book is a synthesis of the Cooperative Regional Assessment (CRA) study of the Eastern Nile Basin conducted by Hydrosult and Associates. We would like to express our appreciation for the marvelous job done by Hydrosult and its partners. We extend our special thanks to Mr. Peter Sutcliffe, Team Leader of the consulting team, for his exceptional effort to accommodate concerns and views of the client and finalize the study on time. Dr. A. J. James, together with Mr. Peter Sutcliffe, has done an excellent job of consolidating and synthesizing the CRA outputs into one concise report. Dr. James has also been involved in the design and layout of the publication.

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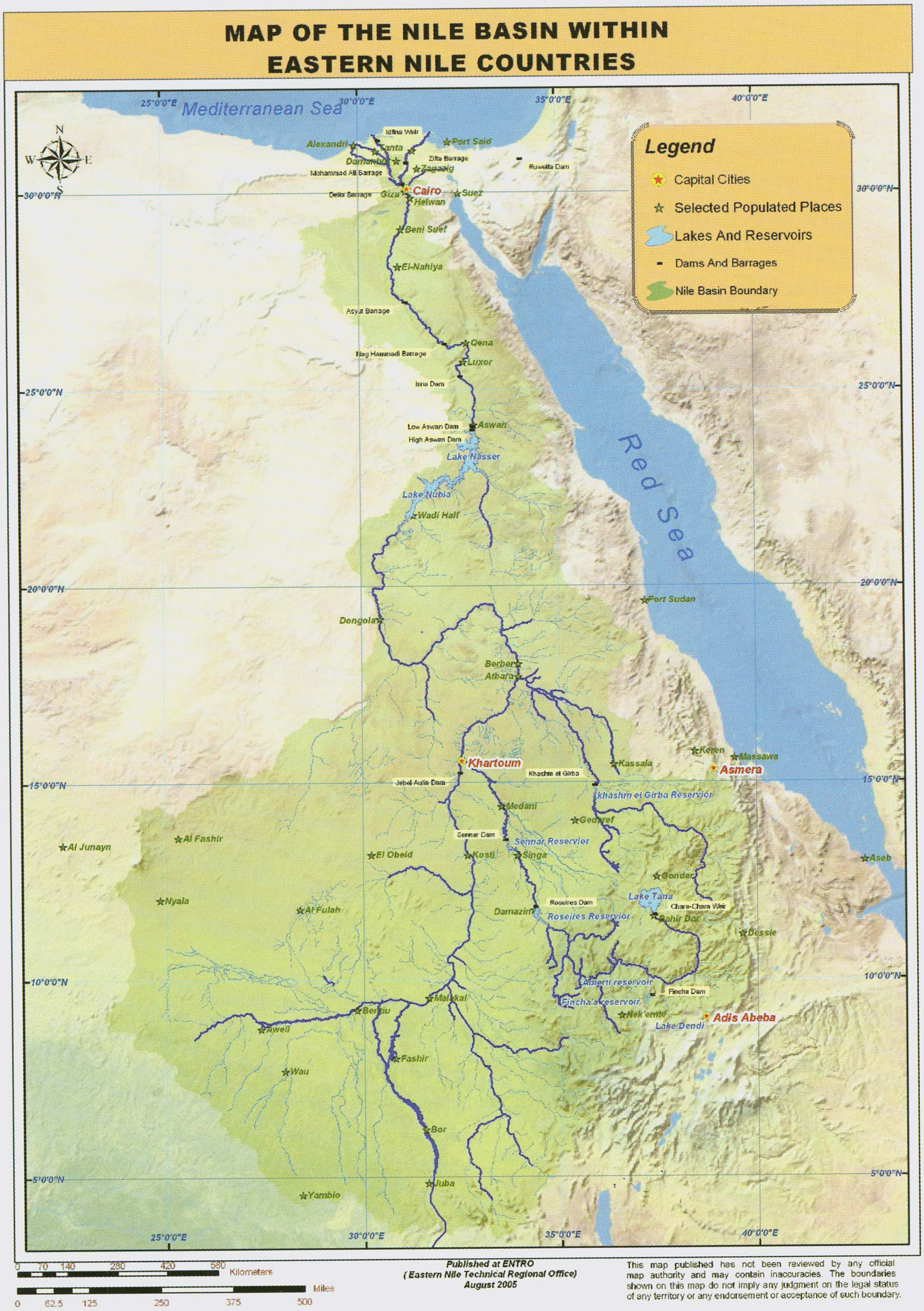
August 2008

Map. Nile Basin within the Three Eastern Nile Basin Countries



FOREWORD

The Nile Basin Initiative (NBI), a partnership of the riparian states of the Nile, seeks to develop the Nile River in a cooperative manner, share substantial socio-economic benefits, and promote regional peace and security. Towards this end, the riparian states agreed on a Shared Vision "to achieve sustainable socioeconomic development through the equitable utilization of, and benefit from, the common Nile Basin water resources," and a Strategic Action Program to translate this vision into concrete activities and projects.

The Eastern Nile (EN) countries, comprising Egypt, Ethiopia and Sudan, are pursuing cooperative development at the sub-basin level through the investment- oriented Eastern Nile Subsidiary Action Program (ENSAP). ENSAP seeks to realize the NBI Shared Vision for the Eastern Nile region, and is aimed at contributing to the reduction of poverty in the region, economic growth, and the reversal of environmental degradation. To facilitate preparation and advance the implementation of ENSAP, the EN countries established the Eastern Nile Technical Regional Office (ENTRO).

Land degradation in the form of de-vegetation, soil erosion, overgrazing and exhaustion of soils, desertification and sand encroachment has been rated as the number one common environmental threat in the Nile Basin countries in general and the Eastern Nile Basin (ENB) in particular. Ongoing land degradation in the watersheds of the ENB is a major factor in perpetuating rural poverty.

The EN countries have realized the gravity of the threat posed by watershed degradation on the livelihood of millions of people residing in the ENB and its negative impact on efforts to reduce poverty and ensure sustainable development in the region. This realization has led to identifying watershed management as one of the key components of the first Integrated Development for the Eastern Nile (IDEN) project. Furthermore, the cooperating countries have adopted a shared understanding that watershed management is a regional undertaking due to the trans-boundary nature of the watersheds and substantial regional benefits that can accrue over time.

The objective of the Eastern Nile Watershed Management project is to establish a sustainable framework for the management of selected watersheds in order to improve the livelihood of their populations through, reduction of soil and water loss, improvement of agricultural productivity and increased food security, reduction of sediment transport and siltation of infrastructure, decreased pressure on natural resources and enhancement of the environment to prepare for sustainable development oriented investments. Long-term regional and global benefits of this project will be increased reservoir life, improved hydropower generation, improved irrigation efficiency, as well as protection of critical aquatic habitats, carbon sequestration and increased biodiversity.

A twin-track approach was adopted to attain the stated objectives: fast track projects and a Cooperative Regional Assessment (CRA). The CRA was undertaken at sub-basin level with the objective of identifying constraints, opportunities and the potential for cooperative action. Key components of the study include a trans-boundary analysis of the watershed system and associated livelihoods, that examines challenges and opportunities (i.e. essentially 'without borders'); a distributive analysis of costs and benefits that will accrue across countries under alternative watershed management interventions (i.e. essentially 'with borders'), a cooperative mechanism analysis, the design for a long-term CRA, recommendations on the way forward and linkages with other EN programs and projects.

The results of the study are published in various volumes (see list of publications in Annexure 2 at the end of the report). This study has enhanced our shared understanding of the sub-basin in terms of the current resource base, trends in resource use, the underlying causes of resource degradation and the cost of taking no action. It also helped to identify long term basin wide actions required to address these issues and identified priority cooperative actions.

This publication is a synthesis of the outputs of this study and aims to disseminate this information to the wider public. It elaborates the integrated, cross-border analysis of the watershed system to identify the major watershed characteristics, watershed management challenges, cooperative opportunities for action, and potential benefits from cooperation.

Readers who wish to obtain more information are encouraged to refer to the other volumes. Comments and suggestions for future enhancement may be sent to ENTRO, P.O.Box 27173-1000, Addis Ababa, Ethiopia or emailed to entro@nilebasin.org.

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EXECUTIVE SUMMARY

The Eastern Nile Basin covers approximately 1.7 million square kilometers and comprises four sub-basins: the Baro-Akobo-Sobat-White Nile, the Abbay-Blue Nile, the Tekeze-Setit-Atbara and the Main Nile from Khartoum to the Nile delta. It is home to more than 100 million people and includes parts of Ethiopia, Sudan and Egypt.

The basin encompasses an extraordinary range of ecosystems from high mountain moorlands, montane forests, savanna woodlands, extensive wetlands and arid deserts. It has been the location of some of the ancient world's most advanced civilizations. The annual Nile flood that carried fertile sediment from the Ethiopian Highlands transformed the deserts of Sudan and Egypt into rich agricultural lands along its course. The majority of the people in Ethiopia and Sudan are rural, depending largely on the natural resource base for their livelihoods. While in Egypt nearly half the population is urbanized, the Nile River provides the basis for agriculture, power generation and water transport.

Notwithstanding the rich natural and human resource base, the basin's peoples face huge challenges. The incidence of poverty is high, and with high population growth rates the pressure on the natural resource base and ecological systems is enormous and increasing. Poverty reduction efforts are constrained by processes of depleting resources such as land degradation, high sediment loads and consequent sedimentation of dams and irrigation canals, the loss of products and services provided by forests and wetlands, overgrazing of rangelands and declining biodiversity. Over arching these are the threat of climatic change and the potential negative impacts on rainfall (amount, distribution and reliability) and the consequences of these on the vulnerability of peoples' livelihoods.

While the knowledge base regarding resource degradation is relatively well-known, understanding fully the complex inter-relationships of the environment-poverty nexus and peoples' ability to invest in sustainable resource management practices is still the subject of considerable research. Nevertheless, a substantial knowledge base is emerging and there are now several lessons of successful and unsuccessful natural resource interventions in integrated watershed management.

Poverty is both a cause and a result of natural resource degradation. In all three countries irrigated by the Nile, poverty is most prevalent amongst rural households whose livelihoods depend on the natural resource base. The determinants and context of poverty, however, are not confined to natural resource degradation but encompass other aspects of livelihoods, such as education, health, access to knowledge and information, and the wider socio-economic framework of markets, prices, technology, credit, government development polices and strategies. This suggests that simply approaching poverty reduction by arresting resource degradation through technical measures will be insufficient if the other determinants and issues related to the broader socio-economic framework are not addressed.

In the absence of sustainable and integrated watershed management interventions soil erosion and degradation and deforestation will continue at accelerating rates, reducing agricultural productivity and increasing the numbers of households 'churning' at and below the poverty line. The Distributive Analysis of the Watershed Management CRA (ENTRO, 2007) conservatively estimated the economic costs[1] of the degradation of the natural resource base in the Eastern Nile Basin is currently some US$ 670 million a year and will reach US$ 4.5 billion a year in 25 years. In social terms the costs of poor nutrition on health and well-being of the peoples of the basin are manifested in physical pain and suffering. In political terms they will lead to increased levels of resource-based conflicts and a breakdown in social order.

Many resource degradation processes have impacts not only locally, but downstream within and beyond the borders of the country within which they occur, as well as on the global community. The Distributive Analysis estimated that some 61 percent of the measurable degradation costs were incurred within countries, 14 percent by the region, and 25 percent, globally. All the regional costs were due to sedimentation in reservoirs and around power turbine intakes, resulting in the need for flushing during periods of high sediment loads and the consequent loss of power generation, the need to clean irrigation canals and the reduction of irrigation water. Other costs of high sediment loads not quantified in the analysis include damage to irrigation pumps and the increased costs of water purification for domestic and industrial water supplies.

A sustainable and integrated watershed management program is thus a critical and indispensable element in enhancing sustainable livelihoods and reducing poverty. Integrated watershed management is a system

-orientated concept with a holistic approach to problems and potentials. For this reason it is necessary that interventions complement each other in a synergistic way. Given the cross-sectoral, sustainable livelihoods and poverty focus of integrated watershed management, with its stated objective of tackling the underlying problems of natural resource degradation in the Eastern Nile Basin, many of these interventions will comprise technological, institutional and policy components.

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 rather than physical measures, using locally available materials wherever possible. A thorough understanding of land use systems and their inter-linking components will ensure that potential technical interventions will not adversely impact on, and where possible support, the other components in the system.

At the micro and mini watershed levels, technical interventions will need to be developed in an integrated manner that take 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. 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 and include inter-linked technologies related to crop, animal and tree husbandry.

It is recognized that there are many synergistic effects between the direct and the supporting interventions that do not emerge in an impact analysis of any single intervention. The benefits of integrated watershed management are therefore identified firstly at the household and community level, and then at the national level (within the sub-basin), the sub-basin level and then at regional and finally global levels.

Addressing both the proximate and the root causes of natural resource degradation in a river basin context requires a very broad-based program of direct and supporting interventions. At the micro-catchment level these direct interventions must be well integrated and address degradation problems of the landscape as a whole.

They require a mix of interventions that target individual and communal lands, cropland and grazing lands and rain-fed and irrigated lands. The interventions must focus on raising and then stabilizing agricultural productivity and must be financially and culturally acceptable to individual and communal investors.

At higher levels the interventions must address the root causes of low investment in sustainable land management (SLM) practices. The Distributive Analysis clearly revealed that while many SLM investments are financially profitable in the medium term there is often a period of negative returns that many resource poor farmers and communities cannot afford. The poorly functioning marketing systems within the Eastern Nile Basin are a major cause of high transaction costs to farmers leading to low crop and livestock prices and high input costs, further exacerbating their ability to undertake SLM investments. Off-farm income is therefore a vital element in the livelihood strategies of many farm and pastoral households, but weak rural-urban linkages mean that employment opportunities do not exist in the many small urban centers.

Thus an integrated watershed management program must also include supporting interventions, such as improved access to markets through feeder road construction, improved access to micro-credit and the provision of safety net support such as food or cash for work, skills and literacy training to increase access to off-farm employment and technical support to small and medium scale enterprises to increase employment levels.

The benefits of an integrated watershed management program of interventions to economic development and poverty reduction accrue at four levels: household or community, national, regional or sub-basin and global. Farm and community level interventions can arrest the degradation of the natural resource base, increase agricultural productivity and food supply with improved levels of nutrition and health, thus reducing vulnerability to climatic, social and economic shocks. As indicated above, there are situations where short-term support (e.g. credit, food or cash for work) may be required. Many interventions also have secondary impacts. For example, interventions that increase accessibility to fuel wood (on-farm tree planting) together with the reduction in firewood consumption (improved stoves) considerably reduce the work loads of women and children. In addition, there are positive impacts on their health and well-being through reduced smoke inhalation, thus reducing the incidence of respiratory diseases.

Such supporting interventions will have substantial positive impacts on households and communities. Measures to increase market accessibility and integration such as feeder roads and extension of telecommunications will reduce market transaction costs thus benefiting both producers and consumers. This will result in an expansion of local economic multipliers, particularly through increased purchases of local non-traded goods as well as backward multipliers (increased purchases of inputs) and forward multipliers (from an increase in marketed agricultural goods). These will in turn increase employment opportunities in many small urban centers.

At the national level regional multipliers will also increase benefits through backward and forward linkages as well as the growth of tertiary and secondary urban centers, thus stimulating sub-regional economies. Increased physical accessibility together with capacity building, literacy and skills training will increase access to information, social services (health and education) and knowledge of improved technology. Support to national agricultural extension and research services will improve linkages between farmers, extension and research workers thereby increasing the relevance and effectiveness of research to the traditional farming sector. Further, targeting the traditional agricultural sector rather than the commercial agricultural sector will result in a proportionally greater impact in reducing the numbers of households living below the poverty line.

At the sub-basin level, while currently there is little trans-boundary trade among the riparian countries, the expansion of the sub-regional economies on both sides of the border and improved cross-border roads links will increase the integration of sub-regional economies. Closer cooperation with crop early warning systems, establishment of joint strategic grain reserves and local purchases of grains for food relief will enable faster responses to local food shortages on both sides of the border. Reduced erosion in the Ethiopian Highlands and lower sediment loads in the Abbay-Blue Nile and Tekeze-Setit-Atbara river systems will bring down downstream costs of dredging power intakes, irrigation canals and the loss of power generating potential due to the need for reservoir flushing. These reductions will also contribute to reductions in costs that could not be quantified, of pump and turbine damage and the removal of sediment for domestic and industrial water supplies. Integrated watershed management measures in the upper Dinder and Rahad catchments will reduce sedimentation of the downstream wetlands thus reducing the incidence of flooding of agricultural lands.

At the global level there are a number of opportunities for increasing the sequestration of carbon dioxide and for conserving genetic, species and habitat biodiversity. The opportunities for carbon sequestration are particularly substantial in the area of increasing soil carbon–a hitherto neglected area. Soil carbon increases substantially under well managed or enclosed pastures and rangeland. The proposed interventions for establishing a trans-boundary park incorporating the Dinder and Alatish Parks will bring substantial benefits of conserved biodiversity in this important area. Similar benefits will accrue with trans-boundary cooperation in the Gambella and Boma National Parks.

The benefit-cost analysis for the WSM intervention in the Eastern Nile Basin finds that the total incremental benefits of US $ 13,176 million exceed the incremental costs of US$ 4,666 million, giving a present value of net incremental benefits of US$ 8,510 million and a benefit cost ratio of 4:1 (ENTRO, 2007). The question is of finding the requisite finances for the proposed watershed management interventions to realize the potential benefits. Funding options include an expansion of the existing funding source for the Nile Basin Initiative (NBI), the Nile Basin Trust Fund (NBTF) and bilateral donor funds, public-private partnerships, the operating programs of the Global Environmental Facility, global carbon funds and payments for environmental services.

Overall, the study finds that, given the natural resource degradation, poverty and vulnerability in the Eastern Nile Basin, the social and political costs of inaction could be catastrophic. The degradation of the natural resource base will accelerate, poverty levels will rise and households will become increasingly vulnerable to climatic and other shocks. With its proven potential to break the vicious cycle of poverty and resource degradation, a sustainable and integrated watershed management program must be a key element in developing any multi-purpose program. A broad-based program of direct and supporting integrated watershed management interventions can arrest the degradation of the natural resource base, enhance agricultural productivity, raise households out of grinding poverty and reduce their vulnerability to external and internal shocks, thus contributing incalculably to the overall ENSAP goal of poverty reduction and sustainable utilization of the natural resource base.

1 Background and Introduction

1.1 Eastern Nile Basin in Context

The Eastern Nile Basin covers around 1.7 million square kilometers and comprises four sub-basins: the Baro-Akobo-Sobat-White Nile, the Abbay-Blue Nile, the Tekeze-Setit-Atbara and the Main Nile from Khartoum to the Nile delta (see map on page v). It is home to 108.6 million people and includes parts of Ethiopia, Sudan and Egypt.

The basin encompasses an extraordinary range of ecosystems from high mountain moorlands, montane forests, savanna woodlands, extensive wetlands and arid deserts. It has been the location of some of the ancient world's most advanced civilizations. The annual Nile flood that carried fertile sediment from the Ethiopian Highlands transformed the deserts of Sudan and Egypt into rich agricultural lands along its course. The majority of the people in Ethiopia and Sudan are rural, largely dependent on the natural resource base for their livelihoods. While in Egypt nearly half the population is urbanized the Nile River provides the basis for agriculture, power generation and water transport. The peoples of the basin pursue a wide range of livelihood systems which include camel herding in the arid deserts of northern Sudan and the Red Sea hills of Egypt, flood-retreat cattle grazing and cropping on the flood plains of the Baro, Sobat and White Nile, mixed livestock and cropping systems in the Highlands of Ethiopia and a wide range of irrigated cropping systems in Sudan and Egypt.

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1.2 Background to the Watershed Management Cooperative Regional Assessment

Nile Basin Initiative (NBI)

The Nile Basin Initiative was launched in 1999 as a partnership of the nine riparian countries of the Nile basin. It is led by the Nile Council of Ministers (Nile-COM) assisted by a Technical Advisory Committee (TAC) and a Secretariat (Nile-Sec) based in Entebbe. It has a strategic action program comprising two sub-programs: a basin-wide Shared Vision Program (SVP) and a Subsidiary Action Program (SAP) to promote cooperation at the sub-basin level. The SVP comprises seven thematic projects and one coordination project. The SAP has two sub-basin components: the Nile Equatorial Lakes Subsidiary Action Program (NELSAP) and the Eastern Nile Subsidiary Action Program (ENSAP).

Eastern Nile Subsidiary Action Program

ENSAP is an investment program of the Governments of Egypt, Ethiopia and Sudan under the umbrella of the NBI. It is led by the Eastern Nile Council of Ministers (ENCOM) comprising Ministers representing key stakeholder ministries and three ENSAP technical country teams (ENSAPT). The primary objective of ENSAP is to achieve joint action on the ground to promote poverty alleviation, economic growth and arrest environmental degradation. At the country level ENSAP has National Focal Points (NFPs) for overall coordination and liaison with National Coordinators, Working Groups of specific projects, and National Social Development Coordinators (NSDCs). The Eastern Nile Technical Regional Office (ENTRO) at Addis Ababa is a legal entity established by ENCOM to manage and coordinate the preparation of ENSAP projects (Figure 1.1).

Eastern Nile Technical Regional Office (ENTRO)

ENTRO was established in 2002 and substantially restructured in 2005. It prepares, manages and coordinates cooperative projects within the Eastern Nile Basin (ENB). Over and above coordinating the implementation of ENSAP, ENTRO strengthens institutions and provides secretariat support to ENCOM and ENSAPT. ENTRO has a Social Development Office (SDO) that supports all ENSAP projects through capacity building in social development, input into project design, formulation of guidelines and the initiation of studies and analysis.

ENTRO is led by the Executive Director and has three Units: (i) Projects Coordination Unit, (ii) Social Development Office and (iii) the Finance and Administration Unit. The Projects Coordination Unit has a senior project coordinator and project coordinators for each of the ENSAP Projects (Figure 1.2)

Figure 1.1: Institutional Structure of the Eastern Nile Subsidiary Action Program

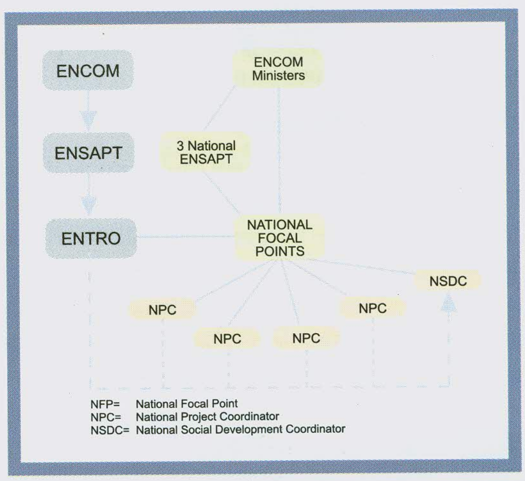
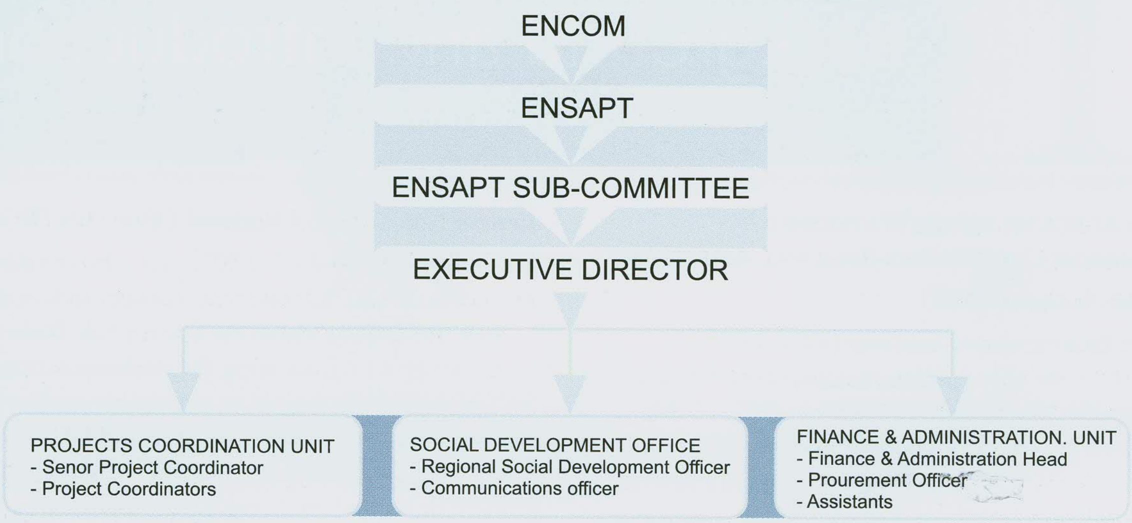


Figure 1.2: Organizational Structure of ENTRO



Integrated Development of the Eastern Nile

The first ENSAP project was the Integrated Development of the Eastern Nile (IDEN) launched in 2001. IDEN comprises seven components one of which is Watershed Management:

- 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

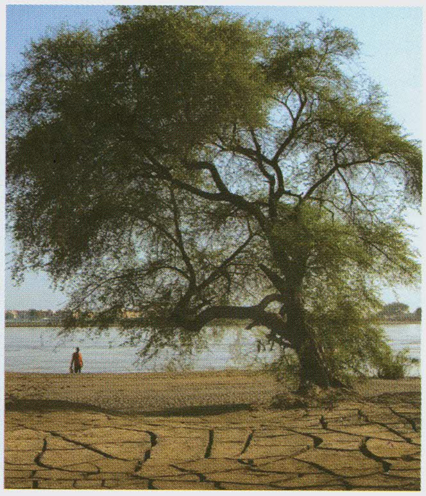
Joint Multi-purpose Program

In 2005 ENCOM launched a Joint Multipurpose Program (JMP) with a comprehensive set of components, including investments in infrastructure linked to the river and power systems, watershed and environmental management, enhanced agricultural production and leveraged growth and economic integration, supported by an information base and institutional regimes.

1.3 Rationale for a Sustainable Watershed Management Framework

Notwithstanding the rich natural and human resource base, the basin's peoples face huge challenges. The incidence of poverty is high, and with high population growth rates the pressure on the natural resource base and ecological systems is enormous and increasing. Poverty reduction efforts are constrained by processes of depleting resources such as land degradation, high sediment loads and consequent sedimentation of dams and irrigation canals, the loss of products and services provided by forests and wetlands, overgrazing of rangelands and declining biodiversity. Over this scenario lies the threat of climatic change and the potential negative impacts on rainfall (amount, distribution and reliability), and the consequences of these on the vulnerability of peoples' livelihoods.

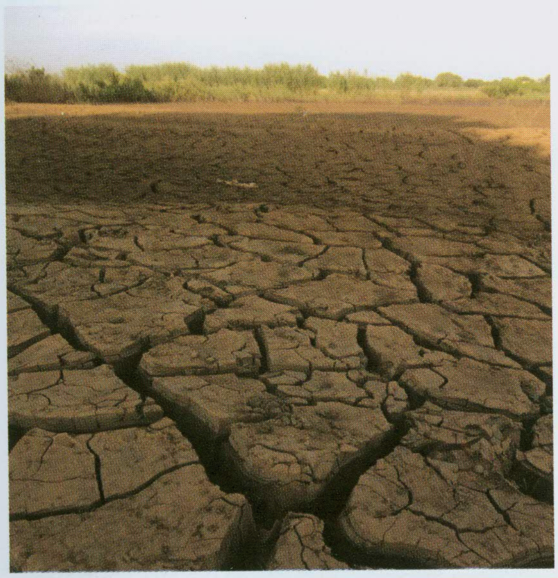
While the knowledge base regarding resource degradation is relatively well-known, understanding fully the complex inter-relationships of the environment-poverty nexus and peoples' ability to invest in sustainable resource management practices is still the subject of considerable research. Nevertheless, a substantial knowledge base of



1 Background and Introduction

complex subject area is emerging and lessons learnt of successful and unsuccessful natural resource interventions in watershed management are now known.

Developing a sustainable framework for watershed management and proposals for interventions must therefore address not only the proximate causes of resource degradation but also the complex underlying and inter-related causes. The focus of the watershed management program of interventions must be on achieving sustainable livelihoods, expanding the range of available livelihood strategies and reducing the vulnerability of communities and households to natural, social and economic shocks.



1.4 Objectives of the Watershed Management Cooperative Regional Assessment

The general elements of the Watershed Management CRA are (i) institutional strengthening, (ii) a participatory process for building trust and confidence, and (iii) analysis to gain a trans-boundary understanding of the watershed system from a basin-wide perspective.

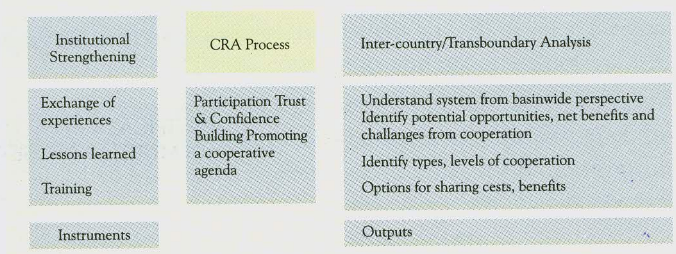
The Watershed Management CRA focuses on four sub-basins: the Abbay-Blue Nile, the Tekeze-Setit-Atbara, the Baro-Akobo-Sobat-White Nile, and the Main Nile from Khartoum to the Aswan High Dam. The overall objectives of this CRA are to develop a sustainable framework for the management of the four sub-basins focusing on reducing vulnerability to shocks, enhancing sustainable livelihoods, achieving food security and alleviating poverty. These objectives will be realized through interventions that will enhance agricultural productivity, protect the environment and reduce resource degradation, sediment transport and siltation. A key approach to their implementation will be the active participation and collaboration of stakeholders at all levels. By adopting a watershed approach, negative environmental, social and economic impacts will be minimized both upstream and downstream.

The framework will lay the foundations for cooperative development activities through a process of sharing experiences and information. This will promote trust and confidence among the riparian countries and contribute to capacity building at all levels. It will identify opportunities for and benefits from cooperative actions among the ENB countries.

1.5 Approach Adopted

Given the complexity of cross-cutting natural resource degradation, livelihoods and poverty issues, the CRA took a holistic and multi-sectoral approach to the development of a sustainable watershed management framework. It was thus not only an analytical undertaking but also a cooperative process to build trust and confidence. The elements of the Watershed Management CRA are shown in Figure 1.3.

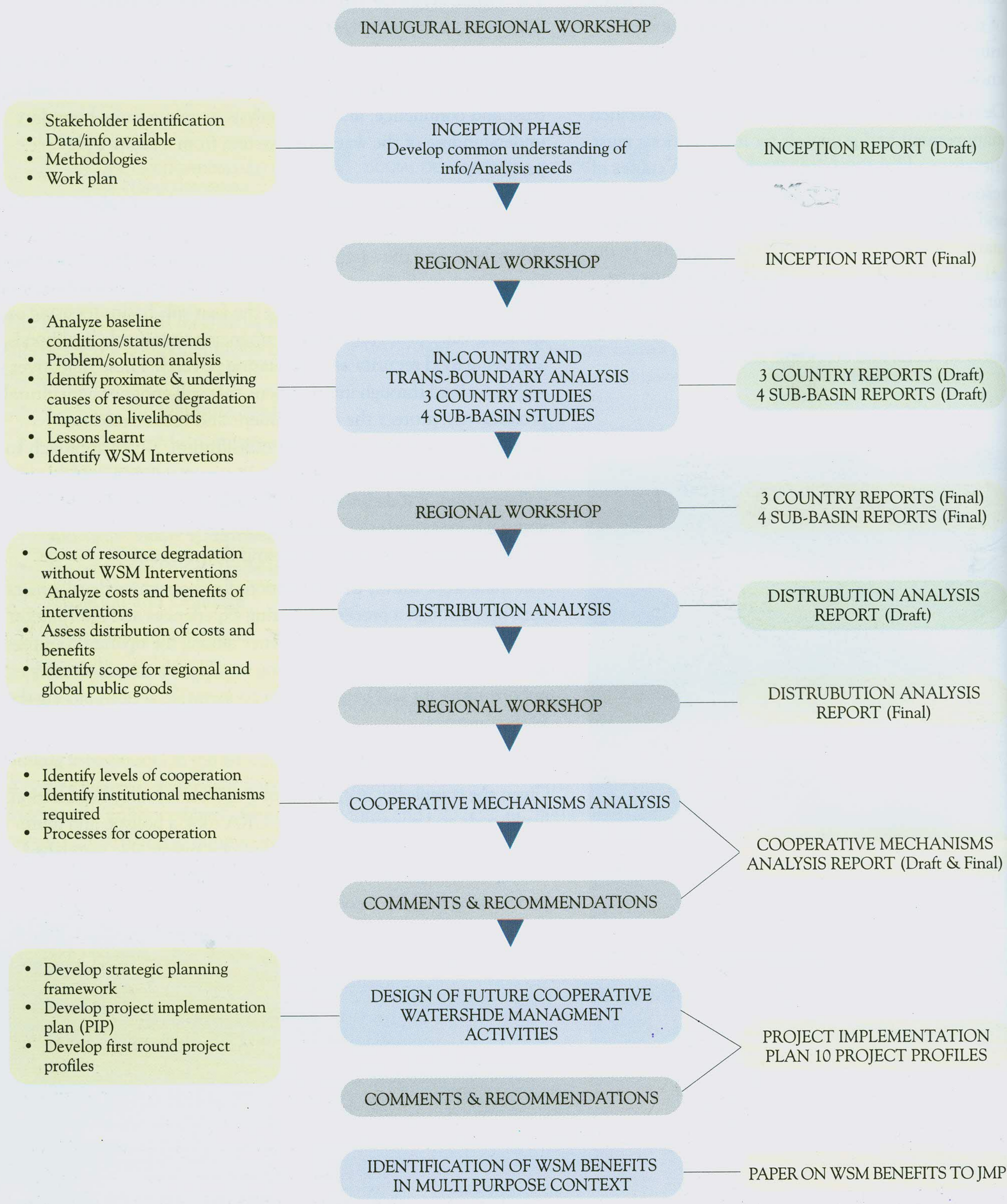
Figure 1.3: Generic Elements of Cooperative Regional Assessment



Inter-country and trans-boundary analysis

The analysis element of the CRA adopted a holistic, integrated and cross-sectoral approach following a sequential process. The full sequence of activities is shown in Figure 1.4.

Figure 1.4: Analytical Process of the Watershed Management Cooperative Regional Assessment



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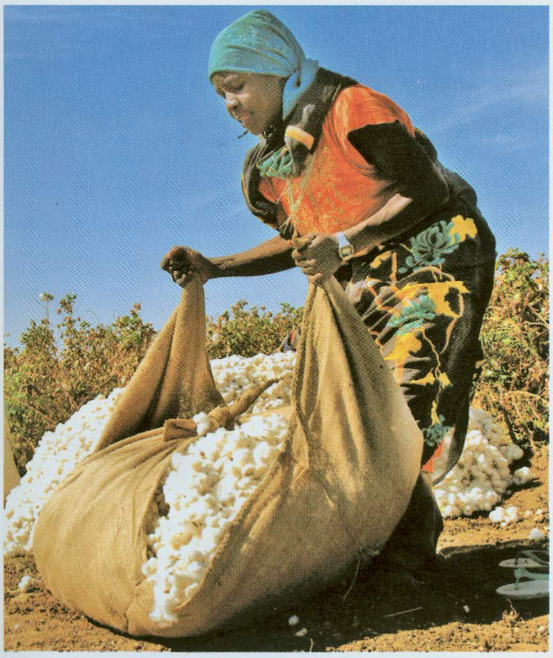


The first stage of the process was to (1) gain a common understanding of the available baseline information, including existing studies on the basin, (2) carry out a stakeholder analysis and clarify the objectives and scope of the work, (3) develop an approach to the methodology and (4) identify the main elements of the assessment. This was followed by in-country and trans-boundary analyses: first at the national level for the three countries and then at sub-basin level, to understand the four sub-basins as integrated systems.

The trans-boundary analysis provided a 'without' borders view of the watershed systems and associated livelihoods. The distributive analysis re-inserted borders to analyze the distribution of costs and benefits that would accrue to each country from the proposed watershed management interventions. In addition, this analysis identified potential 'public good' benefits: i.e., benefits that accrue beyond the national borders at regional and global level. The cooperative mechanism's analysis identified the various levels of cooperation that would be required to implement the various interventions, and analyzed the institutional implications of the various watershed management opportunities identified in the Trans-boundary and the Distributive Analyses.

Drawing on these analyses, a long-term program of watershed management activities was drawn up in the form of a project implementation plan. Profiles of ten first round follow-on projects were developed. Finally, a short summary of important watershed management issues and linkages to be considered in the development of a multi-purpose program was provided.

Process and institutional strengthening

The process element of the CRA was achieved by the consultants carrying out regular and close collaboration and consultations with ENTRO, the three National Steering Committees, their National Project Coordinators and the World Bank. Substantial key stakeholder consultations and field visits were made in Ethiopia, Sudan and Egypt. Draft reports were produced at each stage of the process and were submitted to ENTRO, the three national Watershed Management CRA Coordinating Committees, the Canadian International Development Agency (CIDA) and the World Bank for comments and recommendations. These were then incorporated into the final reports. In addition four regional workshops were held at critical points in the process, to (1) share information and lessons learnt, (2) have detailed discussion and comment on the results of the analysis and (3) develop a common understanding of issues, constraints and opportunities.[2]

The CRA thus provided a process for integrating environmental considerations and sustainability criteria into the design of the Watershed Management Framework. This process also consulted a broader set of stakeholders and created opportunities to incorporate their views and inputs in the program design.

1.6 Outline of the Report

This Report provides a synthesis of the findings from the following six CRA outputs:

- Inter-country Trans-boundary Analysis Reports, consisting of:

  -three Country Reports: (Egypt, Ethiopia and Sudan) and

  -four Sub-basin Reports (Abbay-Blue Nile, Tekeze-Setit-Atbara, Baro-Akobo-Sobat-White Nile and the Main Nile)
- Distributive Analysis Report
- Cooperative Mechanisms Analysis Report
- Project Implementation Plan: Eastern Nile Basin Water Management Program
- Ten Project Profiles for first round watershed management projects
- A paper on the contribution of watershed management interventions to multipurpose investment programs

Chapter 2 summarizes the results of the inter-country trans-boundary analysis, outlines the baseline conditions of the ENB and identifies the key watershed management issues and constraints to improving livelihoods and reducing poverty. In particular, it examines the nexus between natural resource degradation and poverty as it applies to sustainable watershed management, by analyzing the root causes of natural resource degradation and the high levels of poverty.

Chapter 3 examines national and trans-boundary watershed management issues, provides an overview of lessons learnt from watershed management elsewhere, and summarizes the opportunities to improve livelihoods through a program of watershed management interventions.

Chapter 4 summarizes the results of the Distributive Analysis and outlines the impacts and costs of continued natural resource management practices in a 'business as usual' scenario. It examines the potential environmental, social and economic benefits of the proposed program of watershed management interventions as a whole, recognizing that there are many synergistic benefits that do not emerge in an impact analysis of any single intervention. The distribution of costs and benefits are identified at household, community, sub-basin, regional and global levels. The chapter concludes by identifying the options available for sharing costs and benefits.

Chapter 5 examines the challenges and opportunities for watershed management cooperation and details the mechanisms and institutional requirements essential for trans-boundary cooperation at increasing levels of complexity.

Chapter 6 outlines the proposed long-term ENB Watershed Management Program to continue the work of the Watershed Management CRA. This program is to ensure that plans are translated into action and that there is a continued exchange of experiences, monitoring of program impacts and implementation of cooperative trans-boundary activities. It outlines the ten first round cooperative watershed management projects to be developed, funded and implemented during the Watershed Management program. It also identifies linkages to other programs and projects in the framework of the NBI, ENSAP-IDEN and the JMP. The chapter concludes with an outline of the funding options for the Watershed Management Program.

Finally, chapter 7 draws a number of conclusions with respect to the vital importance of a program of watershed management interventions for improving livelihoods, reducing poverty and arresting natural resource degradation.

2 Poverty and Natural Resource Degradation

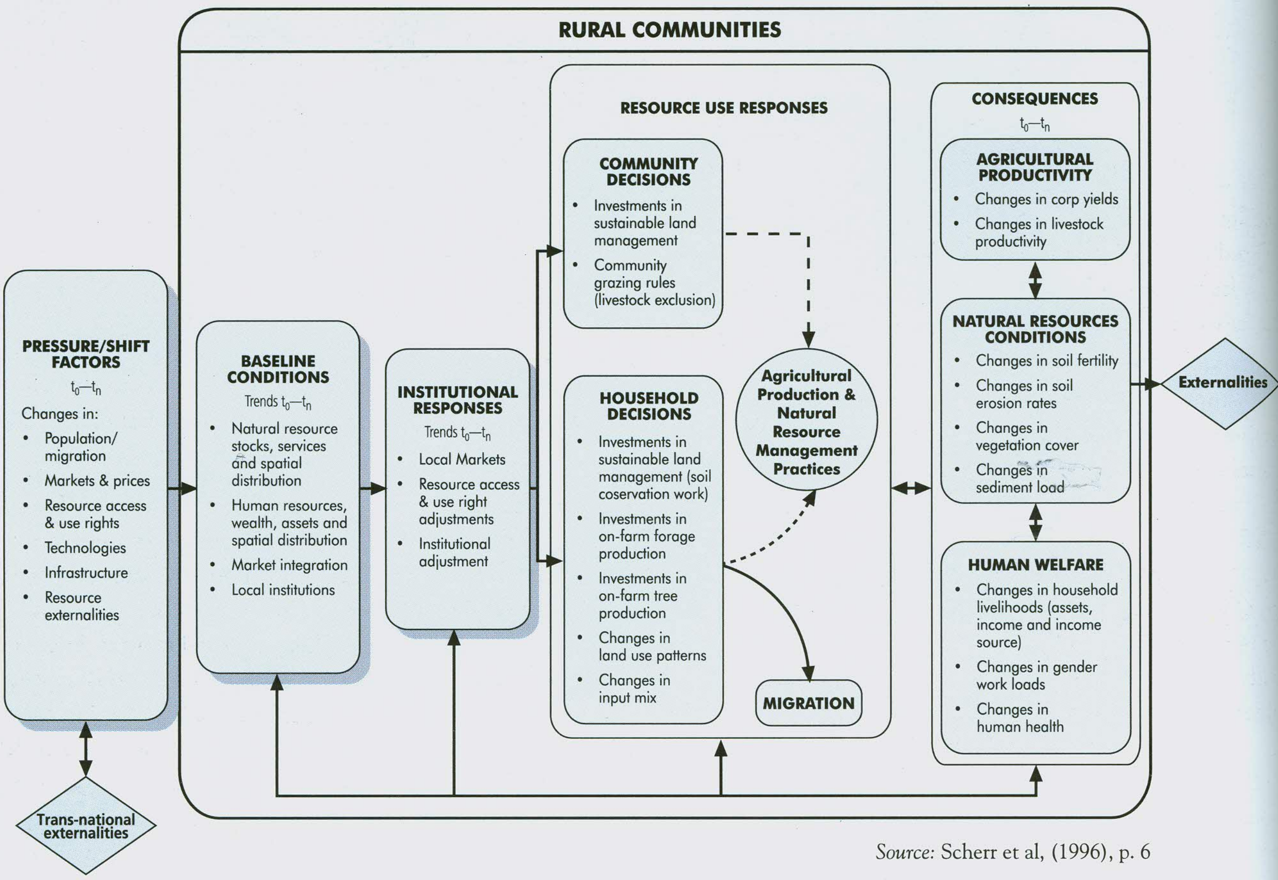
2.1 The Poverty-Environment Nexus

Poverty is both a cause and a resultant of natural resource degradation (Scherr, 1999). In all three countries poverty is most prevalent among rural households whose livelihoods depend on agriculture. Nevertheless, the determinants and context of poverty are not confined to natural resource degradation but encompass other aspects of livelihoods: education, health, access to knowledge and information, and the wider socio-economic framework of markets, prices, technology, credit, government development polices and strategies. This suggests that simply approaching poverty reduction by arresting resource degradation through technical measures may be insufficient if the other determinants and issues related to the broader socio-economic framework are not addressed.

