Eastern Nile Technical Regional Office

Draft SSEA Stage 1

Volume I – Main Report

NILE BASIN INITIATIVE
Initiative du Bassin du Nil

Consulting Services for Studies On Identification of Projects Constituting the First Joint Multipurpose Program (JMP 1) on Abbay/Blue - Main Nile

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LIST OF ACRONYMS AND ABBREVIATIONS

ADLI	Agricultural Development Led Industrialization
AEWA	African – Eurasian Waterbird Agreement
AfDB	African Development Bank
AHD	Aswan High Dam
BCM	Billion (1,000,000,000) cubic meters
BOD	Biological Oxygen Demand
BSG	Benishangul-Gumuz
CADD	Computer Aided Design and Drafting
CBA	Working Session and Communications Based Assessment
CBSI	Confidence Building and Stakeholder Involvement Project
CBWS	Comprehensive Basin-wide Study
CCDD	Convention to Combat Desertification and Drought
CDM	Clean Development Mechanisms
CDO	Civil Defense Office (Sudan)
CFA	Nile Basin Cooperative Framework Agreement
CLEQM	Central Laboratory for Environmental Quality Monitoring
COD	Chemical Oxygen Demand
COMESA	Common Market for East and South Africa
CRA	Cooperative Regional Assessment (Studies)
CSOs	Civil Society Organizations
DaNSS	Database for Nile Secondary Stakeholders
DO	Dissolved Oxygen
DSS	Decision Support System
EAPP	Eastern Africa Power Pool
EEAA	Egyptian Environmental Affairs Agency
EEPCO	Ethiopia Electric Power Corporation
EFTCA	Egyptian Fund for Technical Cooperation
EGYPTERA	Egyptian Electric Utility & Consumer Protection Regulatory Agency
EIA	Environmental Impact Assessment
EMA	Ethiopian Mapping Agency
EMG	Environmental Management Guidance
EN	Eastern Nile
ENCOM	Eastern Nile Council of Ministers
ENPTS	Eastern Nile Power Trade Study
ENSAP	Eastern Nile Subsidiary Action Program
ENSAPT	Eastern Nile Subsidiary Action Program Team
ENTRO	Eastern Nile Technical Regional Office
EPA	Environmental Protection Authority (Ethiopia)
EPFIs	Equator Principles Financial Institutions
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
ESP	Environmental and Social Policy
EWUAP	Efficient Water Use for Agriculture Production
FeMSEDA	Federal Micro and Small Enterprises
FPEW	Flood Protection and Early Warning
FSL	Full Supply Level
FtC	Facing the Challenge
GAFRD	General Authority for Fish Resources Development
GHG	Greenhouse gas
GIS	Geographical Information System
GWWCL	Groundwater and Wadis Central Laboratories
GWWD	Groundwater and Wadis Directorate
HAC	Humanitarian aid Commission (Sudan)
Hec-RAS	Type of hydrological / hydraulic model

HRS	Hydraulic Research Station
IDCM	Internal Displacement Monitoring Center
IDEN	Integrated Development of the Eastern Nile (Projects)
IFC	International Finance Corporation
IOGD	Irrigation Operation General Directorate
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producer
IPP	Indigenous Peoples Plan
IPPF	Indigenous Peoples Planning Framework
IWMI	International Water Management Institute
JMP 1 ID	Joint Multipurpose Program 1 Identification Studies
JMP	Joint Multipurpose Program
MALR	Ministry of Agriculture and Land Reclamation
MASL	Meters above sea level
MCA	Multipurpose Criterion Analysis
MCM	Million Cubic Meters
MFL	maximum Flood Level
MHUNC	Ministry of Housing, Utilities and New Communities
MoE	Ministry of Electricity
MoHP	Ministry of Health and Population
MoIWR	Ministry of Irrigation and Water Resources (Sudan)
MoLD	Ministry of Local Development
MoP	Ministry of Planning
MoT	Ministry of Transportation
MoU	Memorandum of Understanding
MoWR	Ministry of Water Resources
MSE	Micro and Small Enterprises
MSEA	Ministry of State for Environmental Affairs
MWRI	Ministry of Water Resources and Irrigation
NBCBN	Nile Basin Capacity Building Network
NBI	Nile Basin Initiative
NCWR	National Council for Water Resources (Sudan)
NEC	National Electric Corporation
NELSAP	Nile Equatorial Lakes Subsidiary Action Program
NIOF	National Institute of Oceanography and Fisheries
NRI	Nile Research Institute
NTEAP	Nile Transboundary Environmental Action Project
NTFP	Non-timber forest products
NWC	National Water Corporation
NWD	Nile Waters Directorate
OSI	One System Inventory
PAP	Project Affected People
PASDEP	Plan for Accelerated and Sustained Development to End Poverty
PDF	Portable Document Format
PFS	Prefeasibility Study
PJTC	Permanent Joint Technical Joint Commission for Nile Waters
POE	Panel of Experts
RAP	Resettlement Action Plan
RAPSO	Type of hydrological / hydraulic model
RCC	Roller compacted concrete
ROW	Right of Way
SAM	Social Assessment Manual
SAP	Subsidiary Action Program
SDCO	Social Development and Communication Office
SDO	Social Development Office
SIA	Socio-economic impact analysis
SICAS	Stakeholder Consultation and Communication Strategy

SMA	Sudan Meteorological Authority (Sudan)
SMEs	Small and Medium Enterprises
SNWP	Sudan National Water Policy
SPOT	Système Pour l'Observation de la Terre (satellite imagery)
SSEA	Strategic Social and Environmental Assessment
STRM	Shuttle Radar Topography Mission
TO	Transboundary Organization
ToR	Terms of Reference
TWRO	Technical Water Resources Organ
UNEP	United Nations Environment Program
UNESCO	United Nations Education, Scientific and Cultural Organization
USBR	United States Bureau of Reclamation
WB	World Bank
WBISP	Wood Biomass Inventory and Strategic Project
WHO	World Health Organization
WSS	Water Supply and Sanitation
WUA	Water User Associations

EXECUTIVE SUMMARY

Introduction

The Abbay/Blue Nile – Main Nile flowing through the Eastern Nile countries of Ethiopia, Sudan and Egypt, provides freshwater resources for an estimated 100 million people. All three riparian countries depend on the Nile for essential services and utilize the resource to differing degrees. It is estimated that the total population of these three countries will swell to close to 300 million by 2030 at present growth rates (United Nations, 2008), and due to this rapid growing population, the per capita water availability in the basin is decreasing at an equally rapid rate. Consumptive uses of water are growing rapidly and the three Eastern Nile riparian countries are already at or below the "stress level" defined as less than 1,700 m^3/capita/year of renewable water. As a result poverty, conflict, food insecurity and environmental degradation continue to plague the region with only a small percentage of the population of the region's total population having access to potable water, electricity, and a reliable water supply for agriculture. Adding to the disparities, the distribution of water is disproportionate on a spatial and annual scale, with approximately 70% of the annual precipitation occurring in the Ethiopian highlands between June and September, and almost no precipitation in Egypt.

In light of this pressure on the water resource, it is imperative to put in place a regional framework and concerted actions to better use the Nile waters for enhanced food security through increase irrigation efficiency and improved water management to reduce water scarcity in the basin. These actions are of foremost concern to the millions of local people who depend on the river to secure their livelihoods. Furthermore, these actions are of vital interest to the Eastern Nile governments for which the Nile is the cornerstone for economic growth. It has become increasingly important to develop water resource management strategies that address poverty, food insecurity, and environmental degradation. It is suggested that cooperative management of the Nile is key to alleviating these pressures facing the Eastern Nile countries.

History of Nile Cooperation

To address these pressures on the Nile and its importance to the livelihoods of millions throughout the basin, the Nile Council of Ministers (NILE-COM) launched the Nile Basin Initiative (NBI) in 1999. The NBI is guided by a shared vision "*to achieve sustainable socioeconomic development through the equitable utilization of, and benefit from, the common Nile basin water resources*." Through this shared vision and cooperative action, the overarching objectives of the NBI are poverty reduction, reversal of environmental degradation, promotion of economic growth, increased regional cooperation, and integration and enhanced regional peace and security throughout the Nile basin.

The Eastern Nile Technical Regional Office (ENTRO) was established in 2002 as the first joint institution of the Eastern Nile countries under the framework of NBI. Since its creation ENTRO has already initiated several projects as part of the Integrated Development of the Eastern Nile and an associated "fast track" set of investments. Within the context of cooperative management the three Eastern Nile countries have embarked on the Eastern Nile Joint Multipurpose Program (JMP), with guidance and direction from the Eastern Nile Council of Ministers (ENCOM). The JMP is a long-term program that includes a coordinated set of investments and an enabling institutional environment to provide a range of development benefits across sectors and countries. The institutional structure under JMP facilitates the sustainable development and management of the Eastern Nile shared water resources.

Under the Joint Multipurpose Program, ENCOM has authorized a number of activities and studies to help guide the integrated development of the water-related resources of Ethiopia, Sudan, and Egypt, and to facilitate the selection of an initial set of investments under JMP for the Eastern Nile. One of the key activities was a scoping study carried out to assess the water resources of the Eastern Nile and to identify opportunities for cooperative development (Blackmore and Whittington, 2008). To complement the scoping study a Strategic Social and Environmental Assessment (SSEA) has been commissioned in close consultation with key stakeholders in Egypt, Ethiopia, and Sudan.

This SSEA will be conducted in two stages. The Stage 1 is the present report. It provides an analysis of the range of environmental and social issues facing the Eastern Nile Region in regards to transboundary water resources development and the choice of development options. The key issues raised by the SSEA will identify environmental and social issues, which must be addressed by project-specific Environmental and Social Impacts Assessments (ESIAs).

Stage 1 SSEA compares water resources development alternatives considering a range of investments from a no-investment level up to a full cooperative development of the water resources of the Abbay in Ethiopia, looking at investment in infrastructure for hydropower generation and multipurpose uses like flood control, irrigation and drought alleviation. It broadly examines connections and impacts of potential development scenarios on the physical, biological, socio-economic, and cultural resources of the region and determines thresholds and tipping points where the impacts, positive or negative, start to be felt basin-wide.

The Stage 1 SSEA provides a foundation from which to proceed to a more focused strategic analysis related to a JMP 1 Preferred Cascade Development Scenario, which will be the aim of the Stage 2 SSEA in the Phase II of the JMP 1 ID studies.

During the whole process of the SSEA, consultations constitute the main spaces of direct interaction with stakeholders and mark important milestones of the JMP 1 ID process, and the Stage 1 SSEA is also part of this extensive consultation process, which is seen as a *dialogue* with and among key stakeholders of the Eastern Nile basin.

There were two types of consultation meetings, broad consultations and technical consultations. The broad consultations involve the interaction with broad groups of secondary stakeholders from the three riparian countries to discuss social, environmental and development issues related to JMP 1. The technical consultations involved the Regional Working Groups and focus on specific technical issues of the JMP 1 ID process and on the specific studies being carried out by the Consultant.

Determination of Key Strategic Issues

The Stage 1 SSEA presents an analysis, largely based on secondary data available from various sources, of expected key environmental and social issues at stake in the region. The Key strategic Issues retained were first derived from existing material from the One System Inventory developed by ENTRO, and refined in January 2011 during a meeting of a Panel of Experts that included representatives of ENTRO, of the World Bank, three international independent experts, and the Consultant. The Panel of Experts reviewed the preliminary list of themes and issues according to their strategic importance for the region and their relevance to the JMP and developed a list of nine Key Strategic Issues for the region.

Key Strategic Issues

1. Water Security
2. Access to Water and Livelihoods
3. Water Quality
4. Hydropower
5. Erosion and Sedimentation
6. Critical Habitats, Ecosystems Functions and Biodiversity
7. Vulnerable Groups and Resettlement
8. Dam Safety
9. Climate Change

Water security

Water security in the region is not only a matter of water being available in sufficient quantity; it is also a matter of being available to satisfy water demands at any given time.

All three countries are suffering from water scarcity. Egypt is particularly vulnerable because precipitation is extremely rare with most of its water originating from outside of its borders, conjugated with a demand largely outstripping water availability. It is projected that Egypt will be in a situation of *absolute water scarcity* by 2025 with less than 500 m^3 of water per person per year. For Sudan and Ethiopia, the scarcity is attributed to institutional or financial causes restricting water accessibility despite sufficient quantities existing in the countries to meet the population needs. It is forecasted, assuming a medium population growth scenario, that even Ethiopia will reach a *critical water scarcity* level by 2025.

Without any investment in the region, the total quantity of water available in the Eastern Nile would not increase in the short term. In all likelihood, it may even decrease slightly in the short and medium terms due to higher evaporation rate in the Roseires Reservoir after the heightening of the dam. It is very difficult to forecast the long-term because of uncertainty around climatic changes. It is generally accepted that temperature will rise in the region, thus increasing evaporation rates, but precipitation rates are expected to vary from a 15% decrease to a 14% increase. What is generally agreed by everybody is that extreme events will increase in frequency and intensity, translating in more frequent and larger flooding and more frequent and longer periods of drought. The region has no capacity upstream of Aswan Dam to control large flood events and very limited capacity to alleviate droughts.

The cooperative development of the water resources of the Nile and the construction of large hydropower infrastructure on the Abbay in Ethiopia would offer a number of benefits for the three countries in addition to providing a renewable source of energy. A reservoir of about 10 billion cubic meter (BCM) of live storage would offer protection against flood events occurring once every 10 years, a larger storage capacity of about 20 BCM would offer protection for events occurring once every 100 years, and full cascade development of the Abbay, at about 80 to 100 BCM would offer absolute protection against flooding, while providing flexibility to alleviate droughts.

Under a cooperative development of the Abbay, total water available in the system may increase by a few billion cubic meters if some water storage is displaced from Aswan to reservoirs in the Ethiopian Highlands where rates of evaporation are lower, providing water for irrigation purposes.

Investments on the Abbay tributaries, with a total of five smaller dams could also provide about 10 BCM of storage capacity. This 10 BCM threshold of live storage will however have a different magnitude of impact because of the difference in flows and catchment area involved. The total tributaries concerned would account only for about 25% of the total catchment area of the entire Abbay and for only about 20% of the total flow coming out of Ethiopia. Furthermore, these five smaller dams on the tributaries would generate only a fraction of the energy generated by a single larger dam on the Abbay of equivalent live storage, for almost the same cost.

Access to water and livelihoods

Livelihoods of those living along the Abbay/Blue Nile and Main Nile depend on access to water from the river, and on a range of ecosystem goods and services provided by the River. The main livelihoods considered are recession agriculture, pastoralism, subsistence fisheries, and brick-making. The annual floods provide fertile soil as deposited sediment, known as alluvium, and have an important role in maintaining livelihoods along the river. The residual moisture after a flood provides water for crop growth and for maintaining pastureland for grazing herds. It is estimated that over 364,000 ha are under recession agriculture along the Eastern Nile, mostly in Sudan and around Lake Nasser; and over 50,000 people, mostly in Sudan, are involved in brick-making. The number of pastoralists is unknown, but they are concentrated in the Blue Nile basin in Sudan where nomadic and semi-nomadic communities rely primarily on raising livestock for their livelihoods, and they need the grazing areas left after the flooding for their herds.

Under the zero investment scenario, or with only smaller dams on the Abbay tributaries, effects and improvements would be felt only locally in the initiating country, Ethiopia in this case.

The development of large infrastructure on the Abbay has the potential to completely regulate river flow and eliminate flooding. As a consequence all the households and communities relying on the flood plain for their livelihoods would be at risk of disappearing with complete flow regulation, increasing impoverishment and the degree of food insecurity. The extent of this effect, particularly the negative impacts, will be is dependent on the release patterns for environmental flows.

It is estimated that release of seasonal flood equivalent to a one in four year event would provide sufficient flood plain to maintain recession agriculture, brick-making activities and the range of ecosystem services provided by the River. The establishment of irrigation schemes and the development of commercial fisheries are other measures that would be possible under a cooperative development.

Water quality

Human settlements, industrialized areas, and agro-chemical runoff from agriculture areas influence the quality of water for the Nile and the underlying groundwater. The expected trend over the long-term is increasing water quality deterioration due to the expansion of irrigated agriculture and the increased use of agro-chemicals. Also, the creation of reservoirs on the tributaries or on the Abbay will have a direct impact on water quality in the short-term due the decomposition of flooded biomass within the reservoirs and the release of organic matter, nutrients, and heavy metals. However, the flooded biomass concern can be significantly mitigated with the removal of biomass prior to reservoir filling. The implication of displacing water storage from Aswan to reservoirs in the Ethiopian Highlands is complex. The best estimate is that this action will have a negative effect on the water quality in Aswan if no actions are taken to control pollution sources.

With no development, no improvement in water quality from the existing situation and trend is expected as measures to improve water quality would be mostly local and there are limited incentives for upstream countries to protect water quality as it cross their downstream boundary. It is expected that water quality will continue to decrease because of expected expansion of irrigation schemes to feed the growing population in the basin and the use of agro-chemicals reaching the Nile water and the groundwater by runoff or leaching.

Only a basin wide cooperative approach under a cooperative development scenario would provide any opportunity for improving water quality from diffuse pollution on the Abbay/Blue Nile and further downstream on the Nile.

Hydropower development

In 2009, the total installed capacity in Egypt, Sudan and Ethiopia was 32,378 MW. Given current population growth and the current rates of electrification in Ethiopia, Sudan and Egypt a significant quantity of energy must be developed for poverty alleviation and economic growth. It is estimated that it has to be increased to 106,437 MW by 2030 to meet the anticipated required capacity of the 3 countries. That is a net increase of 74,059 MW, from which about 70% would be to meet Egypt's needs.

Were each country to pursue its objectives unilaterally, it is expected that the largest part of the new capacity would be generated from fossil fuels or nuclear, only Ethiopia, and Sudan to a lesser extent, being in a position to generate significant power from hydroelectricity.

Harnessing the potential of the Nile in order to meet part of the projected energy demands of the Eastern Nile Basin in a sustainable manner is an issue of central importance in the region, and the development of hydropower on the Abbay has the potential to make a significant contribution to these energy demands. In addition to power provision, the construction of reservoirs on the Abbay offers important multipurpose benefits (in irrigation, flood control, sediment trapping and improved navigation) as well as a driver for regional economic integration through power sharing agreements. In general the positive economic benefits (revenue from hydropower sales, electricity for industrialization, induced development and improved downstream generation among them) will augment with increased hydropower generation capacity; however these benefits must be balanced with the other environmental and social impacts which occur as a results as described in the sections dealing with other key issues.

Erosion and sedimentation

Erosion and sediment loading in the waters of the Abbay/Blue Nile and Main Nile is a serious issue with important environmental and economic consequences. It is well established that the bulk of the sediment carried by the system comes mostly from the Ethiopian Highlands Plateau through the Abbay and its tributaries.