Population pressure is often cited as a cause of land degradation. The 'neo-Malthusian' hypothesis predicts that agricultural production will be 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. Boserup (1965), however, argues that these negative impacts may be countered by responses from households and communities that include a reduction in fallow periods, intensified use of labor and land, development of labor-intensive technologies and institutional changes. However, recent evidence suggests that more specific conditions are needed to get a Boserupian scenario to operate, such as secure tenure, efficient markets, cash crops, supporting social organization and proven soil and water conservation measures (Tiffen, 1996).

One framework that captures these complex dynamics of change defines pressure or 'shift' variables (e.g., changes in population, migration, markets and market prices, land tenure institutions) that induce changes in baseline conditions of natural resource endowments of households and communities, household assets, market integration, local institutions and property rights (Figure 2.1). These shifts can in turn induce responses at the community and household level. Of particular importance and 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,

Figure 2.1: Factors in Natural Resource Degradation



Source: Scherr et al, (1996), p. 6

forage production) and on human welfare (health, livelihoods). The public policy environment (e.g., agricultural research programs, resettlement policies, land access policies) and interventions (e.g., in infrastructural development) also influences this temporal process at various levels. Understanding the complex determinants of the dynamic poverty-environment nexus is thus a necessary first step to identifying interventions to arrest natural resource degradation and reduce poverty. And this has to be done separately for each country context.

2.2 Poverty and Vulnerability in the Eastern Nile Basin

Large proportions of the rural population in parts of Ethiopia, Egypt and Sudan comprising the Eastern Nile Basin are poor, and vulnerable to poverty caused by natural resource degradation. Yet the determinants of poverty, risk and vulnerability vary considerably across the three countries.

Ethiopia

Incidence of poverty: The proportion defined as poor in 1999-2000 was 45 per cent in rural areas and 37 per cent in urban areas. According to the Sustainable Development and Poverty Reduction Plan (SDPRP) of 2002, rural poverty declined by 4.2 per cent between 1995-96 and 1999-2000 although it increased in urban areas by 11.1 per cent. However, a longer term analysis indicates that overall poverty declined only marginally between 1990 and 2004 (from 38.4 to 36.2 per cent) largely due to no growth or even slightly negative growth in the agricultural sector (World Bank, 2005a). The analysis highlighted the volatility of poverty incidence: poverty declined between 1994 and 1997 but increased between 1997 and 1999. Also, the average numbers hide a substantial amount of moving in and out poverty, described as 'churning on the margins' (Little et al., 2004).

Determinants of poverty: The key underlying cause of poverty in Ethiopia is the degrading natural resource base (Dejene, 2003). Families are locked into a downward spiral of increasing poverty and increasing degradation of their natural resources. The degrading resource base increases households' vulnerability to natural (drought) and social (sickness) shocks and also restricts their ability to adopt alternative livelihood strategies (Ersado et al., 2001).

Population pressure also causes land degradation. Grepperud (1996) found that when population and livestock pressures exceeded the population and livestock carrying capacity of the land, rapid degradation of land takes place. Pender et al. (2001) found in Amhara region of Ethiopia that high population densities were related to the decline in fallowing and manuring, increasing land degradation and worsening household welfare conditions.

2 Poverty and Natural Resource Degradation

In Tigray, they found that high population densities were related to more intense use of resources (more fertilizer, manure and intercropping) at the household level and increased land degradation at the community level.

Risks and vulnerability: Vulnerability to poverty is high: it is estimated that two out of three Ethiopians will be poor in five out of the next ten years. Drought and highly variable rainfall are the major sources of vulnerability, as are highly volatile inter-annual cereal prices (Diao et al., 2005). Some 75 per cent of the population is estimated to be at risk to malaria and there is an increasing incidence of HIV/AIDS in rural areas. Both present significant vulnerability risks. Studies have also found that households with more children under 15 years and those with people older than 65 years are particularly vulnerable to falling into poverty, underscoring the importance of adult labor in the welfare of rural households. Female headed rural households face a 9 per cent higher probability of being poor than male-headed households. Conversely, households cultivating exportable crops (*chat*, coffee) have a much lower probability of being poor, as also those living near towns, having better access to markets and owning farm assets such as oxen.

Sudan

Incidence of poverty: Between 60-70 per cent of the population in the north lives below US$ 1.00 a day, while estimates in the south put the proportion at 90 per cent (JAM, 2006). Despite sustained economic growth since 1997 many experts believe that poverty has remained widespread and has actually increased, as has the gap between the 'haves' and the 'have nots'.

Determinants of poverty: The high rates of poverty in the south are clearly related to the negative impacts of the war, which reduced or wiped out household and community livelihood assets (capital, family labor and secure access to land). Consequently households and communities here are extremely vulnerable to natural and human induced sudden, seasonal and long-term changes in their natural environment and breakdown in the social and economic networks that sustained them in the past.

Risks and vulnerability: Except for the people on irrigated cropland along the Blue and Main Niles, rural households elsewhere generally work on rain-fed cropland where the low and variable rainfall creates a high risk environment. It is not easy to build-up household assets, and there are many cases where these have actually declined through land degradation or alienation of assets. Livestock assets usually provide a buffer in times of need, but where access to water and forage has become limiting, vulnerability to shocks and hazards such as rainfall variability and drought becomes more acute. 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.

Egypt

Incidence of poverty: In 1999-2000 the poverty rate across Egypt stood at 16.7 per cent for around 10.7 million people, with the rural rate being 22.1 per cent compared to 9.2 per cent for urban areas. There are significant differences in poverty alleviation across regions and across different employment sectors (El-Laithy et al., 2003), and even within regions. Thus, while the three governorates around Lake Nasser have rates below the national average, there are three groups that are likely to be below the poverty line: (1) the two groups who live in the Wadi Allaqi on the eastern side of the lake, the Ababda and the Bishari Bedouin (Briggs et al., 1993); (2) the group located in the new settlement areas west of Lake Nasser in three communities of Kalabsha, Khor Galal and Garf Hussien (IDRC, 2004); and (3) the fisher people of the lake, the Saiydis. All three groups depend heavily on the natural resource base for sustenance, and affect the resource base through their poverty-driven resource use.

Determinants of poverty: The key determinants of poverty in Egypt have been identified as education (human capital), employment status (financial capital) of the household head and large family size (World Bank, 2003b). This study also found that the largest proportion of poor is concentrated in the agricultural and construction sectors. Very small farm sizes is a major reason for poverty among irrigator farmers, who can barely make a living from the current irrigated cropped area and cropping pattern (Kishk, 1994).

Risk and vulnerability: Around Lake Nasser, the settlers' lack of knowledge of desert agriculture and an undeveloped marketing system hinders agricultural development (IDRC, 2004). The state of the fishery has remained relatively undeveloped with fisher people living either in their boats or in temporary shelters in 150 fish camps, and thus exposed to a harsh and risk-prone environment.

2.3 Natural Resource Degradation in the Eastern Nile Basin

The detailed trans-boundary analysis of the four sub-basins in the Eastern Nile Basin identified six key types of natural resource degradation, viz., land degradation, sedimentation, deforestation and degradation of forests, desertification and degradation of rangeland, degradation of wetlands and loss of biodiversity.

Infestation of river waters by water hyacinth (Eichhornia crassipes) is another environmental issue as it reduces the area of open water available for fishing, which is an important livelihood strategy for the people of the Sobat sub-basin, and also leads to increased loss of water due to evapo-transpiration. It also acts as an impediment to river navigation along the White Nile, a factor of considerable economic importance. It first appeared in the White Nile in 1957 in the area of the Sudd and has since spread north and southwards (Ahmed, 2006). It appeared in the Baro in Ethiopia about 1976 (EWNHS, 1996) and is also in the Sobat system. It is not dealt with further in this report as current reports indicate that the water hyacinth problem is not as serious as it was in the 1970s and 1980s. But an updated investigation is required inasmuch as ecological and climatological changes might trigger a second, even more severe, episode of infestation (SSC, 2007a).

Each of the six key natural resource degradation types identified is described below along with estimates of the physical extent of the degradation (details of these calculations are in Annexures 2 and 3, while thematic maps for the Eastern Nile Basin are in Annexure 4).

2.3.1 Land degradation

Land degradation comprises a number of processes. The main processes affecting the Eastern Nile Basin include (i) soil erosion by water and wind, (ii) soil nutrient and organic matter depletion, (iii) physical degradation (crusting, pan formation) and (iv) salinization. Of these, the two main land degradation processes are soil erosion by water (and its complement, high sediment loads in streams and rivers) and soil nutrient depletion. Soil erosion reduces moisture-holding capacity and causes nutrient loss, while soil nutrients are depleted due to the burning of dung and crop residues and grain removal. The major impact of these processes is to reduce agricultural production, and thus affect peoples' livelihoods. It must be emphasized, however, that the physical impacts and costs outlined below do not reveal the full extent of the social and

2 Poverty and Natural Resource Degradation

economic costs to the rural (and urban) population in terms of those key elements in the downward spiral of poverty and a degrading resource base, such as poor nutrition and health, poor access to social services (health and education) and restric ted access to alternative livelihood strategies.

Ethiopia

The total amount of soil eroded each year from the 36.15 million hectares of the Eastern Nile Basin within Ethiopia is estimated at 447 million tons. Of this, 151 million tons (33 per cent) is from cultivated land and 201 million tons (66 per cent) is from mainly communal grazing and settlement areas. The area of cultivated land whose use is considered to be unsustainable is estimated at 4.7 million hectares.[3]

Cropland: Soil erosion is estimated to reduce agricultural production by 60,220 tons of grain per year, which is 1 per cent of total annual crop production (CSO, 2003). The cumulative loss over 25 years will be 433,800 tons, or 8 per cent of total annual production in 25 years. Soil nutrient depletion reduces crop production by 885,330 tons per year, or 14 per cent of total annual production. Since this is a non-cumulative loss, the total crop production forgone over 25 years is the same. Put another way, these annual losses could feed 4.7 million adults every year, rising to 6.6 million people in 25 years time. This is the human cost of land degradation in the Ethiopian Highlands.

With the natural increase in population the area under cropland will increase. While some of the expansion will occur as infilling on suitable land, much will take place on land that is marginal for crop production because of shallow soils and steep slopes. In the absence of substantial watershed management interventions it is estimated that by 2025 cropland will expand by some 2.93 million hectares in Ethiopia. Assuming a similar distribution of slopes and soils as current cropland it is estimated that total soil erosion on cropland will increase by 27.2 million tons per year or an increase of 18 per cent on current rates.

Non-cropland: Some 66 per cent of sheet erosion occurs on non-cropland, which is essentially communal lands used for settlement, grazing and fuel wood collection. This land is invariably on steep slopes with shallow soils that are overgrazed with wood biomass extraction rates often exceeding sustainable growth rates. The result is a downward spiral of pasture and woody biomass degradation leading to accelerated soil erosion, increasing shortages of livestock feed and decreasing supplies of fuel wood. Decreasing supplies of fuel wood result in the increasing use of dung and residues as fuel leading to increasing breaches in soil nutrient cycling and to declining crop yields on croplands.

Sudan

Land degradation in Sudan consists of gulley erosion on kerib land, soil productivity losses in semi-mechanized irrigated farms[4] and traditional rain-fed farms, drifting sands and moving sand dunes, and river bank erosion.

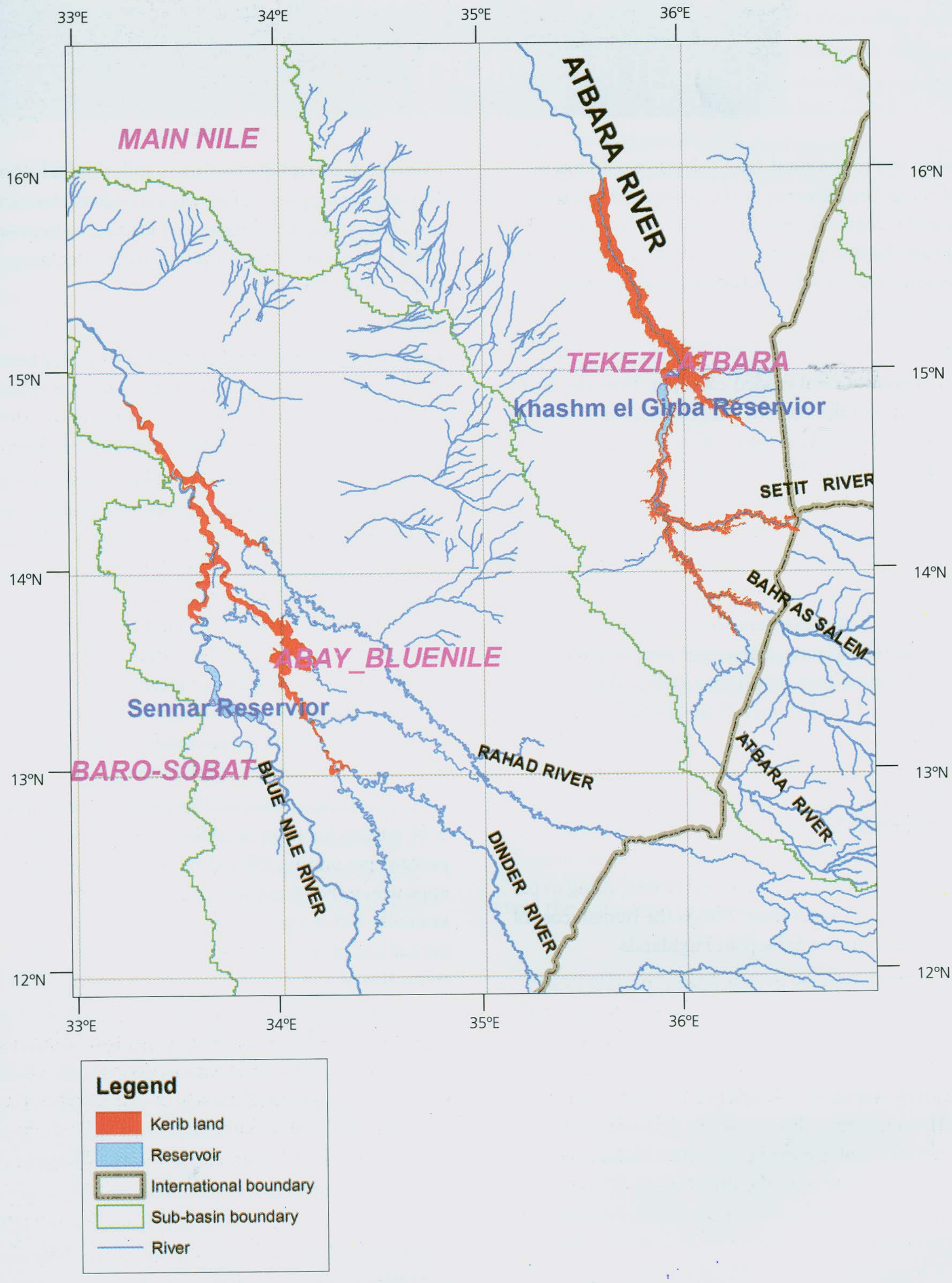
Kerib land: Extensive kerib land is located along the Atbara-Setit River and to a lesser extent along the Blue Nile, Rahad and Dinder Rivers (see Figure 2.2). Along the Atbara River an estimated 3,000 hectares of land are lost each year, some 40 per cent above and 60 per cent below the Kashm el Girba dam. The land above the dam is under traditional rain-fed cropping, while that below the dam is rangeland used for extensive grazing. The value of the annual accumulating loss of agricultural land in human terms is estimated to be equivalent to the total loss of livelihoods for some 25,000 households.

Semi-mechanized farms: The annual decline in yields on 5.94 million hectares of SMFs has been estimated at 2 percent per annum (World Bank, 2003a). Since approximately 3.6 million hectares of SMF's are cropped annually within the Eastern Nile Basin, this represents an annual loss of production of 34,400 tons per year. In human terms this annual loss in grain could feed 176,760 people.

Traditional rain-fed farms: Approximately 672,400 hectares of small-scale rain-fed cropping have been mapped in the Eastern Nile Basin. Assuming the same yields as the SMFs but with half the rate of yield decline (i.e., 1 per cent per year) this would indicate an annual cumulative production loss of 3,230 tons per year. In human terms this annual loss in grain could feed 16,100 people.

Drifting sand areas: Drifting sand in areas along the Lower Atbara, the northern reaches of the White Nile and along the Main Nile reduces crop production in two major ways: (i) damage to growing plants through sand coverage and leaf stripping and (ii) through sedimentation in irrigation canals, which reduces water delivery efficiencies and increases costs of dredging. It is estimated that yields have reduced on approximately 30 percent of cropland affected by sand in the Lower Atbara (Latif, 2005). Drifting sand in canals has also led to the need to increase irrigation frequencies because of the high infiltration rates.

Figure 2.2. Blue Nile and Atbara Sub-basins: Areas of *kerib* Land



Moving sand dune areas: The most hazardous dunes affecting crop cultivation along the river banks are located between Dongella and Karima. The source areas for the dune fields are the very extensive areas of loose and shifting sand that overlies the rock pavement as well as the three larger dune fields to the northwest.

River bank erosion: In addition to increased suspended sediment and bed load, the sand tipped into the river forms sandbars, which in turn cause accelerated river bank erosion. Most river bank erosion in the Main Nile in Sudan occurs in the first and third of four reaches, with the third reach experiencing the most severe erosion. The first reach is between Khartoum and the fifth cataract and the third reach is between the third and fourth cataracts (see Figure 2.3). River bank erosion is caused by the large and rapid changes in water level, high river velocities and induced

Figure 2.3: Main Nile: Location of Cataracts

flow shear on the outer banks acting on the sandy layer which underlies a cohesive clayey bank material. Surveys undertaken by the Sudan Hydraulics Research Station over the period 1989–1999 in the Northern State reach of the Main Nile estimated that some 19,400 feddans have been lost or severely affected by river erosion (Ahamed et al., 2005).

2.3.2 Sedimentation

Soil erosion from cropland leads to increased sediment loads of streams and rivers. These high sediment loads have considerable negative impacts including sedimentation of dams, reservoirs and canals in irrigation schemes, leading to reservoir storage loss, increased costs for removal of sediment in domestic water supply systems, damage to hydro-electric turbines and irrigation pumps, higher irrigation-system operation and maintenance costs, increased dredging in front of turbine in-takes, higher cost of water purification, pump damage, hydroelectricity production forgone and losses in agricultural production and river bed aggradation (which causes accelerated meandering and river bank erosion). Sedimentation, however, has some positive benefits, as sediment deposited in fields through the canal network acts as fertilizer for crops. These gains are annual and not cumulative due to nutrient uptake by crops, leaching and volatization losses.

Ethiopia

The main impact of high suspended sediment loads in Ethiopia is high rates of sedimentation in small dams and water harvesting structures (e.g., tanks and cisterns). A number of evaluations have noted high rates of sedimentation and loss of storage capacity in all these structures. The cost of cleaning dams, ponds and tanks are estimated to be US$ 1.75 million per year.

Sudan

Sedimentation in reservoirs: The five main reservoirs in Sudan are Jebel Aulia, Roseires, Senner, Kashm el Girba and Lake Nubia. Sedimentation in the two dams on the Blue Nile, Roseires and Senner, has now reached equilibrium between sediment entering and leaving the dams although substantial storage has been lost in the past. Sedimentation in Kashm el Girba continues with an annual loss of storage of 1.54 per cent per year. Sediment levels in the White Nile are very low and do not significantly affect the Jebel Aulia dam. Sudan does not use Lake Nubia for hydro-power generation or irrigation and thus the sedimentation in Lake Nubia does not currently incur a cost to Sudan.

The main costs of reservoir sedimentation are due to cleaning of irrigation canals, increased dredging of turbine in-takes and hydro electricity production lost due to the need for flushing the reservoirs at times of high sediment loads. Sedimentation in the Kashm el Girba dam also causes substantial losses of storage for irrigation water, and consequent reductions in the amount of land that can be irrigated. Around 2,457 hectares of irrigated land have been estimated to be lost every year (Diab and Ahmed, undated).

Another cost of the very high sediment loads in the Blue Nile and Atbara rivers is the need to flush the three reservoirs regularly to reduce sediment deposition. This reduces the head and the amount of power that can be generated during this time. It is estimated that there is a reduction of 3.27 mega watt hours due to the need for flushing and an additional US$ 2 million per year is spent dredging the turbine in-takes at Roseires dam.

Flushing of the Kashm El Girba reservoir also causes an annual mass kill of fish (SSC, 2007b). The estimated annual fish catch in the reservoir is 500 tons per year out of an estimated potential of 840 tons per year (FAO, 2004). Although the exact proportion destroyed in not known, a conservative estimate is that 20 per cent of the fish stock is killed each year.

Sedimentation in wetlands: The Rahad-Dinder wetlands comprise a large number of oxbow lakes and cut-off meanders along and between the Rahad and Dinder rivers known as *maya'as*. They are found at various stages of sedimentation, from pristine small lakes through to those completely filled with sediment. The sedimentation is due to the high sediment loads of the two rivers originating in the Ethiopian Highlands. It is reported that the rate of sedimentation in the *maya'as* is increasing, leading to a reduction in flood buffering (Abdelhameed et al., 1997).

Sedimentation in canals: The main irrigation schemes affected by sedimentation in canals are the Rahad, Gezira-Mangil and New Halfa, although smaller schemes are also affected. The sediment deposited in the canals of these three major schemes is estimated to be 19.6 million tons per year.

Sedimentation in the Gash delta: The river bed in the Gash delta is rising at a rate of 3 centimeters per year and sediment is being deposited along the canals. The area irrigated by these canals has reduced from some 300,000 *feddans* in the 1930s to only 40,000 *feddans*. Each year some 10,000 to 15,000 tons of sediment a year are dredged from each of the seven canals. Off-take structures have to be maintained regularly to avoid them being undercut or by-passed and many have to be reconstructed completely.

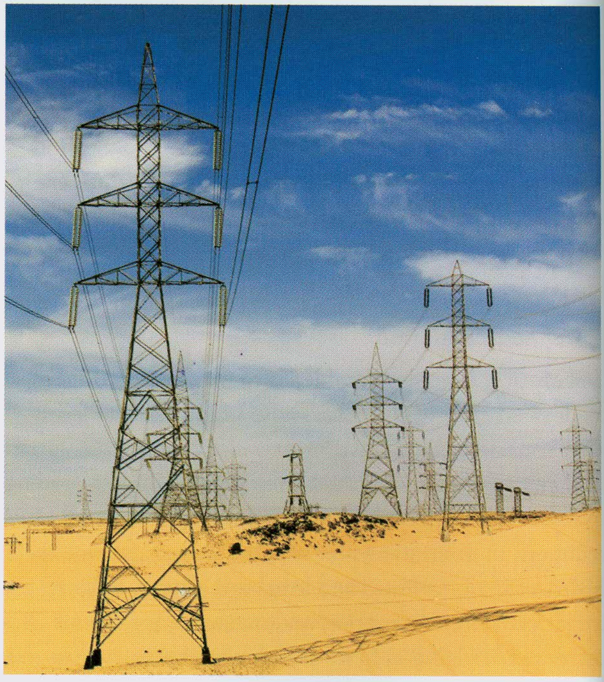
Benefits of sedimentation in fields: Some 38 percent of sediment entering the three main irrigation systems is deposited in the fields. This is equivalent to 70,700 tons of fertilizer since 1 ton of sediment is equivalent to 0.94 kilograms of fertilizer.

Egypt

Sedimentation is a concern only in Lake Nasser in the Egyptian portion of the Eastern Nile Basin. Here it causes loss of live storage, hydro-power, and storage of irrigation water.

Loss of live storage: Shalash (1982) estimated the total annual sediment inflow as 142 million tons and the average rate of outflow as 6 million tons with a net sedimentation within the lake of 136 million tons. Live storage is estimated at 89.7 billion cubic meters (bcm). It is estimated that the live storage lost to date is between 2.5 and 2.8 bcm. This has implications for power generation and for irrigation below the Aswan High Dam (AHD).

Loss of hydro power: The AHD has an installed hydro-power generating capacity of 2.1 million mega watts capable of generating 10,000 mega watt hours (MWh) annually. Production is currently at about 8,000 MWh per year (Abu-Zeid and El-hibini, 1997). With annual cumulative loss of live storage of 0.155 per cent, this represents an annual cumulative loss of approximately 12.4 giga watt hours.



2 Poverty and Natural Resource Degradation

Loss of storage of irrigation water: The annual loss of live storage is 0.139 bcm and the value of water in Egypt for irrigation is estimated to be US$ 0.11 per cubic meter (ESC, 2007).

2.3.3 Deforestation and degradation of forests

Deforestation is the permanent conversion of forest to non-forest land cover and land use. It indicates a complete change in land cover from shrub land, woodland or forest to 'non forest land' and an almost complete removal of wood in the area cleared (e.g., Reitbergen, 1993, p. 6). However, wood removed for fuel does not involve a complete and instant change in land cover and shrub land; woodland or forest may remain as those land cover types for a number of years. There is instead, a gradual erosion of wood stocks and 'degradation' of land cover rather than 'deforestation'. The main cause of forest loss is agricultural clearance, driven by the decline in yields on existing cultivated land (which is subsequently abandoned) and rural population growth. On the other hand, degradation of forest, woodland and shrub land is caused by harvesting of wood (mainly for fuel) in excess of the natural yield and results in a reduction in woody biomass.

Ethiopia

Deforestation: Using 1995 as the base year, it was estimated that by 2015 some 804,300 hectares of forests, 1.7 million hectares of woodland and 0.3 million hectares of shrubland will have been cleared for agriculture and settlement as a result of natural population increase. On an average, 32,200 hectares of high forest and 67,700 hectares of woodland are cleared annually. Further, an estimated 29,100 hectares of high forest (between 1,100 and 1,900 meters above sea level or masl), that is ecologically suitable for wild coffee is cleared annually.

Degradation: In the Eastern Nile Basin an estimated 20 million tons of wood are unsustainably harvested as fuel wood and charcoal each year. This represents an annual accumulating loss of sequestered carbon of approximately 10 million tons. Other unquantifiable losses are of non-timber forest products (fruits, medicinal products, gums and resins, etc) and biodiversity.

Sudan

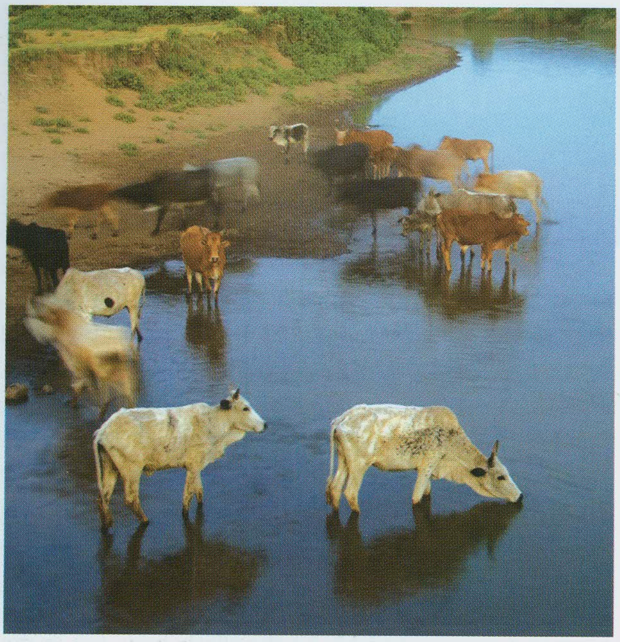
Deforestation: Some 5.94 million hectares of woodland and shrub land were cleared for the semi-mechanized farms. The complete removal of vegetation and the consequent removal of natural predators (snakes and cats) have led to an increase in rats and other vermin. Insect eating birds have disappeared leading to a big increase in the use of insecticides and insect damage. Because the land is totally cleared of all tree cover and combined with years of constant harrowing and disking, the tree seed bank in the soil has been completely destroyed. The abandoned areas are a wasteland with no tree cover. The quality of the grass cover is very poor because of the very low levels of soil fertility. There is consequently, intense pressure on the remaining woodlands for wood removal for charcoal, fuel wood, construction, furniture and lime burning. Estimates are not available for the whole basin but in the Bau locality of the Blue Nile state, it has been estimated, using consumption data from ENTRO (2005) and stocking data from Glen (1996), that some 224,180 hectares of woodland are cleared annually, most of it without permit. In the absence of definitive data it is difficult to place a value on this. In addition, closed woodland cover has a value for watershed services, non timber forest products (NTFPs), potential pharmaceuticals, and species and habitat biodiversity.

Woodland degradation: Not all woodland is clear felled and fuel wood collection often reduces the woody biomass stocks without totally removing tree cover. In the Eastern Nile Basin within Sudan approximately 19.7 million cubic meters of wood fuel and charcoal (per capita consumption of 0.73 cubic meters) are consumed forming about 80 per cent of the total energy consumption (MEPD/HCENR, 2003). This represents a loss of around 5.9 million tons of carbon.

2.3.4 Desertification and degradation of rangeland

The concept of 'desertification' has been discussed extensively in literature since the 1977 UNEP Conference on Desertification held in Nairobi.[5] Desertification has been described as the continuous and sustained diminution or destruction of the biological potential of land in arid or semi-arid environments. The debate revolves around whether man or climate is to blame, with the early debates centered on man as the primary cause, through the cultivation of marginal lands and particularly overgrazing.

More recently the debate has swung back and both climate and human impacts on dry lands have been shown to interact. Research has shown that even though satellite images can detect no changes in greenness, the vegetation composition can often change unnoticed, such as the spread of invasive species that reduce in forage productivity. The vegetation thus represents a new state and a return to earlier vegetation may not be possible (Westoby et al., 1989).



Ethiopia

In the Abbay sub-basin the main areas of overgrazing and hence livestock feed deficits are the upper slopes of Mount Choke in east and west Gojam, the eastern *weredas* in North Shewa and South Wello, and the more isolated areas of East and West Wellega. These areas are largely coincident with the areas of high soil erosion hazard. In the Tekeze catchment, *weredas* along the eastern and north-eastern part of the basin, and those to the north-east of the Simien massif are livestock feed deficit areas, and are thus likely to be severely overgrazed. Again the pattern generally mirrors that of *weredas* where high proportions of area experience moderate to severe soil erosion.

Sudan

In the White Nile, Blue Nile and Atbara sub-basins, the loss of pasture land due to the expansion of the semi-mechanized farms has put additional grazing pressure on the remaining rangelands, which have become severely degraded due to overgrazing. This has been exacerbated over the past two decades by declining rainfall. Rangeland degradation has taken the form of an increase in unpalatable species or species of low forage quality. This in turn reinforces overgrazing. The Ministry of Agriculture now estimates that 50 per cent of the rangelands are degraded (ENTRO, 2005).

In the west and north of Sudan, previously stable sand dunes have been reported to be moving. Agricultural land on the banks of the Nile between Karima and Delgo in the Northern State is now threatened by drifting sand. In 1999, Ali and Bayoumi reported that the desert area in western Sudan has increased from 205,000 square kilometres as reported by Harrison and Jackson (1958) to 340,000 square kilometres in 1982 and that the boundary of desert shifted about 200 kilometres south at a rate of 8 kilometres per year (see Amin, 2001).

2.3.5 Degradation of wetlands in the Eastern Nile Basin

Wetlands have a rich diversity of hydrological and ecological conditions which have given rise to a rich variety of livelihood and socio-economic systems, and varied patterns of ecological habitations, specie diversity and genetic biodiversity. These have over time developed a close response to the seasonal changes in hydrology and ecology. Thus, any proposals for interventions in the hydrology require a detailed and sensitive understanding of these relationships. Wetlands are important components of the hydraulic system and part of environmental, socio-economic and household livelihood systems that influence and are influenced by them (Abbot and Hailu, 2001). The hydrological system is the key environmental linkage. Land use in upper catchments and upstream wetland affects spring and stream flows and groundwater recharge.

These in turn affect sustainable on-site wetland use such as cropping, grazing and reed collection. Similarly, these on-site activities affect users of the wetlands downstream. The agricultural system has close linkages to the wetland system through cropping systems within the wetland, grazing systems and other extractive systems (reed cutting, apiculture, medicinal plant collection). The system also has internal linkages to population growth, labor and oxen constraints, indigenous knowledge, urban market opportunities (e.g., for vegetables), livestock holdings and the need for forage. Wetland cultivation and grazing provide important elements in households' food security strategies. The poorest members of the community rely most heavily on wetlands for collection of reeds and craft products for sale as well as for water supply. Wetland conservation protects the natural state of wetlands and has important social and economic benefits to local users.

Ethiopia

In the Abbay sub-basin the most extensive wetlands are found around the shores of Lake Tana, the shores of Finchaa reservoir and in the headwaters of the Dabus River. However, across the Highlands are hundreds of small poorly drained valley bottoms. A survey and inventory of wetlands in the Amhara region found that many of these wetlands were under threat due to land degradation and sedimentation, and the lack of bylaws and community rules regarding their use (Adgo, 2005). Many wetlands are used for dry season grazing, hay production, thatching grass and grass mats (*cheffe*).

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

2 Poverty and Natural Resource Degradation

crop production and grazing. Conversion to agriculture can seriously jeopardize the hydrological functioning of the wetland and reduce or destroy its environmental services (stabilizing run-off, water purification, hydrological recharge, biodiversity) and natural products (reeds, water supply, medicinal herbs). But conversion can also have benefits such as permitting food crop cultivation in the 'hungry' (dry) season, the cultivation of a second food crop, production of cash crops like vegetables and sugarcane, and forage crop production in the wet season, when upland fields are under crops. Experience however indicates that there is an optimum degree of drainage that will ensure an optimum level of agricultural production. Over-drainage[6] has in a number of cases damaged the wetland beyond recovery for agriculture, as well as caused the loss of many of the environmental services and products. But it is necessary to rest the wetland for one or more years to allow recovery of nutrients and soil organic matter.

Even where a wetland is optimally drained and sustainably managed, the distribution of benefits is not necessarily equitable. Some people gain whilst others lose. People who gain benefits of conversion include those households with sufficient livelihood capital assets (labor, capital) to enable them to cultivate the wetland (Mulegeta, 2004). Also, households with large livestock holdings will gain more than those households with few or no livestock. Large sections of the community will suffer losses if there are severe reductions in the availability of medicinal plants, thatching grass and domestic water supplies. Women in particular will be disadvantaged if springs dry up, as they will be required to travel greater distances for water.

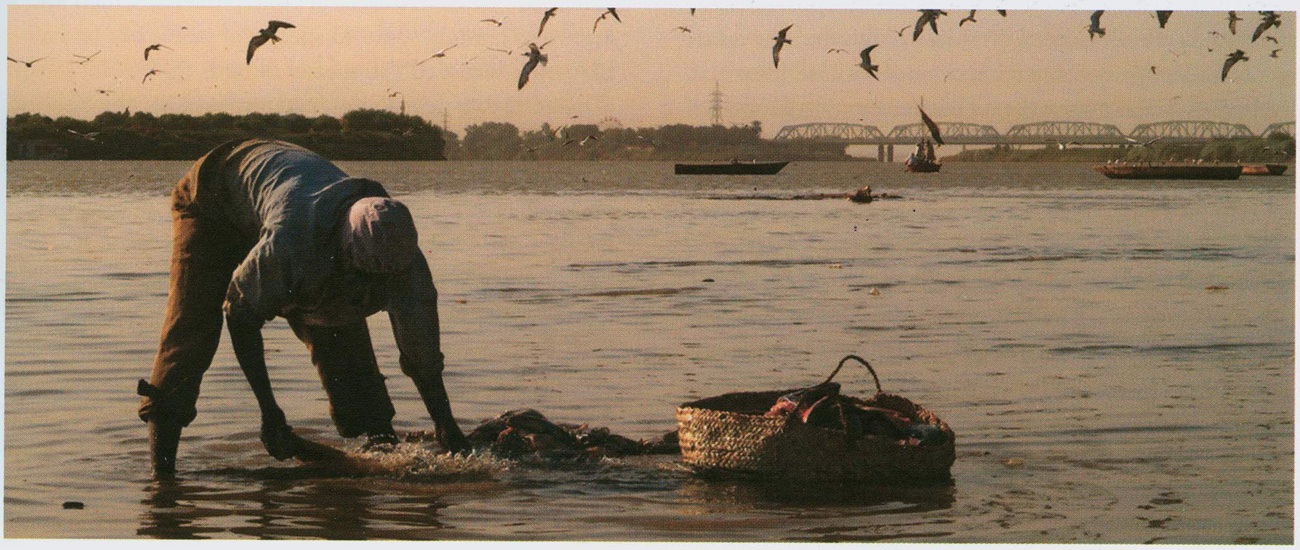
Downstream users may be adversely affected by increased levels of flooding, high sediment loads in streams, poor water quality and the loss of dry season flows.

Sudan

The wetlands in the Sudan are very extensive and extremely varied. They provide vital hydrological, ecological and livelihood services. The major ones are the Rahad-Dinder wetlands, Blue Nile *Sun't* Forest wetlands and the wetlands of the Pibor sub-basin.

Rahad-Dinder Wetlands: The Rahad-Dinder wetlands, known as *maya'as*, provide a number of environmental services and products. Unlike the valley-bottom wetlands of the Ethiopian Highlands they are not cultivated, and are used instead by a considerable number of people and livestock as a source of water, and many people also use them as a source of medicinal plants. More importantly, however, they also trap sediment, which reduces downstream sediment loads on the one hand, but on the other hand, increasing rates of sedimentation of the *maya'as* reduces their flood buffering capacity leading to higher flood peaks. The exact impact of accelerated *maya'as* sedimentation on reducing their buffering capacity is difficult to estimate without some detailed surveys and modeling.

The area between the Rahad and Dinder rivers is subject to frequent flooding causing extensive damage to crops. Some reports show that about 40 percent of crops are destroyed every 3 to 4 years (SSC, 2007b). An examination of the Africover (2003) map of the area between the Rahad and Dinder rivers indicates that there are some 414,180 hectares of large-scale SMFs and 46,000 hectares of traditional farms: a total of 460,180 hectares.



Assuming that 40 percent of this area is flooded and crops destroyed every 4 years gives an estimated area of 165,700 hectares of SMFs and 18,400 hectares of traditional farms affected.

Blue Nile *Sun't* Forest wetlands: The Blue Nile wetlands comprise the *sun't* forests of *Acacia nilotica* and its sub-species *nilotica* and *tomentosa*. These are found in the back-swamp areas and silt-filled oxbow lakes that are seasonally inundated. Although protected in several areas, many of the *sun't* forests are under threat from illegal felling.

Wetlands of the Pibor sub-basin: These wetlands support very distinctive flora and fauna that is uniquely adapted to conditions in the swamps. And 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 that 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. All these changes will have significant impacts on flow regimes and sediment loads.

The sub-basin has seen some thirty 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 the onset of the civil war has been destroyed, severely damaged or lost.

2.3.6 Loss of biodiversity

Biodiversity comprises genetic, species and habitat diversity. Genetic diversity is found in both wild and cultivated plants and animals. Genetic diversity in cultivated organisms has considerable economic importance for sustaining livelihood. The conservation of biodiversity of wild species is heavily dependant on the conservation and protection of habitats and the maintenance of integrity of the ecosystem. The diversity of plant, animal and fish species deriving from the variety and range of habitats of wetlands are of considerable importance to the livelihood of peoples living around wetlands. The proposed watershed management interventions to support traditional agriculture will also enable farm households to be buffered from natural shocks, and allow them to maintain these important gene pools. There are, in addition, several national parks which are rich stores of local bio-diversity.

Ethiopia

The montane forests of the south-western Ethiopian Highlands contain the world's Arabic coffee gene pool, which include strains of coffee resistant to the coffee berry disease that nearly devastated the Kenya coffee sector. The Ethiopian Highlands are one of the 12 Vavilov centers of crop genetic diversity, being a main genetic diversity center for crops such as *enset*, niger seed, sorghum, finger millet, durum wheat, barley and many others. Of particular importance is the gene pool of the cereal crop barley, which includes strains resistant to rust. An Ethiopian variety of barley crossed with other varieties helped save the United States barley crop from being devastated by rust and so saved the United States millions of dollars. *In situ* conservation by traditional farmers of the coffee, barley, *teff* and wheat gene pools are of global significance.

Sudan

In Sudan a large number of natural selections of sorghum and millet have over millennia accrued a gene pool of considerable importance to traditional farmers because of their drought resistance. In addition, the cultivation of *Acacia seyal* for its gum has also through centuries of natural selection accrued an important gene pool for this species in terms of the quantity and quality of its gum.

National parks in Ethiopia and Sudan

Two sets of national parks, the Gambela Regional Park and the Boma National Park, and the Dinder National Park and the Alatish Regional Park are considered in pairs, given their close proximity and the ecological linkages between them.

Gambela Regional Park and Boma National Park: 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 in 1989 inventoried some 88 mammal species of 9 orders and 28 families (Lavrenchenko et al. 1989). In addition to white-eared kob they include elephant, Nile lechwe, topi and the road antelope. In smaller numbers lion, leopard, lelwel hartebeeste and buffalo are also found. There are extensive areas of swamp habitat which are known to contain some 43 species of mammals, and an IBA team recorded 230 species of birds (EWNHS, 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 belonging 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 development is currently underway in the center of the park. There is a critical problem of illegal hunting, with a large number of arms made available to poachers following

2 Poverty and Natural Resource Degradation

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 program (Sokolov, 1989). A bird survey was last undertaken in 1995-96 by the Ethiopian Wildlife and Natural History Society (EWNHS, 1996).

The Boma National Park lies close to the Ethiopian border and just 70 kilometers southwest of the Gambela National Park. It is located between the River Kagen in the west and the Oboth River in the east, and extends 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. 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. The big increase in hunting has caused the migratory routes of the white-eared kob and the elephant to change over 20 years.

Dinder National Park and the Alatish Regional Park: The Dinder National Park which was proclaimed in1935 is located within the three states of Sennar, Blue Nile and Gedarif. It is bounded by the Rahad in the north, the Dinder in the south and the Ethiopian border to the east, and covers an area of 8,960 square kilometers. It is also a notified biosphere reserve and has been designated as an international wetland under the Ramsar Convention. Immediately across the border within Ethiopia, the Amahra Regional State has designated an area as the Alatish Regional Park. The two parks lie on a transition ecotone between two floristic regions, the Ethiopian High Plateau and the arid Saharan-Sudanian biomes. It also lies along the boundary of two major faunal realms of the world, the Palaearctic and the Ethiopian. It is also located along a major north-south flyway of migratory birds. The Dinder National Park has a high level of biodiversity with over 160 species of birds, 27 species of large mammals and unknown numbers of small mammals. It comprises the last extensive tract of woodland in eastern Sudan.

Around the park are a considerable number of Internally Displaced Peoples (IDPs) taking refuge from the war in Dafur in the 1970's. It is estimated that 100,000 people live around the park in 36 villages along the Dinder and Rahad Rivers. They enter the park for fishing, fuel wood and honey collection, and for illegal hunting, thus posing the most serious threat to the park's wildlife.

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

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

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

The Gumuz people have settled to the south of the park and practice hunting and fishing along the Dinder River. Settlement is increasing and agriculture expanding along the northern boundary and numbers are being swelled by migrants from other parts of the Amhara region. People enter the park area to collect honey, gums and resins. There is an urgent need to collaborate with the Beneshangul-Gumuz regional government and with the Government of Sudan to secure the area. The Ethiopian Wildlife Conservation Organization has strongly recommended that the Alatish Park be proclaimed a National Park and that in the future it should form part of a trans-boundary park with the Dinder National Park. There is also an urgent need to develop a park management plan in participation with local communities.

3 Watershed Management for Livelihood Improvement

Watershed management interventions can have a substantial impact on arresting degradation of the natural resource base both on cropland and non-cropland. This is a vital entry point in breaking the cycle of poverty and resource degradation and attacks one of the root causes of poverty in the Eastern Nile Basin. Conservation of non-croplands through enclosure and tree enrichment planting can provide direct benefits to communities in terms of increased livestock feed, improved livestock productivity, increased supply of fuel wood and timber. It can also increase wild plants of food and medicinal values that are of considerable importance to the most disadvantaged community members such as female headed households. There are, however, several approaches to watershed management, and it is useful to review these before defining the approach to be taken for the Eastern Nile Basin.

3.1 Watersheds and Watershed Management

A watershed is usually defined as the area of land that drains to a particular point along a stream.[7] Watersheds are classified in many ways, as Table 3.1 shows (World Bank, 2005c).

3 Watershed Management for Livelihood Improvement

Table 3.1: Watershed management units and hydrological characteristics

Management Unit	Typical area (km2)	Example	Degree of coupling
Micro-watershed	0.1 -5	Typical watershed for MERET interventions (Ethiopia)	Very strong
Sub-watershed	5 – 25	An assemblage of micro-watersheds	Strong
Watershed	25 - 1,000	Guder	Moderate
Sub-basin	1,000 – 0,000	Lake Tana	Weak
Basin	10,000 – 50,000	Abbay-Blue Nile	Very weak

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 a basin 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, and at other times, it moves additional sediment from stream bank erosion and drifting sand.

'Watershed Development' approach can be distinguished from a number of broader 'Watershed Management' approaches (James, 2005). Watershed development comprises a set of interventions aimed basically to increase the bio-physical productivity of the watershed. Watershed management, on the other hand, aims to manage these biophysical resources, especially in watershed facing natural resources degradation. Even here, there is a progression of perspectives. Traditional watershed management actions tend to treat the symptoms of a degrading natural resource base as opposed to the root causes of the spiral of degradation and poverty.[8] Integrated watershed management is today defined as 'an iterative process of integrated decision-making regarding uses and modifications of lands and waters within a watershed. This process provides a chance for stakeholders to balance diverse goals and uses for environmental resources, and to consider how their cumulative actions may affect long-term sustainability of these resources'.[9] In view of the multi-sectoral nature of the problem (land degradation, fuel wood demands, population pressures, illiteracy, lack of alternative sustainable livelihoods, etc.) a comprehensive and integrated approach is required.

Integrated watershed management can be expanded to incorporate a number of perspectives, such as sustainable land management or integrated water resource management. Sustainable Land Management (SLM) encompasses soil conservation, forestry, rangelands and land use planning and emphasizes the need for sustainable use and development of land as an economic production factor, with a farm holding as a basic unit, but with watershed principles respected for the sake of resource sustainability. Integrated Water Resource Management (IWRM) on the other hand, seeks to integrate various water-using sectors. It emphasizes water resources, while still considering all other functions in the basin, and leaving the responsibility for rural development to those with a mandate of integrated regional development. The Technical Advisory Committee of the Global Water Partnership defined IWRM in 2000 as 'a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of the vital ecosystems'.

From the perspectives of the people in the watershed, the livelihoods-based approach incorporates integrated watershed management but as a means to sustain the resource base to address socio-economic concerns such as poverty reduction and sustainable livelihoods. (Box 3.1)

Watershed management interventions can sometimes have unintended side effects, called externalities, due to (i) hydrological linkages upstream and downstream, and in the case of the ENB, across international boundaries, and (ii) socio-economic linkages across property boundaries and communal lands.[10] Externality-based frameworks, however, are not common in watershed management, and are only being understood, documented and evaluated relatively recently (James, 2005).

Box 3.1: Approaches to watershed management

- **Agro-ecosystems Approach:** seeks to maximize multiple objectives of productivity, stability, sustainability and equity. It does not however explicitly consider externalities.
- **Watershed-based Rural Development Approach:** has been adopted in India from the early 1990's and grafts a poverty reduction program onto a watershed management program a poverty reduction program. This approach has generally focused on employment generation through soil conservation activities, although a number of such programs are being transformed using participatory and livelihoods approaches outlined below.
- **Participatory Approach to Watershed Management:** has been pursued in various forms since the 1980's. It seeks to place local stakeholders at the center of planning and implementation. Rhoades (2005) has outlined a number of conceptual and operational challenges in implementing Participatory Watershed Management although Hinchcliffe et al (2005) provide a number of ways of overcoming these challenges. The "Watershed Plus" approach in India addresses stakeholder demands in other sectors such as sanitation, health, education and public infrastructure.
- **Livelihoods Approach to Watershed Management:** was developed by UK DFID in the late 1990's as an analytical approach that could be used for planning, implementing and monitoring a range of development programs including watershed management (Turton, 2000). It has stakeholder participation in planning and implementation at its core and seeks to encourage a more explicit analysis of the ways in which watershed management can directly and indirectly affect peoples' livelihoods and enhance positive poverty reducing impacts.

Clearly, the approach to be adopted in developing a framework for watershed management for the ENB 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 and include, but are not limited to the following:

- Supporting rural livelihoods by integrating interventions in other 'non-watershed' sectors (e.g., health, education, sanitation, hygiene and non-farm employment activities);
- Addressing equity 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 CRAs and the Joint Multi-Purpose Program (JMP);
- Identifying global benefits accruing from national and regional level interventions.

Since watershed management is a system-orientated concept with a holistic approach to problems and potentials, it is necessary to identify 'bundles' of interventions that complement each other where possible in a synergistic way. Many of these 'bundles' will comprise cross-sectoral technological, institutional and policy components as watershed management aims to tackle the underlying problems of natural resource degradation in the EN sub-basins. Most technological interventions are targeted at agricultural[11] and pastoral households and rural communities although some are targeted at medium-scale watersheds. The organizational, institutional and policy interventions and recommendations, on the other hand, are targeted at the higher administrative and political levels.

3.2 Lessons learnt in watershed management

Considerable experience has been built up in Ethiopia, Sudan and elsewhere in the world on the technological aspects of integrated watershed management. Emerging lessons from watershed management projects in Ethiopia, Sudan and elsewhere include the following:

- Existing land use systems and their inter-linking components must be thoroughly understood: This will ensure that any potential technical interventions will not adversely impact on the other components in the system, and instead will support them wherever possible.
- Soil and water conservation structures reduce runoff and increase infiltration to groundwater: There is evidence that where integrated watershed management measures have been implemented on cropland and in enclosed areas on non-cropland groundwater levels have risen and long dormant springs have started to flow (WFP, 2005).
- Biological measures must be undertaken along with physical measures: In contrast to the usual focus on physical measures (such as weirs, gabions and rock-filled dams), biological measures (such as afforestation, vegetative cover on soil bunds and grass strips) need to be used simultaneously, using locally available materials, where possible.
- Technical interventions must be integrated at micro and mini watershed levels: The nested nature of watersheds and the hydraulic system should be taken into account while planning technical interventions. For example, the development of

3 Watershed Management for Livelihood Improvement

small dams and external water-harvesting measures 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. In-field water harvesting measures have 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.

- Participatory processes must be emphasized throughout the project cycle: People must be viewed as central to any watershed management program. Thus, the project design should focus on the process of establishing participation rather than on seeking to achieve physical targets only, while such participation must be assiduously built up to manage and maintain all project-created assets. Most failures of watershed management programs can be traced to a lack of people's participation in the program.
- Appropriate institutions must be developed at community-level: Such development must be appropriate in the sense that institutions are created (or strengthened if already existing) to respond to 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.
- Adequate institutional arrangements must be made at national and sub-national levels: These must allow for multi-disciplinary and multi-agency collaboration even across ministries, and thus go beyond single sector approaches. This is a major handicap of department or ministry-specific programs that are implemented without recognition of the effects of other sectoral development programs in the region.
- Organizational and coordination structures must be simple: These must be based on existing structures and clearly stipulate linkages with higher levels for support.
- Policy and institutional support are vital for sustainable impacts: Local watershed interventions need supportive policy and institutional measures to achieve sustainable successes from watershed management. Such measures include the following:
    - Increased market accessibility and integration such as feeder roads and extension of telecommunications which reduce market transaction costs. These will benefit both producers and consumers, and also enable an expansion of local economic multipliers which in turn will increase employment opportunities for rural and urban households.
    - Capacity building interventions such as increased access to improved technologies, support to extension and research services, and access to literacy and skills training, will increase adoption of improved agronomic technologies. Similarly, support to government extension services to improve information linkages between farmers and research can increase the relevance of agricultural research to the traditional small-holder sector. Increased road accessibility and skills training can enable rural households to have better access to non-farm employment opportunities.
    - Increased access to micro-credit can provide an important enabling environment for farmer adoption of improved technologies, in particular fertilizers and improved seeds, and for the development of small enterprises in small urban centers to further increase employment opportunities.

It must be emphasized that there can be a number of important synergies between the various interventions, most particularly in improving rural-urban linkages, the economic development of small urban centers and increased agricultural production. Thus, for each country as a whole, watershed management interventions can increase the rate of poverty reduction and reduce the number of households needing safety net support.

In both Ethiopia and Sudan the highest incidence of poverty is in the traditional agricultural smallholder sector. By targeting this sector (rather than the commercial agricultural sector) a proportionally greater impact can be achieved in reducing the number of households living below the poverty line. A recent study by the International Food Policy Research Institute (IFPRI) and the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) covering all the countries in the region including Ethiopia and Sudan found that the largest poverty reductions will come not from growth in export sub-sectors but from growth in those sub-sectors for which demand is the greatest – such as crop staples, livestock products, oil seeds and fruits and vegetables (Omamo et al., 2006). Another more detailed study for Ethiopia confirms these findings (Daio et al., 2006). The studies also found that agricultural productivity growth alone is insufficient to meet the poverty reduction targets of the Millennium Development Goals (MDG) and that growth in non-agricultural sectors and improvements in market conditions are also required.

The importance of effective watershed management for the sustainable development of the regions under consideration cannot therefore be over-emphasized.

3.3 Proposed Watershed Management Interventions in the Eastern Nile Basin

The CRA study identified a number of watershed management interventions for each of the four sub-basins studied, based on the problems identified in each sub-basin and the objectives of watershed management. These are presented separately in this sub-section, for each of the three ENB countries, divided into (i) direct interventions, and (ii) supporting interventions. Direct interventions are relatively specific to development domains and address the proximate causes of resource degradation. Supporting interventions seek to address the underlying policy, institutional and capacity constraints and establish an enabling environment for the implementation of the direct interventions. Although both types are inextricably linked and comprise a holistic program of interventions, the responsibility for supporting interventions lies more in the domain of mainstream government development policy. For this reason, the supporting interventions are discussed in the next section on policy and institutional context, while the direct watershed interventions suggested by this study are outlined overleaf for each country.

3.3.1 Direct interventions: Ethiopia

The direct interventions for the three sub-basins falling within the national boundaries of Ethiopia are outlined in Table 3.2 and described below.

Table 3.2: Direct watershed management interventions in Ethiopia

	Interventions	Details
1	Soil conservation and improved soil husbandry	• Construction • Maintenance • Loss of land • Labor: compost production and delivery to field • Broad-bed maker and additional ox days
2	Gully stabilization and reclamation and stream bank protection	• Labor: structures and tree planting • Labor: forage cut and carry
3	Cut off drains/improved road drainage	• Labor: construction of drainage structures
4	Crop intensification and crop diversification (vegetables, fruit trees, organic coffee, spices like corrarima and ginger, improved honey production and marketing)	• Improved seed and chemical fertilizer, integrated pest control • Water harvesting structures • Small/micro dams and water delivery systems • Increased labor (irrigation, weeding, pest control, harvesting) • Transport, storage and marketing
5	On-farm tree production and use of improved stoves	• Tree seedlings • Labor: planting and maintenance • Improved *Mitad* and other improved stoves
6	On-farm forage production (grasses, legumes, multi-purpose trees)	• Seeds and seedlings • Labor: planting and maintenance • Labor: cut and carry
7	Improved animal health	• Veterinary services • Drug provision
8	Area closure: communal lands, and community woodlots	• Loss of forage and fuel wood supply in initial years • Labor: cut and carry of forage • Purchase of forage • Seedlings • Labor: planting and maintenance • Labor: harvesting • Purchase of wood
9	Water conservation and improved utilization	• Labor: construction of water harvesting structures; small and micro dams • Labor: operations and maintenance • Prevention measures for malaria (e.g. nets) and bilharzias (moluscides)

1. Soil and water conservation and improved soil husbandry

Soil and water conservation (SWC) measures such as grass strips and soil bunds are proposed to reduce soil erosion from cropland and sedimentation in water bodies. Although there is currently a program of watershed management interventions in the Ethiopian Highlands of the Abbay-Blue Nile sub-basin, the structures are mainly soil bunds although recently grass strips are also being adopted. These have been shown to be almost as effective as physical structures in Anjeni, Gojam (Herweg and Ludi, 1999).[12] It is now recognized that vegetative measures such as grass strips are more likely to be adopted in the higher rainfall areas of the west in the Abbay-Blue Nile sub-basin where the up-take of soil conservation structures has been much slower (GTZ, 2004). With such SWC measures, the decline in total farm production for the teff-wheat-sorghum farming system in the western Abbay sub-basin can be arrested, although there will be an initial drop in production due to the loss of land for crops taken up by the grass strips or bunds. In the Tekeze sub-basin, however, there have been substantial investments in stone bunds and terraces by farmers, because of the significant and visible benefits to physical soil and water conservation structures. These are aimed partly to reduce soil erosion, but mainly to increase soil moisture and thus soil nutrient availability.

Although yield increases are significant in the longer term, the key problems facing farmer adoption are the initial high labor requirements and the long payback period. But since the financial benefits may not be attractive for resource poor farmers with high personal discount rates, they will need financial support for constructing bunds. Such support can be provided either through cash or food for work under the Food Security and the Safety Net Programs.

In the high rainfall areas of the Baro-Akobo sub-basin, however, the uptake of soil conservation structures has been much slower than in the Abbay or Tekeze sub-basins. Vegetative measures such as grass strips are more likely to be adopted in these areas, with soil bunds used for lands with steeper slopes.[13] 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 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).

2. Gully stabilization and reclamation

Three related approaches are used to stabilize and reclaim gullies: (i) soil conservation measures above the gulley (bunds, cut-off drains) (ii) physical and biological structures (check dams) within the gully itself and (iii) livestock exclusion (GTZ, 2004, MARD, 2005). It is estimated that reclaimed gullies can retain 85 per cent of sediment that was previously lost (Nyssen et al. 2005). Even if 40 per cent of the gullies on cropland and on non-cropland in the Abbay-Blue Nile sub-basin can be reclaimed over a 10-year period, some 2.05 million tons per year of sediment can be retained on non-cropland, and around 1.04 million tons per year on cropland. This amounts to a 2.2 per cent reduction in the sediment load of the Abbay-Blue Nile River, which is currently 140 million tons per year at the border. Similarly, for the Tekeze-Setit-Atbara sub-basin, there would be a 1.5 per cent reduction in the current sediment load of the Tekeze River, which is currently 76 million tons per year at the border.

3. Stream bank erosion control

Research into dam siltation in Tigray determined that 65 percent of siltation was due to river bank erosion above the dam (Haregeweyn et al., 2005). This clearly points to the need to protect river banks above dams, which could be done by area closure a short distance from the bank.

4. Improved road drainage

Research in Tigray has identified poor road drainage as one cause of gully initiation (Nyssen et al., 2005). Gully erosion can be controlled through cut-off drains above the gully which reduce run-off into gullies. However, it is important that water collected in the drain is safely disposed off into waterways. Hence direct run-off from roads needs to be controlled with small check dams and safe outlets into streams.

5. Crop intensification and diversification

Crop intensification: The replacement of nutrient losses through grain removal can only be achieved by the application of organic matter (manure or compost) or chemical fertilizer. The use of chemical fertilizers combined with improved seeds, has been estimated to increase crop yields by up to 114 per cent increase (Diao et al., 2005). Organic fertilizers are being used but generally only on fields close to the homestead. The use of chemical fertilizer is conditioned by a farmer's land, labor and financial assets as well as access to seasonal credit. Farmers' perception of risk to agricultural production from low and variable rainfall is higher in the climatic environment of the Tekeze sub-basin, and is a constraint to investment in chemical fertilizer for rain-fed cropping.

Crop diversification need not be confined to crop production and can include livestock fattening, sheep and goat rearing and improved honey production. In terms of crops a number of initiatives are now being promoted, including vegetables, fruit trees (apples and plums in the highlands, citrus and bananas in the lowlands), and organic coffee, and spices (cardamom, ginger), for all of which water provision from micro-dams and water harvesting structures is critical. The key strategy with respect to diversification is to extend the range of livelihood strategies thus reducing vulnerability to natural and other shocks. effective marketing and integration with other elements of the farming system, such as on-farm forage production for livestock fattening and improved sheep and goat production.

6. *On-farm tree production*

Planting trees helps reduce soil erosion from non-crop land. In the Abbay sub-basin the process of fuel substitution is already underway, while it is only starting in the Tekeze sub-basin (WBISPP/MARD, 2001). If each household fully converts available dung from cropland to fuel wood and burns all the residues, each household would save around 30 kilograms of available nitrogen in the Abbay sub-basin and around 10 kilograms in the Tekeze sub-basin. This is equivalent to 147 kilograms of grain per converting household in the Abbay sub-basin and 50 kilograms in the Tekeze sub-basin. In nutritional terms this is sufficient to feed one adult for 74 per cent of the year in the former and for 25 per cent of the year in the latter sub-basin. In addition there is the value of the trees as fuel wood and/or poles, which could yield a return of up to 35 per cent. However, it would take 8 years to realize the full benefits of this conversion. The opportunities for significantly reducing erosion on non-cropland are much less in the Baro-Akobo sub-basin than the Tekeze and Abbay sub-basins and hence the two main production objectives for area closure are fodder and fuel wood and poles. Unquantifiable benefits in all three sub-basins include reduced pressure on communal grazing areas leading to increased trees, natural pasture production, lower erosion rates and reduced sedimentation in streams.

Improved stoves: Three improved stoves, the *lakech* (a charcoal stove), the *gounziye* (a ceramic wood stove that mimics the traditional three-stone fireplace), and the *mirte* (an improved *mitad* stove for baking *injera*) are available. Adoption of the *mirte* and *gounziye* in the Abbay sub-basin and the Baro-Akobo sub-basin, and the *mirte* in the Tekeze sub-basin[14] could generate total annual savings per family of ETB 277 (USD 28) in the Abbay sub-basin, ETB 183 (USD 19) in the Tekeze sub-basin, and ETB 255 (USD 26) per year in the Baro-Akobo sub-basin. There would also be considerable health improvements because burning biomass fuels on the traditional wood stove is inefficient and as much as 20 per cent of fuel is not completely combusted. In addition, a number of toxic substances are released into the atmosphere, especially in enclosed kitchens as in many rural Ethiopian households.

7. *On-farm forage production*

Small farmers growing sufficient improved forage to meet three months supply at ploughing time or during lactation periods would reduce the area needed for 'backyard forage, i.e., improved forage within the homestead area. An alternative strategy would be to grow improved grasses on grass strips while crops are in the field and cut these grasses for hay or silage. These interventions have the added benefit of improving livestock productivity through increased calving, lower calf mortality and increased draught power.

8. *Improved animal health*

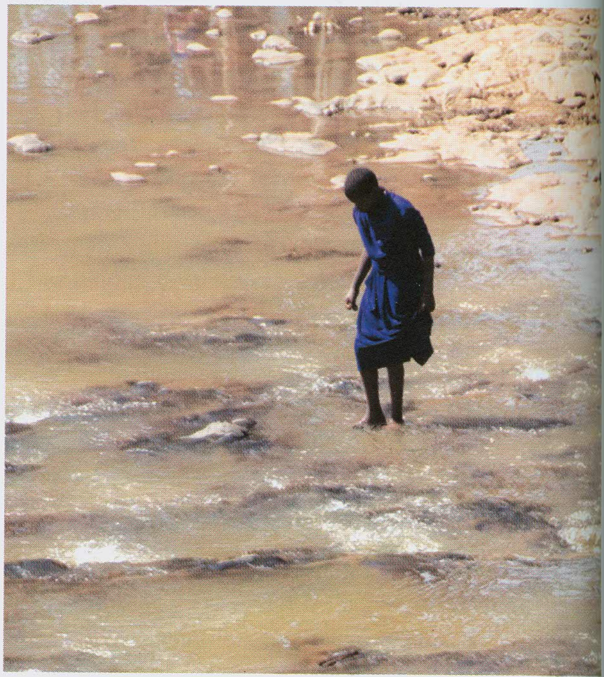
While improved animal nutrition is a key component in disease reduction, providing veterinary services and animal drugs is an important complement to improved forage interventions. Experience is being gained in the use of para-vets and provision of basic drugs by private enterprise in the pastoral areas in both Ethiopia and Sudan. A similar program could be devised for traditional mixed crop-livestock farming system areas.

9. *Area enclosure on communal lands*

The last decade saw a strong program of reclamation of these degraded communal lands in the Abbay and Tekeze sub-basins. These areas are closed to livestock and managed for cut-and-carry forage and for community and individual woodlots. Surveys have demonstrated that soil retention in these areas is almost 100 per cent for catchment areas, which is two to three orders larger than the closed area. In addition, soil retention increases infiltration to groundwater, as well as soil fertility, leading to increased biomass production within the closed area. Further, vegetative reclamation of gullies (with some physical structures) has been shown to be effective in reducing sediment delivery rates by over 90 per cent. Increased feed supply also has positive impacts on livestock health and productivity (milk, draught power, fecundity and reduced calf mortalities). Moreover, enhanced wood supply for fuel and construction relieves pressure on the remaining non-cropland areas. Plants grown within the enclosed areas have considerable importance as sources for traditional medicines (138 species), wild food (30 species) and bee forage and also for religious and cultural activities (Howard and Smith, 2006). The sale of some of these plants provides a vital source of livelihood for the most disadvantaged people in the community (e.g. female-headed households), but their value has not often been recognized (Shackleton et al., 2000).

10. Water conservation and utilization

Small and micro dams and household-level water harvesting structures can be integrated with the crop diversification intervention and used for domestic and livestock water supply and small-scale irrigated cropping. This can increase cash income by around ETB 5700 (USD 585) per hectare of double-cropped irrigated area. However, there are some potential negative impacts of small-scale irrigation. Research in Tigray has revealed that while dams and small-scale irrigation increased farm incomes they also led to an increased incidence of malaria (Ersado, 2005). This in turn reduced allocation of labor to non-farm activities and increased expenditure on medicines. However, malaria can be prevented by spraying in and around houses and by providing impregnated mosquito nets. The introduction and spread of bilharzia through its host the Bulinus spp. snail could result in potential health costs, but could be prevented by the use of molluscicides. Other potential human and livestock health costs could result from the effect of agro-chemicals on down-stream users of the river. Furthermore, downstream river flows could decrease because of increased use of water by irrigated crops (through increased evapo-transpiration compared to rain-fed crops) as well as evaporation from reservoirs. This reduction could have negative impacts on downstream users in terms of water availability for domestic uses, livestock and irrigation.



3.3.2 Direct interventions: Sudan

The direct interventions for the three sub-basins falling within the national boundaries of Sudan are outlined in Table 3.3 and described below.

Table 3.3: Direct watershed management interventions in Sudan

	Intervention	Details
1	Arresting soil degradation on rain fed semi-mechanized farms	• Sub-soiling (5 year interval) • Tied ridging or bunding • Improved seed: Drought resistant crop varieties/High yielding varieties • Furrow planting • Acacia senegal seedlings, planting, maintenance • Shelterbelt establishment: (seedlings, planting, maintenance: contract – traditional rain-fed crop households)
2	Arresting soil degradation on rain-fed traditional farms	• Tied ridging • Improved seed: High yielding varieties
3	Support to rain-fed traditional water harvesting in semi arid areas (Kassala, North Kordofan)	• Improved seed: drought resistant varieties (sorghum, sesame, vegetables) • Multiplication and supply of vetiver grass • Research: Cost effective methods of tera construction/reconstruction
4	Reducing degradation of rangelands in the northern drylands	• Delineation and demarcation of stock routes ("nomad paths") • Provision of water points along stock routes • Improved forage seed: (On-farm forage development for agro-pastoralists) • Test feasibility of aerial sowing of rangelands • Establish Community-based Animal Health Worker (CAHW) scheme • Sustainable supply of drugs

	Intervention	Details
5	Improving rangeland productivity: flood retreat grasslands of the south	• Bunding shallow drainage lines on clay plains • Delineation and demarcation of stock routes • Provision of water points along stock routes • Establishing holding (quarantine) grounds for export animals • Improved forage seed: (on-farm forage development for agro-pastoralists) • Support existing Community-based Animal Health Worker (CAHW) scheme • Sustainable supply of drugs
6	Kerib land reclamation: Atbara, Blue Nile, Rahad & Dinder rivers	• Establish 100 meter zone of deep rooting trees: (seedlings, leguminous tree planting and maintenance) • Micro-catchments: grass and leguminous tree planting (seed, seedlings, planting, maintenance)
7	Halting shifting sand dunes (Main Nile, White Nile)	• 10 kilometers emergency shelter belt at Argi (seedlings, planting, maintenance) • 80 kilometers external shelter belt (seedlings, water provision, plantings, maintenance) • Tree planting within irrigation areas (5per cent) (seedlings, planting, maintenance)
8	Reducing drifting sand onto cropland (Atbara, Main Nile)	• Tree planting on field boundary (seedlings, planting, maintenance) • Fencing (labor)
9	Reducing river bank erosion (Blue Nile, Atbara, Main Nile)	• Undertake survey and assessment of current bank erosion • Establish bank erosion monitoring system • Encourage deep rooting crops near river edge • Construct revetments (in areas with high land values)
10	Survey & assessment: human induced salinity in irrigated land (White Nile, Main Nile)	• Undertake survey and assessment of salinized lands • Logistical support (personnel, transport, equipment, analyses) • Assess remedial interventions required (drainage, gypsum application) • Assess economics of remedial action (need for credit?)

1. *Arresting land degradation on semi-mechanized farms*

Improved technologies to arrest land degradation include five-yearly sub-soiling to break the plough pan, in-furrow planting, drought-resistant varieties (in low rainfall areas) and high-yielding seed varieties (in higher rainfall areas) and the use of *Acacia senegal* for gum arabic as the fallow crop. Over a three-year period, even if only 60 per cent of the cultivated area is under improved seeds of sorghum, sesame and millet, crop productivity can increase over substantial areas: 1.13 million *feddans* (475,200 hectares) in the Blue Nile basin, 721,460 *feddans* (303,000 hectares) in the Atbara sub-basin and 3.3 million *feddans* (1.4 million hectares) in the White Nile sub-basin.

Shelter belt planting: There are two key opportunities for closer collaboration between the semi-mechanized and traditional rain-fed agricultural sectors. The first is the government provision that communities can supply seedlings, plant, maintain and harvest trees on 10 per cent of government lease-hold farms. Contracts to traditional rain-fed farmers for supply of seedlings, planting and care and maintenance could contribute substantially to households' financial assets and widen the range of livelihood strategies. Re-foresting on semi-mechanized farms which do not have Acacia senegal planted on them, under collaborative arrangements can yield benefits in terms of charcoal production. The potential harvest is estimated conservatively to be 31,920 hectares in the Blue Nile sub-basin, 20,200 in the Atbara sub-basin and 91,680 hectares in the White Nile sub-basin. Tree plantation however involves the opportunity cost of the crop production forgone, which may explain why farmers are reluctant to plant shelter belts. This points to the need for tax concessions to encourage their planting.

A second opportunity for collaboration is to use crop residues as livestock feed for transhumant pastoralists. The potential crop residue from the Blue Nile sub-basin is estimated to be 1.7 million tons, sufficient to feed 920,000 tropical livestock units (250 kilograms live-weight each). The corresponding estimates of crop residue from the Atbara sub-basin is 606,000 tons of crop residue and 2.75 million tons from the White Nile sub-basin.

2. *Arresting land degradation on traditional farms*

Improved technologies: Two specific and proven interventions to raise crop productivity are high yielding crop varieties for sorghum, sesame and groundnuts, and the use of tied ridging to increase soil moisture. It is estimated that it is possible to increase crop yields by 50 per cent by using both improved varieties and tied ridging (Latif, 2005). There are an estimated 1.05 million *feddans* (411,080 hectares) of traditional rain-fed farms in the Blue Nile sub-basin, 75,000 *feddans* (31,330 hectares) in the Atbara sub-basin and 476,190 *feddans* (200,000 hectares) in the White Nile sub-basin, and thus there is considerable potential to raise agricultural production using these improved technologies.

Tree plantation: As described in the case of semi-mechanized farms, communities can be involved in the supply of seedlings, plants and in maintenance and harvesting on 10% of large government leases-hold farms in both the Atbara and the White Nile sub-basins. Assuming 60 per cent of the total area is available for re-forestation, there is a potential of re-foresting around 120,240 *feddans* (50,500 hectares) in the Atbara sub-basin and around 545,700 *feddans* (229,200 hectares) in the White Nile sub-basin, under these collaborative arrangements. After 20 years, these would result in an annual cut of 252,000 cubic meters (m3) in the Atbara sub-basin and 1.15 million m3 in the White Nile sub-basin. Also as mentioned earlier, contracts for supply of seedlings, planting and care, and maintenance could also make substantial contributions to households' financial assets as well as widen the range of livelihood strategies of these households. In addition, there is the potential to utilize the residues for livestock feed for transhumant pastoralists. The estimated 425,000 tons of crop residues from the Atbara sub-basin would be sufficient to feed 229,300 tropical livestock units (250 kilograms live-weight) while the 2.1 million tons of residues from the White Nile sub-basin could feed 1.1 million tropical livestock units.

3. *Support to rain-fed traditional water harvesting in semi arid areas (Kassala, North Kordofan)*

Farmers on the plains east and west of the Gash Delta and extending southwards onto the Butana plains and also in North Kordofan use traditional water harvesting and wild flooding. The former includes run-off manipulation by U-shaped earth bunds or *teras* and brushwood panels or *libish*. In order to reduce risk and improve crop productivity a number of interventions are proposed. These include the distribution of drought resistant varieties of sorghum and sesame, improved access to vegetable seed, the multiplication and distribution of vetiver grass to help stabilize the bunds and reduce the need for brushwood, and research into developing cost-effective methods of *tera* construction and reconstruction. These would be supported by improved road access to reduce market transaction costs.

4. *Reducing degradation of rangelands in the northern drylands*

A number of strategies are proposed for the two main affected areas in the Butana plains in the Atbara and Blue Nile sub-basins and the Funj area, south of the Blue Nile covering the Blue Nile and northern Sobat sub-basins. One is to demarcate and establish officially recognized livestock routes (nomad paths) together with water points in collaboration with the large-scale farmers. This will enable easy access to the wet and the dry season grazing areas. This will also allow better use of the currently under-utilized 4 million tons of crop residues, enough to feed nearly 2 million head of cattle. Another is to trial the current proposal to re-seed state forest land (in the dry season grazing areas) and 60 per cent of the Butana (in the wet season grazing area) and, if successful, implement the proposal. This would relieve grazing pressure in the rangelands particularly those within the Dinder National Park. For more sedentary livestock owners, a program to support the production of on-farm forage is proposed, in terms of seed multiplication and provision, and technical support. An important complement to reducing grazing pressure and increasing forage supply will be provision of animal health support, perhaps replicating the successful community-based animal health worker (CAHW) system of southern Sudan. Finally, as part of the overall reform of the land tenure policy, clearly defined and integrated land use plans need to be developed to determine a more equitable distribution and sustainable utilization of natural resources.

3 Watershed Management for Livelihood Improvement

5. Improving rangeland productivity in flood retreat grasslands of the south

Most grassland in the Pibor catchments are rain flooded and thus are used only seasonally. These are grazed early in the rains, when the grass is of high quality but later the grass dries out and becomes 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 using residual moisture. At both times drinking water may be the main factor that limits exploitation of these pastures, and provision of water points would enable more optimum utilization. The plains are drained by a network of very shallow water courses running northwards. 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,* which is a small dam, pond or tank. The value of these bunds would be enhanced if they were 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. Further, as in the case of the northern drylands, the more sedentary livestock owners can be provided with seed multiplication, seed provision, and technical support in order to assist the production of on-farm forage.

Key constraints to increasing livestock production and marketing are the lack of recognized and serviced stock routes with watering points, the lack of holding grounds and quarantine arrangements with Uganda, Kenya and the Democratic Republic of Congo, and animal health provision. 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. Addressing these constraints could improve livestock production considerably. Finally, markets in the Middle East are now well established to the north, and offer considerable opportunities for increasing livestock trade throughout the sub-basin.

6. Arresting kerib land formation and reclaiming kerib land

Kerib land spreads 1,000 metres on average from the river's edge and thus, each 1 kilometer reach of river encompasses around 200 hectares of *kerib* land both sides of the river. Each 100-meter reach of river encompasses 24 *feddans* (10 hectares) of *kerib* land. There is potential to reclaim nearly 192,860 *feddans* (81,000 hectares) of *kerib* land above the Kashm El Girba dam in the Atbara sub-basin. Assuming that 40 per cent of this area can be reclaimed over a period of 10 years, around 32,400 hectares can be reclaimed, over approximately 162 kilometers of river. In addition, an exclusion zone of around 100 meters from the edge of the gullying is required to prevent gully extension. This would require that some 7,720 *feddans* (3,240 hectares) of cropland be enclosed over the 10-year period. Currently, some 2,860 *feddans* (1,200 hectares) of rain-fed cropland are being lost each year above the dam. (There is no rain-fed cropland below the dam.) By reclaiming 40 per cent of the *kerib* land, around 1,145 *feddans* (480 hectares) of cropland can be saved, or around 115 *feddans* (48 hectares) per year. All this will result in a net gain of 760 *feddans* (328 hectares) of cropland. The land to be enclosed is traditional rain-fed cropland which can be planted with a mix of multi-purpose trees and herbaceous forage.

7. Halting shifting sand dunes (Main Nile, White Nile)

The most appropriate intervention to halt the shifting sand dunes in this area would be a full 80-kilometer long shelter belt from Letti to El Bar (as proposed by UNSO) protecting all 14 villages (43,000 beneficiaries) and more than 14,000 hectares of potential cropland. In addition, a 10 kilometer wide emergency shelter belt will be required for the protection of the village at Argi. While internal belts can be implemented and controlled by the villagers, as considerable experience with shelter belts is now available in the area at government (Federal National Council or FNC), community and individual farmer levels, the external belts will have to be undertaken as public works. It would make sense to incorporate the planting of the outer shelter belts into the overall design of the Meroe Irrigation Project.

8. Reducing drifting sand onto cropland (Atbara, Main Nile)

Considerable experience has been gained by the Government (FNC) in the selection of the most appropriate tree species for use in field shelter belts. Tree seedlings and technical assistance in care and maintenance will be provided.

9. Reducing river bank erosion (Blue Nile, Atbara, Main Nile)

A survey and assessment of current bank erosion is needed in order to provide a reliable baseline for a subsequent river bank erosion monitoring program. This would be essential if there are significant reductions in sediment load from upstream watershed management programs and high dam construction. Current bank protection measures include revetments to stabilize the banks and groynes to deflect strong currents from the bank. The latter have not been very successful. Given their expense, revetments would only be economic in areas of high land values. Deep-rooted species of trees appear to be the most effective at stabilizing and protecting banks from erosion. In addition, there is a need for clear land use zoning in a 1 kilometer buffer zone on each side of the river that would allow cultivation and would help to prevent tipping of material into the river and extraction of sand for building and other purposes.

10. Survey and assessment: human induced salinity in irrigated land (White Nile, Main Nile)

Human-induced salinity is prevalent along the Main Nile and the lower Atbara rivers, particularly in the basin irrigation areas that have been under irrigation for centuries. Expanding irrigation is tapping fossil salinity reservoirs along the White Nile. Given the increasing shortage of irrigable land, there is a need to undertake a comprehensive survey and assessment of salinized land and determine the proximate and underlying causes, assess the remedial interventions required (e.g. drainage, gypsum application) and estimate their costs and benefits.

3.3.3 Direct interventions: Egypt

The direct interventions for the three sub-basins falling within the national boundaries of Egypt are outlined in Table 3.4 and described below.

Table 3.4: Direct watershed management interventions in Egypt

	Intervention	Details
1	Livelihoods Support: Resettlement Schemes around Lake Nasser	• Extend research results (bio-fertilization, bio pest control) to settlers • Strengthen research-extension-farmer linkages • Establish micro-credit facilities • Extend range of social services (secondary schools, health facilities) and electricity • Construct settlement-market access roads • Develop market price information communications system • Undertake salinity/alkalinity study on irrigated lands
2	Livelihoods Support: Ababda & Bishari Communities: Wadi Allaqui	• Develop open-canopy acacia woodland in Wadi Allaqui (seedlings, planting and initial maintenance) • Switch to fodder crops (seeds, technical support)

1. Livelihoods support for resettlement schemes around Lake Nasser

The proposed livelihood support interventions are broad and varied, embracing work in the fields of agriculture, soil and water conservation, micro-finance, capacity building, institutional strengthening, information technology, better settlement conditions and community development. The goal of these interventions is to improve the socioeconomic conditions, especially farming conditions, and the livelihoods of settler communities living in a desert-fragile ecosystem in and around Lake Nasser, as well as in the eastern and western deserts. The suggested interventions are the following:

- Extend to farmers the improved agricultural practices suitable for desert farming developed at the research station, particularly in the fields of bio-fertilizer and biological pest control.
- Strengthen the two way linkages between research, extension and farmers.
- Develop a micro-credit line for crop production to avoid indebtedness to traders.
- Accelerate the provision of social services (such as secondary education and health) to reduce seasonal migration from the scheme areas.
- Improve transportation and marketing accessibility, and provide commodity price information to enable settlers to plan crop mixes and seasonal patterns better.
- Establish and support partnerships and participation for sustainable community-based management of natural resources based on agro-ecosystem action research.
- Coordinate work in different fields through vertical and horizontal coordination among concerned agencies, authorities, ministries and NGOs.
- Study and mitigate salinity, alkalinity and drainage problems in the Tushka project, Abu Simble area and around the lake area.

2. Livelihood support in the Wadi Allaqui

For the Ababda and the Bishari people in the Wadi Allaqui, two potential development pathways are (1) greater use of existing resources of vegetation for charcoal production and livestock grazing and (2) changing over from vegetable cash cropping to fodder production. An open-canopy Acacia woodland cover could be established fairly readily over the Wadi Allaqi, providing shade and a sustainable source of fuel wood and charcoal. The trees would require irrigation or shallow groundwater for their initiation but thereafter could exploit deeper groundwater. The very good returns to charcoal production would ensure sustainable production in the long-term by stimulating the increase in the amount of woody biomass in the area. Increased shade would benefit both humans and livestock in the hot summers, and would also reduce pressure on the Acacia trees in the Red Sea hills.