Sediment accumulates in reservoirs and irrigation infrastructure in Sudan and in Lake Nasser and has significant economic consequences due to cost of dredging and maintaining irrigation and hydroelectric infrastructure. In addition, high sediment loading is responsible for a loss of hydro energy during peak flow periods as water is flushed through the reservoirs to avoid sedimentation in the reservoir and loss of storage capacity. On the other hand, release of sediment with annual flooding is important as a source of nutrients and organic matter for recession agriculture, as well as silt and clay for brick-making.

Under the no investment scenario, no significant improvement in erosion and sediment control can be expected. Under the cooperative development scenario, effects would start to be felt basin-wide with at least one of the large dams on the Abbay when reduced sediment loading could be expected because of sediment trapping in the reservoir. Two large dams would offer the potential of trapping almost all of the sediment carried by the Abbay. This would facilitate the optimization of various irrigation and energy production infrastructure in Sudan and lower maintenance costs, but would negatively impact communities relying on recession agriculture and brick-making as their livelihoods.

Also, because significant flow regulation for extreme peak flows could be achieved with one or more large dams, bank erosion along the river is expected to be less severe further reducing sediment loads.

Critical habitat and ecosystems functions

The flood plain and the seasonal wetlands are the most important habitats to maintain, at least in part, in order to sustain several ecosystem functions. They provide habitat for a large number of species supporting biodiversity, spawning areas for fish, and groundwater recharge. It is estimated that the total flood plain along the Abbay/Blue Nile and Main Nile covers about 6,000 km^2 for a flood with a 1:2 return period. Fish spawning is usually triggered by flooding that enables them to move to their spawning grounds in tributaries or on the flood plain.

Several impacts are usually associated with the construction of the dams and reservoirs. Dams often impede the migration of several fish species towards the tributaries where are often located their spawning grounds. Flow regulation can also modify their behavior since spawning is usually triggered by flooding that enables the fish to move to their spawning grounds in tributaries or on the flood plain. On the other hand, reservoirs may provide under certain conditions opportunities to develop fish rearing capabilities and commercial fisheries; but they also favour proliferation of invasive species such as the water hyacinth in the presence of nutrients generally derived from untreated wastewater from settlements of fertilizers.

The development of large-scale infrastructure on the Abbay has the potential to regulate river flow and eliminate flooding. By doing so critical habitats and natural services supported by the flood plain will be significantly affected and may disappear with consequences not only on the fauna and flora, but also on people relying on the ecosystem functions: subsistence fishing, Arabica gum, etc. Mitigation measures are possible by maintaining critical environmental flows at specific periods of the year and managing releases to provide a controlled flood regime that would preserve the flood plain and its critical habitats in a sustainable manner.

Cooperation and coordination amongst the Eastern Nile countries would be required to successfully preserve the flood plain and ecological services that the flood plain provides. It is estimated that flood plain management may be achieved reproducing the normal flood found on average every 2 to 4 years with about 10 BCM of live storage (one large dam).

There are three protected areas located in the study area: the Dabus Valley Controlled Hunting Area, located on the Dabus River; the Dinder national park in Sudan and the adjacent Alatish Park in Ethiopia. Only the Dabus Valley Controlled Hunting Area would be at risk of being impacted by a small dam on the Dabus River or by the flooding of the reservoir of the Border dam. Mitigation or compensation measures may be possible. The Dinder National Park in Sudan and the adjacent Alatish Park in Ethiopia may be indirectly affected by pastoralists or other groups moving in the parks to look for grazing areas or other means of survival if flood plain along the Blue Nile disappears or because of expansion of irrigation schemes.

Vulnerable groups and involuntary resettlement

Physical and economic displacement of people and communities is often the most controversial and visible social impact of large-scale projects. For some of the projects considered, there may be significant costs associated with compensation payments, as well as challenges in the design, implementation, and monitoring of strategies to relocate people, restore incomes, or other initiatives to assist project-affected people.

The smaller dams on the Abbay tributaries would displace less people in absolute number due to their smaller size in comparison to the larger dams and reservoirs on the Abbay. Depending on choice of projects and the combinations thereof, it is estimated that the smaller dams would physically displace between zero and 1,118 people, whereas larger dams on the Abbay could physically displace up to 15,525 people. When comparisons are made on the basis of number of persons affected by megawatt (MW) produced, the four large dams on the Abbay taken all together would affect 7 persons per MW produced compared with 37 persons per MW for the five smaller dams on the tributaries.

Ethnic groups who rely on traditional resource-based livelihoods may be more vulnerable to these changes caused by the construction of dams and reservoirs and the modifications of the flow regime. These groups include the Gumuz, Berta, Amhara, Funj, Kenana, Fulani, Nubians, Danagla, Bedirya, Rekabia, Gaa'lian, Shaigia, Kawahla, Kababish, Hassaniya all of whom use the stretch of the Abbay/Blue Nile and Main Nile sub-basins to differing degrees.

Possible expansion of irrigated agriculture along the Blue Nile made more likely under cooperative large development on the Abbay would affect pastoralist's livelihoods. Pastoralists' access to water, for both human and animal consumption, is key to supporting their livelihoods. Expansion of irrigated agriculture would restrict their traditional grazing areas and disrupt their migration routes. There is a possibility that some of the pastoralists along the Blue Nile may migrate north into the Dinder Park placing additional pressure on the resources.

The development of the Border project in the lowlands of Ethiopia has the potential for increased social conflict between the Gumuz ethnic groups and newcomers. There is a history of conflicts in the Benishangul-Gumuz region between local ethnic groups that practice extensive, shifting cultivation and previous migrants, which practice a more sedentary agricultural system.

To minimize the potential for social conflict, mitigation measures for any loss of recession agriculture, pastoralism, as well as supplementary activities such as brick-making, should be implemented well in advance of any changes in flow regime.

Dam safety

All the dams that will be built on the Abbay or its tributaries are by all means considered as large, although the ones on the Abbay are much larger than the ones on the tributaries and may not have any precedent in term of similar scale and/or construction type.

The failure of the dam structure itself, the failure or malfunction of other structures (e.g., spillway gates), as well as the failure of warning systems, or unforeseen spillover due to extreme precipitation increase induced by climate change has the potential to cause important negative environmental, economic and human impacts downstream, including potential loss of lives. The magnitude of the consequences of the failure of one of the dams or of a cascade will be commensurate to the volume of water stored.

A dam safety program will be required by Ethiopia and the financing organizations for all dams constructed on the Abbay or its tributaries. The financing agencies will demand that the local government dam safety agency obtain necessary analytical, advisory and inspection services from recognized international consultants specializing in dam safety. The larger dams on the Abbay will require a more substantial program in terms of number, professional breath, technical expertise and experience of Panel members.

Climate change

Climate change will affect all of the three Eastern Nile countries through changes in temperature and precipitation averages and extremes. It also has the potential to impact the future development investments in the region and affect electric power generation, irrigation, flood management, flood plain sustainability and ability to sustain droughts. Directly or indirectly, the development of reservoirs on the Abbay and its tributaries would provide an adaptation opportunity to potential changes induced by climate change. As such it is suggested that additional storage capacity can be seen as an adaptation strategy addressing the region vulnerabilities, especially in agriculture and water management by ensuring a stable water supply for irrigation and for humans and cattle as well as flood control. Ten BCM of live storage are the minimum to provide some degree of flexibility to alleviate flooding and drought, but it is suggested that 20 to 25 BCM and more is the minimum to really provide the flexibility to address extreme events likely to increase in frequency and intensity in the future. Under a zero investment scenario, adaptation opportunities are limited and community based.

None of the three countries are party to the Kyoto Protocol or have commitments to reduce its greenhouse gases; however it is important to examine how the development scenarios will contribute to the global reduction of greenhouse gas (GHG) emissions. Under a zero investment scenario GHG emissions are expected to increase as the result of increased thermal energy production in Sudan and Egypt pursuing unilateral development to satisfy their needs. Under a cooperative development scenario significant reductions in the GHG emissions from the Eastern Nile countries will be expected. The saving will increase with the size of the investments. Under some conditions the contribution of these projects to the reduction of GHG could give rise to some Clean Development Mechanisms credits.

Institutional capacity

The Stage 1 SSEA summarizes the present institutional capacity in the Eastern Nile countries to manage impacts with respect to the possible investments considered under the development scenarios outlined. For each of the identified key issues, there are specific responsible institutions, laws, and policies for each country that protect social and environmental resources likely to be affected. In addition, in all international donors financed projects the Equator Principles for Financial Institutions (EPFIs) have been designed to effectively mainstream social and environmental issues, providing assurances and protections for environmental and social issues. The World Bank, the African Development Bank and other donors have also specific requirements and safeguards for projects they finance. These safeguards are triggered whenever impacts are expected. As a further strengthening of the institutional setting ENTRO is developing guidelines on transboundary social and environmental issues to supplement and support the implementation of required safeguards.

In summary

The Stage 1 SSEA has presented a clear picture of the expected results from a continuum of investment on a variety of water management, environmental, and social themes. The Stage 1 SSEA indicates that the minimum investment where impacts are felt basin-wide and where there is sufficient flexibility to alleviate some of the challenges expected from climate change is at least one large dam on the Abbay/Blue Nile with about 10 BCM of live storage. Supplementary live storage capacity at about 20 to 25 BCM brings significant added benefits in the capacity of managing negative impacts while providing more opportunities to optimize benefits. The tributary dams offer some local benefits but do not have sufficient capacity for flood and drought protection, sediment control, and hydropower production.