Further, the vegetable cash crop currently grown for sale in the Aswan market could be substituted by fodder crops (lucerne) that could be sold to the *dabuka* (camel trains) and used as feed for their own animals. This would be in keeping with their traditional livelihood strategy of sheep and camel production.

3.4 Policy and Institutional Issues

3.4.1 The role of policies and institutions in watershed management

At the heart of the poverty-environment nexus is the ability and willingness of households and communities to invest in sustainable land management technologies and thus break out of the poverty-environmental degradation cycle. Responses from households and communities depend not only on watershed management interventions, but also on the policy and institutional context. Constraints to sustainable increases in agricultural production include poor management practices, inefficient markets, low technology transfer, inadequate agricultural services, low ratio of extension agents to farmers, lack of adapted varieties and insufficient certified seed. Thus, it is apparent that in many areas there are a number of constraints to farmers breaking out of neo-Malthusian trap and that there will be a continuing negative impact of population pressure.

Decisions to adopt sustainable land management technologies depend on households' asset endowments, including labor and livestock, their perceptions of the risk and potential profitability of improved land management technology and farmers' private discount rates. In addition, better access to markets and roads can lead to better opportunities for off-farm employment and increased adoption of improved land management technologies, while poor access can result in lower adoption rates. However, the potential impact on adopting or not adopting improved land management technologies is ambiguous as off-farm employment may reduce labor inputs but increase availability of financial capital for on-farm investment.

Addressing poverty effectively thus needs substantial government support in terms of providing rural infrastructure, establishing a climate for efficient markets and providing support to agriculture in terms of credit, extension and research. Critical policy and institutional issues such as land tenure, agricultural extension and credit programs, public programs, coordination within governments and lack of policy frameworks, are discussed below.

- **Land tenure:** Land tenure is a complex subject in all the Eastern Nile Basin countries and includes insecurity of tenure, ability to use land as collateral, transferability of property rights and the impacts these have on land investment or factor (land, labor or capital) allocation. Land tenure issues and their impacts on land management and technology investment in Ethiopia have been well studied over the past decade (e.g., Yesuf and Pender, 2005). 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) more 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. Much of this evidence is also of relevance to the situation in Sudan even if the context is somewhat different. Problems relating to current land tenure and land policies in Sudan include limited access to credit for a majority of farmers who cannot use land as collateral and a lack of incentives for sustainable land development and management. This leads to continual cultivation and destruction of soils in semi-mechanized farms, conflicting land use rights and consequent civil strife between pastoralists and sedentary crop farmers, because land has not been demarcated. There is a pressing need for rural reconstruction and establishing agricultural credit institutions, but a key problem has been the lack of a national or regional land use plans to strategically guide land development activities. Thus the expansion of the mechanized farm sector was largely uncontrolled as no assessments were made on the environmental, social or economic impacts of these very large developments. Although States are now mandated to develop regional land use plans no guidelines appear to have been issued, and there is an urgent need for a thorough reform of the land tenure policy. In Egypt, the 1952 land reform reduced inequality and poverty by giving tenants formal contracts of near-to full ownership. In recent years, however, there has been some reversal of these developments in favour of land owners (Lofgren, 2001).
- **Agricultural extension and credit programs:** The agricultural extension program in Ethiopia strongly promoted the use of fertilizer and improved seeds supported by credit. Studies indicate that greater access to credit increases farmers' likelihood of using fertilizer. In low rainfall areas, however, risk is a crucial factor in determining whether farmers will take credit for fertilizer even where it is readily available. Since technical advice tends to come with the credit, the source of credit can also determine the uptake of credit and specific use of the credit. Credit uptake was also seen to increase the adoption of fertilizer but reduce investments in soil and water conservation, contributing to increased soil erosion (Pender et al., 2001).

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The increase in fertilizer prices since 2002, following the removal of the subsidy, led farmers to increase the cultivation of crops requiring low fertilizer applications and to reduce investment in soil conservation where the intervention was yield decreasing (e.g., soil bunds taking up cropland). The impact of extension on the uptake of improved land management is probably more positive in the high potential areas (Yesuf and Pender, 2005). In Sudan currently, credit and extension for the traditional agricultural sector are very weak, the extension worker-to-farmer ratios are extremely low, and credit and input supply services have hitherto focused mainly on the large-scale irrigation sector. The key problems are non-viable collateral, small loan levels, geographical distance and logistics of recovery. Attempts have been made to form cooperatives but without success. However, this situation may soon improve with the signing of a 6-year US$ 269 million micro-finance project aimed in part at the traditional agricultural sector (FAO/WFP, 2006).

- **Public programs:** Although public programs such as food for work have been in operation for nearly three decades, their potential impact on private land management is subject to much debate. Advocates assert that these programs promote improved land management by relieving financial constraints and that there are additional benefits in terms of acquired skills through 'learning by doing'. Critics argue that they adversely affect improved land management through competition for labor, but the empirical evidence is mixed. Both evidence for adverse effects of food for work and no effects on the adoption of improved land management have been found, although some evidence may be anecdotal rather than empirical. A recent empirical study has found no evidence that food aid fosters dependency and creates disincentives (Hoddnot, 2003). One finding of interest is that food for work increased the use of seeds but reduced labor, oxen and manuring, suggesting that seeds are substituting for labor-intensive inputs. Another study indicated that food for work could promote SWC investments if they are applied within agriculture, but not if applied outside agriculture (e.g., road construction).
- **Coordination within governments:** The main institutional issue that affects sub-basins divided between two or more regional governments is of course coordination between different regional governments. Several resource management issues specifically require inter-regional coordination due to hydrological flows, land use impacts, wildlife movements and the trans-boundary nature of forests. Institutional issues not only involve coordination but also getting the regions to give equal, or appropriate, attention to the issues of the sub-basin. The other major institutional issue is the need for coordination between sectoral agencies, which often have competing interests about how best to use the resource base. At present there is no coordination of regional governments' actions, while sectoral coordination within regions is limited to annual financial planning.

- **Lack of policy frameworks:** National policies are reasonably well developed in Ethiopia and regional interpretations of these have been developed in the last five to ten years. While master plans exist for all sub-basins they have a rather narrow focus and are not formally recognized or used. Further, technical policies are designed and implemented in isolation and without a coherent framework. In many areas these lack sensitivity, having been designed with national priorities in mind, or adjusted only to the main characteristics of a region with little attention to the specific conditions in the parts of the sub-basin which are in the region. Decentralization should have helped improve policies so that they are sensitive to regional variations but this adaptability is still generally quite limited.

Even when there are specific government policies to support the sustainable use of the country's resource base, practice on the ground is far from achieving this. The reasons relate to inappropriate policies, conflicting policies, poor training of development agents, lack of staff and resources, and an inability to liaise with the local population and build support. At the field level there is often a lack of horizontal and vertical coordination between and among responsible agencies, organizations and ministries. One example is the inability of the state to control land use designated as Regional Priority Forests and Regional Parks. The absence of clearly demarcated and gazetted boundaries in many cases, and the inability of the state to enforce legislation has led to these areas being regarded as 'open access' resources. Another issue is the lack of an agreed development plan, as illustrated by the problems in the Gash delta irrigation scheme in Sudan (Box 3.2).

Box 3.2: Local governance in securing access to land and water in the Gash delta in Sudan

The problems facing the Gash Delta irrigation Scheme are an example of how it is often a combination of many factors that constitute the poverty-environment nexus in Sudan. While not all factors are present everywhere, many are, and the case study of the Gash delta highlights the complexity and difficulty of disentangling root causes of poverty and environmental degradation, as well as the lack of a simple solution to these causes. In the Gash delta, as elsewhere in Sudan, the level of rural poverty is closely related to agricultural production and productivity. In the past 20 years, total cultivated area in the delta decreased by over 50 per cent while the total cultivated area per tenant declined from 7 to less than one *feddan*. Managerial, institutional and policy factors are the root causes of this process of impoverishment (IFAD, 2004). Chief among these factors has been the lack of an agreed approach and a plan for the development of the area resulting in an ad hoc use of current resources and investments and unpredictable local and extra local resource allocations. The last includes inequitable patronage systems, lack of transparency in the management of the Gash area resources and investments, the diversion of surpluses extracted from the area away from re-investment in the area, erratic support services, frequent exemptions from non-payment of services charges (such as water rates) and weakening of traditional solidarity and social support mechanisms. The fragile and harsh agro-ecology and the cumulative degradation of natural resources further aggravated the situation.

Source: Kirkby, J (2001)

3.4.2 Supporting interventions for watershed management

Supporting interventions form a sub-set of a much broader array of rural development and poverty reduction activities. These are described below for each of the Eastern Nile Basin countries.

Ethiopia

In Ethiopia supporting interventions are well developed and clearly articulated in the country's Sustainable Development and Poverty Reduction Program (SDPRP) and its successor, the Plan for Accelerated and Sustainable Development to End Poverty (PASDEP). The PASDEP is also supplemented by the Poor Area Program comprising a safety net program for the chronically poor and a Planned Resettlement program. Nine broad sets of supporting interventions identified are detailed in Table 3.5.

Table 3.5: Interventions to support the watershed management program in Ethiopia

	Intervention	Details
1.	Capacity building - Physical capacity development - Human capacity development - Support to land registration - *Wereda* database development - Regional /National park development	• Purchase equipment, vehicles, etc • Short and long term training • Training surveyors and equipment provision • Database equipment and training • Capacity building Park staff
2.	Strengthening extension	• Farmer Training Centres (FTCs) • Training Development Agents (DAs) • Radio broadcasts
3.	Development of community assets	• Construction of feeder roads constructed • Construction of improved market facilities
4.	Support to non-farm income generation and small and micro enterprise development	• Construction Vocational Training Centres (VTCs) • Literacy or Vocational Training provision • Experience transfer (migratory employment) • Managerial or enterprise capacity training • Provision of market demand information
5.	Support to micro finance institutions (MFIs)	• Needs assessment and curricula development • Training of trainers • Training MFI staff
6.	Improved market linkages	• Training provision: Farmer Marketing Cooperatives (market intelligence, cooperation with traders)
7.	Sustainable management and development: Baro-Akobo highland wetlands	• Detailed survey and assessment of highland wetlands systems • Specialised training: sustainable wetland management systems (*wereda* or *kebelle* extension staff) • Establishment of Water User Groups (WUG's) • Farmer training • Formulation of Monitoring and Evaluation System
8.	Strategic land use planning: high forest areas:	• Provision of remotely sensed images, interpretation Abbay and Baro-Akobo sub-basins and survey equipment • Field survey and assessment of remaining high forest areas • Inter-regional participatory Forest Land Use Zoning • Preparation of Forest Management plans
9.	Community forest management planning and implementation	• Capacity building Extension Service: Participatory community forest management planning- Field level: Community forest management planning

Sudan

In Sudan, development policy is currently in a state of considerable flux following the Comprehensive Peace Agreement (CPA). Outline proposals have been identified in the Joint Appraisal Mission's (JAM) report in nine cluster reports but many details have yet to be determined and worked out. The supporting interventions identified for Sudan are in Table 3.6.

Table 3.6: Interventions to support the watershed management program in Sudan

	Intervention	Details
1.	Capacity Building - Physical capacity development - Human capacity development	• Office construction • Purchase equipment, vehicles, etc • Short (in-service) and long term (University) training
2.	Strengthening Extension Service	• Agricultural agent training centers • Farmer Training Centres (FTC's) • Training: Agricultural agents • Radio broadcasts
3.	Support to agricultural research: Rain-fed cropping	• Physical capacity development (buildings, equipment, materials) • Human capacity development (short and long term training) • Operating and maintenance costs • Establish closer research-extension linkages
4.	Support to Micro Finance Institutions (MFI's)	• Needs assessment and curricula development • Training of trainers • Training MFI staff
5.	Improved accessibility and market linkages	• Construction of feeder roads • Construction of improved market facilities
6.	Rain-fed: Traditional: Central Clay Plains: Ngessena hills and Nuba mountains	• Survey of all land occupied by SMF leases & utilization status • Reversion back to State of abandoned/non utilized land • Land suitability assessment of reverted land • Land use zoning and re-allocation to traditional agricultural sector
7.	Sustainable management and development Dinder-Rahad Wetlands	• Detailed trans-boundary survey and assessment of Dinder Rahad wetland systems • Satellite images/Air photos, survey equipment • Develop sustainable wetlands management plan
8.	Sustainable management and development Baro-Sobat-White Nile wetlands	• Detailed trans-boundary hydro-ecological survey and assessment of Baro-Sobat-White Nile wetlands system • Satellite Images/Air Photos, Survey Equipment
9.	Sustainable management and development of Blue Nile wetlands	• Assessment of conservation status of Blue Nile Wetlands (Logistics: personnel, transport, equipment and materials) • Identify areas for strict conservation and reservation • Designate as Forest Reserves

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	Intervention	Details
10.	Community woodland management planning and implementation	• Capacity building extension service: (Participatory community woodland management planning- Field level: Community forest management planning
11.	Support to establishment of Dinder-Alatish Trans-boundary Park	• Establishment of permanent joint park management institution (Administrative expenses, travel) • Harmonization of park management plans • Harmonization of park monitoring systems
12.	Trans-boundary Collaborative Wildlife and Habitat Survey and Assessment	• Establishment of Joint Steering Committee (travel, meetings) • Trans-boundary inventory and habitat assessment (aircraft hire, vehicles, equipment)
13.	Trans-boundary Biosphere Reserve: Wadi Allaqi	• Establishment of permanent joint management organization • Harmonization of conservation activities • Harmonization of development activities
14.	State-wide Strategic Land Use Planning: Northern Sudan	• Establish national-level planning guidelines and principles • Establish Institutional Framework: for collaborative planning (Identify relevant stakeholders: meetings, workshops) • Undertake surveys (Natural resource base, resource use systems, land access institutions (formal and informal) • Draft Strategic Land Plan • Logistics (Personnel equipment, remote sensing images, transport, technical support)
15.	Support to Southern Commission for natural resources	• Capacity building (physical and human capacity) • Technical support (in-service training, equipment)
16.	Community level land use planning: Northern Sudan	• Link traditional land allocation institutions with formal state institutions • Capacity building and training: (Participatory planning techniques) • Logistic support (Personnel, transport, equipment, technical support)
17.	Community level land use planning: Southern Sudan	• Link Traditional land allocation Institutions with Formal State Institutions • Capacity building and training: (Participatory planning techniques) • Logistic support (Personnel, transport, equipment, technical support)

Egypt

In Egypt the supporting institutions and mechanisms required for the implementation of the proposed direct interventions are largely in place. The key additional supporting interventions identified are in Table 3.7.

Table 3.7: Interventions to support the watershed management program in Egypt

	Intervention	Cost Items
1.	Capacity Building (HDLDA, MALR and Settlers)	• Training: agricultural Agents (Participatory action research and extension) • Training: Settlers (Use of bio-fertilizer and bio-pest control measures) and market planning • Radio broadcasts
2.	Capacity Building (MOH)	• Training health workers in eco-system health surveys and monitoring (Participatory rural appraisal, Focused group discussions, Semi-structured interviews)
3.	Capacity Building: CDAs	• Training CDA members (Project management, Board management, Monitoring and Evaluation, Proposal writing, Financial management, Inventory control) • Basin training in new bio-agricultural techniques
4.	Support to MFIs	• Needs assessment and curricula development • Training of trainers • Training MFI staff
5.	Improved Accessibility and Market Linkages	• Construction of feeder roads • Market price communication system installed

4 Distribution of Costs and Benefits of Watershed Management Interventions

4.1 Costs of Natural Resource Degradation

The costs of natural resource degradation in the Eastern Nile Basin have been calculated as best as possible, given limitations of data, time and other resources. This is essentially a 'without program' or 'business as usual' scenario. Many of these costs are cumulative and the analysis provides estimates of annual costs and costs after 25 years. These costs are detailed first by type of natural resource degradation (Table 4.1), and then by level of costs, i.e., whether national, regional, basin or global (Table 4.2).

Deforestation and degradation of wood biomass is the largest component of the measurable costs of natural resource degradation (64 per cent), followed by soil degradation (19 per cent), sedimentation (11 per cent), loss of biodiversity (6 per cent) and finally wetland degradation (0.2 per cent). It has not been possible to quantify or value wetland conversion and the addition of such global environmental costs may increase resource degradation costs.[15]

Table 4.1: Costs of natural resource degradation in the Eastern Nile Basin by type

	Resource	Annual US$ million	25 years US$ million	%
1.	**Soil Erosion/degradation**	**270**	**793**	**19%**
	Erosion (sheet. gully, *kerib*, river bank) (Ethiopia, Sudan)	31	221	
	Nutrient breaches and fertility loss (Ethiopia, Sudan)	221	554	
	Dune encroachment (existing, potential) (Sudan)	18	18	
2.	**Sedimentation**	**33**	**439**	**11%**
	Sedimentation: Irrigation area lost (Ethiopia, Sudan)	18	393	
	Sedimentation: Dredging and Weed cleaning (Sudan)	12	12	
	Sedimentation: Dredging turbine in-takes (Sudan)	2	2	
	Sedimentation: Hydro-power lost: Flushing (Sudan)	0	0	
	Sedimentation: Hydro-power lost: Storage loss (Sudan)	1	31	
3.	**Deforestation and Wood Biomass Degradation**	**137**	**2,621**	**64%**
	Deforestation: Timber value forgone (Ethiopia, Sudan)	49	1,233	
	Deforestation: Pole value forgone (Ethiopia, Sudan)	6	140	
	Deforestation: Fuel wood value forgone (Ethiopia, Sudan)	13	335	
	Deforestation: Loss of carbon sequestration (Ethiopia, Sudan)	5	132	
	Degradation: Loss of carbon sequestration (Ethiopia, Sudan)	58	636	
	Deforestation: NTFPs, pharmaceutical value forgone (Ethiopia, Sudan)	1	32	
	Deforestation: Watershed services lost (Ethiopia, Sudan)	5	115	
4.	**Wetland Degradation**	**8**	**8**	**0.2%**
	Wetland sedimentation: Flooding (Sudan)	8	8	
	Wetland degradation: Over-drainage (Ethiopia)	-	-	
5.	**Genetic, Species and Habitat Biodiversity Loss**	**9**	**227**	**6%**
	Deforestation: Coffee gene pool value forgone (Ethiopia)	6	160	
	Deforestation: Habitat/species biodiveristy value forgone (Ethiopia, Sudan)	3	66	
	TOTAL GROSS COSTS	457	4,087	100%
	Benefits: Sediment as fertilizer (Sudan)	2	2	
	Benefits: Crop production on forest and woodland (Ethiopia, Sudan)	18	453	
	TOTAL NET COSTS	437	3,632	

4 Distribution of Costs and Benefits of Watershed Management Interventions

It must be emphasized that the costs estimated here do not reveal the full extent of the social and economic costs to the rural and urban populations in these countries in terms of key elements in the downward spiral of poverty and a degrading resource base such as poor nutrition and health, poor access to social services (health and education) and restricted access to alternative livelihood strategies.

Table 4.2: Costs of natural resource degradation in the Eastern Nile Basin by level

Resource	Annual US$ million	%	25 years US$ million
NATIONAL COSTS	**340.1**	**61%**	**2,501.6**
Soil erosion: Ethiopian Highlands	17.4		185.5
Nutrient breaches: Ethiopian Highlands	213.1		391.8
Soil fertility loss: SMF - Sudan	7.4		146.8
Soil fertility loss: Traditional sector - Sudan	0.7		15.4
Kerib land formation (Sudan)	0.9		22.6
Dune encroachment: Existing cropland (Sudan)	3.4		3.4
Dune encroachment: Potential cropland (Sudan)	14.6		14.6
River bank erosion (Sudan)	12.5		12.5
Sedimentation (ponds, small dams) (Ethiopia)	1.8		1.8
Deforestation: Timber value forgone (Ethiopia, Sudan)	49.3		1,232.6
Deforestation: Pole value forgone (Ethiopia, Sudan)	5.6		140.1
Deforestation: Fuel wood value forgone (Ethiopia, Sudan)	13.4		334.5
Wetland conversion	-		-
REGIONAL COSTS	**43.9**	**14%**	**559.5**
Sedimentation: Irrigation area lost (Sudan, Egypt)	15.7		391.3
Sedimentation: Dredging and Weed cleaning (Sudan)	12.0		12.0
Sedimentation: Dredging turbine in-takes (Sudan)	2.0		2.0
Sedimentation: Hydro-power lost: Flushing (Sudan)	0.3		0.3
Sedimentation: Hydro-power lost: Storage loss (Sudan)	1.2		31.1
Watershed Services lost(60%) (Ethiopia, Sudan)	4.6		114.7
Wetland sedimentation: Loss of flood buffering (Sudan)	8.1		8.1
GLOBAL COSTS	**73.3**	**25%**	**1,026.2**
Carbon sequestration : Deforestation (Ethiopia, Sudan)	5.3		131.7
Carbon sequestration : Degradation (Ethiopia, Sudan)	57.7		635.9
NTFP, Pharmaceutical value forgone (Ethiopia, Sudan)	1.3		31.7
Coffee gene pool value forgone (Ethiopia)	6.4		160.4
Habitat and species biodiversity value forgone (Ethiopia, Sudan)	2.7		66.4
TOTAL GROSS COST	**457.3**	**100%**	**4,087.2**
Less: Value of sediment as fertilizer (Sudan)	1.8		1.8
Less Crop production (Ethiopia, Sudan)	18.1		453.1
TOTAL NET COST	437.4		3,632.4

The division of natural resource degradation costs across regions shows that the majority of costs (61%) accrue at the local and national level, while 25% are global and only 14% are regional (Table 4.3).

Table 4.3: Summary costs of natural resource degradation in the Eastern Nile Basin by level

Resource	1 year US$ million	% of total 1 year costs	25 years US$ million	% of total 25 year costs
Local and national costs	340	74%	2,502	61%
Regional and basin-wide costs	44	10%	560	14%
Global costs	73	16%	1,026	25%
Benefits	20		455	
Net Costs	437	100%	3,632	100%

4.2 Benefits of Direct and Supporting Interventions

There are many synergistic impacts between the direct and the supporting interventions of an integrated watershed management program that do not emerge in an impact analysis of any single intervention. Thus, benefits of all proposed interventions are identified at the household and community level, the national level (within the sub-basin), the sub-basin and regional level and finally the global level.

4.2.1 Household and community level benefits

The program of interventions will have a substantial impact on arresting degradation of the natural resource base both on cropland and on non-cropland. This is a vital entry point in breaking the cycle of poverty and resource degradation and attacks one of the root causes of poverty in the Eastern Nile Basin. Specific benefits of the proposed direct interventions include the following:

- **Reduced run-off and increased groundwater:** SWC structures on cropland and the enclosed areas on non-cropland will reduce runoff and increase infiltration to groundwater, causing groundwater levels to rise and long dormant springs to begin flowing again.
- **Increased livestock productivity and forest products:** Conservation of non-croplands through enclosure and tree enrichment planting will provide not only direct benefits to communities in terms of increased livestock feed, improved livestock productivity and increased supply of fuel wood and timber, but will also increase wild plants with food and medicinal value that are of considerable importance to the most disadvantaged community members such as female headed households.
- **Reduced work loads and better health:** Increasing the availability of easily accessible supplies of fuel wood (through on-farm tree planting) and reducing its consumption (using fuel efficient stoves) will reduce the work loads of women and children. In addition, the resultant reduction in smoke inhalation will positively impact their health and well-being by reducing the incidence of respiratory diseases.
- **More income and less vulnerability:** On-farm and community interventions will increase household farm incomes and food supply with improved levels of nutrition and health, reduce vulnerability to climate, social and economic shocks and improve the quality of the natural resource base.

A number of these interventions however have substantial labor costs for construction or establishment. Also, it will take a number of years to realize the benefits of a number of these interventions, including on-farm and community tree planting and SWC measures. This suggests that government policy support may be required, either to include these households and communities in on-going food for work, cash for work and safety net support measures, especially if the high costs of initial labor requirements will impede adoption of these watershed management measures.

The benefits of the proposed supporting interventions to households and communities are described below.

- **Reduced market transaction costs:** More feeder roads and extended telecommunication systems will increase market accessibility and integration and thus reduce market transaction costs, which will benefit both producers and consumers.
- **Better access to technology and skills:** Capacity building interventions to improve literacy and skill levels, along with increased support to improve extension and research services, will help increase the adoption of improved agronomic technologies.
- **More access to non-farm employment:** Increased road accessibility and skills training will enable rural households to have better access to non-farm employment opportunities.
- **Enhanced lab-to-land transfers:** Greater support from a strengthened extension service will improve information linkages between farmers and research and thereby increase the relevance of agricultural research to the traditional small-holder sector.

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- **Increased adoption of fertilizer and improved seeds:** Enhanced access to micro-credit will provide strong support to farmers to adopt improved technologies, in particular fertilizer and improved seeds.
- **Development of small enterprises:** Support to small enterprise training, together with credit, will also enable the development of small enterprises in the small urban centers, further increasing employment opportunities.
- **Reduced conflicts over natural resources:** Support to community level land use planning, and community woodland management planning (e.g., in Sudan) will enable rural communities to better manage the natural resource base and harvest wood and other non-wood products in a more sustainable manner. This will in turn assist in reducing local conflicts over natural resource use and increasing access to all groups.
- **Sustainable management of natural resources:** Strategic land use planning and zoning in forest areas, based on stakeholder participation and sustainable land suitability principals, will clearly and transparently delineate areas for small-holder and large-scale commercial agricultural development, which will allow for sustainable development and management of the forest and land resources at the local level.

It must be emphasized that there a number of important synergies between the various interventions most particularly in improving rural-urban linkages, increasing economic development of small urban centers and increased agricultural production. All these interventions will enable an expansion of local economic multipliers. At the local level these will occur through increased incomes being spent on purchases of local non-tradable goods i.e., goods made locally rather than those imported.[16] In addition, there will be an increase in backward multipliers (from an increased demand for improved inputs) and in forward multipliers (from an increase in marketed agricultural products) which, in turn, will increase employment opportunities for rural and urban households in the many small urban centers.

4.2.2 Sub-regional and national level benefits

The major sub-regional and national level benefits of the proposed watershed management interventions are the following:

- **Poverty reduction:** Reducing the numbers of poor households needing safety net support, especially in the traditional agricultural smallholder sector, which has the highest incidence of poverty in both Ethiopia and Sudan.
- **Increasing market linkages and urban growth:** Reducing transaction costs through interventions to increase market accessibility and integration will stimulate the development of backward and forward market linkages and the growth of tertiary and secondary urban centers, and thus contribute to the growth of sub-regional economies in each country.
- **Fostering regional economic development:** Feeder road construction, small-scale irrigation, water harvesting, improved small livestock production and diversification activities such as wool and honey production, the development of deciduous fruits, cash crop coffee and cut flower production will stimulate regional economic development.
- **Stimulating agricultural growth:** The growth of non-agricultural sectors particularly services, through the expansion of commercial rain-fed crop production and sub-regional tourism, will increase the demand for agricultural products thus stimulating agricultural growth.
- **Increased domestic and export earnings from livestock:** Enhanced access to rangelands through improved stock routes and water points will substantially increase livestock productivity and increase domestic and export earnings. The increased use of crop residues from SMFs by pastoralists, agro-pastoralists and livestock holders in the large irrigation schemes will also contribute to increased livestock productivity in the sub-regional economies.
- **Increased effectiveness of agricultural extension and research services:** The capacity building interventions will contribute to the increased effectiveness of the agricultural extension and research services. In each country this increase in the quantity and quality of human capital will impact on the quality of research outputs and on extension advice.

Policy change will play an important role. The land policy reforms in Sudan, for instance, will have far reaching effects in increasing access to natural resources by the most disadvantaged, reducing sub-regional and regional conflicts over resource access and use and in increasing crop and livestock productivity. These will further re inforce sub-regional economic growth and its attendant multipliers.

4.2.3 Sub-basin and regional level benefits

Benefits at this level cut across political boundaries and accrue to the Eastern Nile Basin as a whole.

- **Reduced sediment loads in the river systems:** Reduced erosion in the Ethiopian Highlands will reduce costs within Sudan of dredging power intakes and irrigation canals, and also reduce the loss of power generating potential due to the need for reservoir flushing. This will also reduce pump and turbine damage, sediment in domestic and industrial water supplies, and siltation of the *maya'as* (wetlands) in Sudan, thus reducing the incidence and extent of flooding and the damage this causes to crop production. Reduced soil erosion will also decrease sedimentation of dams and reservoirs in the entire system (including the new Tekeze and Meroe dams) and increase their economic life, besides reducing the loss of live storage in Lake Nasser/Nubia and the loss of potential irrigation water and power generation for Egypt.
- **Stimulating integration of sub-regional economies:** Currently there is little trans-boundary trade between Ethiopia and Sudan but the expansion of economic development on both sides of the border, coupled with an extension of cross-border road-links, will increasingly integrate the sub-regional economies of both countries. Good road access from Gambella town to the Juba–Lokichokia road to Kenya would not only reduce transport costs, but also open both the Boma area in Sudan and the Gambella area in Ethiopia to markets in Kenya, Uganda and the Democratic Republic of Congo. Also, the construction of the proposed rail link between Sudan and Ethiopia and the expansion of cross-border power transmission will integrate these economies even further.
- **Reducing transport costs:** Increased access to Port Sudan for western Ethiopia would have a positive impact in reducing transport costs for both imports and exports.
- **Improved food security:** Closer cooperation in crop early warning systems, establishing joint strategic grain reserves and purchase of grains for food relief either side of the border would enable faster responses to local food shortages to the mutual benefit of both countries. Increased food security on both sides of the border will contribute to overall food security for the region.
- **Increased bio-diversity conservation and eco-tourism:** The establishment of trans-boundary parks such as Dinder-Alatish and preservation of wetlands such as in the Rahad-Dinder will increase the effectiveness of biodiversity conservation and eco-tourism potential, which in turn will improve employment opportunities for local people.
- **Increasing off-farm employment options:** The expanding industrial sector in Sudan could provide off-farm employment opportunities for both Sudanese and Ethiopian households and also provide financial capital for investment in agricultural production, agricultural processing and small-scale service sector enterprises in the small urban centers.
- **Intangible benefits:** The proposed interventions will also result in regional benefits such as increased aesthetic and recreational value and the preservation of ecosystem functioning and local biodiversity. Improved water flows in downstream waterways permits the design of river-side recreational facilities like parks and wildlife sanctuaries, which could stimulate local, regional and international tourists. Augmented water flows in rivers and into downstream water bodies can stimulate habitats for local and migratory birdlife and other wildlife, and could help sustain local biodiversity. These, in turn, could also provide aesthetic benefits to downstream stakeholders, local and outside recreational and eco-tourists. Also, ecosystems provide a variety of complex life-support functions services of energy, nutrient and water cycling, maintaining balance between prey and

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predator populations in the food chain, etc. Along with other interventions, improved water availability and reduced sedimentation could help improve ecosystem functioning, especially in special threatened downstream ecosystems such as lakes and wetlands(for more details see, *inter alia*, James, 2005).

4.2.4 Global level benefits

The direct and supporting watershed management in the Eastern Nile Basin will result in the following global benefits:

- **Carbon sequestration:** The proposed interventions will substantially increase the amount of carbon sequestered in wood biomass, herbaceous biomass and soil carbon. The small scale example of improved rangeland management supported by the Global Environmental Facility (GEF) in Bara Province of North Kordofan indicates how this may be implemented at the local level (see Box 4.1).

Box 4.1: Community-based Rangelands Rehabilitation Project: Bara Province, North Kordofan State, Sudan

This project funded by the Global Environmental Facility (GEF) is testing a simple model of community-based natural resource management using participatory techniques with short-term economic and long-term environmental objectives. The project is seeking to reverse the negative environmental trends by planting trees and grass to stabilize sand dunes, creating kilometers of windbreaks comprising two rows of trees, planting native perennial species of grasses to improve the rangeland, and developing land use and rangeland management plans. The project activities have resulted in much of the area being re-seeded with reduced wind erosion, increased soil organic matter, greater carbon sequestration and increased plant species diversity. There have been significant positive impacts on livestock production and on livelihoods, in particular among the poor and women.

Source: Near East Foundation, (2001)

- **Conservation of biodiversity:** Interventions targeted at the traditional and the commercial farming sectors in Ethiopia and Sudan, such as sustainable land management practices at the local level, will result in significant benefits to biodiversity, including an increase in native plant species in pasture land and in enclosed areas (that have all but disappeared in the open access communal areas) and an increase in below ground biodiversity (including insects and other invertebrates that play a vital role in maintaining soil fertility). However the greatest impacts on biodiversity will be indirect, as increasing land productivity will reduce the need to clear more agricultural land and thus reduce deforestation and preserve biodiversity. In addition, substantial conservation of genetic, species and habitat diversity will result from the supporting interventions to the Dinder and Alatish parks and to the development of the management plan for the Dinder-Rahad wetlands.

- **Intangible benefits:** The proposed interventions will also result in global benefits such as preservation of 'option value'.[17]

4.3 Overview of Benefits and Costs of Watershed Interventions

The economic costs and benefits for the whole Eastern Nile Basin, that could be quantified given the time and resources available, have been aggregated into national, regional and global estimates (Table 4.4). The present value of the net benefits using a real discount rate of 10 per cent over 50 years is US$ 8,510 million. The ratio of benefits to costs is 2:8, implying that benefits of the proposed watershed management interventions are significantly higher than the costs of direct and supporting interventions. A large proportion of these incremental benefits accrue at the national level (92 per cent), followed by global benefits (5 per cent) and regional benefits (2 per cent).

Table 4.4: Costs and benefits of watershed management interventions: Eastern Nile Basin

(US$ million)

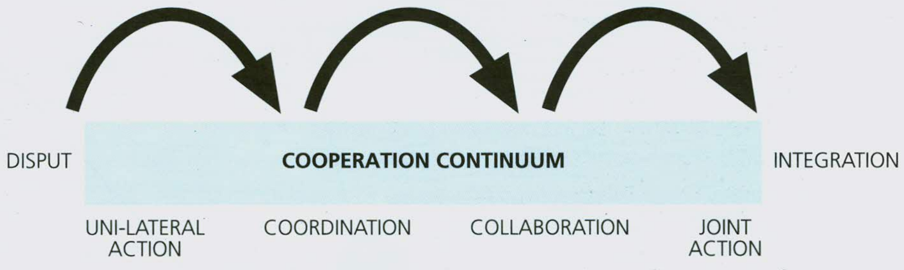
Intervention	Cost without project	Cost with project	Benefit without project	Benefit with project	Incremental cost	Incremental benefit	Benefit to cost ratio
ETHIOPIA	1,929	3,459	6,024	16,538	2,390	10,643	4.5
National	1,929	3,459	6,024	16,538	2,390	9,984	4.2
Soil conservation: bunds	166	520	1,415	1,548	77	133	1.7
Soil conservation: grass strips	577	583	1,156	1,209	6	53	8.6
Fertilizer/Improved seed	559	721	1,810	2,616	162	0	0.0
On-farm forage	1	23	217	565	22	348	15.6
On-farm trees: fuel wood	1	29	219	498	28	279	10.1
On-farm trees: crop production saved: soil nutrient retained	0	0	0	0	0	141	
Improved stoves	0	6	0	83	6	83	14.4
Area enclosure	576	1,162	1,086	9,138	585	8,053	13.8
Small-scale irrigation	49	416	121	881	366	760	2.1
Small-scale irrigation: multiplier impacts	0	0	0	0	0	135	
Supporting interventions					1,137		0.0
Regional	**0**	**0**	**0**	**0**	**0**	**0**	
Global	**0**	**0**	**0**	**0**	**0**	**659**	
Soil conservation: soil carbon sequestration	0	0	0	0	0	66	
On-farm trees: tree carbon	0	0	0	0	0	19	
Improved Stoves: fuel saving: tree carbon sequestration	0	0	0	0	0	8	
Enclosed areas: tree carbon	0	0	0	0	0	395	
Enclosed areas: soil carbon	0	0	0	0	0	170	
SUDAN	1,161	2,385	1,842	3,995	2,277	2,256	1.0
National	**1,161**	**2,385**	**1,842**	**3,995**	**2,277**	**2,188**	**1.0**
Traditional rain-fed farms: crop production	809	1,311	1,338	2,560	502	1,222	2.4
Semi-mechanized farms: crop production	352	1,024	503	1,396	672	893	1.3
Semi-mechanized farms: charcoal production	0	46	0	30	46	49	1.1
Semi-mechanized farms: Residue: Livestock feed	0	0	0	0	0	16	
Reclamation: *kerib* land	0	3	0	8	3	8	2.5
Supporting interventions					1,052		
Regional	**0**	**0**	**0**	**0**	**0**	34	
Increased irrigation water	0	0	0	0	0	10	
Reduced operation and maintenance costs of irrigation schemes	0	0	0	0	0	34	
Reduced fertilizer value: sediment	0	0	0	0	0	-10	
Kerib land: reduced sediment load in Atbara	0	0	0	0	0	0	
Kerib land: reduced fertilizer value of sediment	0	0	0	0	0	0	
Global	**0**	**0**	**0**	**0**	**0**	34	
Traditional rain-fed farms: soil carbon	0	0	0	0	0	23	
SMFs : soil carbon	0	0	0	0	0	12	
SMFs : tree cover: soil carbon	0	0	0	0	0	39	
Kerib land: soil carbon	0	0	0	0	0	1	
EGYPT	0	0	0	0	0	277	
Regional							
Reductions in lost power generation	0	0	0	0	0	16	
Reductions in lost irrigation water	0	0	0	0	0	243	
EASTERN NILE BASIN	3,089	5,843	7,865	20,533	4,666	13,176	2.8

5 Modes, Processes and Institutional Mechanisms for Watershed Management Cooperation

5.1 Levels of Watershed Management Cooperation

Sadoff and Grey (2005) describe a continuum of modes and cooperative mechanisms that require increasing cooperative effort. There are four main levels of cooperation (Figure 5.1).

Figure 5.1: The cooperative Continuum



Source: Sadoff and Grey (2005).

At one extreme there is no cooperation and this is termed 'unilateral action'. With an increasing degree of cooperation there is 'coordination' progressing to 'collaboration' and finally to 'joint action'. The continuum is seen to progress from a situation of 'dispute' to one of 'integration'.

An example of the first level of cooperation is the exchange or cooperative gathering of information on the Eastern Nile Basin. In the context of the Watershed Management CRA that process has already begun. Moving to a higher level of cooperation is the area of collaborative activities. These will require more intensive cooperation and more elaborate institutional mechanisms. At the highest level of cooperation are joint activities. These will require even more complex cooperative institutional mechanisms that include joint planning, financing and implementation.

5.2 Modes of Cooperation

5.2.1 Coordination

Information and data collection and sharing for watershed management

Coordination is the first move along the continuum of cooperation from unilateral action. Exchange and sharing of information is probably the key mechanism of cooperation in this regard. The undertaking of Cooperative Regional Assessments is another and these can even pre-date formal protocols for information sharing.

Information in terms of basin development includes data on hydrology (including sediment loads), meteorology, agriculture, socio-economic (e.g., poverty), the macro economy and trade. Such data will be essential in developing cooperative development projects and programs. Any mechanism for cost and/or benefit sharing must have as its basis good quality information on the physical and economic basis.

In the three riparian countries poverty reduction strategies have, or are being, developed and baseline data is being collected to monitor progress in achieving objectives. Sharing these data will help to provide a more holistic assessment of progress in the implementation of watershed management interventions and are thus of considerable value in informing decision makers of progress in achieving the overall goals of the ENSAP program.

Hydrological station networks are operational in all three countries, although with common shortcomings (lack of continuity of data, shortage of long term records and low density of gauging stations that can provide long term reliable records). The required mechanism for Eastern Nile Basin cooperation with regard to monitoring of larger rivers will be the exchange of key data on a readily accessible basis or, at the best, on a basis of regular pro-active exchange. There would be a need to ensure operational quality and harmonization of measuring methodologies (especially of sediment monitoring).

There remains ample scope under ENSAP for applied research on erosion, sediment production, soil nutrient losses and the mitigating effect of soil and water conservation and integrated watershed management practices. It is very important to address simultaneously the dual purposes of monitoring sediment and nutrient transport in water courses on the one hand, and monitoring and research of erosion-sedimentation processes and the effects of watershed management practices in micro-catchments on the other.

It will also be important that a process of Strategic Social and Environmental Impact Assessment (SSEIA) be integrated into the process of policy, strategy and program formulation. The NBI is developing sustainability strategies and guidelines and these will inform the SSEIA process. This will be a separate exercise from the more project-orientated Social and Environmental Impact Assessment undertaken as part of individual project preparation.

Within the context of ENSAP watershed management data by itself is of little use unless it is translated into information that can be used by policy makers to understand specific issues such as the underlying causes of poverty and environmental degradation, and to determine the social, economic and environmental impacts of current programs within the Basin in a process of policy review.

5 Modes, Processes And Institutional Mechanisms For Watershed Management Cooperation

Institutional implications for information sharing

More sophisticated river flow and sedimentation modeling within government organizations will require capacity building in this field. The same applies for implementation of an overall river basin management information system, which is an indispensable planning and management tool. Institutional strengthening in suspended sediment data collection and analysis and database management has been identified as an area for technical capacity building. Technical capacity building in the areas of GIS and natural resources database management has also been identified as a need. These could be implemented under the NBI Applied Training Project or under the auspices of the NBCBN-RE project.

While evaluation and review of national policies, strategies and programs is well developed in the three countries such a process is still in its embryonic stage in terms of trans-boundary policies, strategies and programs that affect the Eastern Nile Basin as a whole. ENTRO is charged with serving ENCOM and ENSAPT in providing technical expertise for the coordinated identification, preparation and possible implementation of regional development programs and projects in the Eastern Nile Basin (ENTRO, 2006). It would be logical for ENTRO to expand its mandate to one encompassing trans-boundary program evaluation and policy review for ENSAPT and ENCOM.

Organizational Implications

An expansion of ENTRO's mandate would impact on its Projects Coordination Unit, which currently focuses on project identification, preparation, implementation and coordination, increasingly functions as a knowledge base and GIS data base (from the One Source Inventory and the CRAs). Three core functions can be identified:

- Project identification, preparation, implementation, management and supervision
- Strategic planning, Strategic Social and Environmental Impact Assessment, program evaluation and policy review, and
- Data and information collation and coordination, GIS and structural database (social, economic, demographic).

These three functions are closely inter-related and a strong case can be made for having them grouped within one organizational unit.

Within the ENB, an assured and long-term commitment to funding will be required if an effective erosion-sediment data collection, analysis and monitoring system is to be implemented.

5.2.2 Collaborative activities

Types of collaborative activities

There are two broad types of collaborative activities: (i) time and space bound 'project-like' activities, such as joint research, studies and surveys, and (ii) 'process-like' activities, such as collaboration between countries in terms of sharing and adapting national level plans within a basin-wide perspective.

Examples of the first kind of collaborative activity include the following:

- Collaborative planning: e.g. developing a Dinder-Rahad watershed management Plan.
- Collaborative research: e.g. soil erosion, shifting sand and shelter belts, river bank erosion.
- Collaborative studies: e.g. hydro-ecological-livelihood relationships in the Baro-Sobat White Nile sub-basin.
- Collaborative surveys: e.g. wildlife and habitat surveys in the area in and around the Boma and Gambella National Parks (white-eared kob and elephant migratory routes).

An example of the second type of activity could be the adaptation of National Watershed or Basin Plans to accommodate a trans-boundary and basin-wide perspective.

Institutional implications

The first type of collaborative activity would have an identified source of funding that could include both country and international financing. These could be undertaken by joint teams of experts from the collaborating countries, by consultant teams working with joint national steering committees or a mix of both. Overall supervision and coordination could be undertaken by the Projects Coordination Unit of ENTRO. ENTRO could undertake or facilitate project preparation, sourcing of international funding, project implementation, dissemination of results and identification of follow-on projects.

The modalities for such cooperative mechanisms have been well developed by ENTRO with the planning, preparation, sourcing of funds, facilitation and coordination of the CRAs.

The second type of collaborative activity is less well defined than the first. The cooperative mechanisms for this type of activity have no precedent in the Eastern Nile Basin and are much further along the continuum of cooperation than collaborative research, studies or surveys. A first step in developing such a mechanism could be 'prior information' where a country would merely inform or share national plan components through ENCOM. A second and more complex step would entail discussion and negotiation on one or more areas of contention and the subsequent adaptation of national sub-basin plans to accommodate the concerns of other countries.

ENTRO's role here could be to provide impartial technical advice to ENCOM on specific aspects of these plans. ENTRO could also commission outside impartial technical opinion or provide outside technical support to the country developing the plan on potential basin-wide impacts of their plan. Collaboration in this case is likely to be more forthcoming if it can be demonstrated that the benefits of such changes in a national plan would benefit not only the 'aggrieved' country, but also the country making the changes – the so called 'win-win' situation. This may require additional and more complex analysis than either country could afford and here again ENTRO could play a supporting or facilitating role in financing and obtaining impartial and transparent analysis that would find support from both or all affected countries.

5.2.3 Joint long-term activities

Types of long-term activities

Long-term joint action occurs when riparian countries are partners in the design, investment and management of a trans-boundary entity. The types of mechanisms required for this level of cooperation are much more complex and situation-specific. This level of cooperation will have to be formalized by international legal agreements. Situations that lend themselves to such a level of cooperation are those for which there already is some mutual interest in the collaborative activity and where national institutions are in favor of such collaboration. Within the watershed management context in the Eastern Nile Basin one such example could be the establishment of a trans-boundary park incorporating the Dinder National Park in Sudan, and the Alatish Regional Park in Ethiopia. A second example would be the establishment of a joint biosphere reserve in the Wadi Allaqui by Egypt and Sudan. In both cases expressions-of-interest have been made and there are mutually-supportive institutions in both countries.

Institutional issues

There are a number of recommended principles that can guide the preparation and negotiation process that include the following:

- Identify and promote common values
- Promote coordinated and co-operative activities, achieve coordinated planning and harmonized, coordinated or joint management
- Involve and benefit local people
- Work towards funding sustainability
- Obtain and maintain support of decision-makers

Flexibility of approach implies that the form and level of cooperation can be site-specific and the levels of cooperation can be chosen at convenience in order to best fulfill objectives.

6 Proposed Long-term Watershed Management Activities and First Round Projects

6.1 Strategic Planning Framework

6.1.1 Objectives of a watershed management program

The immediate objective of a long-term Eastern Nile Watershed Management Program is to provide continued and enhanced support to sustainable watershed management of the Eastern Nile Basin. Its overriding regional significance will be the contribution to enhanced food security and poverty alleviation in the region, and its long term contribution to arresting the degradation of the natural resource base. This is in accordance with the policy guidelines adopted by the NBI's Council of Ministers of Water Affairs (Nile-COM) in February 1999 that further define the primary objective:

- Develop the water resources of the Nile basin in a sustainable and equitable way to ensure prosperity, security, and peace for all its peoples
- Ensure efficient water management and the optimal use of the resources
- Ensure cooperation and joint action between the riparian countries, seeking win-win gains
- Target poverty eradication and promote economic integration
- Ensure that the program results in a move from planning to action

6.1.2 Key watershed management issues to be addressed

Cooperation and coordination among riparian countries

The Trans-boundary Analysis and the Distributive Analysis of the Watershed Management CRA identified environment, natural resources and development synergies and sustainable watershed management opportunities in the basin as a major priority. More effective cooperation and coordination between the riparian countries is essential if the natural resource base of the Eastern Nile Basin is to be managed in ways that help improve the quality of life of the inhabitants.

In strategic terms it is vital that cooperation and coordination between the riparian countries is strengthened through trans-boundary activities including establishing a watershed management data and information system, monitoring of watershed management interventions, supporting erosion-sedimentation research, undertaking longer-term hydro-ecological-livelihood studies and institutional capacity building.

Emphasis must be given to encouraging diverse stakeholder groups to work together, not only within their own countries but especially with counterparts in other riparian countries, as an essential contribution to building the mutual understanding, relationships and trust that will be critical for collaborative problem-solving for the Eastern Nile Basin as a whole.

Enhancing and expanding the watershed management knowledge base

The Trans-boundary and Distributive Analyses revealed data gaps and imperfectly understood science of many aspects of watershed management. This is particularly so in the areas of soil erosion by water, sediment deposition within the landscape and sediment delivery to the drainage system. Factors operate at different intensities at different watershed scales making analysis and prediction of these complex systems extremely difficult. The difficulties of analysis are compounded by the lack of consistency in the type and quality of the required data. The impacts of soil erosion on agricultural productivity and the linkages to livelihood strategies in terms of the private profitability of conservation technologies are also imperfectly understood.

Another important area of watershed management and developing interventions to enhance sustainable livelihoods is the important role that wetlands play in livelihood strategies. Wetlands comprise complex hydro-ecological systems and are of considerable importance to household and community livelihoods in the three countries. Apart from their importance in supporting livelihoods, wetlands also provide important hydrological functions in river systems and have considerable importance in terms of biodiversity conservation. Complex trade-offs between conservation and development of wetlands will be necessary if the twin goals of sustainable livelihoods and biodiversity conservation are to be met. This is an area where research is essential in order to achieve the sustainable management of wetlands.

Data and knowledge gaps will require cooperative solutions in terms of shared information and data collection, harmonization of data collection and research methods and the integration of information and research results into policy formation.

Monitoring and evaluating watershed management interventions

Currently a wide range of watershed management activities are on-going and many more are proposed. It will be essential to monitor the impacts of these activities and undertake detailed evaluations of their impacts on household and community livelihoods. There is considerable scope for knowledge sharing amongst the three riparian countries on experiences gained and lessons learnt in watershed management. This will enable solutions to be rapidly developed to address problems identified by the monitoring and evaluation activities.

It will be important to integrate and coordinate data and information collection and research results across the Basin to achieve maximum synergy. There are also implications for capacity building and institutional strengthening at various levels to support these cooperative activities.

Capacity building and institutional strengthening

The Cooperative Mechanisms Analysis in the previous chapter revealed the increasing complexity of institutional mechanisms required for cooperative activities. Mechanisms can be relatively simple at the first level (e.g., information sharing), but as the level of cooperation rises to involve joint trans-boundary activities, mechanisms increase in complexity. Joint activities require coordination by basin-wide institutions such as ENTRO as well as by concerned government and non-government institutions within each country. The complexity of existing institutions involved with watershed management activities has been alluded to in the country reports and the sub-basin Trans-boundary Analysis. Support will be necessary to strengthen ENTRO and national institutions as more complex cooperative mechanisms are required to coordinate joint trans-boundary activities.

Trans-boundary cooperative watershed management activities are relatively new in the Eastern Nile Basin – this Watershed Management CRA being one of the first. The need for capacity building across a wide range of disciplines and subjects at all levels has been identified in the Trans-boundary Analysis of the CRA as a key pre-requisite for effective trans-boundary watershed management data collection, multi-disciplinary watershed management research and monitoring and evaluation of watershed management activities.

6 Proposed Long-term Watershed Management Activities and First Round Projects

Addressing trans-boundary biodiversity and natural resource hot spots

The Trans-boundary Analysis identified a number of important environmental and biodiversity hot spots that are under considerable pressure from expanding human activities. Three areas in particular involve national parks or biosphere reserves that are trans-boundary in nature. These are the Wadi Allaqi that is located in both Egypt and Sudan, the Dinder national park and the Alatish regional park that adjoin each other across the Sudan-Ethiopia border and the Gambella and Boma national parks that are important elements in the massive circulatory migration of the white-eared kob between Sudan and Ethiopia.

Other trans-boundary natural resource hot spots include the Abbay-Blue Nile highland and lowland wetland systems, and those of the Baro-Akobo-Sobat-White Nile sub-basin. The complex hydro-ecological systems of these wetlands are imperfectly understood and yet play vital roles in supporting livelihood systems, as repositories of genetic, species and habitat diversity and in performing essential hydrological functions. There is a clear need to obtain a deeper understanding of these very important watershed management roles.

Harmonizing national policies

Trans-boundary cooperative watershed management will require some degree of harmonization of national policies, particularly in respect of data collection and information sharing, and in cooperative monitoring and evaluation of watershed management activities. To be of use to policy makers it is important that data and information and research results are relevant to policies in question and presented in a form that is easily understood for policy review and revision.

6.1.3 Key elements of a long term watershed management strategy

Arising from the watershed management issues that have been identified in the Trans-boundary and Distributive Analyses a number of areas for long-term cooperative watershed management have been identified. These include:

- Developing a coordinated system of watershed management data collection and information sharing.
- Developing a coordinated system of monitoring and evaluation of watershed management activities.
- Undertaking research into the complex relationships between soil erosion (water and wind), deposition, sediment delivery to river systems, impact on agricultural productivity and the impact on sustainable livelihoods.
- Undertaking surveys and studies of the existing complex hydro-ecological livelihoods systems to enable more effective and sustainable development and watershed management planning.
- Undertaking surveys and studies and developing mechanisms and institutions for cooperative conservation of genetic, species and habitat biodiversity resources.
- Capacity building in the fields of (but not limited to) watershed management planning, relationships between land degradation and livelihoods, relationships between wetland environmental, hydrological and livelihoods functions, and monitoring, evaluation and impact analysis.
- Providing institutional support to ENTRO to enable effective program coordination, enhancing cooperative mechanisms and supporting confidence building and trust among the riparian countries. Support will also be required at the national level to enable effective coordination within a trans-boundary context of the various activities that will form part of the long-term cooperative program.

6.2 Long-term Cooperative Watershed Management Program

6.2.1 Introduction

This section outlines the cooperative Eastern Nile Watershed Management Program (ENWMP) that will continue the work of the completed Watershed Management CRA, ensure continued exchange of experiences, professional exchanges, monitoring of program impact and support to capacity building activities necessary to sustain a successful program of action.

Hitherto, the countries of the Eastern Nile Basin have generally worked in isolation when developing and implementing their plans for the use, conservation or development of the Basin's resources. This program will help build bridges between the countries to better enable a variety of key stakeholders to identify and take advantage of the opportunities offered by trans-boundary collaboration. In its totality, the program aims to create many 'points of contacts' among and between a large and varied set of stakeholders in the three Eastern Nile Basin countries. As these contacts grow and as independent networks are established around common issues of concern, the program is expected to contribute to an overall reduction of tensions, the building of greater understanding and trust, and to pave the way for sustainable cooperative development for poverty alleviation and enhancing sustainable livelihoods.

6.2.2 Program components

The ENWMP will provide enhanced support to sustainable watershed management activities that address the root causes of poverty of the peoples of the basin. There are five main components: (1) program coordination, (2) establishing a watershed management data and information monitoring and evaluation system (3) identifying and prioritizing first and second round watershed management investment projects, (4) undertaking knowledge development activities such as a joint hydro-ecological-livelihoods study in the Baro-Akobo-Sobat-White Nile sub-basin, and (5) supporting capacity building in the fields of watershed management planning, monitoring, evaluation and impact assessment. Each of these is briefly described below.

Component 1: Program coordination

This component will establish a Program Steering Committee and Program Coordinating Unit for effective coordination of program implementation and management. It will increase the capacity of ENTRO to effectively coordinate cooperative watershed management activities across the Eastern Nile Basin and ensure effective cooperation among the riparian countries and across other ENSAP and NBI programs and projects. It will also provide for building institutional capacity at the national level by supporting three National Program Coordinators (NPCs). The NPCs will interact between the regional thematic specialists and national individuals, institutions and organizations involved in implementing all of the program's components within their respective countries. The Program Steering Committee will provide strategic guidance to the project, review and approve annual work plans, and will receive and review annual substantive and financial reports on project activities.

Component 2: Establishing a watershed management data and information monitoring and assessment system

This component will establish within ENTRO, in coordination with the One System Inventory and the Water Resources Planning Model, a system to systematically collate and store relevant data and information for effective watershed management planning, monitoring and evaluation and for undertaking environmental, social and economic impact studies. The system will comprise a documentation center, a social, environmental and economic data base and a GIS. The data and information system will build on that established by the Watershed Management CRA. This component will also establish a long-term coordinated system of monitoring erosion (water and wind) and erosion control, sediment loads and land cover change at various catchment scales.

6 Proposed Long-term Watershed Management Activities and First Round Projects

It will be important to not only monitor implementation of watershed management interventions but also determine their impacts at the local, regional and global levels. Assessment of impacts will include physical, social and economic characteristics. Since it may not be feasible to undertake this across the whole basin, a number of hydrologically-linked micro- and sub-catchments will be selected, representative of specific agro-ecological and livelihood systems (e.g. annual cropping, perennial cropping, agro-pastoral, pastoral), and studied in detail to obtain a deeper understanding of the impacts of watershed management interventions on livelihoods and on poverty reduction. The component would also support the purchase of transport and equipment, participatory field studies, data collection and analysis.

Given the large seasonal variation and very rapid response times in stream flows of the Abbay-Blue Nile and Tekeze-Setit-Atbara rivers the sharing of flow, sediment and meteorological data collection has a number of mutual advantages to the three countries. One major gap in the investigation of the hydrological regimes of the Nile Basin is the measurement and analysis of erosion and sediment load, particularly for the Abbay-Blue Nile and Tekeze-Atbara sub-basins.

Monitoring of suspended sediment loads throughout the sub-basin at the outlets of micro-catchments, sub-catchments and catchments of varying size will provide inputs into research to develop a more complete understanding of the linkages between catchment size, geomorphology, soils and land use and the dynamics within the sub-basin. It will therefore be important that data collection systems be harmonized across the Eastern Nile Basin.

It will be important to monitor any changes in bed sediments and bank erosion in the downstream catchments given the possibility of significant reductions in suspended sediment from catchments in the upper sub-basins as a result of ongoing and future watershed management interventions (soil and water conservation structures, water harvesting and small dams) as well as new large dams proposed and under construction. An integrated erosion-sediment monitoring program could be combined with a bed and bank erosion monitoring program downstream to provide a complete system-wide understanding of erosion, sediment delivery, suspended sediment, bed aggradation and degradation, and river bank erosion.

In addition to the monitoring of physical impacts it will be vital to monitor and evaluate impacts of watershed management interventions on the livelihoods of households and communities and the incidence and prevalence of poverty levels. This will require a social and economic impact analysis that must be integrated with the systems of physical monitoring. Given the complexity and size of the Eastern Nile Basin an effective system of sampling will be required to capture this diversity and to make the program manageable.

It is important that the results of the monitoring and evaluation studies feed into the national and basin-wide development policy making process. The research and evaluation results will address the policy implications of the findings and recommendations for policy review and possible revision and trans-boundary harmonization.

Component 3: Preparing first and second round investment project profiles

The Watershed Management CRA identified and prepared project profiles for a number of potential follow-up watershed management projects. These are detailed in the following section. In a first phase the program will support ENTRO in prioritizing and preparing full project documents from these profiles, seeking financing sources and coordinating their implementation. In collaboration with the ENSAP teams, criteria for prioritizing the projects will be established. It is possible that in some cases projects may be integrated where synergy between the projects can be achieved.

Analysis of the monitoring and impact assessments being undertaken under the auspices of Component 2 and also of the outputs of the first round of watershed management projects will reveal a number of issues and constraints not previously identified in the Watershed Management CRA. Some of these could be the result of major changes in national policies and strategies that impact on peoples' livelihoods and their utilization of the natural resource base. Other issues could emerge from the implementation of other ENSAP-IDEN projects and of components in the Joint Multi-purpose Program. It is important to recognize that the context within which watershed management interventions are being implemented is extremely dynamic and ENTRO must be responsive to these dynamics.

As with the first round projects ENTRO will identify and prepare full project documents and determine implementation modalities for second-round projects. It will also continue to seek funding and initiate and coordinate project implementation.

Component 4: Knowledge development activities

Prior to undertaking major development activities, there is an urgent need to undertake studies and other research to improve the knowledge base regarding the complex hydrology, ecology and livelihood systems of the peoples living in the environmental hot spots identified by this study. There are grave risks of going ahead with an investment program for watershed development and management without fully understanding the eco-hydrological and livelihood systems characterizing the sub-basin.

A case in point is the Baro-Akobo-Sobat White Nile sub-basin, the most isolated of the four sub-basins. The sub-basin exhibits a complex system of hydrology and ecology that strongly influences the livelihood systems of the peoples of the sub-basin. Although some studies have been conducted in connection with the construction of the Jonglei canal, the Baro-Akobo-Sobat sub-basin was largely not covered. The sub-basin lowlands have seen nearly two decades of civil war with the resulting breakdown in physical, economic and social infrastructure. Under the Comprehensive Peace Agreement (CPA) the region is now initiating development programs to support sustainable livelihood development and reduce vulnerability to external shocks. As some of the peoples of the sub-basin are found in both Ethiopia and Sudan, and given the strong hydrological and ecological linkages, it would be important that this is undertaken as a joint Ethiopian-Sudanese study.

The component would support participatory field studies, data collection and analysis, transport and equipment. 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 the Report of the Joint Assessment Mission (JAM) have analyzed in considerable detail the modalities and conditionalities required to achieve these problems. In terms of watershed management to achieve sustainable livelihoods the key problems can be summarized as follows:

- The need to obtain a detailed knowledge of the complex systems of hydro-ecology in the whole of the Sobat-White Nile sub-basin (in both Ethiopia and Sudan). While the Bahr el Jebel River 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 hydro-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.

6 Proposed Long-term Watershed Management Activities and First Round Projects

- The need to determine the potential impacts of upstream hydrological developments (dams, hydro-power, irrigation) on the sensitive hydro-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.

This is just one example of studies required to unravel the existing complexities in these sub-basins, and all such studies will require careful coordination by ENTRO. Consultation and knowledge sharing with stakeholders (including donors) will be important and ENTRO will have to provide the forum for this to take place. A longer list of potential knowledge development projects that could be undertaken under the supervision of ENTRO is detailed in section 6.3.

Component 5: Capacity building and institutional strengthening

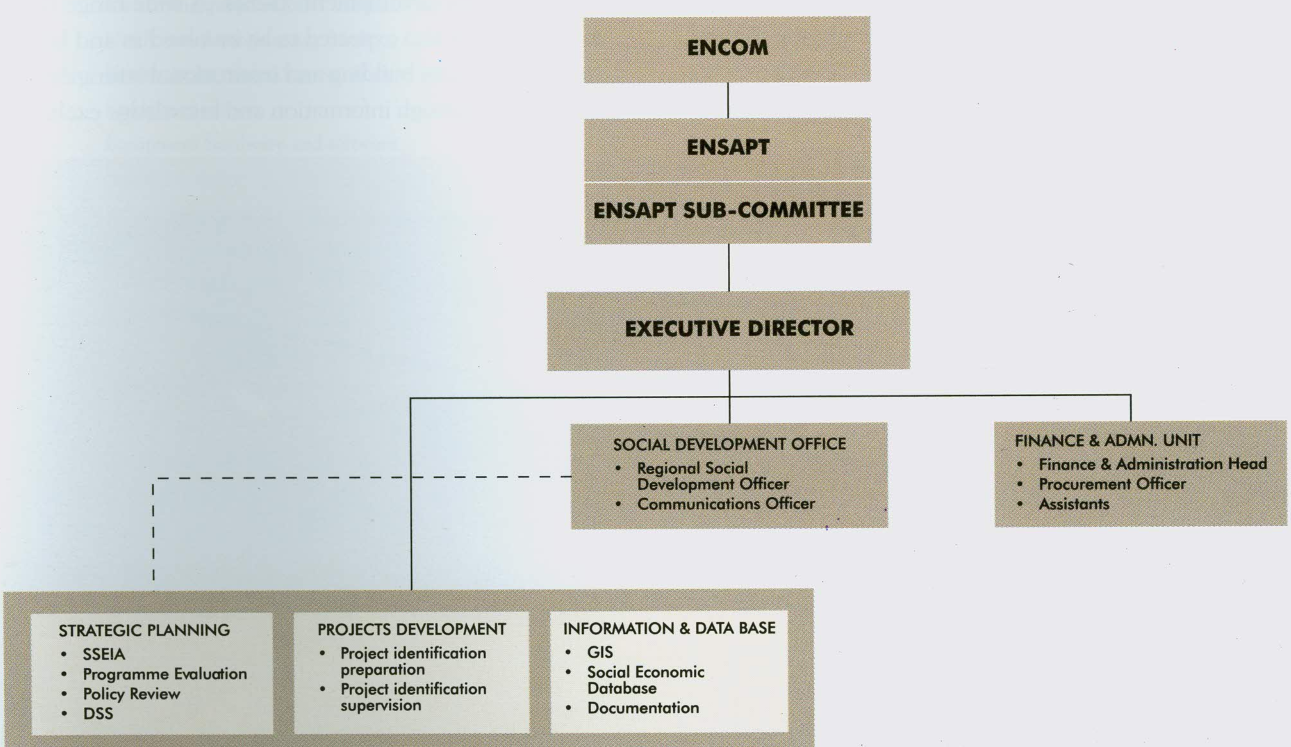
This component would support capacity building and institutional strengthening in watershed management planning, monitoring, evaluation and impact studies through improved communication, information exchange and specific training. These would be implemented through specially commissioned courses, regional training workshops, linkages to universities and national research institutes and civil society organizations involved in watershed management activities. It would have strong linkages with Components 2 and 4.

6.2.3 Management and implementation arrangements

ENSAP and ENTRO

As the Joint Multi-purpose Program (JMP) moves into Phase II and the long-term IDEN Projects come into operation, the organizational structure of the Projects Coordination Unit is likely to see considerable expansion. Although its exact composition cannot be determined at this stage it would incorporate a functional structure as shown in Figure 6.1.

Figure 6.1: Possible Future Organizational Structure of ENTRO



The Eastern Nile Watershed Management Program would be coordinated through the Projects Development Unit and in particular through ENTRO's Regional Watershed Management Coordinator who will be the Eastern Nile Watershed Management Program Coordinator. The Program Coordinator will be supported by technical specialists in project planning and in monitoring and evaluation.

Program Steering Committee

A Program Steering Committee will be established to provide strategic guidance to the Program. The Steering Committee will review and approve annual work plans and will receive and review annual substantive and financial reports on program activities. The steering committee will be composed of the watershed management focal point from each participating country and any relevant donor partners. The World Bank and other appropriate parties will be invited as observers to the meetings.

The Steering Committee is expected to meet at least annually and its location may circulate among the three countries. It will be alternately chaired by the host country member of the Steering Committee, while ENTRO's Project Coordinating Unit will provide secretariat support.

National Program Coordinators

The Program will employ a National Project Coordinator (NPC) in each of the participating countries. The NPCs will be responsible for supervising and coordinating the implementation of program activities at the country level. At the national level the NPC will keep the National Focal Point (who covers all activities, projects and programs under ENSAP) informed on all matters relating to the watershed management program. The NPC will provide a critical link between ENTRO's Watershed Management Program Coordinator, the national and international specialists and the various organizations involved in implementing different program components within the respective countries. The NPC will be a full-time position that is program-funded and competitively hired with the active involvement of the concerned Ministry. The NPCs will be housed in a Ministry to be selected by each country. They will be supported by a National Working Group (NWG) comprising representatives from a wide range of concerned stakeholders.

Universities and research institutes

Two sub-components of Component 2, the sample watershed erosion-sediment monitoring and the sample watershed impact assessment studies, will be contracted to research teams from universities and/or research institutes. This will support the program's capacity building component, contribute to the sharing of knowledge and enhance cooperation among the riparian countries.

Participation and stakeholder involvement

The program components aim to broaden and deepen stakeholder involvement in watershed management. Program implementation will ensure participation of all relevant stakeholders, including ministries of water, agriculture, and forestry, NGOs, educational institutions, local and traditional communities, and private sector organizations. Local stakeholders, especially communities and smaller NGOs and CBOs will be actively involved. This will be particularly important in implementing the impacts assessments undertaken at the local level and in the knowledge development studies. A wide range of stakeholders is also expected to be involved in and benefit from the capacity building and institutional strengthening component through information and knowledge exchange.

6.2.3 Program cost summary

The total cost of the proposed Watershed Management Program is US$ 15.133 million, as detailed in Table 6.1.

Table 6.1: Costs of the proposed watershed management program US$ '000

	Component	Cost
1	**Program coordination**	**2,903**
1.1	Program management staff	1,946
1.2	Program office equipment	80
1.3	Vehicles	22
1.4	Program management expenses	460
1.5	National Program Coordinator expenses	315
1.6	Unallocated contingency funds	80
2	**Watershed management information database and impact assessment monitoring**	**2,125**
2.1	Document center	70
2.2	Environmental, social and economic database	40
2.3	Geographical information system	105
2.4	Basin-wide sediment monitoring system	300
2.5	Erosion and sediment monitoring and research: sample watersheds	775
2.6	Environmental, social and economic impact assessment	775
2.7	Unallocated contingency funds	60
3	**Preparation of first and second round watershed management projects**	**4,270**
3.1	Prioritizing, preparing and coordinating implementation of 1st round projects	1,988
3.2	Identifying, preparing and coordinating implementation of 2nd round projects	1,982
3.3	Unallocated contingency funds	300
4	**Knowledge development activities**	**660**
4.1	Study preparation	100
4.2	Equipment hardware and software	150
4.3	Study contracts	300
4.4	Knowledge sharing, report production and dissemination	90
4.5	Unallocated contingency funds	20
5	**Capacity building**	**5,175**
5.1	Formal training	3,550
5.2	Regional training workshops	1,475
5.3	Unallocated contingency funds	150
	PROGRAM TOTAL	**15,133**

6.3 FIRST ROUND OF COOPERATIVE WATERSHED MANAGEMENT PROJECTS

This section outlines potential first-round investment projects that will be prepared in detail as Component 3 of the Cooperative Watershed Management Program. The projects have been identified as having met four broad sets of criteria:

- The projects will support and enhance cooperation among the three riparian countries in sustainable watershed management.
- Local, national, regional and where possible global benefits will accrue to the projects.
- The project will address the threats to the biodiversity and natural resource degradation 'hot spots' identified in the trans-boundary analysis.
- The projects will support other IDEN projects, the JMP and other NBI projects.

The interventions identified in the trans-boundary analysis and costed in the Distributive Analysis were assessed using the criteria outlined above. Costs are approximate and were estimated on the basis of similar components of projects within the NBI and other recent project documents. The results of the assessment are presented in Table 6.2. All projects have the potential to be included in the first round of watershed management projects to be prepared for the long-term Eastern Nile Watershed Management Project. Whether all or only a selection of these projects is included in the first round and the order in which they are prepared is a decision to be made by ENTRO, ENSAPT and ENCOM. However, this analysis provides a basis for such an assessment.

Table 6.2: A strategic framework for investment

PROJECT	CHALLENGES	DIRECT INTERVENTIONS	SUPPORTING INTERVENTIONS	DIRECT BENEFITS	SECONDARY BENEFITS	REGIONAL/GLOBAL BENEFITS
PROFILE 1. Integrated Watershed Management: Abbay Sub-basin – Chemoga Watershed, Ethiopia	• Severe land degradation in area of high agricultural potential • Catchment major contributor of sediment to Abbay River • High population densities • Land shortage • Livestock feed deficits	• SWC on cropland • Area closure on communal land • Micro-credit fertilizer & improved seed • On-farm forage development • Dairy production • Small-scale irrigation • Crop diversification	• Feeder roads • Improved market infrastructure • Increased access to market information • Capacity building for extension and research • Increased access to micro-credit • Literacy and skills training	• Arresting crop and communal land degradation • Increased crop and livestock productivity • Increased food security • Increased farm incomes • Reduced time for biofuel collection • Increased access to technology and Information • Wider range of livelihood strategies	• Improved nutrition and health • Increased availability of wild plants • Reduced vulnerability to climatic, economic and social shocks • Improved access to off-farm employment • Improved human and social capital assets	• Reduced sediment loads and downstream sedimentation • Reduced loss of biodiversity (crop and wild plants) • Increased sequestration of soil carbon

PROJECT	CHALLENGES	DIRECT INTERVENTIONS	SUPPORTING INTERVENTIONS	DIRECT BENEFITS	SECONDARY BENEFITS	REGIONAL/GLOBAL BENEFITS
PROFILE 2. Integrated Watershed Management: Abbay Sub-basin – Fincha'a Watershed, Ethiopia	• Severe land degradation in area of high agricultural potential • Sedimentation of Fincha'a Reservoir and Chomen Wetlands • High population densities • Land shortage • Livestock feed deficits	• SWC on cropland • Area closure on communal land • Micro-credit fertilizer and improved seed • On-farm forage development • Dairy production • Small-scale irrigation • Crop diversification	• Feeder roads • Improved market infrastructure • Increased access to market information • Capacity building for extension and research • Increased access to micro-credit • Literacy and skills training	• Arresting crop and communal land degradation • Increased crop and livestock productivity • Increased food security • Increased farm incomes • Reduced time for biofuel collection • Increased access to technology and Information • Wider range of livelihood strategies	• Improved nutrition & health • Increased availability of wild plants • Reduced vulnerability to climatic, economic & social shocks • Improved access to off-farm employment • Improved human and social capital assets	• Reduced sediment loads & downstream sedimentation • Reduced loss of biodiversity (crop & wild plants) • Increased sequestration of soil carbon

6 Proposed Long-term Watershed Management Activities and First Round Projects

PROJECT	CHALLENGES	DIRECT INTERVENTIONS	SUPPORTING INTERVENTIONS	DIRECT BENEFITS	SECONDARY BENEFITS	REGIONAL/GLOBAL BENEFITS
PROFILE 3. Integrated Watershed Management: Abbay Sub-basin – Upper Beshilo Watershed, Ethiopia	• Severe land degradation in area of low agricultural potential • Low but variable rainfall – high crop risk • Poor road & market accessibility • High population densities • Land shortage • Livestock feed deficits	• SWC on cropland • Area closure on communal land • Micro-credit fertilizer & improved seed • On-farm forage development • Improved small livestock production • Small-scale irrigation • Crop diversification	• Feeder roads • Improved market infrastructure • Increased access to market information • Capacity building for extension and research • Increased access to micro-credit • Literacy and skills training	• Arresting crop & communal land degradation • Increased crop & livestock productivity • Increased food security • Increased farm incomes • Reduced time for biofuel collection • Increased access to technology and Information • Wider range of livelihood strategies	• Improved nutrition and health • Increased availability of wild plants • Reduced vulnerability to climatic, economic and social shocks • Improved access to off-farm employment • Improved human and social capital assets	• Reduced sediment loads & downstream sedimentation • Reduced loss of biodiversity (crop and wild plants) • Increased sequestration of soil carbon

PROJECT	CHALLENGES	DIRECT INTERVENTIONS	SUPPORTING INTERVENTIONS	DIRECT BENEFITS	SECONDARY BENEFITS	REGIONAL/GLOBAL BENEFITS
PROFILE 4. Integrated Watershed Management: Abbay Sub-basin – Upper Jema Watershed, Ethiopia	• Severe land degradation in area of low agricultural potential • Low but variable rainfall – high crop risk • Poor road and market accessibility • High population densities • Land shortage • Livestock feed deficits	• SWC on cropland • Area closure on communal land • Micro-credit fertilizer & improved seed • On-farm forage development • Improved small livestock production • Small-scale irrigation • Crop diversification	• Feeder roads • Improved market infrastructure • Increased access to market information • Capacity building for extension & research • Increased access to micro-credit • Literacy and skills training	• Arresting crop and communal land degradation • Increased crop & livestock productivity • Increased food security • Increased farm incomes • Reduced time for biofuel collection • Increased access to technology and Information • Wider range of livelihood strategies	• Improved nutrition and health • Increased availability of wild plants • Reduced vulnerability to climatic, economic and social shocks • Improved access to off-farm employment • Improved human and social capital assets	• Reduced sediment loads and downstream sedimentation • Reduced loss of biodiversity (crop and wild plants) • Increased sequestration of soil carbon

PROJECT	CHALLENGES	DIRECT INTERVENTIONS	SUPPORTING INTERVENTIONS	DIRECT BENEFITS	SECONDARY BENEFITS	REGIONAL/GLOBAL BENEFITS
PROFILE 9. Arresting Gully Erosion and Restoration of *Kerib* Land, Atbara Sub-basin, Sudan.	• Extreme gully erosion and loss of rainfed cropland • High rates of sediment delivery to Atbara River	• Establishment tree nurseries • Establishment of forage grass seed banks • Technical support of arresting gully erosion	• Capacity Building • Strengthening Extension Service • Support to Micro Finance Institutions (MFI's) • Improved Accessibility and Market Linkages • Community Woodland Management Planning and Implementation • Support to State-wide Strategic Land Use Planning • Support to Community Level Land Use Planning	• Loss of cropland arrested • Increased supply of fuel wood & wood products • Increased supply of forage	• Reduced time for fuelwood collection • Increased livestock productivity • Increased household incomes	• Reduced sediment load in Atbara River & sedimentation in Kashm el Girba Reservoir and New Halfa Irrigation Scheme • Increased plant biodiversity • Increased soil carbon sequestration

PROJECT	CHALLENGES	DIRECT INTERVENTIONS	SUPPORTING INTERVENTIONS	DIRECT BENEFITS	SECONDARY BENEFITS	REGIONAL/GLOBAL BENEFITS
PROFILE 10. Reducing Rangeland Degradation and Improving Livestock productivity in the Butara Plains, Atbara & Blue Nile Sub-basins, Sudan	• Rangeland degradation • Lack of access to rain season grazing areas • Reduced livestock feed supply • Low livestock productivity	• Designation of stock routes to wet season grazing areas • Development of livestock water points • Fodder bank development at permanent villages • Experimental rotational grazing and aerial seeding • Establishment of Community –based Animal health Workers	• Capacity building • Strengthening extension service • Support to Micro Finance Institutions (MFI's) • Improved accessibility and market linkages • Community woodland management planning and implementation • Support to state-wide Strategic Land Use Planning • Support to community level Land Use Planning	• Rangeland degradation arrested • Increased livestock feed • Improved animal health • Increased livestock productivity • Increased animal off-take	• Increased access to livestock markets • Increased households incomes • Improved nutrition and health	• Increased soil carbon sequestered • Increased floral species biodiversity

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Proposed Long-term Watershed Management Activities and First Round Projects

PROJECT	CHALLENGES	DIRECT INTERVENTIONS	SUPPORTING INTERVENTIONS	DIRECT BENEFITS	SECONDARY BENEFITS	REGIONAL/GLOBAL BENEFITS
PROFILE 11. Reducing Rangeland Degradation and Improving Livestock productivity in the Flood Retreat Grasslands of the Pibor-Sobat-White Nile Sub-basin, Sudan	• Short period of soil moisture for pasture production • Livestock feed deficits • Poor/No access to livestock markets	• Support to construction of check dams in depressions • Designation of stock routes to livestock markets • Development of livestock water points • Fodder bank development at permanent villages • Support to Community –based Animal health Workers	• Capacity building • Strengthening extension service • Support to Micro Finance Institutions (MFI's) • Improved accessibility and market linkages • Community woodland management planning and implementation • Support to state-wide Strategic Land Use Planning • Support to community level Land Use Planning	• Increased livestock feed • Improved animal health • Increased livestock productivity • Increased animal off-take	• Increased access to livestock markets • Increased households incomes • Improved nutrition and health	• Increased species biodiversity

PROJECT	CHALLENGES	DIRECT INTERVENTIONS	SUPPORTING INTERVENTIONS	DIRECT BENEFITS	SECONDARY BENEFITS	REGIONAL/GLOBAL BENEFITS
PROFILE 12. Livelihoods Support to the Ababda and Bishari Communities in the Wadi Allaqi, Sudan and Egypt.	• Extremely fragile environment • Strong reliance on charcoal production from scarce Acacia tree stocks • Need for alternative to vegetable production with acute marketing problems	• Tree nursery establishment • Technical support to Acacia tree establishment • Technical support to increase efficiency of charcoal production • Technical support to irrigated forage production (including foundation seed supply)	• Capacity building	• Sustainable charcoal production ensured • Secure source of cash from fodder sales	• Reduced vulnerability to shocks • Increased household income • Improved nutrition and health	• Improved conservation of biodiversity

PROJECT	CHALLENGES	DIRECT INTERVENTIONS	SUPPORTING INTERVENTIONS	DIRECT BENEFITS	SECONDARY BENEFITS	REGIONAL/GLOBAL BENEFITS
PROFILE 13. Establishment of the Dinder-Alatish Trans-boundary National Park	• Area of high biodiversity threatened from unsustainable grazing and harvesting of NTFPs and illegal hunting • Alatish park requires national recognition and Park Management Plan • Need to harmonize two Park Management Plans • Communities living in and around the Park rely heavily on water, fuelwood and NTFP's from inside the Parks	• Support to Sudan and Ethiopia to establish formal Transboundary Park status and align Park Management Plans • Support to Community engagement in Park management Planning, Implementation and Monitoring • Support to both countries for information sharing and joint Park monitoring • Livelihoods support to Communities in and around the Parks to reduce pressure on natural resources (domestic and livestock water supplies; on-farm forage development, on-farm and community tree planting; Improved seed)	• Capacity building • Strengthening extension service • Support to Micro Finance Institutions (MFI's) • Improved accessibility and market linkages • Community woodland management planning and implementation • Support to state-wide Strategic Land Use Planning • Support to community level Land Use Planning	• Increased crop and livestock productivity • Increased households incomes • Increased employment opportunities • Increased protection for wild flora and fauna and habitats	• Shared experiences in community-based park management • Cost-effective joint management of the Park as one eco-system • International recognition and ability to secure both Government and external funding. • Local communities actively involved and part of conservation process	• Biodiversity preserved and enhanced.

Given that there is considerable on-going national-level investment in various components of integrated watershed management in these areas, the best approach would be to design them to be incremental and supplementary to on-going investment. These projects could be incremental either in terms of components or in terms of geographical coverage. They could also start as pilot projects which could be scaled up in terms of geographical coverage after an initial period of investment, say 3-5 years.

6.4 Knowledge development activities

Potential knowledge development projects and research that can be further detailed as Component 4 of the ENWMP are outlined in this section. The knowledge development activities mentioned in the section outlining the Components of the ENWMP are vital to guiding investment in the environmental hot spots identified by the Watershed Management CRA. Further, the trans-boundary nature of these hot spots, or the fact that their effects flow across national boundaries, implies a strong coordination role for ENTRO in overseeing these knowledge development activities.

A set of eight such activities have been detailed in terms of their estimated costs, their links to ongoing or proposed NBI projects, the degree of institutional complexity and their likely primary, secondary and regional or global benefits (Table 6.3). This information is to assist the final choice of activities, which will be at the discretion of the Eastern Nile Subsidiary Action Program.