1 INTRODUCTION

The overall purpose of the SSEA is to provide an inclusive and participatory assessment of Cooperative Water Resources Development in the Abbay/Blue Nile and Main Nile. The outcome is an assessment of the environmental and social issues associated with various development options to allow for informed and transparent decision-making in identification and selection of investments for water resources development.

1.1 THE NILE

The Nile River, gathering water from the farthest upstream reaches of the White Nile in Burundi and those of the Abbay/Blue Nile in Ethiopia spans over 6,500 kilometers making it the longest river in the world. The Abbay/Blue Nile portion stretches over 1,500 kilometers and its flows and accompanying floods, caused by the seasonal downpours in the Ethiopian highlands, have for centuries provided water for some of Earth's earliest civilizations.

The Eastern Nile portion of the basin, covering an area of 1,787,624 km^2 (OSI, 2009), begins at the source of the Abbay River at Lake Tana in the Ethiopian highlands, running across the border of Sudan, where it is known as the Blue Nile, after which it joins with the White Nile in Khartoum. The confluence of the Blue Nile and the White Nile forms the Main Nile, which flows through northern Sudan into Lake Nasser at the Egyptian border, and finally through Egypt to its final destination, the Mediterranean. This Abbay/Blue Nile portion of the Nile basin flows through the Eastern Nile countries of Ethiopia, Sudan and Egypt, providing freshwater for an estimated 100 million people.

1.1.1 Eastern Nile Region

All three riparian countries of the Eastern Nile basin depend on the Nile for essential services and utilize the resource to differing degrees.

Ethiopia, the most upstream country in the Eastern Nile basin with a population of 83 million and a GDP per capita of $201 in constant 2000 prices (World Bank, 2011), is amongst the poorest countries in the region, and is the source of over 80% of the Nile flow. Ethiopia is currently experiencing one of the world's highest rates of economic growth and is seeking to develop its water resources for continued economic development, both for hydropower and for irrigation.

Sudan, before it's splitting in 2011, was the continent's largest country by land with a population of 42.3 million and a GDP per capita of $537 in constant 2000 prices (World Bank, 2011). It has traditionally used the Nile mostly for recession agricultural and pastoralism, but is increasingly using the Nile for large scale irrigation, constructing some of the world's largest irrigation schemes.

Egypt, the most downstream country in the Nile basin, with more than 96% of its freshwater inflow originating from outside its national boundaries, is the most economically developed country in the region with a population of 83 million and a GDP per capita of $1,836 in constant 2000 prices (World Bank, 2011). The Nile waters, which flow into Lake Nasser created by the Aswan High Dam (AHD) generate 2.1 GW of hydropower and provide about half of Egypt's hydro- electricity or about 10% of the total installed capacity from all sources.

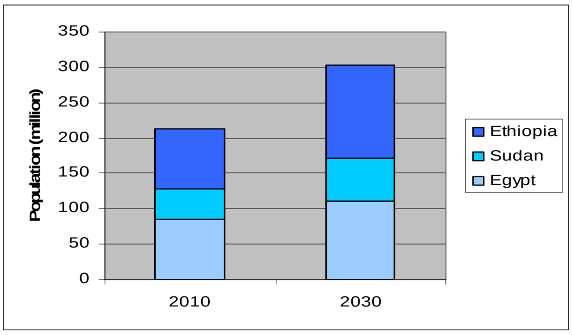
1.1.2 Water Security

The Eastern Nile riparian countries are among the most dynamic and populated countries in Africa. It is estimated that the total population of these three countries will swell to close to 300 million by 2030 at present growth rates (United Nations, 2008).

Due to rapidly growing populations, the per capita water availability in the basin is decreasing at an equally rapid rate (Swain, 2008). Due to highly variable precipitation, the Nile River flows vary considerably from year to year (from a high of 120 km^3/year in 1916 to a low of 42 km^3/year in 1984).

Furthermore the distribution of water is disproportionate on a spatial and annual scale, with approximately 70% of the annual precipitation occurring in the Ethiopian highlands between June and September.

Figure 1-1 Population Projections – Eastern Nile



Important consequences of this hydrological variability include recurrent droughts, intense flooding, and massive soil erosion, all of which have costly socio-economic impacts.

Although predictions in regards to the effects of climate change on precipitation in the Eastern Nile basin remain mixed, changing global weather patterns add an element of uncertainty to the issue of water security in the Eastern Nile basin.

Consumptive uses of water are growing rapidly and the three Eastern Nile riparian countries are already at or below the "stress level" defined as less than 1,700 m^3/capita/year of renewable water (FAO, 2010). In the Eastern Nile basin, 500 billion cubic meters (BCM) of water evaporate annually from surface water bodies, the land surface, or through vegetation (Blackmore and Whittington, 2008). As a result poverty, conflict, food insecurity and environmental degradation continue to plague the region with only a small percentage of the population of the region's total population having access to potable water, electricity, and a reliable water supply for agriculture.

Optimizing the use of water and reducing the risks associated with water scarcity is critical for the sustained development of the Eastern Nile Region. In light of population pressure, actions to make better use of Nile waters for enhanced food and fiber production and programs to reduce soil erosion and increase irrigation efficiency are of interest. The goal of these actions is to improve water security for the millions of local people whose livelihoods depend on the river and for the Eastern Nile governments for which the Nile is the cornerstone of economic growth.

Because of these pressures on the Nile and the central role that the Nile plays in the histories, economies and societies of the Eastern Nile countries, it has become increasingly important to develop strategies for the sustainable management of this limited water resource. It is suggested that cooperative management of the Nile is key to alleviating the most pressing problems, and addressing water security issues facing the Eastern Nile Region.

1.2 HISTORY OF NILE COOPERATION

1.2.1 The Nile Basin Initiative

To address these pressures on the Nile and its importance to the livelihoods of millions throughout the basin, the Nile Council of Ministers (NILE-COM) launched the Nile Basin Initiative (NBI) in 1999. Since its creation, the NBI has been widely recognized around the world as a landmark effort in transboundary resource management and cooperation between the nine Nile riparian states. The NBI is guided by a shared vision "*to achieve sustainable socioeconomic development through the equitable utilization of, and benefit from, the common Nile basin water resources*." Through this shared vision and cooperative action, the overarching objectives of the NBI are poverty reduction, reversal of environmental degradation, promotion of economic growth, increased regional cooperation, and integration and enhanced regional peace and security throughout the Nile basin.

A number of Subsidiary Action Programs (SAPs) were created under the NBI as a vehicle to initiate concrete investments and action on the ground at the sub-basin level of the Eastern Nile (ENSAP) and

Nile Equatorial Lakes (NELSAP). These programs, carried out through the identification and preparation of investment projects, seek to supplement national planning frameworks by providing regional perspectives and transboundary solutions to national problems. The programs are expected to demonstrate that basin-wide cooperation, by adopting good practices in technical studies, economic analysis, and social and environmental management, can make a difference in terms of improving the lives of the poor.

Recognizing that institutional capacity in the region is limited in regards to transboundary water management and that gaps exist in transboundary water policy at the regional and national levels, the NBI is developing an overarching Environment and Social Policy (ESP) to provide environment and social management guidance to the SAPs. The NBI Environment and Social Team carries out the ESP development process. Integral to this process is the undertaking of an assessment of institutional, technical and policy issues in the nine NBI countries to determine the capabilities of the countries to implement the required level of environmental and social practice to sustain SAP projects, and to ensure that there is a robust policy framework to support the aforementioned goals.

1.2.2 Eastern Nile Technical Regional Office (ENTRO)

The Eastern Nile Technical Regional Office (ENTRO) was established in 2002 as the first joint institution of the Eastern Nile countries under the framework of NBI. Since its creation ENTRO has already initiated several projects as part of the Integrated Development of the Eastern Nile (IDEN) and an associated "fast track" set of investments. These projects span a range of resource management issues, including irrigation and drainage, power export and interconnection, regional watershed management, flood preparedness and water resource use planning. Many of these projects are underway or have been completed. These projects are designed to demonstrate the benefits of cooperation at an early stage and to facilitate dialogue about a broader program of activities amongst the riparian countries.

Furthermore to complement NBI's ESP activities, ENTRO has begun activities to enhance the management of ENSAP environmental and social issues. Ongoing is a consultancy to develop ENSAP specific Environmental Management Guidance (EMG) information that will be integrated with the existing ENSAP Social Assessment Manual (SAM). ENTRO has consulted with the other NBI Centers and Development Partners to agree on strategies to synchronize ENSAP guidance. The goal is to ensure an integrated approach in regards to the incorporation of environmental and social standards in project planning.

The ENSAP Fast Track Projects include:

- Ethiopia Irrigation and Drainage Project
- Egypt West Delta Water Conservation and Irrigation Project
- Ethiopia/NBI Power Export Project: Ethiopia-Sudan Interconnector
- Watershed Management (Ethiopia, Sudan, Lake Nasser-Nubia)
- Flood Preparedness and Early Warning – Phase I including Technical Background Reports and Implementation Plans
- EN Planning Model

1.2.3 The Joint Multipurpose Program (JMP) and JMP 1

Within the context of Nile cooperation described above, the three Eastern Nile countries have embarked on the Eastern Nile Joint Multipurpose Program (JMP) with guidance and direction from the Eastern Nile Council of Ministers (ENCOM). The JMP is a long-term program that includes a coordinated set of investments and an enabling institutional environment. The JMP aims to facilitate the sustainable development and management of the Eastern Nile shared water resources by providing a range of development benefits across sectors and countries.

The JMP was launched at the nineteenth meeting of ENCOM (comprised of the Ministers of Water Affairs from Egypt, Ethiopia and Sudan) on February 15–16, 2005 in Alexandria, Egypt.

The JMP was launched by embarking on a series of analytical and consultative activities, designed to conceptualize the JMP, to gather baseline information relevant to investment and associated decision-making in the basin, and to assess the existing institutional capacity available in support of such an investment program.

The JMP Launch phase activities included:

- The creation of the "**One System Inventory**", which established a 'no-borders' database of natural resources and information across the Eastern Nile sub-basin.
- An independent **Scoping Study** that examined water resources matters to broadly assess development options in the basin, which would fulfill JMP criteria.
- The preparation of **Thematic Papers** on "Financing and Implementation Arrangements" and on "Institutional and Broad Legal Considerations".

In keeping with the spirit of cooperative development for maximum benefits and reduced risk, the three major criteria for JMP investments were defined and are as follows:

Criteria for JMP Investments

1) These investments should provide **benefits to all three participating riparian** countries: each should benefit as a result of cooperation.
2) The investments should be **multipurpose**: they should yield various types of benefits that can be shared by all three riparian countries and that will foster economic integration.
3) The investments should cause "**no regrets**": they should not foreclose desirable investment options in the future or set the participants on a development path from which serious negative consequences might arise in the long term.

The above criteria limited the investigation of JMP investment possibilities to upstream sub-basins that lie at least partly in Ethiopia, due to the fact that sub-basins further downstream would not have benefits for all riparian countries of the Eastern Nile basin.

In 2008, ENTRO successfully completed the major activities of the Launch Phase of the JMP. The Launch Phase has led to the initiation of the First JMP (JMP 1), which seeks to initiate a regional, integrated, multipurpose program through the identification of a first set of investments.

The Scoping Study: As an input to the JMP 1, ENCOM requested the World Bank to commission an independent Scoping Study on the opportunities and risks of the Eastern Nile river management and development. ENCOM endorsed a proposal for an independent study to help guide the integrated development of the water-related resources of Ethiopia, Sudan, and Egypt, and to facilitate the selection of an initial set of investments under JMP for the Eastern Nile.

The Scoping Study, entitled "**Opportunities for Cooperative Water Resources Development on the Eastern Nile: Risks and Rewards"** (Blackmore and Whittington, 2008)had as its goal an objective assessment of the water resources of the Eastern Nile and the opportunities available for cooperative development, in line with the determined criteria of a JMP. Upon examination of the opportunities and risks associated with three sub-basins as possible locations for launching an initial set of JMP investments (including the Baro-Akobo Sobat, the Tekeze Atbara and the Abbay/Blue Nile sub-basins) the study came to several important conclusions.

The scoping study was reviewed and commented upon by stakeholders from all three Eastern Nile riparian countries. One of the major comments from the scoping study was that it did not sufficiently deal with the environmental and social impacts resulting from proposed development scenarios on the Blue Nile, particularly in regards to Egypt. Furthermore, although the study confirmed that some scenarios would result in a deficit of releases, levels, storage and power generation from the Aswan High Dam (AHD), there was no attempt to assess the economic and environmental effects, which may occur in Egypt. Both the Scoping Study and the associated comments were taken into account in the development of JMP 1 activities.

Main Conclusions of the Scoping Study

- The Abbay/Blue Nile Sub-basin offers the most favorable opportunities for an initial set of cooperative investments that would spur regional, multipurpose benefits for all three countries without eliminating future development options.
- New water storage facilities on the Abbay/Blue Nile Sub-basin would generate large amounts of hydropower and would provide important multipurpose benefits to downstream riparians, including flood control, sediment management, and improved navigation.
- Water storage and hydropower generation facilities in this sub-basin could be complemented by investments in watershed management and irrigated agriculture.
- The anchor investment of this first JMP initiative could be large multipurpose water storage and hydropower facility on the Abbay/Blue Nile River in Ethiopia and that, coupled with complementary investments, could offer significant benefits to all three Eastern Nile riparians.

JMP 1 Identification Project: Following the completion of the JMP Launch Phase studies, ENCOM authorized additional work to identify and define an initial package of investments in JMP 1. This identification phase, known as JMP 1 Identification Project (JMP 1 ID), consists of analytical and consultative work critical to make an informed selection of the component projects under JMP 1. The JMP 1 ID includes a two-stage strategic social and environmental assessment (SSEA). The scope of JMP 1 ID includes the identification of a preferred cascade development scenario and a first priority multipurpose dam on the Abbay/Blue Nile, identification of an Anchor Project, identification of proposed non-anchor projects, economic and financial analysis, and financing and institutional studies. The JMP 1 ID is to be carried out in close collaboration with stakeholders in order to provide sufficient information to enable the governments of Egypt, Sudan and Ethiopia as well as for investors and donor partners to make a decision to proceed to detailed project preparation. The JMP 1 ID has two components: (i) JMP 1 Identification Studies; and (ii) Capacity Building and Implementation Support.

Site Specific Studies, Country Studies and Special Studies: In parallel to the JMP Launch phase studies and the JMP 1 ID, several complementary studies have been undertaken, or are being carried out, to provide further information to decision makers on potential investments.

These studies cover a range of technical, scientific, and socio-economic issues and are designed to provide more detailed analysis as well as useful tools for the eventual choice and implementation of bankable projects. For example, the already completed Cooperative Regional Assessments (CRAs) are regional studies geared at understanding the benefits and costs of irrigation, drainage, and watershed management across the Eastern Nile riparian countries, while demonstrating the incremental benefits of cooperation. As well, several country-led site-specific studies have been carried out for water resources development projects that were previously identified in the national development plans of the riparian countries and that may qualify as suitable projects under JMP 1 ID. In addition to these completed studies, site specific feasibilities studies for Mandaya and Beko-Abo were underway at the time of preparing this report.

Site Specific Studies

- Watershed Management Cooperative Regional Assessment
- Irrigation and Drainage Cooperative Regional Assessment, and related pre-feasibility studies
- EN Regional Power Trade Study Phase 1 and Phase 2
- Pre-feasibility studies of Karadobi (Ethiopia), Mandaya (Ethiopia), Border (Ethiopia) and Dal (Sudan)
- Reconnaissance Study for Beko-Abo (Ethiopia)

Finally, a series of special studies is planned to address important gaps in the current baseline data and to analyze the possible impacts of large-scale infrastructure development on the Abbay/Blue Nile. These special studies include:

- Water Saving Measures Study
- Groundwater Resources Study for Agriculture along the Blue/Main Nile in Sudan
- Recession Agriculture Studies
- Financing and Institutional and Legal Arrangements for Anchor Project
- Preparation of a Roadmap for JMP 1
- Benefit Sharing Studies

1.3 OBJECTIVES OF THE STAGE 1 SSEA

The Stage 1 SSEA for the JMP 1 ID provides the context for increasingly sophisticated cooperation between the Eastern Nile riparian countries as well as for greater upstream planning and strategic decision-making. The Nile Transboundary Environmental Action Project (NTEAP), the various Cooperative Regional Assessments (CRAs) and their associated stakeholder consultations, as well as the issues raised in the Scoping Study and by other related pre-feasibility studies and environmental impact assessments at the pre-feasibility level (EIAs), were the main sources of information upon which the Stage 1 SSEA has been built.

The JMP 1 ID was divided into several analytical tasks, which form the building blocks for the identification of an investment project. To undertake a thorough assessment at a strategic level of a range of development options on the Abbay/Blue Nile, the analysis has been divided into two phases. Phase I focused on data gathering, preparation of the Stakeholder Consultation Strategy and Program, and the Stage 1 Strategic Social and Environmental Assessment (SSEA).

The Stage 1 SSEA compares a range of water resources development alternatives in the Abbay/Blue Nile and Main Nile basin from a zero-level investment to full cooperative development of the Abbay and its tributaries, and identifies key strategic issues.

Phase II will concentrate on the specific investments on the Abbay/Blue Nile and a more focused Stage 2 SSEA will be prepared.

Specifically, the SSEA for JMP 1 targets two key topics: (i) strategic analysis of different options based on the JMP Launch Phase Studies for water resources development of the Abbay/Blue Nile and Main Nile and (ii) the identification/selection of a Cascade Development and Investment Sequencing option.

Accordingly, the SSEA is being conducted in two separate and consecutive stages. The first stage focuses on the comparison of the development options recommended by the Launch Phase, and the second focuses on the Cascade Development and Investment Sequencing Study. This report deals exclusively with the Stage 1 SSEA.

1.3.1 Stage 1 SSEA

In general an SSEA can be defined as: "*A process directed at providing the authority responsible for policy development and the decision-maker with a comprehensive understanding of the environment, social and economic implications of the policy proposal, expanding the focus well beyond what were the original driving forces for new policy*" (Brown and Therivel, 2000). SSEA is a process that promotes inclusion of environmental and social criteria in policy-making and planning. Specifically, a SSEA helps to assess environmental and social impacts of development options with the goal of reducing upfront planning and preparation costs by screening out inappropriate or unacceptable projects at an early stage. A SSEA is a critical step in identification of bankable projects.

The Stage 1 SSEA provides an identification of environmental and social issues in regards to transboundary water resources development and the choice of development options facing the Eastern Nile Region, and is the initial planning stage of joint cooperative developments. The issues identified by the Stage 1 SSEA will guide project-specific Environmental and Social Impacts Assessments (ESIAs) by identifying environmental and social concerns of the specific project.