6 Proposed Long-term Watershed Management Activities and First Round Projects

Table 6.3: Potential knowledge development activities

Interventions	Outline costs (US$ million)	Links to IDEN JMP, NBI projects	Institutional complexity	Direct benefits	Secondary benefits	Regional/Global benefits
PROFILE 1: Collaborative Research into arresting drifting sand and moving sand dunes	1.65	Yes Fast track WSM (Egypt, Sudan)	Simple: In-country Research on-going	• Practical and effective means of arresting drifting sands and moving dunes established	• Shared scientific knowledge of the physics of wind blown sand	• Firm foundation and modalities established for future collaborative research and cooperation
PROFILE 2: Establishment of the Trans-boundary Wadi Allaqi Biosphere Reserve	1.20	Yes Fast track WSM Egypt	Simple: Biosphere Reserve already established in Eqypt	• Shared experiences in Biosphere Reserve management, • cost-effective joint management of the Reserve as one eco-system	• Shared scientific knowledge of this unique ecosystem.	• Enhanced conservation of biodiversity
PROFILE 3: Joint Tekeze-Atbara Ground and Surface Water Survey & Development Plan	8.22	Yes Fast Track WSM Sudan, IDEN Irrigation & Drainage	Moderately complex: Some institutional networking thru UNESCO-HELP	• Improved and more potable water supplies and improved health and well-being. • Improved water supplies for livestock.	• Sustainable exploitation of surface water in terms of water harvesting & irrigation would increase crop production, reduce food insecurity and improve livelihoods.	• Experience would be gained in joint surveys and development planning of shared natural resources. • Sustainable exploitation of surface and sub-surface water resources would be achieved across the sub-basin

Interventions	Outline costs (US$ million)	Links to IDEN JMP, NBI projects	Institutional complexity	Direct benefits	Secondary benefits	Regional/Global benefits
PROFILE 4: Joint Dinder-Rahad Watershed Management Plan	8.50	Yes IDEN Flood Control, Irrigation & Drainage	Moderately complex: Need to establish new institutional mechanisms	• Upstream at the local level WSM interventions would have a positive impact on crop and livestock production through reduced soil erosion and degradation	• Positive impacts on livelihoods and increased food security. • Downstream at the local level reduced sediment loads and sedimentation of *maya'a* wetlands • More assured water supply for human, livestock and wildlife.	• Increased flood buffering capacity of *Maya'as* reducing flood damage on rainfed and irrigated cropland. • Biodiversity value of the maya'a wetlands would be enhanced
PROFILE 5: Abbay-Blue Nile Wetlands Survey and Management Plan	8.10	Yes IDEN Flood Control, Irrigation & Drainage	Moderately complex: Need to establish new institutional mechanisms	• Accurate inventory and threat assessment of the Blue Nile Wetlands would be obtained; • Sound plan for their sustainable management and conservation would be developed	• Hydrological services maintained (flood buffering, sediment reduction, dry season flows enhanced) • Sustainable livelihoods enhanced; vulnerability reduced	• Biodiversity value of wetlands preserved and enhanced.
PROFILE 6: Joint Wildlife and Habitat Inventory and Assessment: Boma & Gambella National Parks	2.80	Yes NBI Environment	Moderately complex: Need to establish new institutional mechanisms, although work already commenced in Sudan	• Shared experiences in wildlife and habitat inventory and assessment, • Shared experiences in scientific research, • Cost-effective joint survey across an area of two countries	• Assessment of the total ecosystem and a firm foundation for Park Management Planning for the two Parks	• Firm foundation and modality established for future cooperation in biodiversity conservation between the Sudan and Ethiopia • Enhanced conservation of biodiversity

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Proposed Long-term Watershed Management Activities and First Round Projects

Interventions	Outline costs (US$ million)	Links to IDEN JMP, NBI projects	Institutional complexity	Direct benefits	Secondary benefits	Regional/Global benefits
PROFILE 7: Comprehensive Watershed Management Research project: Choke Mountain Chain, Abbay-Blue Nile Sub-basin	9.80	Yes IDEN Flood control, Irrigation & Drainage	Moderately complex: Need to establish new institutional mechanisms	• Increased scientific knowledge of the complex relationships between land cover, land management, hydrology, erosion, deposition in the landscape, sediment delivery to the river system and fluvial sediment transport	• More effective watershed management interventions and a deeper understanding of their potential impacts at various scales	• Increased cooperation and knowledge sharing and confidence building among countries of the Eastern Nile Basin; • Increased capacity in sciences of hydrology, erosion and sedimentation and the establishment of a cadre of professionals knowledgeable in the practical applications of these areas
PROFILE 8: In-depth Study: Determination of the Economic, Social and Environmental benefits & Costs of Watershed Management Interventions in the Eastern Nile Basin	0.95	Yes IDEN Eastern Nile Planning Model	Simple: Some on-going work thru TerrAfrica	• Increased knowledge of the economic, social and environment al benefits and costs of watershed management interventions in the context of multi-purpose cooperative development of the eastern Nile Basin and thus increasing the scope and effectiveness of impact assessment of such investments;	• Increased capacity in environmental and social economics and the establishment of a cadre of professionals knowledgeable in the practical applications of this area of economics.	• increased cooperation and knowledge sharing and confidence building among countries of the Eastern Nile Basin;

6.5 Funding Options

This section outlines the options for sharing program costs at the regional and the global levels. At the regional level 'process financing' is an incremental way of developing confidence and capacity of the riparian countries, and includes direct financing from bi-lateral and international funding organizations such as trust funds, revolving funds and public-private partnerships. At the global level the Global Environmental Fund (GEF) and the Carbon Fund are two of the most accessible financing sources. These are discussed in more detail below.

6.5.1 Trust funds

One option to fund the watershed management interventions is the existing multi-donor and World Bank-managed Nile Basin Trust Fund (NBTF) (Box 6.1).

Box 6.1: The Nile Basin Trust Fund

The Nile Basin Initiative (NBI) is essentially funded by a consortium of bilateral and multilateral donors, besides the riparian countries themselves. The development partners of the NBI comprise national governments of the riparian countries, governments of Canada, Netherlands, Denmark, Norway, Sweden, United Kingdom, Finland, Italy, France, United States of America, and Germany, multilateral agencies (World Bank, European Union and the African Development Bank), and United Nations organizations (Food and Agriculture Organization, United Nations Development Program, The United Nations Office for Project Services). Till date the development partners have contributed over US$ 130 million of the original pledge of US$ 150 million. Of the total program cost, $14.4 million has come from counterpart funding by the governments of riparian countries.

In 2003, a multi-donor trust fund called the Nile Basin Trust Fund (NBTF) was set up at the request of the Nile Basin Council of Ministers. NBTF is managed by the World Bank and major contributors are bilateral donors (Canada, Denmark, Netherlands, Norway, Sweden and the United Kingdom). The majority of funds supporting NBI programs and projects are administered through the NBTF, which has proved to be an effective mechanism for harmonizing donor support to the NBI.

Source: www.nilebasin.org accessed on 25 September 2007

The NBTF is an example of process financing (Nicol et al., 2002, ODI/Euroconsult, 2001) where consortium finances are found for different components of the investment program. The NBTF currently supports the preparation and implementation of NBI programs, including the basin-wide Shared Vision Program (SVP) and the sub-basin investment programs in the Eastern Nile (ENSAP) and the Nile Equatorial Lakes Region (NELSAP).[18] Other examples of process financing include the Indus Basin (by the World Bank) and the Mekong Basin (by UNDP). Other potential initiatives can assist not only with financing but also with policy coordination and sustainable development at the local level. Examples of these include the Global Water Partnership (GWP) which promotes integrated water resource management; the Trans-boundary River Basin Initiative (TRIB) and the Global Water Alliance. The NBI is aware that as preparation of the subsidiary action programs progresses, innovative financing mechanisms beyond the NBTF will be needed for preparing and implementing large-scale investments. Some of the alternative financing options available are explored below.

6.5.2 Bilateral Funds

As an alternative to the NBTF, bilateral donors can provide support to individual projects of the NBI through mutually agreed channels. These donors can thus directly fund the ENWMP.

6.5.3 Global Environmental Facility

Since many of the watershed management interventions proposed have significant global benefits, including conservation and an increase in genetic, species and habitat biodiversity, the Operational Programs (OPs) of the Global Environmental Facility (GEF) are a useful source of additional funding. The GEF typically funds only 'incremental' costs but can assist in leveraging funding from other sources. The relevant GEF OPs of interest in the current context are the following:[19]

- OP3: Forest Ecosystems operational program
- OP8: Waterbody-based operational program
- OP9: Integrated Land and Water Multiple Focal Areas operational program
- OP12: Integrated Ecosystem Management operational program
- OP13: Biodiversity for Agriculture
- OP15: Sustainable Land Management

The World Bank, UNDP and FAO are the three implementing agencies of the GEF, and there are four types of grants: full-sized projects, medium-sized projects, enabling activities and small grants. Regular full-sized projects are USD 1 million and above, while all the others are below USD 1 million. In some cases, the actual cost of the project may be supported. Separate allocations for biodiversity conservation have been made under the GEF 4 program for the period 2006-2010. For the three Eastern Nile Basin countries this totals US$ 16.3 million overall, and US$ 8.0 for the first two years (Table 6.4).

Table 6.4: Indicative country-specific GEF allocations for biodiversity conservation (US $ million)

Country	Indicative allocation for GEF4 (2006-2010)	Indicative allocation for 2006-2008
Egypt	4.3	2.1
Ethiopia	7.7	3.8
Sudan	4.3	2.1
TOTAL	16.3	8.0

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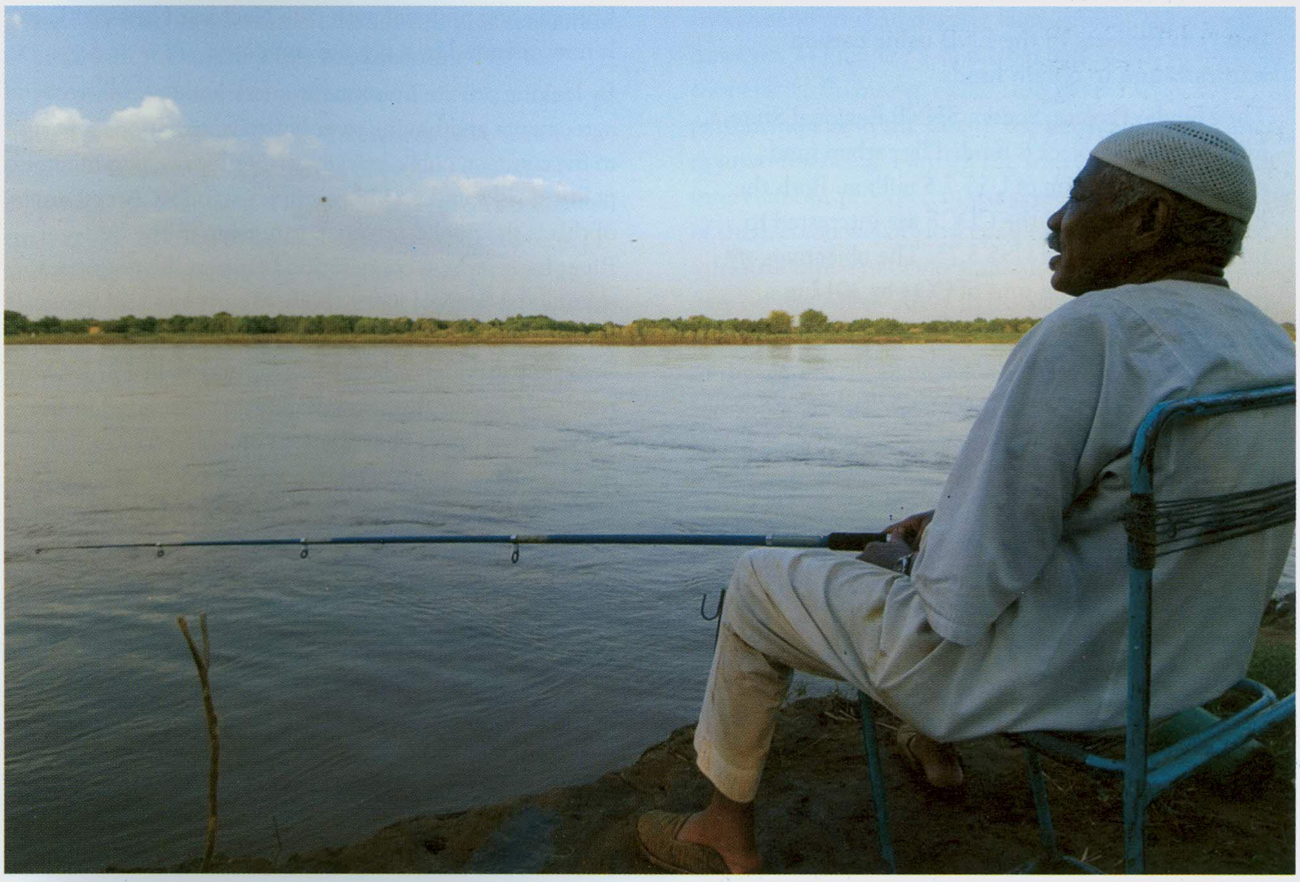
These funds clearly will finance only a portion of the total cost of the proposed watershed management program, but could be a useful source of additional funding for individual projects and activities.

6.5.4 Carbon Funds

The main funding options available to support carbon sequestration efforts world-wide are the Prototype Carbon Fund (PCF), the BioCarbon Fund, the Community Development Carbon Fund (CDCF) and the country funds and technical assistance facilities of the Organization for Economic and Cooperation and Development (OECD). Carbon funds owe their origins to the Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC), which in 1997 introduced flexible trade instruments comprising Emission Trading (ET), Joint Implementation (JI) and the Clean Development Mechanism (CDM) in order to help achieve greenhouse gas emission reduction objectives. The CDM enables emissions from developed countries to be offset in developing countries in which emissions reduction accruing to specific projects is quantified relative to baseline scenarios. These are supposed to represent the probable emissions in the absence of intervention. The CDM is geographically eligible for Ethiopia, Sudan and Egypt as its purpose is to help less developed countries (LDCs) achieve sustainable development and assist developed countries (DCs) to attain compliance with their quantified emission limitation. Carbon funds work as agents buying carbon credit on behalf of government and large corporations to help them offset their emissions with one carbon credit equivalent to 1 ton of greenhouse gas including carbon dioxide. These credits are issued if the government meets the CDM standards of additionality, quantification, permanence, leakage, monitoring and verification.

Forestry measures are not yet included under the CDM but are likely to be included soon, given the significance of forests in developing countries within the global carbon cycle and the importance of terrestrial carbon fluxes within the national emission inventories of most developing countries.



The role of forests within such trading systems could be important as a means of providing a cap to the cost of emission reduction at least in the medium term. Assessment of pilot projects around the world indicates that large amounts of carbon may be sequestered by forestry at costs in the range of US$ 10 - 30 per ton of carbon. The global potential for enhancing forest carbon storage may reach 60 - 90 giga-tons of carbon through decreasing the deforestation rate and increasing the reforestation rate.

Currently, however, only reforestation appears to be eligible for financing under recent rules agreed to under the Kyoto Protocol. Carbon funds cannot finance incremental costs because they are only available at the end of the project-cycle. The BioCarbon Fund and the Finnish JI/CDM Pilot Program are interested in afforestation or reforestation CDM projects even though the BioCarbon Fund is currently oversubscribed.

Terracing, agroforestry, afforestation, reforestation, grazing regulation and area protection are watershed management interventions that may be eligible for carbon funding with the most frequently quoted activities being water, wind, sun, biomass and hydropower. But carbon funds are reluctant to fund 'sink projects' where carbon is sequestered through land use, land use change and forestry (LULUCF) including afforestation and reforestation because of the problems of verification and leakage.

Two projects in the Eastern Nile Basin are presently using carbon sequestration to obtain financing: one in Ethiopia and the other in Sudan (Box 6.2 and Box 4.1).

Box 6.2: Projects in the ENB using carbon sequestration to obtain funds

The Humbo Project, Soddo, SNNP Regional State, Ethiopia: The project is funded by carbon fund purchases to the sum of US$ 7.5 million. Both the BioCarbon Fund and the CDCF are interested to purchase at a price of US$ 3.75. The objectives are to sequester 2 million tons of CO_2 by 2012 in a biodiverse forest and to simultaneously reduce poverty in the Humbo and Soddo *weredas* with support to education, health and food security financed by carbon funds. Some 15,000 hectares of biodiverse natural forest are to be restored and conserved. The stock of carbon would be monitored and verified over time. In addition the project will pilot community ownership and management of public land within a framework of broad core values (carbon sequestration, biodiversity enhancement, natural resource management, poverty reduction), and restore the habitats for a number of threatened species including the Ethiopian Banana Frog, the Ethiopian Thicket Rat and the Nechisar Nightjar.

Source: World Bank (2005d)

6.5.5 Inter-riparian countries financing using national funds

Investments in trans-boundary waters are usually solely on a national basis. But financing between riparian countries is possible where countries finance investments beyond their borders. Examples of such financing include the dredging of the Westerschelde estuary undertaken by the Dutch but funded by Belgium. Pre-requisites for such financing arrangements include an obvious benefit to the financing country that exceeds the financial (and political) costs of implementation; a precise definition of the scope of works, defined responsibilities for cost overruns and a joint management structure to oversee the works (Nicol et al., 2002).

6.5.6 Private-public partnerships

Although the private sector has had only limited engagement in trans-boundary water management, it has played a significant role in other sectors with regional or global implications. One example is the role of the private sector in ozone depletion and climatic change: A revolving fund has been set by the GEF in Thailand to introduce cleaner refrigerators. It is suggested that similar revolving funds could be set up at the trans-boundary level to promote private sector investments with regional and global benefits such as watershed management, water treatment and pollution abatement by providing grants, technical assistance and loans to the private sector. In the Eastern Nile Basin, for example, a revolving fund could be set up to establish a trans-boundary national park incorporating the Dinder National park and Alatish Regional Park. In Ethiopia one national park (the Nechisar National Park) is now operated by a private company.

By locking private investment into trans-boundary agreements and having river basin organizations a party to the contract, public-private partnerships help to minimize political risks and provide contract stability. An example of this is the public-private partnership in the Senegal River basin, where cooperation between the countries sharing the Senegal River (Mali, Mauritania and Senegal) resulted in the signing of a convention to establish the Senegal River Development Organization in 1972. One result of this was the Manantali Dam completed in the 1990's using donor contributions and US$ 620 million worth of loans guaranteed by export credit agencies. By 1997 trans-boundary legal and institutional arrangements were reinforced by the establishment of an inter-state public company (SOGEM) for the management and the exploitation of the Manantali dam. SOGEM awarded Escom of South Africa the contract to operate and maintain the power generating unit.

Public-private partnerships can be supplemented by political risk insurance and investment guarantees such as those provided by the Multilateral Investment Guarantee Agency (MIGA) which is part of the World Bank Group and the Lloyds Syndicate in the private sector.

6.5.7 Payments for environmental services

Payments for environmental services (PES) are innovative instruments for the financing of sustainable watershed management interventions and typically involve the payment of a user fee by downstream entities to upstream dwellers for the provision of environmental services. The latter may include planting on degraded mountain slopes and the up-rooting of invasive plants and vegetation. PES offer the prospect of simultaneously diminishing land degradation and reducing income poverty with typical schemes that rely on legal, government and financial institutions to function well. There are, however, examples that show that PES are adaptable and may function well even under atypical conditions (Landell-Mills and Porras, 2002).

PES implementation in the Eastern Nile Basin is possible provided that it is adapted to site and well thought through, including anti-poverty targeting. It may be an option to start implementing PES at local levels through NGOs in the absence of strong official institutions, but it is important to give the PES legitimacy in the community eyes in order to help sustainability and compliance. There is, however, a need for careful assessment, monitoring and evaluation of land-water relations while implementing PES for improved watershed management.

Initiatives to develop PES in watersheds have mainly focused on identifying potential buyers and payment collection mechanisms. The latter depend on consumers' trust in the efficacy of actions to ensure the provision of and access to watershed services even though they may have public good characteristics. PES options include (i) payment of the opportunity cost for forests at risk, (ii) flat payment scheme with a cap on allowable hectares, and (iii) opportunity cost payment for forests at risk, that maximizes the services per dollar paid. The last may be the most efficient and the second the most egalitarian. Larger and more remote communities receive most of the budget but payments to them are not necessarily more efficient. This scheme results in more, though smaller, payments to poor and indigenous communities and is thus more efficient than payments to non-poor and non-indigenous forest communities.

However, PES are typically smaller in scale than the full range of watershed management interventions being contemplated, although it would be a useful adjunct to other component-specific funding sources.

6.5.8 Overview of funding opportunities

The benefit-cost calculations for the watershed management intervention in the Eastern Nile Basin clearly indicate that the total sum of incremental benefits exceed the incremental costs (ENTRO, 2007). The question is of finding the requisite finances for the proposed watershed management interventions to realize the potential benefits. Process financing has a much longer history than the more innovative financing mechanisms indicated above. The IDEN projects are part of a process financing mechanism. The NBI process financing also includes a trust fund mechanism for financing particular projects. A continuation of the process financing mechanism would be the most advantageous process in the short to medium term. Investments in shared water management infrastructure, however, will require a shift from trust funds to regional cooperative financing, either through public-private partnerships as in the case of the Senegal basin or inter-riparian financing. Further, the watershed management interventions proposed in the present report or a sub-set of these could well form a component in such a shared infrastructure. An obvious case is the proposed Karadobi dam on the Abbay River in Ethiopia, which is currently under consideration in the Joint Multi-Purpose Program. If the watershed management interventions were incorporated into the overall design of the dam it would have benefits in terms of increased sustainability of livelihoods of the inhabitants in the catchment area, but also reduced sediment loads in the Abbay and the conservation of biodiversity and increased sequestration of soil and wood carbon.

7 Conclusions

This chapter summarizes the key issues and linkages to be considered when developing watershed management programs designed to enhance sustainable livelihoods of poor households, reduce poverty and arrest resource degradation.

7.1 Costs of natural resource degradation

The Eastern Nile Basin and its river systems form an important shared resource for the three riparian countries. However, rising populations, natural resource degradation, increasing levels of poverty and livelihood vulnerability pose serious challenges to sustainable development.

In the absence of watershed management interventions soil erosion and degradation and deforestation will continue at accelerating rates, reducing agricultural productivity and increasing the numbers of households 'churning' at and below the poverty line. Even though many costs of resource degradation were not possible to quantify in the time available, the Distributive Analysis of the Watershed Management CRA conservatively estimated that the (measurable) economic costs of the degradation of the natural resource base in the Eastern Nile Basin are currently some US$ 437 million a year and these will reach US$ 3,632 million in 25 years time. In social terms the costs of poor nutrition on the health and well-being of the peoples of the basin are manifested in physical pain and suffering. In political terms they will lead to increased levels of resource-based conflicts and a breakdown in social order.

7 Conclusions

Many resource degradation processes have impacts not only locally, but downstream within and beyond the borders of the country within which they occur as well as on the global community. The Distributive Analysis estimated that, of the measurable degradation costs. some 61 per cent were incurred in-country, 14 per cent were incurred regionally and 25 per cent were incurred globally. All the regional costs were due to sedimentation in reservoirs and around power turbine intakes, resulting in the need for flushing during periods of high sediment loads and the consequent loss of power generation, the need to clean irrigation canals and the reduction of irrigation water. Other costs of high sediment loads not quantified in the analysis include damage to irrigation pumps and the increased costs of water purification for domestic and industrial water supplies.

7.2 Benefits of watershed management

It has been recognized that cooperative development and management of the Eastern Nile Basin as one river system offers tremendous opportunities for economic development (ENTRO, 2003). Sustainable watershed and environmental management and enhanced agricultural productivity are two key entry points for arresting and reversing the downward spiral of poverty and natural resource degradation. To be successful, however, watershed management interventions must address the high rates of poverty and unsustainable livelihoods affecting many of the peoples of the basin.

7.2.1 Watershed management interventions

To address both the proximate and the root causes of natural resource degradation in a river basin context requires a very broad-based program of direct and supporting interventions. At the micro-catchment level the direct interventions must be well integrated and address degradation problems of the landscape as a whole. They require a mix of interventions that target individual and communal lands, cropland and grazing lands and rain-fed and irrigated lands. The interventions must focus on raising or stabilizing agricultural productivity and must be financially and culturally acceptable to individual and communal investors.

At a higher level the interventions must address the root causes of low investment in sustainable land management (SLM) practices. The Distributive Analysis clearly revealed that while many SLM investments are financially profitable in the medium term there is often a short-term period of negative returns that many resource poor farmers and communities cannot afford. Also, the poorly functioning marketing systems within the Eastern Nile Basin are a major cause of high transaction costs to farmers, leading to low crop and livestock prices and high input costs, which further reduce their ability to undertake SLM investments. Off-farm income is a vital element in the livelihood strategies of many farm and pastoral households but employment opportunities in the many small urban centers do not exist because of weak rural-urban linkages.

Thus a watershed management program must comprise supporting interventions such as improved access to markets through feeder road construction, improved access to micro-credit, the provision of safety net support such as food or cash for work, skills and literacy training to increase access to off-farm employment, and technical support to small and medium scale enterprises to increase employment levels.

7.2.2 Economic development and poverty reduction

The benefits of a watershed management program of interventions to a development and poverty reduction program accrue at four levels: household or community, national, regional or sub-basin, and global.

The results of the benefit-cost analysis of on-farm and community level interventions demonstrate that farm and community level interventions can arrest the degradation of the natural resource base, increase agricultural productivity and food supply with improved levels of nutrition and health, thus reducing vulnerability to climatic, social and economic shocks. As indicated above, there are situations where short-term support (e.g. credit, food or cash for work) may be required. Many interventions also have secondary impacts. For example, interventions that increase accessibility to fuel wood (on-farm tree planting) together with the reduction in firewood consumption (improved stoves) considerably reduce the work loads of women and children. In addition, there are positive impacts on their health and well-being through reduced smoke inhalation, thus reducing the incidence of respiratory diseases.

Supporting interventions will have substantial positive impacts on households and communities. Measures to increase market accessibility and integration such as feeder roads and extension of telecommunications will reduce market transaction costs thus benefiting both producers and consumers. This will result in an expansion of local economic multipliers, particularly through increased purchases of local non-tradable goods as well as backward multipliers (increased purchases of inputs) and forward multipliers (from an increase in marketed agricultural goods). These will in turn increase employment opportunities in many small urban centers.

At the national level regional multipliers will also increase benefits through backward and forward linkages as well as the growth of tertiary and secondary urban centers, thus stimulating sub-regional economies. Increased physical accessibility together with capacity building, literacy and skills training will increase access to information, social services (health and education) and knowledge of improved technology. Support to national agricultural extension and research services will improve linkages between farmers, extension and research workers thereby increasing the relevance and effectiveness of research to the traditional farming sector. Further, targeting the traditional agricultural sector rather than the commercial agricultural sector will result in a proportionally greater impact in reducing the numbers of households living below the poverty line.

At the sub-basin level, while currently there is little trans-boundary trade among the riparian countries, the expansion of the sub-regional economies on both sides of the border and improved cross-border roads links will increase the integration of sub-regional economies. Closer cooperation with crop early warning systems, establishment of joint strategic grain reserves and local purchases of grains for food relief will enable faster responses to local food shortages on both sides of the border. Reduced erosion in the Ethiopian Highlands and lower sediment loads in the Abbay-Blue Nile and Tekeze-Setit-Atbara river systems will lower downstream costs of dredging power intakes, irrigation canals and the loss of power generating potential due to the need for reservoir flushing. These reductions will also contribute to reductions in costs that could not be quantified, of pump and turbine damage and the removal of sediment for domestic and industrial water supplies. Integrated watershed management measures in the upper Dinder and Rahad catchments will reduce sedimentation of the downstream wetlands thus reducing the incidence of flooding of agricultural lands.

At the global level there are a number of opportunities for increasing the sequestration of carbon dioxide and for conserving genetic, species and habitat biodiversity. The opportunities for carbon sequestration are particularly substantial in the area of increasing soil carbon–a hitherto neglected area. Soil carbon increases substantially under well managed or enclosed pastures and rangeland. The proposed interventions for establishing a trans-boundary park incorporating the Dinder and Alatish Parks will bring substantial benefits of conserved biodiversity in this important area. Similar benefits will accrue with trans-boundary cooperation in the Gambella and Boma National Parks.

7.3 Funding options

The benefit-cost calculations for the WSM intervention in the Eastern Nile Basin clearly indicate that the total sum of incremental benefits exceed the incremental costs (ENTRO, 2007). The present process financing mechanism, using the Nile Basin Trust Funds, may not be sufficient to cover all the costs of the proposed watershed management interventions. The options for consortium funding of different components of the proposed interventions include the carbon fund options, the various operational programs of the Global Environmental Facility, and regional cooperative financing either through public-private partnerships or through inter-riparian countries.

7.4 Conclusions

The primary objectives of watershed management in the Eastern Nile Basin are to arrest natural resource degradation, alleviate poverty and support more sustainable livelihoods for the peoples of the Basin.

Watershed management and its impact of enhancing agricultural production is the key to developing any multi-purpose program, given its potential to break the vicious cycle of resource degradation and poverty. The costs of not implementing watershed and environmental management interventions are expected to rise from US$ 437 million currently to US$ 3,632 million in 25 years time. The social and political costs of inaction could be catastrophic. Without a program of watershed management interventions degradation of the natural resource base will accelerate, poverty levels will rise and households will increasingly face vulnerability to climatic and other shocks.

The benefits of a broad-based program of direct and supporting watershed management interventions will accrue at four levels: household or community, national, regional and global. Degradation of the natural resource base will be arrested, enhanced productivity will raise households out of grinding poverty and their livelihoods will be secured from external and internal shocks. The present value of benefits are conservatively estimated at US$ 13,176, and could increase if all potential environmental benefits are included. On the other hand, the current costs of direct and supporting interventions are estimated to be US$ 466 million, giving a present value of net incremental benefit of US$ 8,510.

Clearly, an integrated and effective watershed management component will contribute incalculably to the overall goal of ENSAP of poverty reduction and a sustainable utilization of the natural resource base.

1. Of only those costs that could be quantified – many costs of resource degradation were not possible to quantify in the time available.

2. Regional workshops were held at Barhir Dar (Ethiopia), Khartoum (Sudan), Alexandria (Egypt) and Makelle (Ethiopia).

3. These are areas where the rate of soil loss exceeds that of soil formation of 9 tons per hectare per year.

4. The Government of Sudan provided land on lease to set up large-scale rain-fed cultivated farms which are called semi-mechanized farms (SMFs). These are semi-mechanized because, while land preparation, seeding and some threshing is mechanized, weeding and harvesting is undertaken using seasonal labor (World Bank, 2003a).

5. Most researchers credit Aubreville (1949) with the term

6. Over-drainage is caused by constructing the central drainage channel too deep and lowering the water table below the rooting level of most plants.

7. This definition is from http://www.dcnr.state.pa.us/brc/rivers/riversconservation/registry/Sewickley_Creek/watersheddef.pdf, which goes on to state: 'Each stream has its own watershed. Topography is the key element affecting this area of land. The boundary of a watershed is defined by the highest elevations surrounding the stream. A drop of water falling outside of the boundary will drain to another watershed. The US EPA defines a watershed as 'the area of land where all of the water that is under it or drains off of it goes into the same place' (US EPA http://www.epa.gov/owow/watershed/whatis.html, accessed on 22 September 2007).

8. Terms of reference of the Watershed Management Cooperative Regional Assessment, 2004.

9. http://www.michigan.gov/deq/0,1607,7-135-3313_3682_3718-14389--,00.html, accessed on 23 September 2007.

10 Kerr et al, (2006), p.1. An externality is said to occur when 'the activities of one person affects the welfare or production functions of other people who have no direct control over those activities' (Dorfman and Dorfman 1977). For a comprehensive overview of the role of positive and negative externalities in watershed development in India, see World Bank (2006).

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

12. Similar findings have been found Central America and the Caribbean (Lutz, et al., 1994).

13. A. Wood, personal communication, 2006

14. Since there already is an efficient traditional stove in Tigray, a reflection of fuel wood scarcity over a long period, the adoption of the gounziye is unlikely in the Tekeze sub-basin

15. Adding environmental benefits and costs have been known to increase NPV and EIRR substantially. In the China Hubei Hydropower project, adding environmental benefits raised NPV by 49% & EIRR by 1.9%, while in the Armenia natural resource management project, including local and regional environmental benefits raised NPV by 130% and IRR by 4%, and in the Loess Plateau Watershed Rehabilitation Project, adding sedimentation reduction & global benefits raised EIRR from 19% to 22% (James, 2005).

16. Work in an inaccessible area of Nigeria similar to many parts of rural Ethiopia and Sudan suggested a multiplier of 1.32 for the non-tradable sector (Hazell and Roell, 1983).

17. The preservation of 'options' for future human development, which may be yet-unknown and contained within ecosystems, is a benefit to the global population, giving them an interest in preserving the ecosystem or watershed in question.

18. All details of the funding mechanisms of the Nile Basin Initiative are from the official website of the NBI, http://www.nilebasin.org/index.php?option=com_contentandtask=viewandid=43andItemid=97; accessed on 27 September 2007.

19. The procedures for funding and further details of each OP are available on the GEF website: http://www.gefweb.org/operational_policies/raf/IndicativeAllocations.html

20. Where the rate of soil loss exceeds that of soil formation of 9 tons per hectare per year.

21. This compares with an MOA (2006a) estimate of the annual average rental value of SMF land of SDD 4,144 per feddan (SDD 9, 867 per hectare). The present value over 50 years at 10 per cent discount rate is SDD 97,826 per hectare (US$ 489 per hectare).

22. Comments on the first draft of the Distributive Analysis Report from the Sudan Steering Committee (SSC, 2007b).

23. From a Table of Indicator Values for Egypt received from Egypt Steering Committee (ESC, 2007).

24. Baro-Akobo land cover was mapped using 1989 Landsat imagery and Abbay using 2000 imagery.

25. Comments on the first draft of the Distributive Analysis Report from the Sudan Steering Committee (SSC, 2007b).

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Afforestation	Planting trees on land that has not been covered with forest historically.
Biodiversity	Biodiversity or biological diversity refers to the variety of species of plants, animals and micro-organisms, and the ecosystems and ecological processes of which they are part. Diversity does not refer to the number of individuals within species.
Carbon financing	The World Bank Group's carbon fund activities including their own carbon funds as well as the carbon funds they manage for other organizations.
Carbon dioxide sink	A carbon reservoir that is increasing in size and the opposite of a carbon 'source'. The main natural sinks are the oceans and plants and other organisms that use photosynthesis to remove carbon from the atmosphere by incorporating it into biomass. This concept of CO2 sink has become more widely known because of its role in the Kyoto Protocol. Natural CO2 sinks are soil and forests:
(i)	Soil: Carbon as plant organic matter is sequestered in soils: Soils contain more carbon than is contained in vegetation and the atmosphere combined. Soils' organic carbon (humus) levels in many agricultural areas have been severely depleted. Grasslands contribute to soil organic matter, mostly in the form of roots, and much of this organic matter can remain unoxidized for long periods.
(ii)	Forest: Carbon is incorporated into forests and forest soils by trees and other plants. Through photosynthesis, plants absorb carbon dioxide from the atmosphere, store the carbon in sugars, starch and cellulose, and release the oxygen into the atmosphere. A young forest, composed of growing trees, absorbs carbon dioxide and acts as a sink. Mature forests, made up of a mix of various aged trees as well as dead and decaying matter, may be carbon neutral above ground. In the soil, however, the gradual buildup of slowly decaying organic material will continue to accumulate carbon, but at a slower rate than an immature forest. The forest eco-system may eventually become carbon neutral. Forest fires release absorbed carbon back into the atmosphere.
Carbon sequestration	The uptake and storage of carbon. Trees and plants for example absorb carbon dioxide, release the oxygen and store the carbon. Fossil fuels were at one time biomass and continue to store the carbon until burned. Carbon sequestration is the term describing processes that remove carbon from the atmosphere. To help mitigate global warming, a variety of means of artificially capturing and storing carbon -- as well as of enhancing natural sequestration processes -- are being explored.
Certified emission reduction	A carbon credit generated by a Clean Development Mechanism carbon project.
Clean development mechanism	One of the flexible mechanisms under the Kyoto Protocol for trading with carbon credits.
Income11 Or consumption. poverty	Poverty defined with respect to a money-based poverty line for income or expenditure. The distinction is made between this and other concepts that emphasize the many dimensions of poverty. The income poverty line is set internationally at one dollar a day.
Incremental net benefit	The net benefit of a project investment is equal to the gross benefit minus the cost. It is a residual that is available to recover the investment (return of capital) and to compensate for the use of the resources invested in the project (return to capital). Deducting the without-project net benefit from the net benefit gives the incremental net benefit.
Internal rate of return (IRR)	The internal rate of return is a discounted measure of project worth and may be defined as the discount rate that makes the NPV of the incremental net benefit or incremental cash flow equal to zero. The internal rate of return may also be defined as the maximum interest rate that an investment project can pay for the resources used if the project is to recover its investment and operating costs and still just break even. The selection criterion is to accept all independent investment projects with an IRR greater than the cut-off rate which generally is the opportunity cost of capital.
Kyoto protocol	Because growing vegetation absorbs carbon dioxide, the Kyoto Protocol allows countries that have large areas of forest (or other vegetation) to deduct a certain amount from their emissions thus making it easier for them to achieve the desired net emission levels. Some countries want to be able to trade in emission rights in carbon emission markets to make it possible for one country to buy the benefit of carbon dioxide sinks in another country. If overall limits on greenhouse gas emission are put into place, such a "cap-and-trade" market mechanism will tend to find cost-effective ways to reduce emissions. There is as yet no carbon audit regime for all such markets globally and none is specified in the Kyoto Protocol. Each nation is on its own to verify actual carbon emission reductions and to account for carbon sequestration using some less formal method. In the Clean Development Mechanism, only afforestation and reforestation are eligible to produce CERs in the first commitment period of the Kyoto Protocol (2008–2012). Forest conservation activities or activities avoiding deforestation which would result in emission reduction through the conservation of existing carbon stocks, are not eligible at this time. Also agricultural carbon sequestration is not possible yet.
Land degradation	Reduction of the capacity of the land – together with factors such as climate, topography, soils, hydrology, and vegetation - to produce goods and services. It is more than just a physical or environmental process. Ultimately it is a social problem with economic costs attached as it consumes the product of labor and capital inputs into production.

National poverty line	Poverty lines drawn by national governments or national statistical offices to measure poverty. It is not possible to make comparisons between countries using national poverty lines as each is calculated on the basis of criteria specific to that country.
Net present value	The net present value is a discounted measure of project worth and may be defined as the present worth of the incremental net benefit or incremental cash flow. The selection criterion is to accept all independent investment projects with an NPV greater than zero when discounted at the opportunity cost of capital.
Poverty determinants	The characteristics that are closely associated with being poor such as living in a rural area or having a large number of children. These can be used to target public expenditure in the absence of detailed information relating to every household of the individual.
Poverty gap	A measure of the average distance of poor individuals or households below the income poverty line.
Poverty line	Represents the level of income or consumption necessary to meet a set of minimum requirements to feed oneself and one's family adequately and/or to meet other basic requirements such as clothing, housing and health care. Those with incomes or expenditure equal to or above the line are not poor. While what the minimum should be has an important subjective element, poverty lines are typically anchored to minimum nutritional requirements plus a modest allowance for non-food needs.
Public good	A public good is one that benefits a lot of people at the same time and the benefit to any one person is not affected by the benefit to another (joint consumption). It is also difficult to prevent anyone from enjoying benefit once it is provided (Appropriation problem). When local benefits have no market such as those of indirect use values like watershed protection, they are local public goods. When environmental benefits are global making if difficult for countries to appropriate benefits, the latter are called global public goods.
Risk	Probability of a hazard occurring.
Sensitivity analysis	Sensitivity analysis illustrates the impact on the NPV, IRR or ERR of a given percentage change in a key variable. It highlights the most critical variables that might need more careful specification but has limited value in assessing the confidence placed on the NPV, IRR or ERR estimates.
Soil degradation	A broader term for declining soil quality encompassing the deterioration in physical, chemical, and biological attributes of the soil. Soil degradation is a long-term process. Both erosion and nutrient breach are part of soil degradation.
Soil erosion	A physical process referring to the wearing away of the land surface by water and/or wind as well as to the reduction in soil productivity due to physical loss of topsoil, reduction in rooting depth, removal of plant nutrients, and loss of water. Soil erosion events are quick processes.
Standard conversion factor	A standard conversion factor is a number usually less than 1 that can be multiplied by the domestic financial market price, opportunity cost or value in use of a non-traded item to convert it into an equivalent economic border price that reflects the effect of trade distortions on domestic prices of that good or service.
Targeting	The process by which expenditure is directed to specific groups of the population defined as poor or disadvantaged in order to increase the efficiency of the use of resources.
Vulnerable	Vulnerability defined by combination of exposure to risk, sensitivity to shock (i.e. impact when a shock happens) and level of resilience and often referring to persons with an income poverty equal to 0.75 - 1.25 times the income poverty line.

ANNEXURE 1 | LIST OF REPORTS PRODUCED

1. **Inception Report**
2. **Trans-boundary Analyses Reports**

   2.1 *Country analysis*
   Egypt Country Report
   Ethiopia Country Report
   Sudan Country Report

   2.2 *Sub-basin analysis*
   Baro-Sobat-White Nile Sub-basin Report
   Abbay-Blue Nile Sub-basin Report
   Tekeze-Atbara Sub-basin Report
   Main Nile Sub-basin Report

3. **Distribution Analysis Report**
4. **Cooperative Mechanisms Analysis Report**
5. **Proposed Long-term Watershed Management Activities and First Round Projects**

   5.1 Eastern Nile Cooperative Watershed Programme
   5.2 Ten Project Profiles: First Round Watershed Management Projects

6. **Paper:** 'Contribution of watershed management interventions to a multipurpose investment programme for Eastern Nile Basin'

A2.1 Soil erosion and degradation and loss of agricultural production

A2.1.1 Sheet and rill erosion (Ethiopia)

Agricultural production lost as result of soil erosion is caused by reduced soil depth and thus moisture-holding capacity, and by nutrient losses in the soil that is eroded. Using estimates of soil loss rates on cropland derived from geographical information system (GIS) analysis, and the impact reduced soil moisture has on crop yields enabled an estimate to be made of the annual accumulating reduction in crop yields and the accumulating loss of crop production. Similarly using estimates of the commensurate loss of the soil nutrient – nitrogen - and its relationship to crop yield enabled estimates to be made of the annual reductions in crop yield from the annual loss of plant available nitrogen.

The total amount of soil eroded each year in the Ethiopian Highlands of the Eastern Nile Basin is estimated at 447.0 million tons of which 150.5 million tons is from cultivated land and 296.5 million tons is from mainly communal grazing and settlement areas. The area of cultivated land whose use is considered to be unsustainable,[20] is estimated at 4.46 million hectares.

The impact on crop production due to the decline in soil-moisture holding capacity caused by soil erosion is the loss of 18,665 tons of grain equivalent per year. Each year this loss accumulates so that the loss of crop production in 25 years is 466,585 tons per year. Soil erosion also causes a nutrient loss that decreases crop production annually and non-cumulatively by 53,566 tons per year. Annual losses due to soil erosion are US$ 17.4 million rising to US$ 125.2 million.

A2.1.2 Breaches in soil nutrient cycle (Ethiopia)

Loss of agricultural production is also caused by breaches in the soil nutrient cycle caused in turn by the burning of dung and crop residue and removal of crop grain. Using data from a national household energy survey on dung collected from cropland and crop residues that are used as fuel together with their nutrient values enabled an estimate to be made of the annual loss of nutrients from the soil. The nutrients contained in grain removed from cropland constitute another loss. Accounting for annual natural replenishment of available nitrogen to the soil nutrient pool gave the net loss of nitrogen. Focusing on the key soil nutrient nitrogen and using the estimated incremental crop yield due to nitrogen application enabled estimates to be made of the crop production forgone.

The breaches in soil nutrient cycling caused by dung/crop residue burning and crop grain removal reduces crop production annually and non-cumulatively by 207,980 tons and 680,256 tons respectively. Taken together with the annual loss of nitrogen due to soil erosion these crop losses are valued at US$ 213.2 million annually.