1.3.2 The Stage 1 SSEA Report

The objective of this Stage 1 SSEA report is an inclusive and participatory assessment of environmental and social issues associated with various development options to allow informed ad transparent decision-making in the identification and selection of investments for water resources development. The Stage 1 SSEA report broadly examines linkages and cumulative impacts of a range of investments on existing physical, biological, socio-economic, and cultural environment and identifies tipping points in the range of investments where impacts starts to materialize in the basin, whether negative or positive. The key issues such as natural habitats and involuntary resettlement as well as mitigation measures are addressed. Finally, the Stage 1 SSEA report presents the current institutional capacity in the basin to handle possible investments according to the development outlined and highlights international safeguards that might be triggered by investments.

The Stage 1 SSEA has been undertaken in close consultation with key stakeholders in the three countries involved (Egypt, Ethiopia, Sudan). Independent reviewers have also advised ENTRO and the consultant during preparation of the Stage 1 SSEA.

The Stage 1 SSEA provides a foundation from which to proceed to a more focused strategic analysis related to a proposed JMP 1 Anchor project, which will be the aim of the Stage 2 SSEA in the Phase II of the JMP 1 ID studies.

1.4 CONTENT AND STRUCTURE OF THE STAGE 1 SSEA

The Stage 1 Draft SSEA comprises two Volumes. Volume I is the present document and constitutes the Main Report while Volume II includes baseline information on the bio-physical and socio-economic environments as well as on institutional and legislative frameworks.

Chapter 2 of this report describes the Approach and Methodology used to carry out the Stage 1 SSEA, and also outlines the key strategic environmental and social issues of concern in the Eastern Nile Region. Chapter 3 provides a summary description of the baseline conditions organized according to the issues identified in Chapter 2. Chapter 4 presents the main drivers, threats and scope of the issues, assessing their likelihood of occurrence and severity. The threats include climate change, effects on water quality, change in water demand, loss of livelihoods, increased water stress, and loss of biodiversity.

Chapter 5 provides an assessment of the institutional and regulatory frameworks and identifies gaps that need to be addressed to make a joint investment bankable. Chapter 6 provides an assessment of the range of development investments, describing the effects cooperative development would have. The major environmental and social impacts, both positive and negative, constitute the basis of the analysis with emphasis on risks against sustainability. Chapter 7 provides a summary of the assessment as well as recommendations for the path forward.

2 METHODOLOGY AND PROCESS

2.1 THE CONSULTANCY MAIN TASKS

The Stage 1 SSEA activities are comprised of the following tasks:

- Screening,
- Preparation of an environmental and social baseline based on existing information, focusing on aspects of the biophysical and socio-economic environment likely to be affected by the JMP 1 investments,
- Scoping of key environmental and social issues within the regional context,
- Analysis of key strategic environmental and social issues,
- Assessment of environmental and social risks along continuum of joint investments from zero joint investment, up to the full development of the Abbay, defined by four large dams on the Abbay, not precluding the building of smaller dams on the Abbay tributaries,
- Identification of relevant national and international safeguard policies and guidelines that may be triggered, and assessment of the institutional and policy framework for the management of environmental and social issues,
- Organize and host a series of public sessions to present and validate the findings, and
- Complete the final Stage 1 SSEA report considering the stakeholder input.

2.2 DATA COLLECTION AND ANALYSIS

2.2.1 Sources of Data

The Stage 1 SSEA is based on existing data, which was available from a number of sources. The main source of data was from documents prepared by ENTRO and the NBI and from additional documents identified through a literature review. These data were augmented by visiting relevant institutions, ministries, and agencies of the three countries and through the contributions of several local experts, including the Consultant's local partners in Egypt, Sudan, and Ethiopia. Appendix B contains the list of organizations and experts contacted.

A Geographical Information System (GIS) was used to illustrate the baseline data and to conduct spatial analysis on the data. The objective of the analysis was to understand the current situation, to summarize the data available for each issue, and to identify data and information gaps. The analysis helped to identify the main drivers for the current situation and to provide an indication of future trends.

2.2.2 Data Quality and Data Gaps

All data used in this report has been screened for accuracy and consistency and where possible the source of data has been documented. This step was particularly important as it was noted that reports from various sources, which used the same base data, were inconsistent in the units and in some cases introduced errors. Other data, such as chemical analysis data, had to be used with discretion, as data was collected during different periods of the year and was highly influenced by flow variations. Some data were simply not credible and were discarded.

Data collected from the available pre-feasibility studies was in general adequate for a pre-feasibility level, but was lacking in detail and accuracy to quantify the scale of potential adverse environmental and socio-economic impacts, especially at the basin-wide level. Field work was mostly limited to short inventories in the immediate vicinity of the proposed projects location and did not represent seasonal variations. A large number of information used to document the baseline for these pre-feasibility studies came from previous non site-specific reports dating several years. While this may be acceptable for a pre-feasibility study in areas not subject to rapid changes because of low population pressures, like the Abbay gorge, it may not represent as well changing conditions in areas under high population pressures like on the Blue and Main Nile.

Important data gaps have been identified and are reported and discussed in the relevant sections of Chapter 3, which presents the baseline situation with respect to the key strategic issues retained.

It is important to note that there are six Special Studies, which run in conjunction with JMP 1 ID. Part of their purpose is to fill information gaps for JMP 1 ID assessments.

The Consultant feels that the data retained and used in the present analysis is of sufficient quality and quantity to support the conclusions and the recommendations provided. Where data was not sufficient, recommendations for additional studies have been made in Chapter 7.

2.3 SSEA CONSULTATION PROCESS

Consultations are the backbone of the entire JMP 1 itself. They constitute the main space of direct interaction with secondary stakeholders and mark important milestones of the JMP 1 ID process. ENTRO has formulated a Stakeholder Involvement and Communication Strategy (SICAS) of the JMP 1 Identification Studies and an Implementation Plan was formulated by the Consultant through a collaborative and iterative process with the Social Development and Communication Office (SDCO) of ENTRO and therefore it embodies a common understanding about stakeholder involvement and communication in the frame of the JMP 1. The SICAS Implementation Plan is a living document that will evolve in accordance with the JMP process (ENTRO, 2010).

The Stage 1 SSEA is also part of this extensive consultation process, which is seen as a *dialogue* with and among key stakeholders of the Eastern Nile basin.

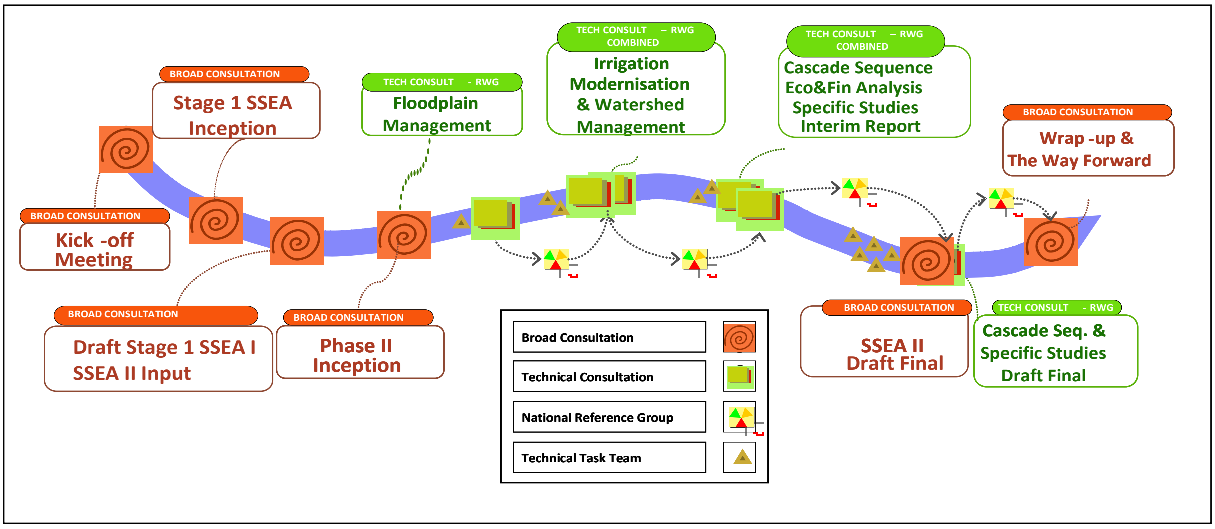
There were two types of consultation meetings, broad consultations and technical consultations.

- The broad consultations involved the interaction with broad groups of secondary stakeholders from the three riparian countries to discuss social, environmental and development issues related to JMP 1.
- The technical consultations involved the Regional Working Groups (RWG) and focused on specific technical issues of the JMP 1 ID process and on the specific studies being carried out by the Consultant.

The consultations were intended to share and legitimize the findings and conclusions with a broad range of technical and non-technical stakeholders and to directly involve them in the decision making process.

The Stage 1 SSEA involved two specific Broad Consultation Workshops as depicted in Figure 2-1.

Figure 2-1 JMP 1 Identification Studies Consultation Process



The Broad Consultation Workshop for the Stage 1 SSEA Inception took place on March 27-28, 2010 and the third consultation for the Draft Stage 1 SSEA Input was not scheduled at the time of writing this report.

At the March 2010 Inception Workshop, issues were discussed amongst the stakeholders, including the time horizon of the study and the definitions of No-JMP and JMP development alternatives. The general approach, proposed by the Consultant to carry out the Stage 1 SSEA, was also discussed.