A2.1.3 Soil fertility decline (Sudan)

Semi-mechanized rain-fed farms

Annual decline in yields on the semi-mechanized farms has been estimated between 2 and 5.1 per cent per annum (World Bank, 2003a). The conservative figure of 2 per cent has been used in the analysis. This yield decline is attributed to declines in soil fertility caused by the lack of fallowing combined with loss of soil structure, sub-soil compaction and excessive weed growth (in particular the parasitic weed *striga*).

Assuming that approximately 3.59 million hectares are cropped annually this represents an annual accumulating loss of production of 34,350 tons declining to 23,204 tons in 25 years time. This represents a loss of US$ 7.3 million in the first year rising to US$ 146.8 million after 25 years.

Traditional Rain-fed Farms

The problem of soil nutrient depletion and degradation on traditional held land is not as severe as on the SMF land. This is because traditional farmers are to some extent able to fallow their land. In addition, they do not use heavy machinery for cultivation. Finally, most traditional farmers practice crop rotation with sorghum followed by sesame, which although it does not increase soil fertility does reduce the build up of weeds (particularly *striga*).

Nevertheless, because of the encroachment of the SMF's, the land available for fallowing has decreased leading to longer periods of cultivation. This in turn leads to declining soil fertility and an increase in weeds. Farmers' do not use manure on their fields as they say that it spreads weed seeds and leads to a build of weeds. Crop residues are removed from fields as livestock feed, construction material and to facilitate tractor operations.

Approximately 672,400 hectares of small-scale, rain-fed cropping have been mapped in the Eastern Nile Basin. The World Bank estimate for yield declines in the traditional rain-fed farm sector is 1 per cent per year. This would indicate an annual cumulative loss production of 3,227 tons declining to 2,535 tons in 25 years time. This represents a loss of US$ 0.73 million in the first year rising to US$ 15.4 million after 25 years.

A2.1.4 Gully erosion: *kerib* land (Sudan)

Extensive *kerib* land is located along the Atbara-Setit River, along the lower Dinder and Rahad Rivers, and parts of the Blue Nile River. Area data and soil loss rates are only available for the Atbara-Setit River. It is estimated that some 3,000 hectares of land rain-fed cropland are lost each year. Using current net returns to rain-fed cropping and using a discount rate of 10 per cent and an infinite time horizon, it is estimated that the value of rain-fed cropland is US$ 301 per hectare.[21] The value of the annual accumulating loss of agricultural land is estimated to be US$ 0.9 million per year which will rise to US$ 20.7 million in 25 years time.

A2.1.5 River bank erosion (Sudan)

While certain information exists for certain reaches or a specific irrigation scheme there is no information on annual rates of bank erosion across the whole of the Eastern Nile Basin. Surveys undertaken by the Sudan Hydraulics Research Station over a period 1989 – 1999 in the Northern State Reach of the Main Nile estimated that some 19,400 *feddans* (8,150 hectares) had been lost or severely affected by river erosion. Assuming an estimated value of irrigated land of US$ 1,538 per hectare this would indicate that the cost of river bank erosion for those areas that have been surveyed as US$ 12.5 million.

A2.1.6 Encroachment of moving dunes

The dominant wind direction is from the northeast and the most hazardous dunes are located to the northeast of the Main Nile. These are located between Dongella and Karima. There are 14 smaller dune fields on (4) or close (10) to the river, and three larger fields 20 to 60 kilometers from the river. The source areas for the dune fields are the very extensive areas of loose and shifting sand that overlies the rock pavement as well as the three larger dune fields to the northwest. In addition to increased suspended sediment and bed load the sand tipped into the river causes point bars to form and these in turn cause accelerated river bank erosion. Currently the dunes threaten three villages of Argi, Abkar and Afaad, some 2,240 hectares of existing irrigated cropland and 9,520 hectares of potential cropland (10,000 beneficiaries).

The cropping pattern on the irrigated land is winter wheat and summer sorghum, vegetables and forage crops, together with permanent stands of date palm. Assuming net returns to irrigated summer sorghum and winter wheat of US$ 33.07 per hectares and US$ 120.69 per hectare and a discount rate of 10 percent and an infinite time horizon gives an estimated value of irrigated land of US$ 1,538 per hectare.

Thus the loss of existing irrigated land to dune encroachment would represent a cost of US$ 3.4 million and that of the potential cropland of US$ 14.6 million. The total potential cost of dune encroachment onto existing and potential cropland is US$ 18.1 million.

A2.2 Costs and benefits of sedimentation

A2.2.1 Costs of irrigation area lost to pond and small dam sedimentation (Ethiopia)

Small ponds

Small ponds have an average live storage capacity of 190 cubic metres (m3). There is a lack of data on rates of sedimentation of ponds. It was assumed that 100,000 ponds have been constructed and that 10 per cent are subject to a sedimentation rate of 5 per cent of live storage per year. Pond capacity is 190 m3 and the amount of sediment dredged is 9.5 m3. Actual dredging costs are US$ 4.62 per m3 of sediment giving an annual cost of US$ 0.44 million per year.

Small dams

Information was available for 54 small dams. The average sediment deposition was 5,900 per m3 per year (Haregeweyn et al., 2005). With dredging costs of US$ 4.62 per m3 total annual costs were estimated to be US$ 26,200 per year for each dam. Spread across 54 dams this would amount to US$ 1.4 million per year. These represent the annual damage avoidance costs of sedimentation in small dams.

A2.2.2 Irrigation area lost to reservoir live storage sedimentation (Sudan and Egypt)

Sudan

Annual loss of storage in the Roseires and Senner Reservoirs is approximately 0.007 per cent and 0 per cent per year.[22] At these storage loss rates there is little or no impact on loss of irrigation water.

Annual loss of storage in the Kashm El Girba Reservoir is approximately 1.54 per cent per year. Sedimentation is leading to downstream agricultural production forgone due to the loss of water for irrigation. Assuming a water duty of 8,140 cubic meters per hectare, the annual area of irrigated land lost is 2,457 hectares. Note that these losses are cumulative. The estimated net returns of US$ 61 per hectare for *Acala cotton* were used to estimate the financial value of production forgone (World Bank, 2000). Total first year costs are US$ 0.15 million rising to US$ 7.23 million after 25 years.

Egypt

The value of water in Egypt for irrigation is estimated to be LE 0.64 per m3 (US$ 0.11 per m3).[23] The annual loss of live storage is 0.139 billion m3, which represents an annual accumulating cost of US$ 15.5 million rising to US$ 387.5 million after 25 years.

A2.2.3 Costs of dredging and weed cleaning from irrigation canals (Sudan)

In 1991 some 9.78 million cubic meters of silt entered the irrigation canal system of the Gezira-Managil of which 62 per cent was deposited in the canals with the remainder being deposited in fields (World Bank, 2002). Desilting the 17,244 kilometers of irrigation and 10,650 kilometers of drainage canals in the Gezira scheme alone was estimated in 1997-98 to cost US$ 6.83 million per year. It is estimated that 0.70 million tons of silt enter the Rahad and other pump schemes along the Blue Nile River per year. Using the pro rata costs for cleaning, the estimated annual costs for cleaning the Rahad scheme are US$ 0.4 million. It is estimated that 6.08 million tons of silt enter the New Halfa scheme per year. Based on the costs incurred in the Gezira-Managil scheme the annual costs of cleaning would be approximately US$ 4.53 million. The only major irrigation scheme on the White Nile is the Kenana Sugar scheme. It is estimated that 0.27 million cubic meters of silt enter the Kenana scheme along the White Nile River per year. Using the pro rata costs for cleaning the Rahad scheme estimated annual costs are US$ 0.2 million.

A2.2.4 Costs of dredging turbine intakes (Sudan)

The need to dredge in front of turbine intakes occurs only at Roseires dam. More than 100,000 (m3) of sediment is removed annually from the intakes prior to the flood season (Siyam et al., 2005). Costs of clearing the intake are said to be US$ 20 per m3 at a total annual cost of US$ 2.0 million.

A2.2.5 Hydro-power lost due to flushing sediment through dams (Sudan)

Using data from the Sudan Electricity Corporation for the years 1965 to 2005 the average drop in power generation in the month of August when the dam is flushed compared with other months was 1.3 (MWh) with a value of US$ 0.13 million per year. Data for Rosieres is not available but assuming the same proportion of drop in total power output (1.53 per cent of mean annual output) this would be equivalent to about 1.86 MWh with a value of US$ 0.2 million per year. Annual power output data for Kashm El Girba were not available, but assuming the same proportion of drop in total power output this would be equivalent to about 0.11 MWh with a value of US$ million 0.01 per year.

A2.2.6 Hydro-power lost due to loss of reservoir live storage (Sudan and Egypt)

Sudan

The loss of hydro-power generation due to the very small or zero sedimentation rates in Roseires and Senner reservoirs is negligible. Sedimentation of the live storage in the Kashm el Girba reservoir leads to hydroelectricity production forgone and its estimated annual value is US$ 0.1 million per year. This loss is cumulative and the total value of electricity production forgone in 25 years will be US$ 2.8 million per year.

Egypt

The Aswan High Dam (AHD) has an installed hydro-power generating capacity of 2.1 million (MW) capable of generating 10,000 million kilo watt hours (kWh) annually. Production is currently at about 8,000 million kWh per year (Abu-Zeid and El-hibini, 1997). With annual (cumulative) loss of live storage of 0.155 percent this represents an annual accumulating loss of approximately 12.4 GWh. Using a value of LE 0.58 per kWh (US$ 0.10 per kWh) this represents an annual accumulating loss of US$ 1.2 million) rising to US$ 30 million after 25 years.

A2.2.7 Benefits of sedimentation in fields (Sudan)

In the large irrigation schemes some 38 per cent of sediment is deposited in fields: 2.99 million tons in Gezira, 0.93 million tons in Rahad, 2.31 million tons in New Halfa and 0.10 million tons in the Kenana scheme. No data is available for Sudan on the fertilizer equivalent of sediment deposited in fields. Some data is available from Egypt. Nixon (2004) estimated that prior to the construction of the Aswan High Dam some 35 million tons of sediment were deposited in the fields. Abu Zied and El-Shibini (2004) estimate the nitrogen content of the sediment deposited was 0.13 per cent, of which one third was available for plant growth. This would indicate that the sediment contained 45,500 tons of nitrogen of which 15,165 tons of nitrogen were available for plant growth. Urea fertilizer has a nitrogen content of 45 per cent. The available nitrogen is thus equivalent to 32,970 tons of urea. Thus each ton of sediment is equivalent to 0.94 kilograms of urea.

This would indicate that deposition of sediment in Gezira, Rahad, New Halfa and Kenana is equivalent to 6,118 tons of urea fertilizer. With a price of urea at US$ 286 per ton the benefits accruing to sediment deposition amount to US$ 1.75 million for the Gezira, Rahad, New Halfa and Kenana schemes. The gains are annual and not cumulative due to nutrient uptake by crops, leaching and volatization losses.

A2.3 Deforestation and forest/woodland degradation

To obtain an estimation of the cost of deforestation three Direct Use and five Indirect Use values were estimated. Direct Use values included the sustainable supply of (a) timber, (b) poles, and (c) fuel wood. Indirect use values included (i) carbon sequestration, (ii) watershed services, (iii) potential pharmaceutical products, (iv) species and habitat biodiversity, and (v) wild coffee gene pool.

It was assumed that clearing was for traditional agriculture. Thus to obtain the net value of forest products and services lost the value of agricultural production replacing the forest was subtracted from the gross value of forest removed. In addition it was assumed that 40 per cent of watershed services would continue to be provided by land under crop production (e.g. reduced evapo-transpiration from trees and increased water yield; continued use of traditional soil conservation measures and reduced erosion and sedimentation).

There has been no monitoring of land cover changes in response to the new resettlement and agricultural investment programs in Ethiopia or Sudan. For Ethiopia the WBISPP attempted to forecast future land cover changes resulting from natural population increase and agricultural land requirements in the Baro-Akobo and the Abbay sub-basins using 1990 and 2000 as the base years respectively.[24] Because of the ease of clearing, the land cover change model assumed that potentially arable land with shrubland would be cleared first, followed by woodland and then forest (WBISPP/MARD, 2001, WBISPP/MARD, 2003). In Sudan an estimate of woodland clearing was only possible for one locality in Blue Nile state.

The analysis was conducted at the *wereda* level using current population growth rates and crop, grazing and settlement land requirements of the existing farming systems. No account is taken of resettlement and migration, or of expansion of large medium scale commercial agriculture. On average 25,260 hectares of high forest and 107,190 hectares of woodland are cleared annually. Using altitude as the criteria (between 1,100 and 1900 masl) it is estimated that 29,100 hectares of high forest that is ecologically suitable for wild coffee is cleared annually.

A2.3.1 Deforestation: timber, poles and fuel wood value foregone

The wood biomass estimates of forest and woodland were obtained from the WBISPP inventory data. Values for timber, poles and fuel wood were taken from market data obtained by WBISPP. These are shown in Table A2.1.

Table A2.1 Unit values of timber, poles and fuel wood

Value	Unit	Unit Value (US$)
Timber	m3	35
Poles	m3	5
Fuel wood	m3	5

The total gross value of timber, poles and fuel wood foregone is shown in Table A2.2.

Table A2.2 Total gross value of timber, poles and fuel wood foregone due to deforestation

Value	Unit	Amount	Annual (US $ million/year)	In 25 years (US $ million/year)
Timber	m3	1,408,550	49.3	1,232.6
Poles	m3	785,700	5.6	140.1
Fuel wood	m3	251,900	13.4	334.5
Sub-total			68.3	1,707.2

Set against these losses is the value of crop production on the land cleared. This amounts to US$ 18.1 million per year rising to US$ 453.1 million per year in 25 years.

A2.3.2 Deforestation and degradation: loss of sequestered carbon

Two modes of long term carbon sequestration are possible in the present context: carbon sequestered in wood biomass and carbon sequestered in the soil. The relationship between wood biomass and its carbon content is approximately 50 per cent. Wood biomass in standing stocks of natural forest and woodland and of plantation species were obtained from the WBISPP inventory results for Ethiopia, from FAO (2004) and the Blue Nile Inventory (Theriault, 1995).

Carbon sequestered can be traded in the carbon market. Purchase prices vary widely. In Ethiopia the Humbo Woodland Conservation project is to receive US$ 3.75 per ton of carbon permanently sequestered. In the present analysis a more conservative value of US$ 3.00 per ton C has been used.

Deforestation: loss of sequestered carbon

An estimated accumulating 1.7 million tons of sequestered carbon are lost due to deforestation with a total value of US$ 5.1 million per year rising to US$ 127.5 million in 25 years.

Degradation: loss of sequestered carbon (Ethiopia)

An estimated 20 million tons of wood are unsustainably harvested as fuel wood and charcoal each year. This represents an annual accumulating loss of sequestered carbon of approximately 10 million tons valued at US$ 40.1 million per year rising to US$ 230.4 million in 25 years.

***Degradation: loss of sequestered carbon* (Sudan)**

In Sudan an estimated 13.3 million tons of wood are unsustainably harvested as fuel wood and charcoal each year. This represents an annual accumulating loss of sequestered carbon of 6.6 million tons valued at US$ 17.6 million rising to US$ 405.5 million in 25 years.

A2.3.3 Deforestation: non-timber forest products (NTFP's)

Estimates of the option value of potential pharmaceutical products vary from US$ 0.9 to US$ 6.3 per hectare (World Bank, 2005e). The value of NTFP's in Kenya's forests has been valued at US$ 17 per hectare although the study estimated that 30 per cent of this was unsustainable.

In the present valuation a conservative estimate of US$ 5 per hectare was used. Using these the estimated total value of NTFP's lost to deforestation is US$ 1.3 million per year rising to US$ 31.7 million in 25 years.

A2.3.4 Deforestation: loss of coffee gene pool

Hein and Gatzweiler (2006) have estimated the total value of Ethiopia's coffee gene pool to be between US$ 1,458 million (5 per cent discount rate) and US$ 420 million (10 per cent discount rate). The breakdown of this value is shown in Table A2.3. The valuation was based on an assessment of the potential benefits and costs of the use of C. arabica genetic information in breeding programs for enhanced coffee cultivars. The study considered there types of enhanced cultivars: increased pest and disease resistance, low caffeine content and increased yield potential. Costs and benefits were compared for a 30 years discounting period using 10 per cent and 5 per cent discount rates.

Table A2.3 Economic value of Ethiopian coffee genetic resources

Characteristic	NPV (US$ million) at discount rate	
	5 per cent	10 per cent
Disease resistance of which	617	169
CBD	61	11
Meloidogyne spp.	232	65
Coffee rust	323	94
Decaffeinated coffee	576	175
Yield increase	266	75
TOTAL VALUE	**1,458**	**420**

Source: Hein and Gatzweiler (2006)

The lower value of US$ 420 million was taken and divided by the number of hectares of high forest that was within the ecological limits (1,100 – 1,900 masl) for C. aribica to obtain the value of US$ 280 per hectare. Using this value the estimated value of losses is US$ 6.4 million per year rising to US$ 160.4 million in 25 years.

A2.3.5 Biodiversity values

Biodiversity values cover all other genetic, species and habitat resources. A World Bank cost assessment of environmental degradation of Iran placed a value US$ 16 per hectare on the value of biodiversity conservation of the Caspian forests (World Bank, 2005e). Akpalu and Parks (2007) used an estimate of US$ 23 per hectare for the value of biodiversity in Ghana's forests. Pearce (1996) in a review of a number of estimates for biodiversity value came to the conclusion that US$ 5 per hectare would be the most appropriate value. In the absence of estimates from Ethiopia or East Africa the value of US$ 5 per hectare was used in the analysis. Using this value the total value of loss of biodiversity due to deforestation is US$ 2.7 million per year rising to US$ 66.4 million in 25 years.

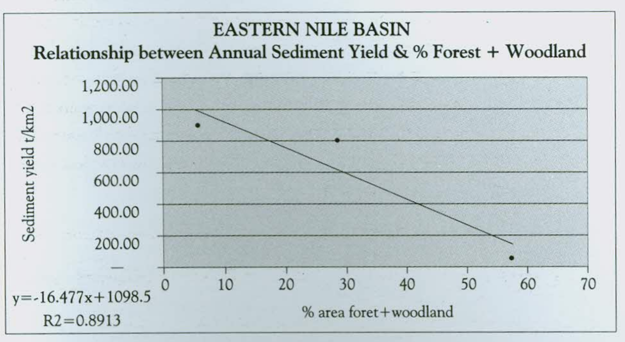
A2.3.6 Deforestation: loss of watershed services of forests and woodlands

The indirect values of forests and woodlands include watershed services. Chomitz and Kumari (1998) and Calder (2005) have warned that these benefits can be over estimated. However there is general agreement that they have the capacity to protect land from soil erosion and thus their removal can increase sediment loads in rivers.

The sediment delivery ratios (SDR) of the Tekeze-Setit-Atbara, Abbay-Blue Nile and Baro-Akobo-Sobat sub-basins (60 per cent, 43 per cent and 22 per cent respectively) are indicative of the value of forest and woodland cover in sediment retention. These were calculated as follows: the total amount of soil eroded in each of the three sub-basins within Ethiopia was determined from the GIS analysis (see below). The average sediment load of the Baro-Akobo, Abbay and Tekezi at the border was obtained. The SDR was calculated by dividing the average annual sediment load by the annual total soil loss in the sub-basin. The sediment yield was obtained by dividing the total annual sediment load at the border by the area square kilometers (square kilometres) of the sub-basins upstream of the border. The area of woodland and forest in each of the sub-basins was obtained from the WBISPP land Cover maps.

Figure A2.1 shows the sediment yield in tons per square kilometres in relation to the percent area of forest and woodland for the three catchments. For every 1 per cent increase in forest-woodland cover there is a reduction of 16.5 tons per square kilometres in sediment yield. Related to reduced sediment is the improved quality of water.

Figure A2.1 Annual sediment yield and forest and woodland cover for the Tekeze-Atbara, Abbay-Blue Nile and Baro-Sobat sub-basins



Flood dampening at the catchment or sub-catchment scale is another service provided by woodland and forest cover, although this is not likely to occur at the sub-basin level.

Placing values on all of these services requires considerable time and resources that were not available in the present study. Very detailed work has been carried out in Kenya on the watershed values of the Mau forests that are very similar floristically and structurally to the southwest montane forests of Ethiopia (Wass, 1995). This study estimated these values as US$ 42 per hectare. Emerson and Asrat (1998) valued the watershed services of vegetation cover in Eritrea using the replacement cost method – that is the cost of replacing vegetation with tree planting. Their value was US$ 844/hectare, which is considerably higher than the Kenya value.

The value of US$ 42 per hectare was used in the present analysis for montane forest and US$ 21 per hectare for dense Savanna Woodland given that woodland has a less dense ground cover. However it was assumed that under the new land cover (cropland and grazing land) some 40 percent of the original watershed services would remain. Using this value the total estimated value of watershed management services lost to deforestation is US$ 4.6 million per year rising to US$ 114.7 million in 25 years.

A2.4 Wetland degradation and loss of flood buffering services

Wetlands provide a number of environmental services and products. These include the following:

(i) Ecological benefits (environmental services):
- recharge of groundwater
- moderation of stream flow and buffering flood peaks
- sediment trapping
- biodiversity (species and habitats)
- pasture for wild animals

(ii) Socio-economic benefits from environmental services
- reduced health problems from purification of drinking water
- reduced sedimentation of downstream dams and reservoirs

(iii) Socio-economic benefits from wetland products
- human water supply
- livestock watering
- pasture for livestock
- medicinal plants

Insufficient data was available to make estimates of the loss of most of these wetland services in the Eastern Nile Basin. A first estimate was made of the loss of flood buffering services provided by the *maya'a* wetlands of the Rahad and Dinder rivers in the Blue Nile sub-basin.

The sediment trapping properties of these wetlands has both costs and benefits. Sediment trapped in the *maya'as* reduces downstream sediment loads. On the other hand increasing rates of sedimentation of the *maya'as* reduces their flood buffering capacity leading to higher flood peaks. The exact impact of accelerated *maya'a* sedimentation on reducing their buffering capacity is difficult to estimate without some detailed surveys and modeling. Bullock and Acreman (2003) examined 439 published papers on wetlands. Of these 23 out of 28 studies found that flood of plain wetlands reduce or delay floods.

The area between the Rahad and Dinder rivers is subject to frequent flooding causing extensive damage to crops. Some reports show that about 40 per cent of crops are destroyed every 3 to 4 years.[25] An examination of the Africover (2003) map of the area between the Rahad and Dinder rivers indicates that there are some 414,180 hectares of large-scale semi-mechanized farms (SMFs) and 46,000 hectares of traditional farms: a total of 460,180 hectares. Assuming that 40 per cent of this area is flooded and crops destroyed every 4 years gives an estimated area of 165,700 hectare of SMFs and 18,400 hectares of traditional farms affected.

The net value of production on the semi-mechanized farms is US$ 4.13 per hectare (MOA, 2006a) and that on the traditional farms US$ 12.6 per hectare (MOA, 2006b). This translates into losses every 4 years of US$ 0.68 million for the SMFs and US$ 0.23 million for the traditional farming sector: a total of US$ 0.92 million). On annual-basis this would be US$ 0.23 million. Using a social discount rate of 5 per cent and a time period of 50 years gives a net present value of these losses of US$ 8.1 million. This provides an indication of the value of the *maya'as* wetlands flood buffering services.

A3.1. Abbay-Blue Nile sub-basin

All costs and benefits for Ethiopia and Sudan broken down into national, regional and global are shown in Table A3.1. The overall sub-basin B:C ratio is 4:0. Measurable global benefits comprise approximately 5 per cent of total benefits. Net regional benefits are relatively small: comprising benefits from reduced sediment loads but with the offsetting costs of reduced fertilizer effect of sediment. In Ethiopia global benefits raise the B:C ratio from 4:4 to 4:7 but in Sudan there is only a slight increase.

Table A3.1: Costs and benefits of watershed management interventions: Abbay-Blue Nile sub-basin

(US$ million)

Intervention	Cost without project	Cost with project	Benefit without project	Benefit with project	Incremental cost	Incremental benefit	Benefit cost ratio
ETHIOPIA	**1,811**	**2,604**	**4,859**	**12,909**	**1,844**	**8,669**	**4.7**
National	**1,811**	**2,604**	**4,859**	**12,909**	**1,844**	**8,202**	**4.2**
Soil conservation: bunds	285	330	953	1,045	45	91	2.0
Soil conservation: grass strips	551	558	1,034	1,082	5	48	9.2
Fertilizer/Improved seed	536	684	1,364	2,369	149	735	4.9
On-farm forage	1	17	167	419	16	250	15.3
On-farm trees: fuel wood	1	22	170	383	22	213	9.9
On-farm trees: crop production saved: soil nitrogen retained	-	-	-	-	-	116	
Improved stoves	-	4	-	63	4	63	14.4
Area enclosure	436	809	869	7.330	373	6,462	17.3
Small-scale irrigation	3	181	32	220	178	189	1.1
Small-scale irrigation: multiplier impact	-	-	-	-	-	36	
Supporting interventions	-	-	-	-	1,051	-	
Regional	-	-	-	-	-	-	
Global	-	-	-	-	-	**467**	
Soil conservation: soil carbon sequestration	-	-	-	-	-	36	
On-farm trees: tree carbon	-	-	-	-	-	15	
Improved stoves: fuel saving: tree carbon sequestration	-	-	-	-	-	7	
Enclosed areas: tree carbon	-	-	-	-	-	282.6	
Enclosed areas: soil carbon	-	-	-	-	-	126	
SUDAN	**484**	**1,019**	**773**	**1,715**	**587**	**962**	**1.6**
National	**484**	**1,019**	**773**	**1,715**	**587**	**952**	**1.6**
Traditional rain-fed farms: crop production	327	805	441	1,187	478	746	1.6
Semi-mechanized farms: crop production	158	191	332	514	33	182	5.5
Semi-mechanized farms: charcoal production	-	24	-	14	24	14	0.6
Semi-mechanized farms: Residue: Livestock feed	-	-	-	-	-	10	
Supporting interventions	-	-	-	-	53	-	
Regional	-	-	-	-	-	5	
Reduced operation and maintenance costs of irrigation schemes	-	-	-	-	-	3	
Reduced dredging power intake	-	-	-	-	-	6	
Reduced fertilizer value: sediment	-	-	-	-	-	-3	
Global	-	-	-	-	-	5	
Traditional rain-fed farms: soil carbon	-	-	-	-	-	2	
SMFs : soil carbon	-	-	-	-	-	3	
SMFs : tree cover: soil carbon	-	-	-	-	-	0.1	
SUB-BASIN	**2,296**	**3,623**	**5,632**	**14,623**	**2,431**	**9,630**	**4.0**

A3.2 Tekeze-Setit-Atbara sub-basin

All costs and benefits for Ethiopia and Sudan broken down into national, regional and global are shown in Table A2. The overall sub-basin B:C ratio is 5:4. Global benefits comprise approximately 6 per cent of total benefits. Net regional impacts are just over 1 per cent of total benefits comprising benefits from reduced sediment loads and the greater offsetting costs of reduced fertilizer effect of sediment. The B:C ratio for Ethiopia increases from 6:2 to 6:7 with global benefits, and that of Sudan from 1:1 to 1:5 with the inclusion of the regional and global benefits.

Table A3.2: Costs and benefits of watershed management interventions: Tekeze-Setit-Atbara sub-basin

(US$ million)

Intervention	Cost without Project	Cost with Project	Benefit without project	Benefit with project	Incremental Cost	Incremental Benefit	Benefit Cost Ratio
ETHIOPIA	**298**	**618**	**671**	**2,843**	**366**	**2,432**	6.7
National	298	618	671	2,843	366	2,270	6.2
Soil conservation: bunds	128	153	330	361	26	31	1.2
Fertilizer/Improved seed	3	4	13	18	1	4	4.5
On-farm forage	0.1	5	34	115	5	80	17.3
On-farm trees: fuel wood	0.2	4	38	74	4	36	8.9
On-farm trees: crop production saved: soil nitrogen retained	-	-	-	-	-	25	
Improved stoves	-	1	-	13	1	13	13.8
Area enclosure	121	277	177	1,698	157	1,521	9.7
Small-scale irrigation	46	174	79	566	128	487	3.8
Small-scale irrigation: multiplier impacts	-	-	-	-	-	73	
Supporting interventions					45		
Regional	-	-	-	-	-	-	
Global	-	-	-	-	-	**162**	
Soil conservation: soil carbon sequestration	-	-	-	-	-	18	
On-farm trees: tree carbon	-	-	-	-	-	33	
Improved Stoves: fuel saving: tree carbon sequestration	-	-	-	-	-	2	
Enclosed areas: tree carbon	-	-	-	-	-	74	
Enclosed areas: soil carbon	-	-	-	-	-	70	
SUDAN	**82**	**121**	**260**	**375**	**91**	**163**	**1.8**
National	**82**	**121**	**260**	**375**	**91**	**120**	**1.3**
Traditional rain-fed farms: crop production	25	34	62	92	9	30	3.4
Semi-mechanized farms: crop production	57	61	198	259	4	61	16.8
Semi-mechanized farms: charcoal production	-	23	-	16	23	16	0.7
Semi-mechanized farms: Residue: Livestock feed	-	-	-	-	-	6	
Reclamation: *kerib* land	-	3	-	8	3	8	2.5
Supporting interventions	-	-	-	-	53	-	
Regional	-	-	-	-	-	**37**	
Increased irrigation water	-	-	-	-	-	11	
Reduced operation and maintenance costs of irrigation schemes	-	-	-	-	-	31	
Reduced fertilizer value: Sediment	-	-	-	-	-	-5	
Kerib land: reduced sediment load Atbara	-	-	-	-	-	0.1	
Kerib land: Reduced fertilizer value of sediment	-	-	-	-	-	-	
Global	**0**	**0**	**0**	**0**	**0**	**5.7**	
Traditional rain-fed farms: soil carbon	0	0	0	0	0	0	
SMFs : Soil carbon	0	0	0	0	0	4.7	
SMFs : Tree Cover: Soil carbon	0	0	0	0	0	0.5	
Kerib land: Soil carbon	0	0	0	0	0	0.5	
TOTAL: SUB-BASIN	**380**	**739**	**931**	**3,218**	**457**	**2,594**	**5.7**

A3.3 : Baro-Sobat-White Nile sub-basin

All economic and environmental costs and benefits for Ethiopia and Sudan broken down into national, regional and global are shown in Table A3. The overall sub-basin B:C ratio is 2:0. Global benefits comprise approximately 4 per cent of total benefits. Net regional impacts are negligible comprising benefits from reduced sediment loads and the greater offsetting costs of reduced fertilizer effect of sediment. The B:C ratio for Ethiopia increases from 1:8 to 2:1 with global benefits, and that of Sudan increases only very slightly with the inclusion of the regional and global benefits.

Table A3.3: Costs and benefits of watershed management interventions: Baro-Sobat-White Nile sub-basin

(US$ million)

Intervention	Cost without Project	Cost with Project	Benefit without project	Benefit with project	Incremental Cost	Incremental Benefit	Benefit Cost Ratio
ETHIOPIA	**97**	**237**	**493**	**786**	**180**	**375**	2.1
National	97	237	493	786	180	319	1.8
Soil conservation: bunds	31	37	132	143	6	11	1.8
Soil conservation: grass strips	26	27	122	126	1	5	4.9
Fertilizer/Improved seed	20	33	163	230	13	67	5.2
On-farm forage	-	1.4	16	34	1	18	13.3
On-farm trees: fuel wood	0.1	2	12	41	2	30	14.6
On-farm trees: crop production saved: soil nitrogen retained	-	-	-	-	-	0.3	
Improved stoves	-	1	-	8	1	8	15.4
Area enclosure	20	75	40	110	55	70	1.3
Small-scale irrigation	1	61	10	95	60	85	1.4
Small-scale irrigation: multiplier impacts	-	-	-	-	-	26	
Supporting interventions					41		
Regional	-	-	-	-	-	-	
Global	-	-	-	-	-	**57**	
Soil conservation: soil carbon sequestration	-	-	-	-	-	12	
On-farm trees: tree carbon	-	-	-	-	-	2	
Improved Stoves: fuel saving: tree carbon sequestration	-	-	-	-	-	0.1	
Enclosed areas: tree carbon	-	-	-	-	-	34	
Enclosed areas: soil carbon	-	-	-	-	-	9	
SUDAN	**671**	**923**	**3,548**	**5,407**	**947**	**1,916**	**2.0**
National	**671**	**923**	**3,548**	**5,407**	**947**	**1,877**	**2.0**
Traditional rain-fed farms: crop production	215	265	2,713	4,007	51	1,294	25.5
Semi-mechanized farms: crop production	457	472	835	1,282	16	447	28.6
Semi-mechanized farms: charcoal production	-	186	-	118	186	118	0.6
Semi-mechanized farms: Residue: Livestock feed	-	-	-	-	-	19	
Supporting interventions	-	-	-	-	695	-	
Regional	-	-	-	-	-	**0.2**	
Reduced operation and maintenance costs of irrigation schemes	-	-	-	-	-	0.2	
Reduced fertilizer value: Sediment	-	-	-	-	-	-0.01	
Global	-	-	-	-	-	**39**	
Traditional rain-fed farms: soil carbon	-	-	-	-	-	15	
SMFs : Soil carbon	-	-	-	-	-	21	
SMFs : Tree Cover: Soil carbon	-	-	-	-	-	3	
TOTAL: SUB-BASIN	**787**	**1,160**	**4,041**	**6,192**	**1,127**	**2,292**	**2.0**

A3.4 : Main Nile sub-basin

All costs and benefits for Sudan and Egypt are broken down into national, regional and global are shown in Table A4. Net regional impacts comprise 96 per cent and national benefits 4 per cent. There are no measurable global benefits. The B:C ratio for decreases from 4:4 to 3:7 because of the losses of fertilizer value of the reduced sedimentation. Clearly the incremental benefits to Egypt are considerable.

Table A3.4: Costs and benefits of watershed management interventions: Main Nile sub-basin

(US$ million)

Intervention	Cost without Project	Cost with Project	Benefit without project	Benefit with project	Incremental Cost	Incremental Benefit	Benefit Cost Ratio
SUDAN	-	-	-	-	3	9	3.7
National	-	-	-	-	3	11	4.4
Arresting sand dunes	-	-	-	-	3	11	1.8
River bank protection	-	-	-	-	10	10	1.0
Regional	-	-	-	-	-	-2	
Reduced fertilizer value: sediment	-	-	-	-	-	-2	
Global	-	-	-	-	-	-	
EGYPT	-	-	-	-	-	259	
Regional	-	-	-	-	-	259	
Reduction in lost power generation	-	-	-	-	-	16	
Reduction in lost irrigation water	-	-	-	-	-	243	
TOTAL: SUB-BASIN	-	-	-	-	3	268	

DISCLAIMER

The maps in this report are provided for the convenience of the reader. The designations employed and the presentation of the material in these maps do not imply the expression of any opinion whatsoever on the part of the Eastern Nile Technical Office (ENTRO) concerning the legal or constitutional status of any administrative region, state or governorate, country, territory or sea area, or concerning the delimitation of any frontier.