Although the definitions for No-JMP, JMP small dams and large JMP were extensively discussed at the meeting, the definitions for the purposes of analysis and comparison have evolved with input from the stakeholders, ENTRO, the World Bank, as well as definitions used in previous reports, such as the Scoping Study. Furthermore, in January 2011 it was proposed by an Independent Panel of Reviewers, the JMP core and extended team members, and representatives from the World Bank that performing the analysis according to a range of possible investments, from a zero investment to a full development of the Abbay, would better reflect the present situation and widen the analysis spectrum.

2.4 ANALYTICAL PROCESS

2.4.1 Determination of Spatial and Temporal Boundaries

The Stage 1 SSEA methodology used for the study begins by establishing a baseline of actual conditions in a determined geographical area and then proceeds to take into account near future impacts based on existing trends and probable impacts anticipated during the study time horizon.

The approach allows the Stage 1 SSEA to identify the risks and opportunities of the JMP 1 against conditions expected to evolve based on present trends, as well as future conditions likely to arise with each country pursuing either and unilateral or cooperative development across the possible range of investments.

The spatial boundaries have been determined as the area in which the development of water resources of the Abbay/Blue Nile and Main Nile can have environmental and social impacts, whether direct or indirect. Although that investment is planned upstream on the Abbay River or its tributaries, it is recognized that implications of development may extend well beyond the investment area. Consequently the study area extends from just downstream of Lake Tana to the Aswan High Dam, fully recognizing that for some issues such as water quality the study area may extend to the Nile Delta.

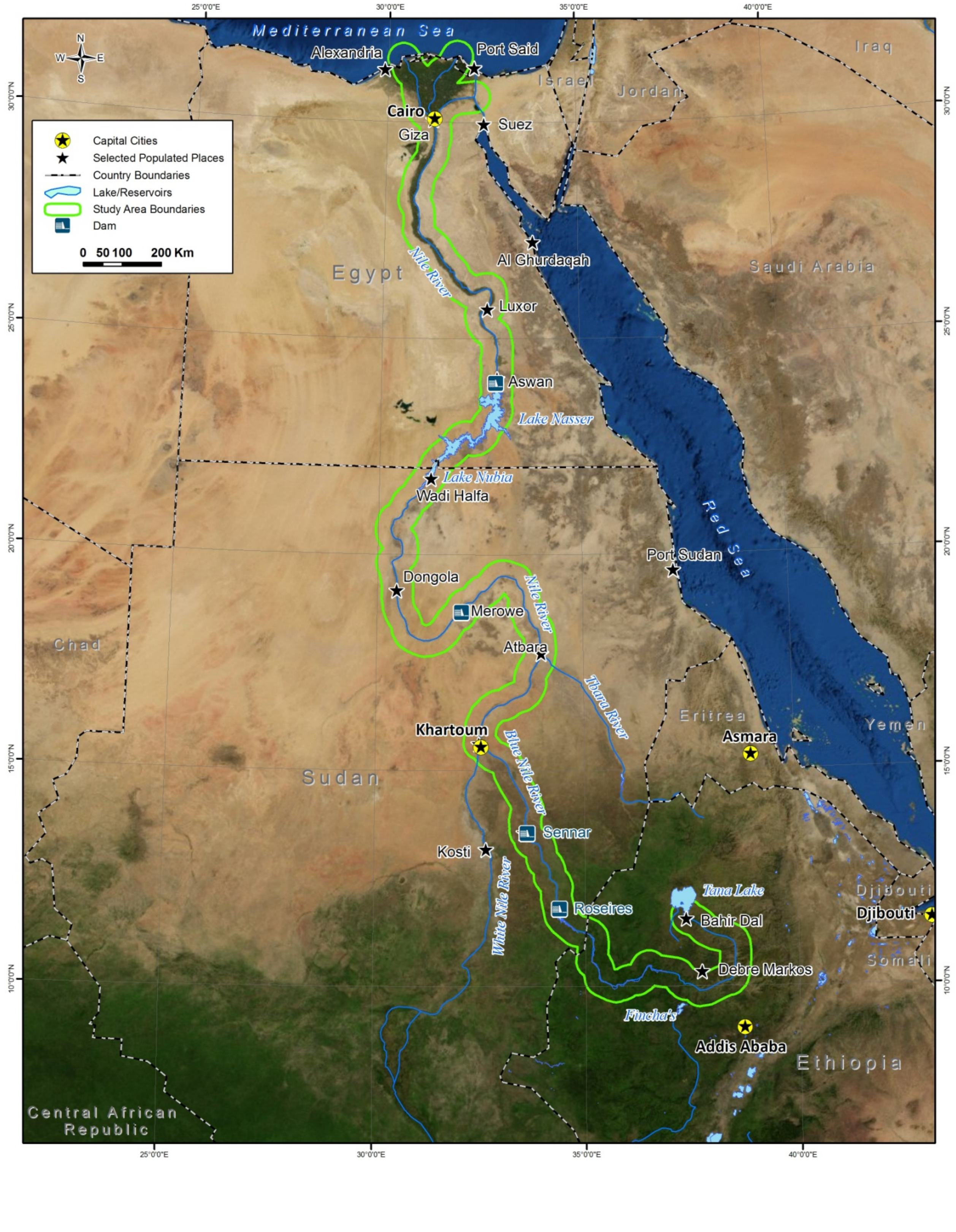
Although the planned interventions are limited to a large extent to the Abbay/Blue Nile, the Abbay tributaries, and the Main Nile, it is necessary to define a corridor on either side of the river that would be affected by the investments. The most obvious physical manifestation of the river is the seasonal flooding during and after the rain season. Accordingly, the study area was limited to the corridor affected by flooding during extreme events for most issues. However, some impacts will manifest themselves beyond this corridor, for example atmospheric emissions from biomass decomposition, thermal development or animals and populations migrating away from the study area in the protected areas of Dinder in Sudan. This has been taken into consideration as appropriate. Figure 2-2 presents the extended study area.

Time Horizon: The time horizon used for the Stage 1 SSEA was 2030. The time horizon was arrived at by considering the length of time it takes to develop major hydro projects.

Based on the Consultant's experience, approximate lead times for each project were estimated based on their level of preparedness and the average time for each of the individual activities leading up to implementation and commissioning. It was recognized that lead times may vary, depending on environmental approval process, private or public ownership, commitment of the host government, feasibility of financing, size and complexity of the project, and the extent to which activities may be fast tracked. Taking this experience into account, then the earliest commissioning dates that could be expected is January 2022 for Karadobi, Beko-Abo, Mandaya and Border projects and January 2020 for the small projects on the tributaries of the Abbay River.

If a cascade of projects is considered, there would be considerable logistical strain with the construction of several projects in parallel, and therefore it is prudent to assume that such large projects would be commissioned a few years apart. Given the region's Generation Expansion Plans, as presented in Appendix C and the above assumptions, then a likely time horizon of 2030 is reasonable.

Figure 2-2 Extended Study Area



2.4.2 Determination of Key Strategic Issues

Key strategic issues were initially determined using existing material from the One System Inventory (OSI, 2009) developed by ENTRO, which provided a 'no-borders' database of natural resources and information across the Eastern Nile basin. The water and related environmental issues for the Eastern Nile basin as the result of this database are shown in Table 2-1.

Table 2-1 Major Environmental Issues related to Water according to OSI 2009

Abbay/Blue Nile	Main Nile
• Water quality deterioration because of high sediment load • Water-related diseases, particularly malaria, but also schistosomiasis, typhoid, diarrhea, helminthiasis, leshimaniasis, onchocerchiasis • Soil degradation and decrease of soil fertility • Deforestation and degradation of biomass • Sheet erosion and gully erosion in Ethiopian Highlands due in part to poor drainage and removal of vegetation • River bank erosion • Dam and reservoir siltation • Degradation of wetlands due to land degradation and sedimentation, as well as draining to convert for cultivation • Loss of biodiversity	• Water quality deterioration due to agricultural and industrial pollution • Water-related diseases due to water and sewage: salmonella, shigella, vibrio cholera, parasites, hepatitis A and E, viral gastroenteritis and poliomyelitis virus • Potential impacts of agricultural development around Lake Nasser and Tushka Project • Use of agro-chemicals • Increased population pressure • Threats to biodiversity

To complement the issues extracted from the OSI database, each country's National Development Plans were reviewed.

In Ethiopia, poverty reduction and its ultimate eradication have been and still is the overriding development agenda of the Government. An important element to achieve this goal is the optimal use of the country's water resources. As a consequence, Ethiopia has launched a long-term plan focused on the provision of clean water, the development of irrigation, and electric power generation.

In Sudan, agriculture faces serious challenges including land degradation, underdeveloped technology, overgrazing, competition for resources, rural-to-urban migration, and low economic development. Siltation of its reservoirs and irrigation channels along the Blue Nile and Main Nile is negatively affecting both agricultural production and Sudan's capacity to produce hydroelectric power. Also, like many of its neighbors, Sudan has experienced frequent floods and droughts and is subject to damaging floods and ongoing desertification. Both are having considerable negative effects on the environment, human activities, and regional economy.

Egypt's development goal for the period 2007 to 2012 is to increase the general welfare of its citizens. Less than 10% of its area is suitable for cultivation and some 95% of its water supply comes from outside its borders. To feed its population Egypt has relied on irrigated agriculture, which has been an integral part of its economy and culture for thousands of years (El-Din Amer *et al.*, 2005). For economic development to occur, Egypt requires greater access to reliable energy.

Considering the OSI work and the National Development Plans a preliminary list of environmental and social issues, which could be expected from the development of water resources in the Eastern Nile was compiled in Table 2-2.