Figure A4.1 Administrative units

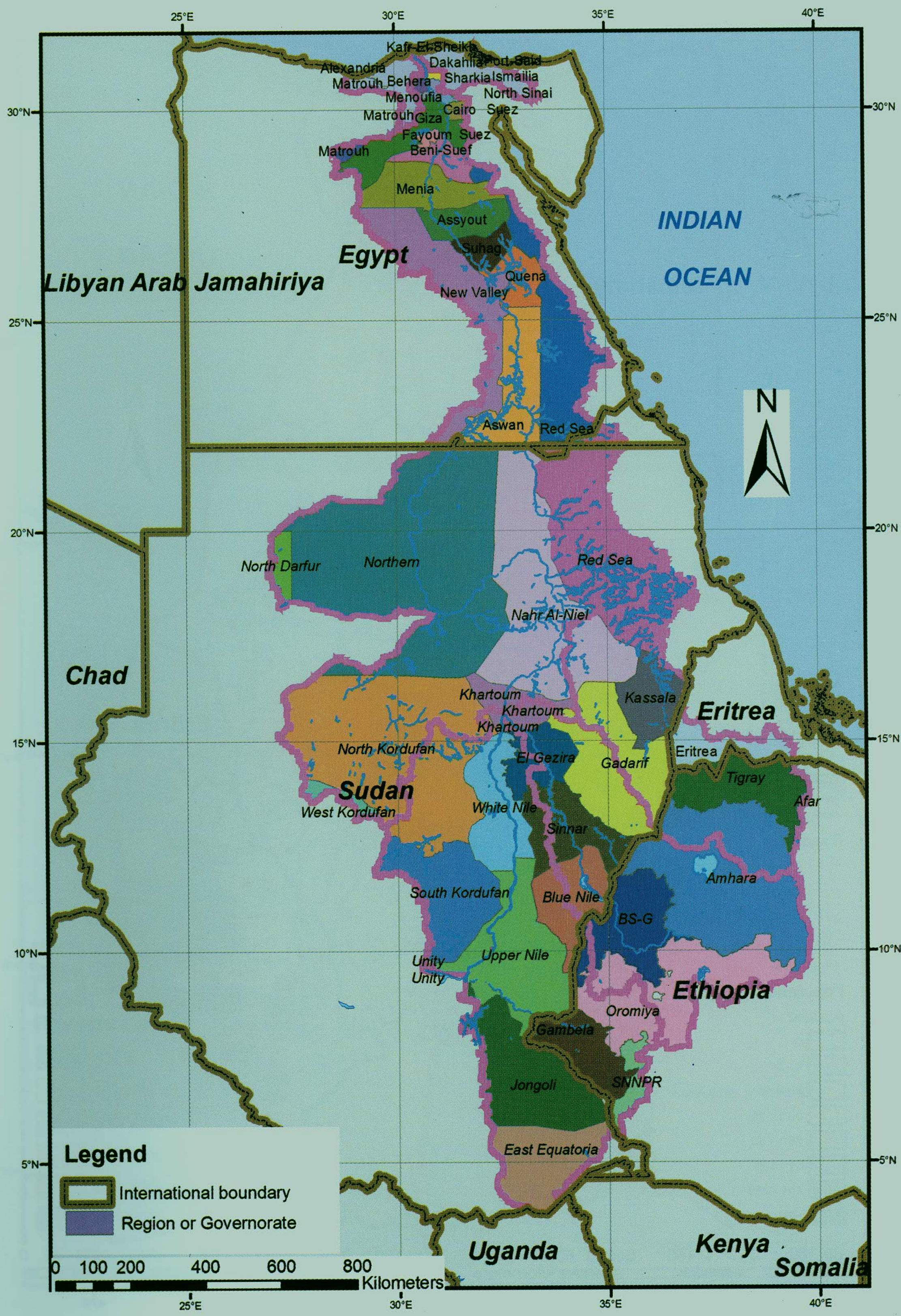


Figure A4.2 Population density

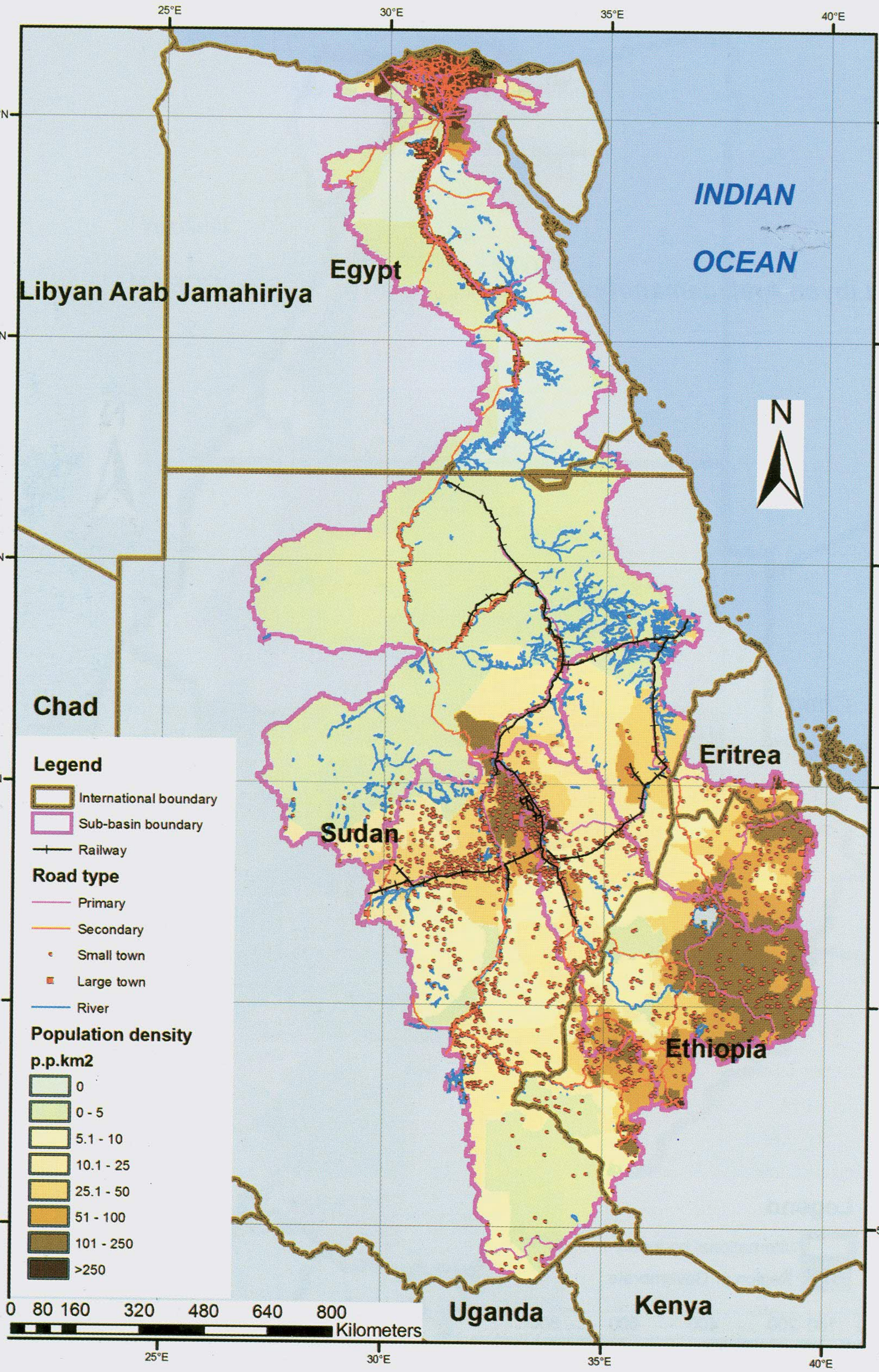


Figure A4.3 Poverty rates

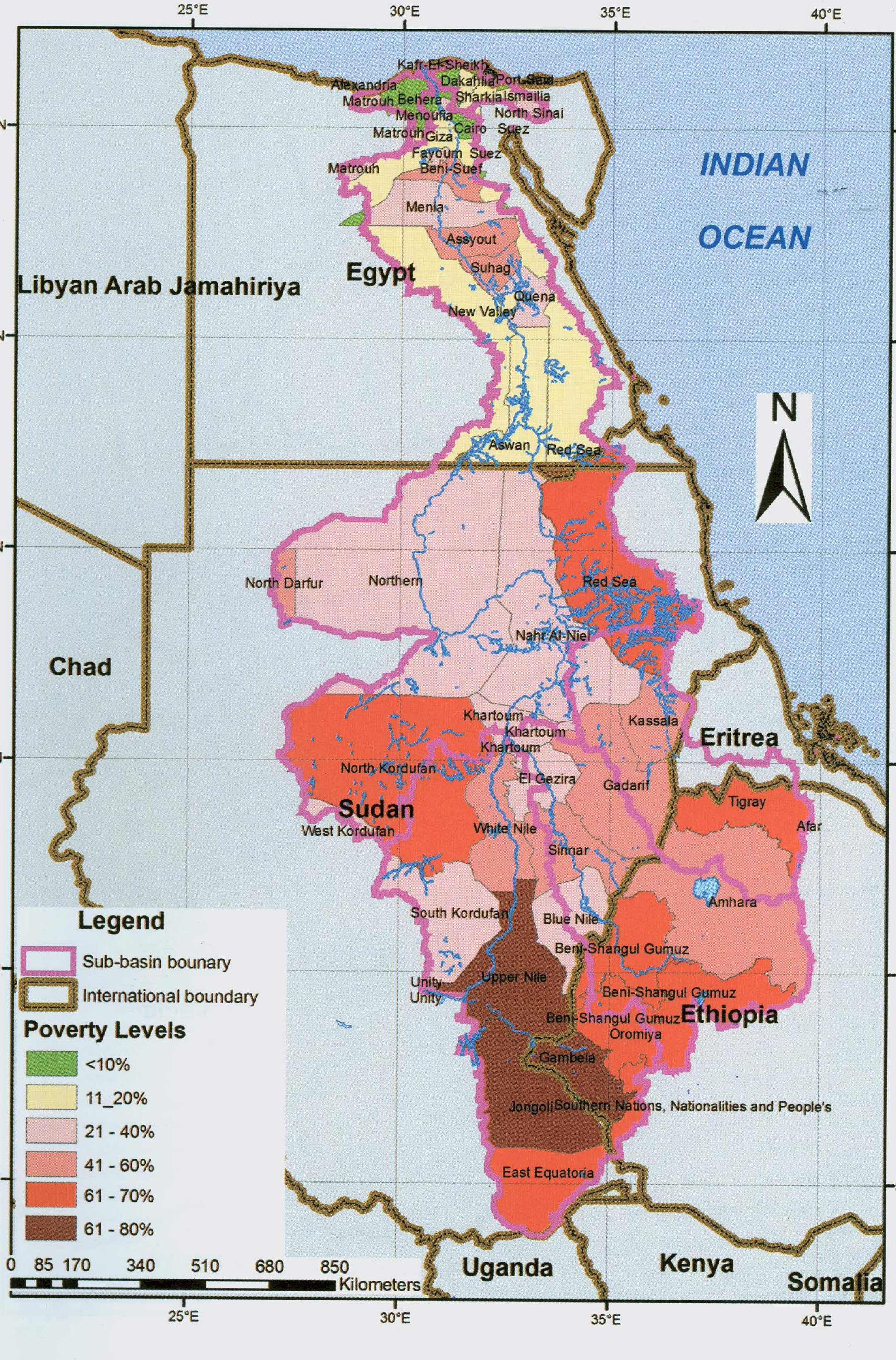


Figure A4.4 Mean annual temperature

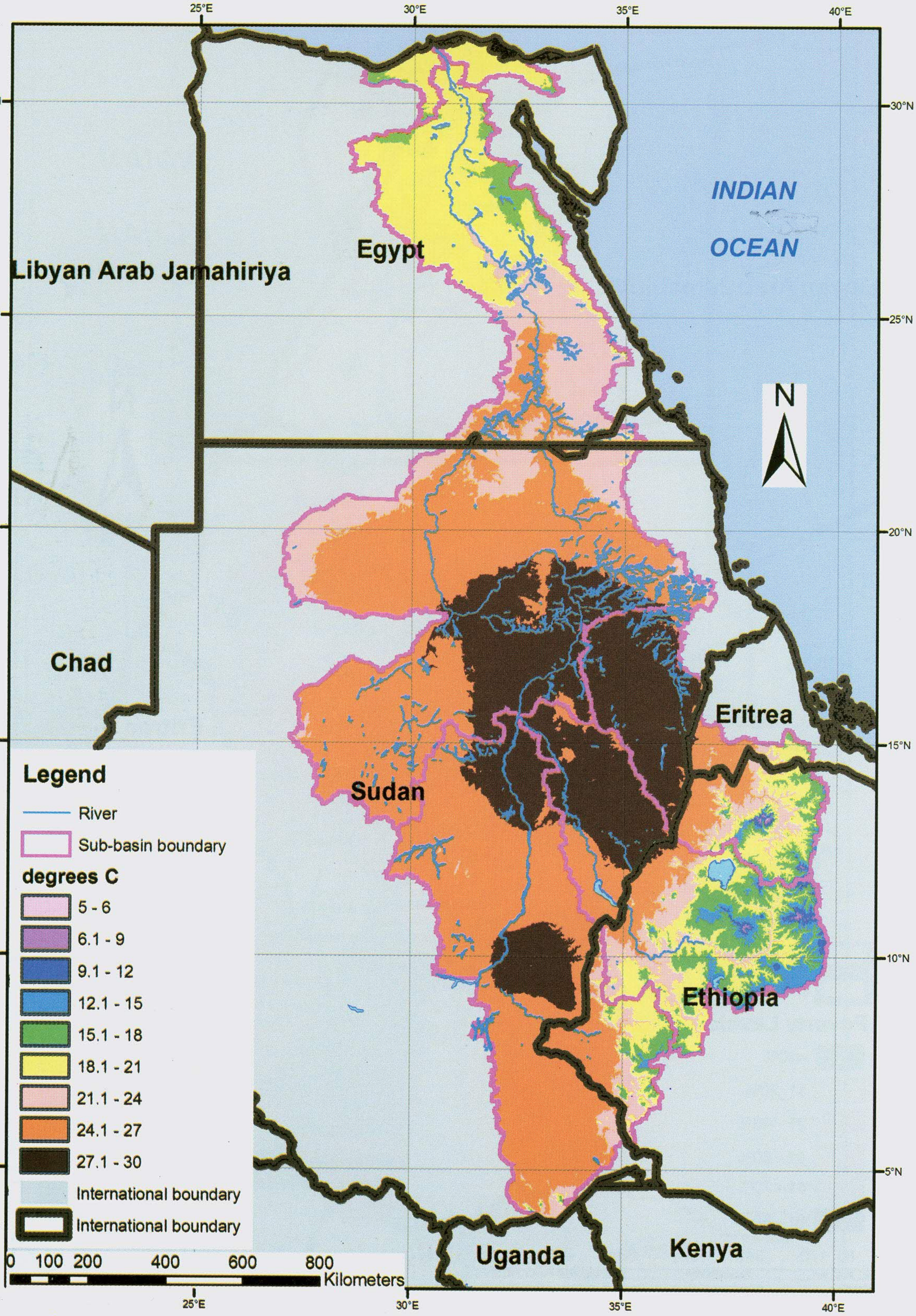


Figure A4.5 Dominant land cover

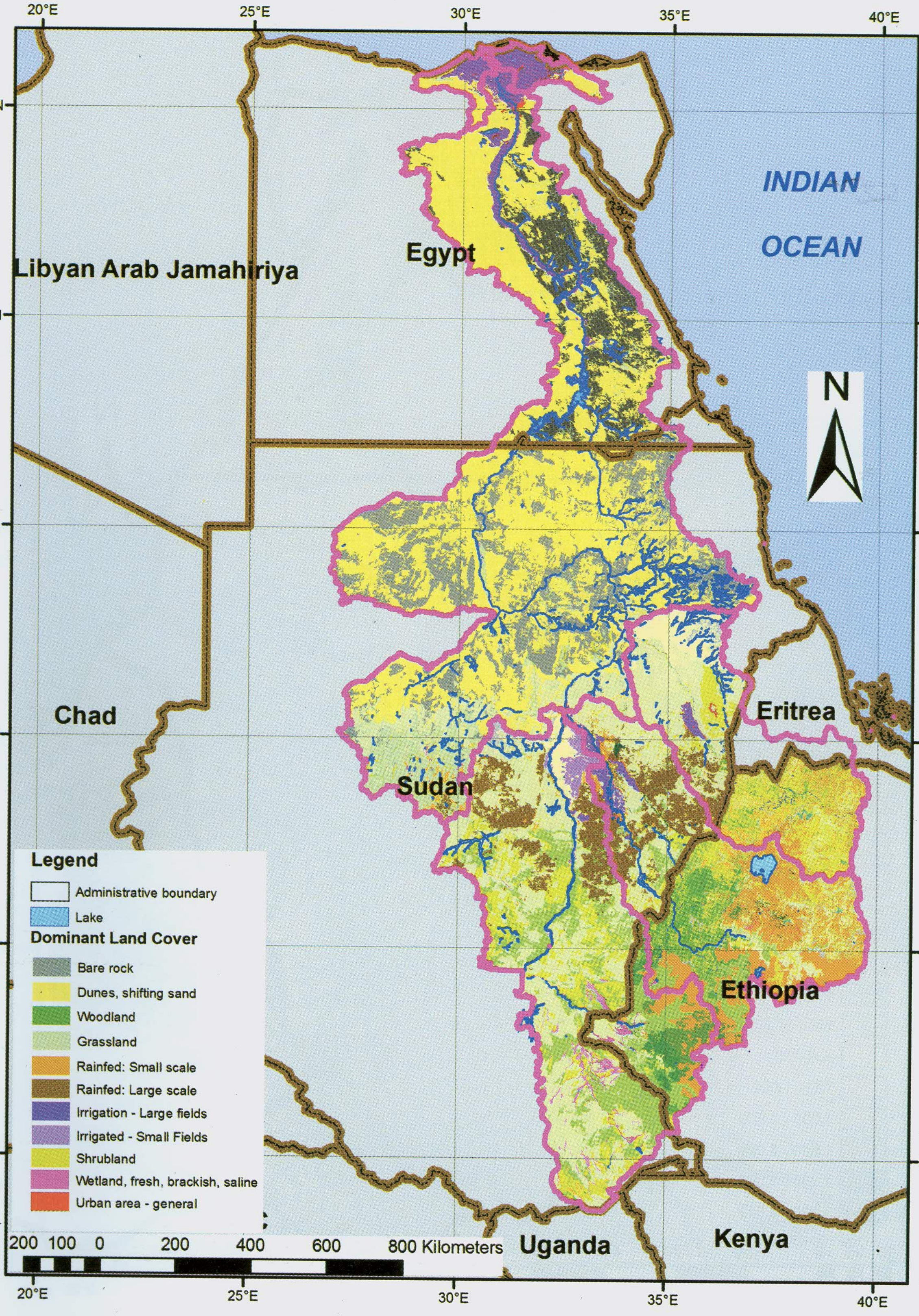


Figure A4.6 Relief and drainage

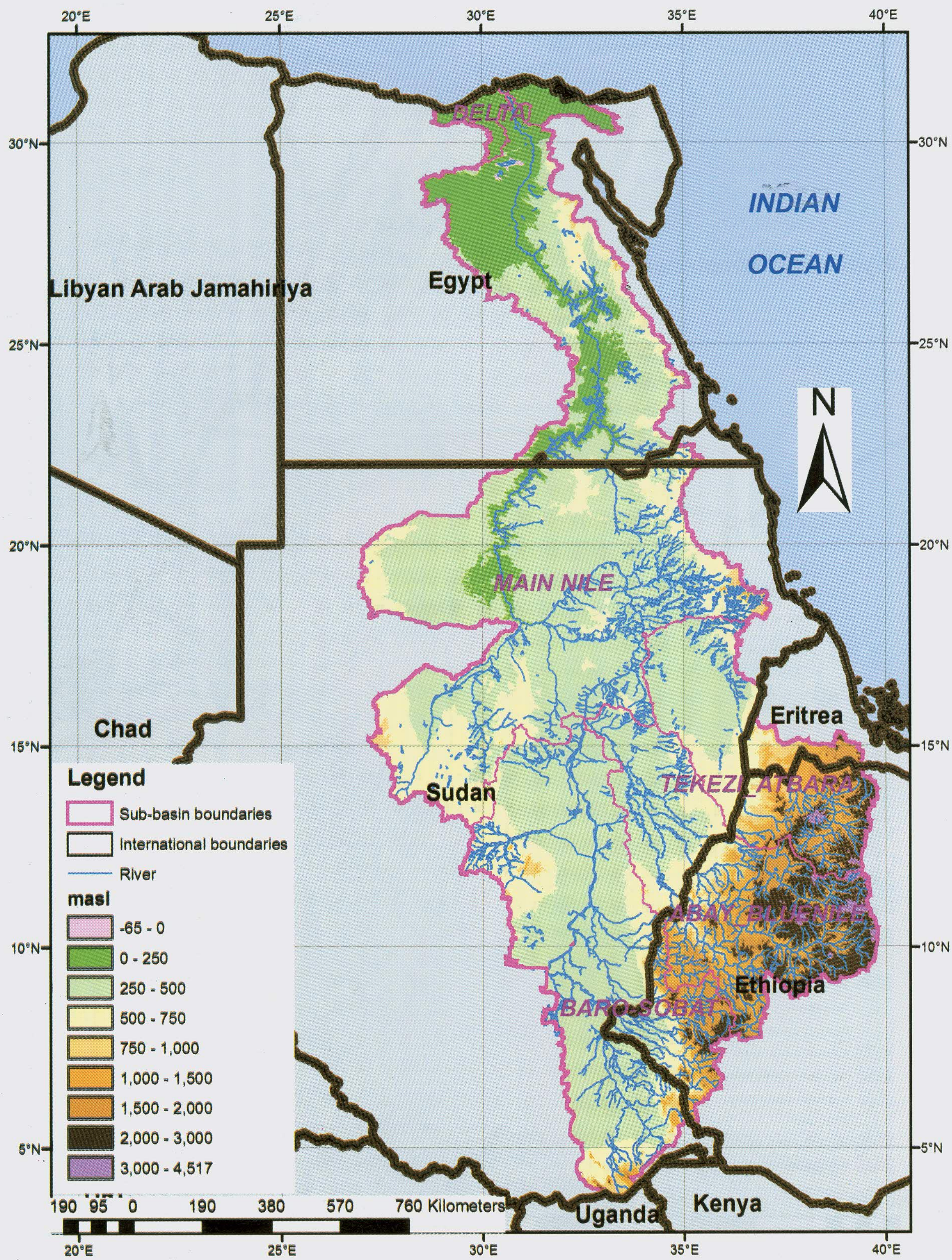


Figure A4.7 Geology

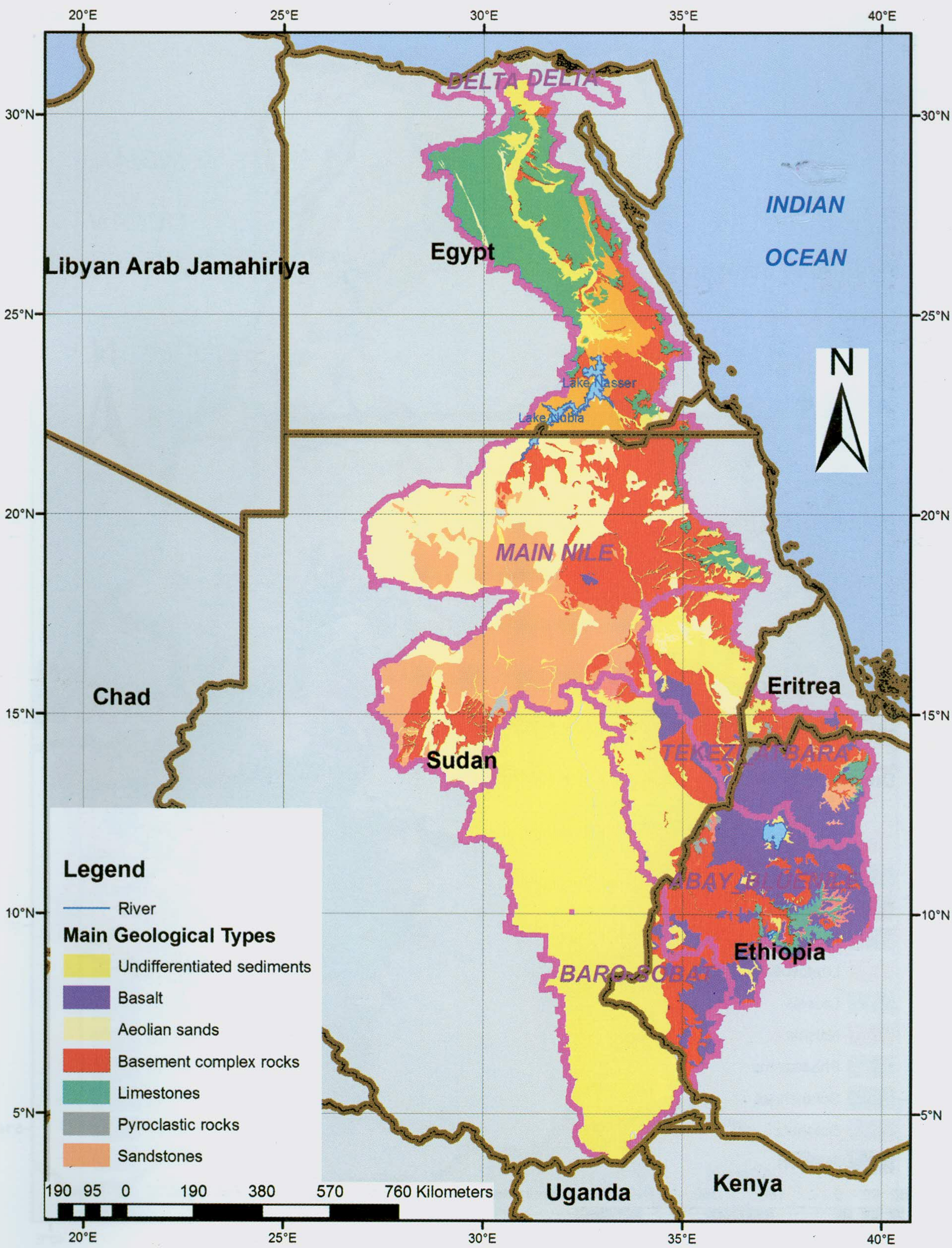


Figure A4.8 Dominant soil types

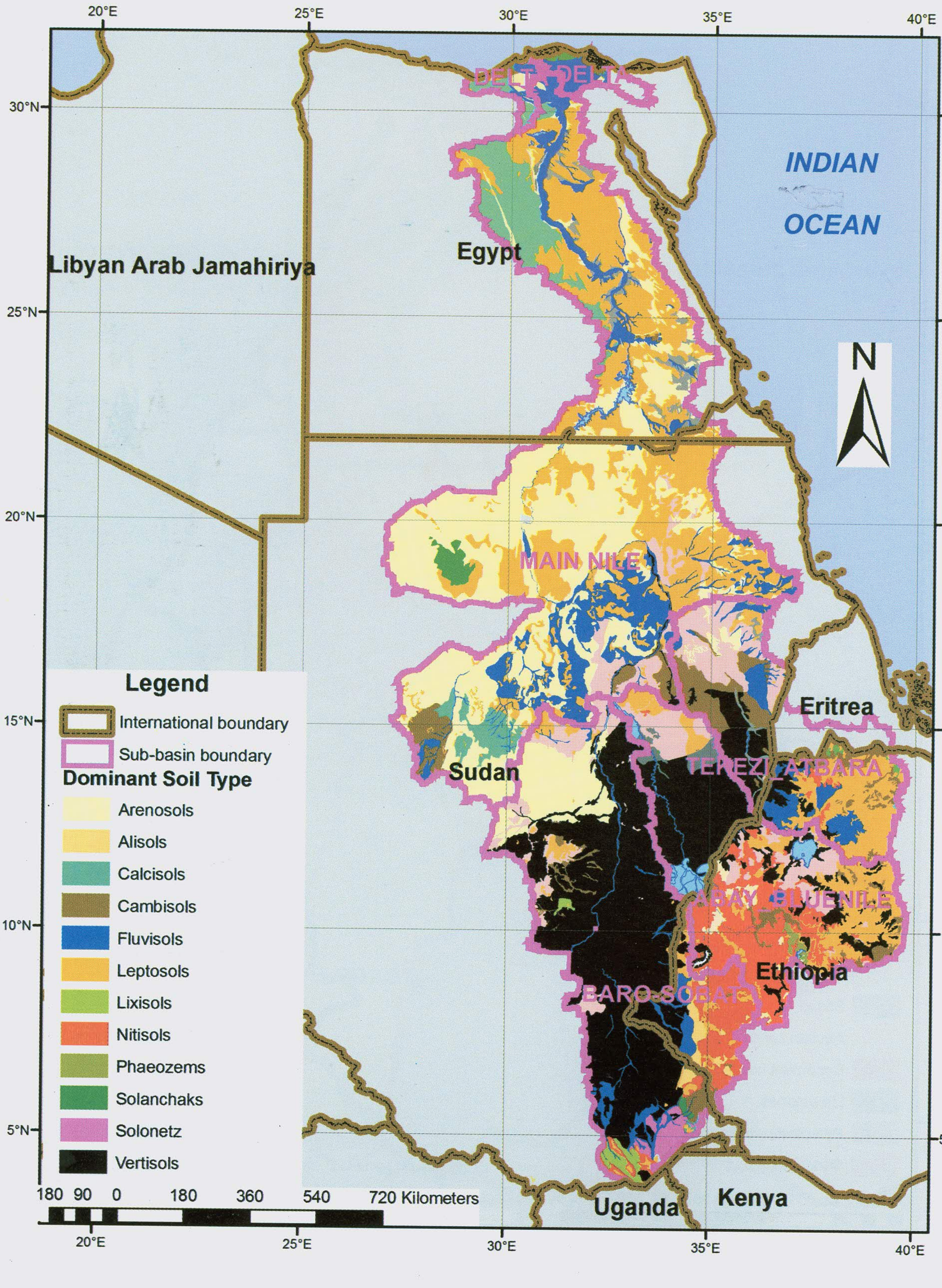


Figure A4.9 Mean annual rainfall

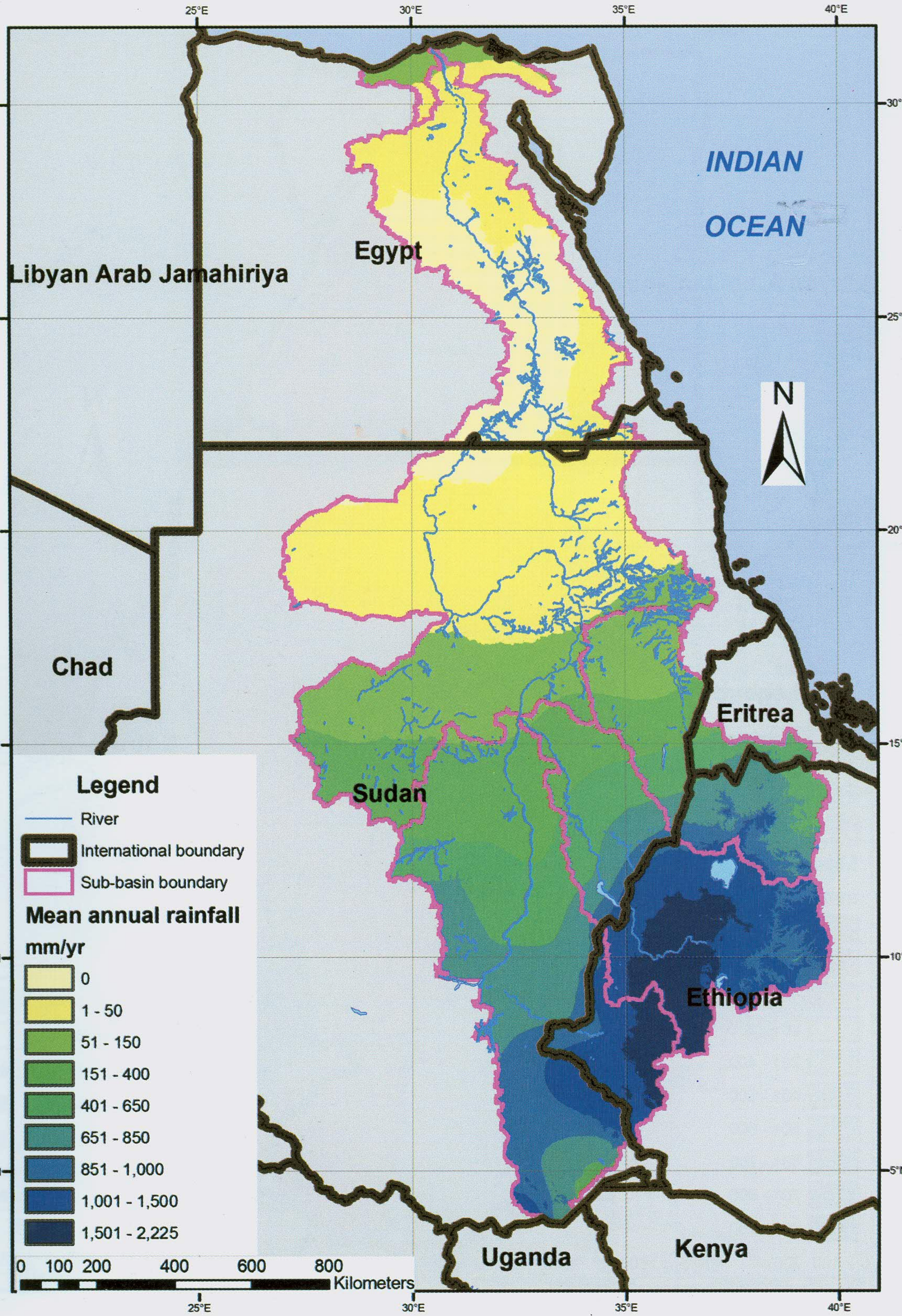


Figure A4.10 Mean annual rainoff

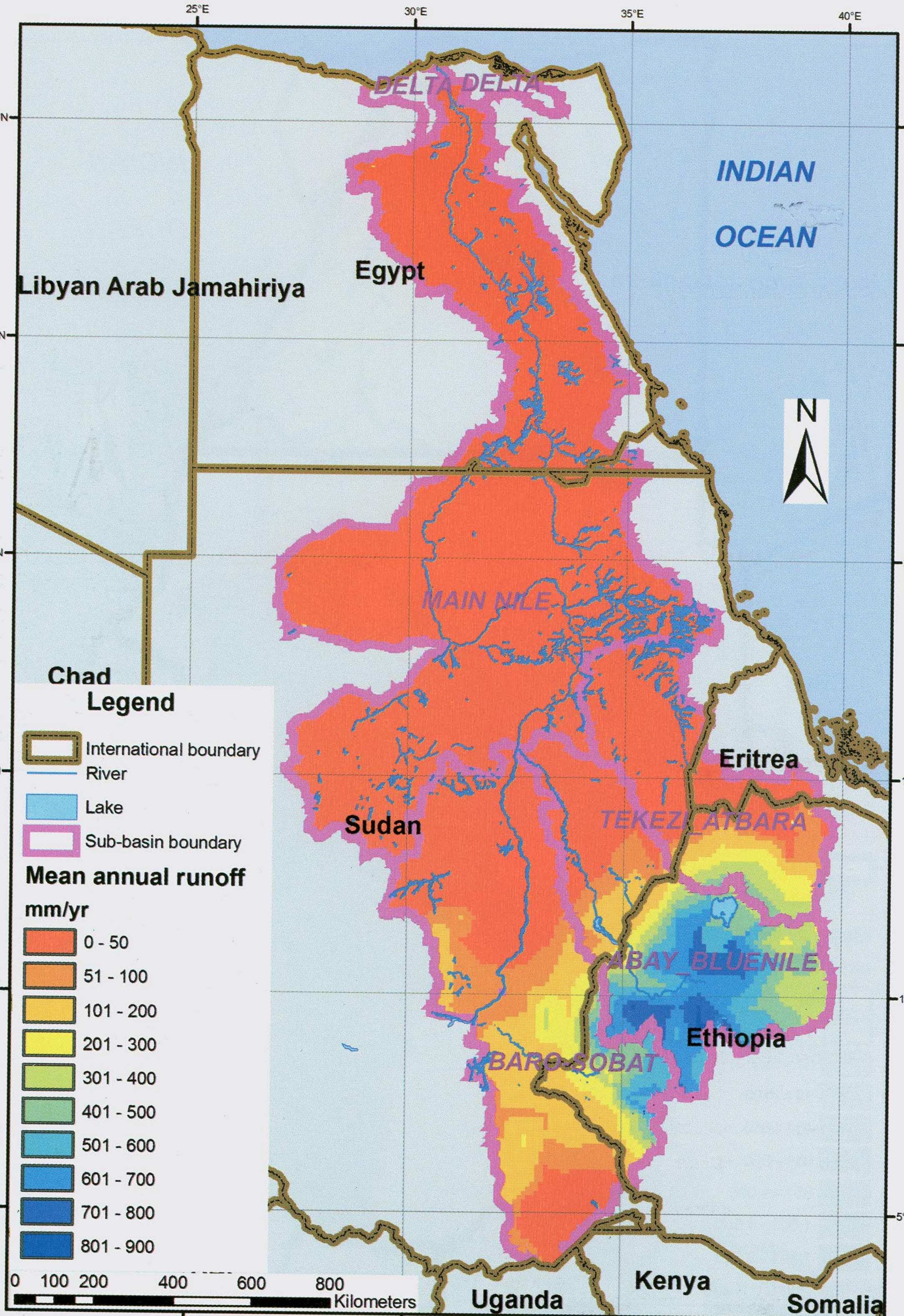


Figure A4.11 Dams and barrages

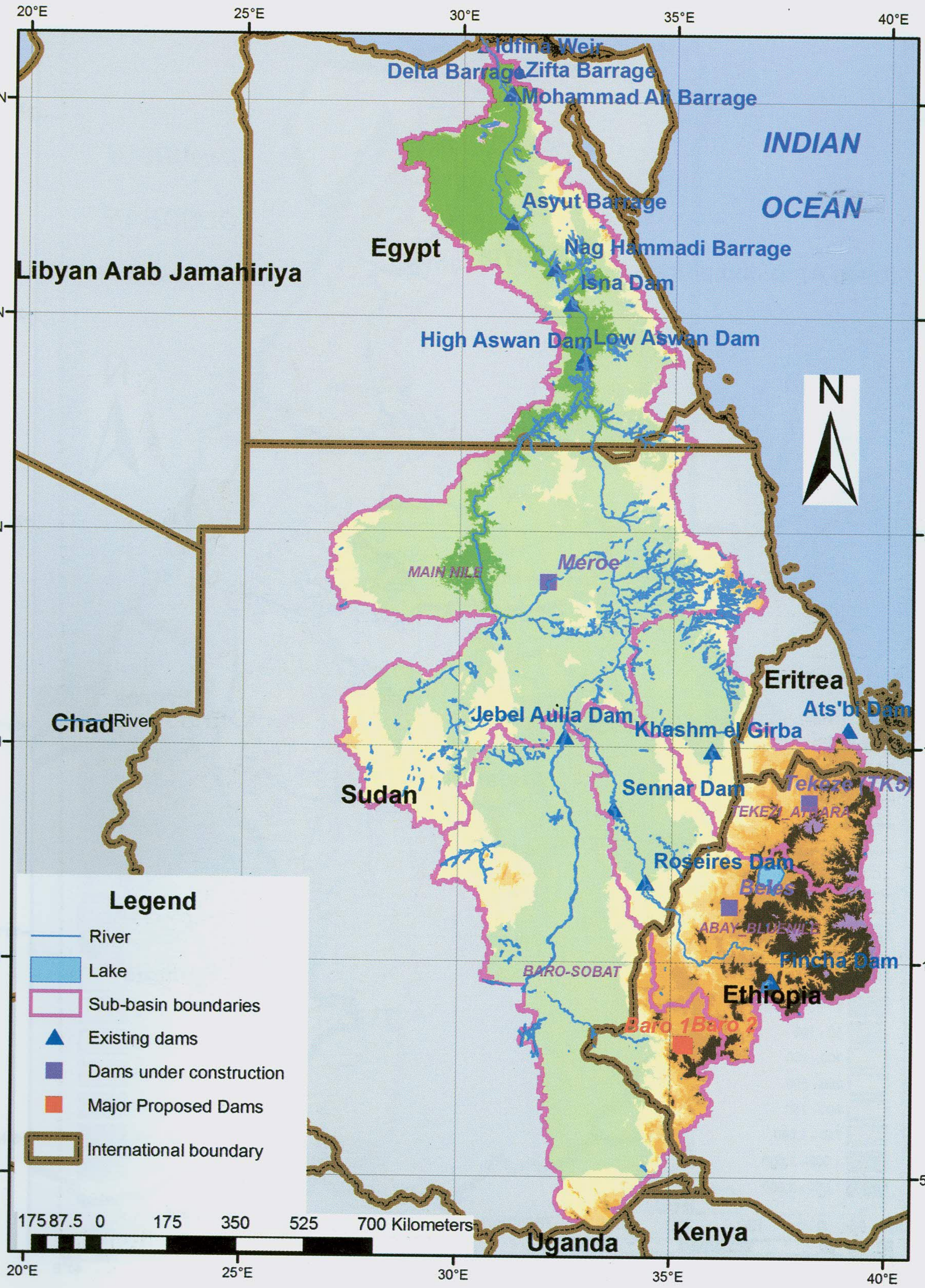


Figure A4.12 Road and rail network

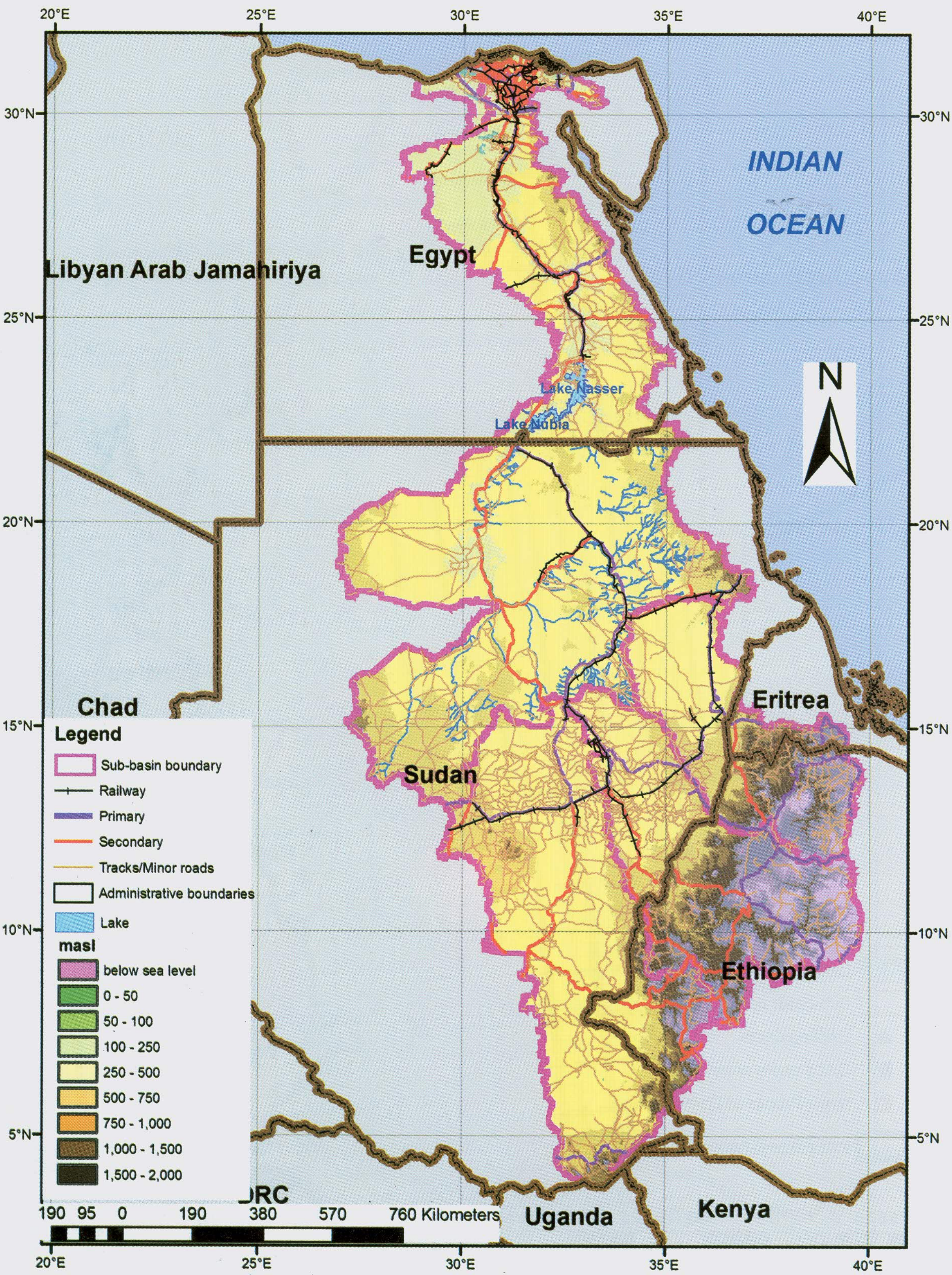


Figure A4.13 Cattle density

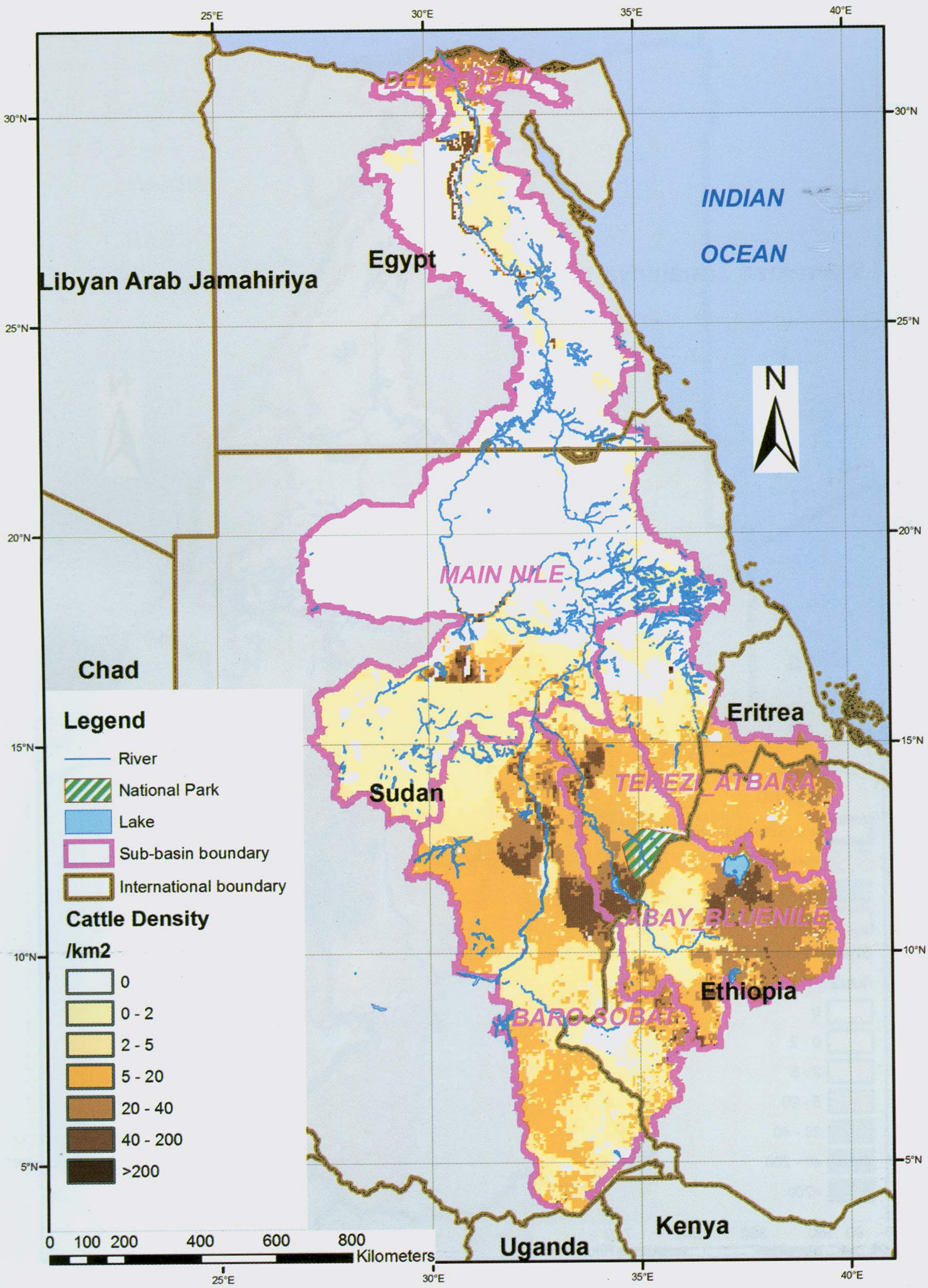


Figure A4.14 Sheep and goat density