Table 2-2 Preliminary Themes and Issues Considered

Themes	Issues / Effects		Social	Environmental	Economic
Power Provision and Development	Importance of power generation for regional power demand and expansion generation needs	Significance of hydropower for long term power supply in the region, and the extension of electricity distribution networks			•
		Reliable low cost of power generation			•
	Compatibility of mainstream hydropower and domestic electrification with poverty alleviation		•		
	Significance of hydropower in the reduction of carbon emissions			•	•
	Dam safety		•	•	
Water Resources Management	Flood control management and flood forecasting		•		•
	Water Storage - Evaporation control	Drought Management	•		•
		Evaporation Control			•
	Hydrology / sedimentation	Changes in sediment regime/transport		•	•
		Erosion and river morphology changes		•	•
	Groundwater recharge in flood plain			•	
	Water quality changes			•	
Social Livelihoods Issues	Livelihoods systems/Ecosystems services	Pastoralism and grazing areas	•		
		Recession agriculture	•		
		Brick-making	•		
		Water supply	•		
		Subsistence Fisheries	•		
		Navigation/transport	•		
	Health and nutrition		•		
	Ethnic and cultural impacts		•		
	Economic and physical displacement, resettlement and migration		•		
	Poverty reduction		•		
	Social Equity and benefits sharing		•		
Economic Development	Power demand and energy sales and revenues				•
	Irrigated agriculture		•		•
	Commercial fisheries				•
	Transport and Navigation				•
	Industry				•
	Tourism				•
	Mining				•
	The impacts of dams on broader energy economics and secondary stimuli on national/regional development				•
Critical Habitats	Protected areas			•	
	Conservation forestry			•	
	Flood plain and seasonal wetlands	Spawning areas	•		•
		Impacts on livelihoods		•	
	Changes in composition of fauna and flora	Species with special status		•	
		Invasive species		•	•
Climate Change	Water security		•		•
	Potential GHG emissions reductions and other emissions			•	
	The vulnerability of mainstream hydropower to a changing climate		•	•	•
	Carbon financing opportunities for mainstream hydropower				•

These issues were carefully examined to differentiate between development opportunities and potential impacts; they were then analyzed in terms of importance and narrowed down and prioritized into Key Strategic Issues by a Panel of Experts.

The meeting of a Panel of Experts was held in Addis Ababa on January 13 and 14, 2011 and included representatives of ENTRO, four representatives of the World Bank, three international independent experts, and the Consultant. The Panel of Experts reviewed the preliminary list of themes and issues according to their strategic importance for the region and their relevance to the JMP and developed a list of Key Strategic Issues. Table 2-3 summarizes the Key Strategic Issues retained and briefly expands on the type information that the assessment is expected to provide.

Table 2-3 Key Strategic Issues

Key Strategic Issues
1. Water Security • What is the quantity of water available? • How is it used? Who is using it? • What are the main factors affecting water security now and in the future? • What is the situation for each of the three countries? • How would JMP affect water security?
2. Access to Water and Livelihoods • What are the livelihoods based on the environmental services of the river and the flood plain? • How many people depend on them? • What are the present trends and how would those dependent on the flood plain be affected by JMP?
3. Water Quality • What is the present water quality situation? • What are the factors affecting it and what are the trends? • Are there transboundary mechanisms in place to address water quality issues? • How would JMP affect water quality?
4. Hydropower • What is the present power demand in the Eastern Nile Basin and how can it be met sustainably? • What are the benefits and tradeoffs of hydropower generation in the basin? • What are the benefits of hydropower as a clean source and how much can be produced in Ethiopia, Sudan and Egypt to meet the demand? • What other power generation alternatives could be considered and what are the multipurpose benefits of hydropower? • How much storage would be necessary to generate benefits such as flow regulation?
5. Erosion and Sedimentation • How much sediment is there in the system, where does it come from? • How serious is bank erosion? • How would JMP affect the sediment load and the bank erosion?
6. Critical Habitats, Ecosystems Functions and Biodiversity • What portion of surface area is flood plain and how much is used for recession agriculture? • What are its characteristics? • What is the biodiversity in the study area? How is it related to the flood plain? • Are there any protected areas and species with special status? • Could the flood plain, the protected areas and the species with status be affected by JMP?
7. Vulnerable Groups and Resettlement • What segments of the population should be considered as vulnerable groups? • Why are they vulnerable in the current situation? • How could they be directly or indirectly affected by JMP? • What are the potential claims of these vulnerable groups and how can they be satisfactorily addressed?
8. Dam Safety • Are there any risks related to the construction of large dams on the Abbay? • Could climate change pose a risk for dam safety?
9. Climate Change • How could climate change affect water security? • Could climate change affect or maybe even compromise JMP?

2.4.3 Scoping of Key Strategic Issues

The detailed scoping of the Key Strategic Issues shown in Table 2.3 is discussed in Chapter 4 with respect to their relative importance from a regional context and their significance given the time horizon of the SSEA.

The following criteria were used to support the scoping discussion:

- Scope, severity, and expected range of the predicted effects,
- Confidence in the occurrence of change from the baseline situation,
- Possibilities of avoidance, mitigation, and enhancement,
- Synergies and cumulative impacts,
- Whether World Bank Safeguards are likely to be triggered, and if so at what point,
- Possibility of conflicts from a number of reasons: ethnic; resources sharing, in-migration, etc.

3 BASELINE

This section highlights the baseline information relevant to the Key Strategic Issues retained by the Panel of Experts as noted in Chapter 2. Additional baseline information can be found in Volume II – Baseline of the Stage 1 SSEA report.

3.1 WATER

3.1.1 Climate and Precipitation

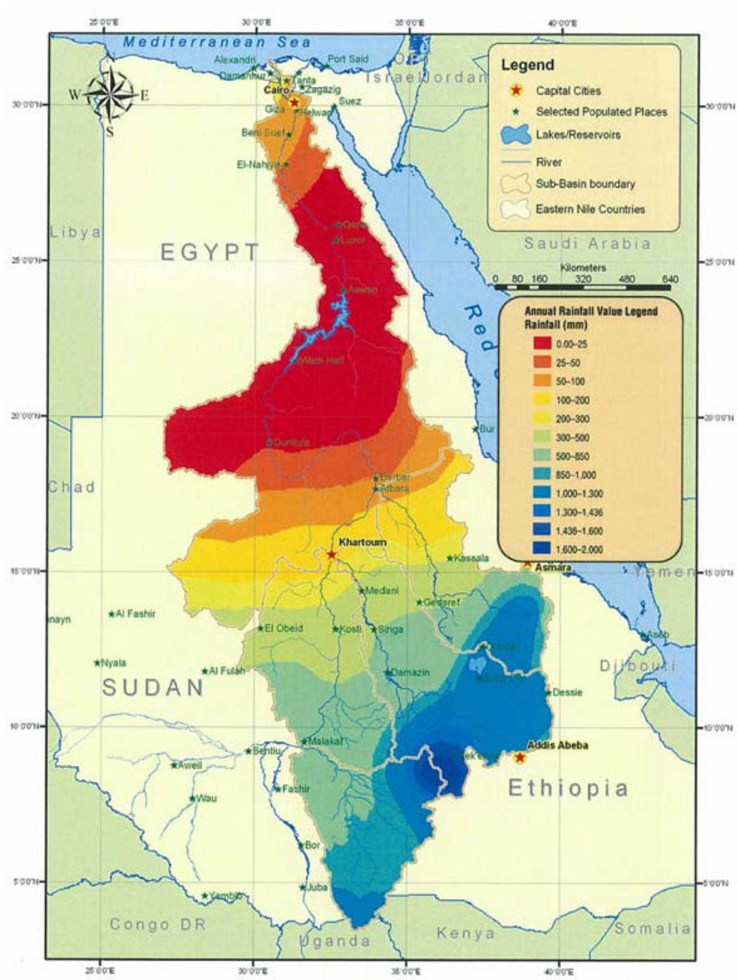
Climate in the upper course of the Abbay/Blue Nile basin is of the humid and sub-humid tropical type with wet seasons in the western highlands of Ethiopia, including the Abbay basin. Climate in the lower course of the Blue Nile (beyond the Ethio-Sudan border) is hot tropical with a dominant dry season. The dry and hot tropical climate dominates the further northern reaches, as part of Sahara desert. The Main Nile is characterized by an arid climate where moisture is almost non-existent.

Mean annual temperatures, at high altitudes (>2,300 masl) in the western highlands plateau of Ethiopia, are in the range of 17ºC to 19.5ºC. Temperatures rise, ranging from 24ºC to 26.5ºC, toward the Ethio-Sudan border where altitude drops to less than 1,000 masl. At the confluence of the Blue Nile with the Main Nile, around Khartoum, the altitude is below 500 masl and temperatures range from 28.5ºC to 30.5ºC. Temperature in this sub-basin is very hot, with mean annual daily temperature varying from above 30ºC (around Dongola and AHD) to 18ºC in the coastal areas (Alexandria).

Rainfall in the Abbay/Blue Nile basin varies both seasonally and spatially. Horizontal variation ranges from above 1,500 mm in the southern portion of its upper course to about 1,000 mm in its northern portion. Similarly, in its lower course mean annual rainfall ranges from 700 mm (south portion at El-Damazin station) to less than 500 mm in its northern portion. The length of the wet spell lasts for more than five months (April/May to October/November) in the southern half of the Ethiopian Highlands to less than three months in most of the northern part, with higher seasonal variability.

More than 65% of the Main Nile basin has a mean annual rainfall of less than 50 mm and only 17% of the basin has a mean annual rainfall of above 100 mm. Main seasonal precipitation is concentrated in the May – October period in the southern part of the basin while it is spread over October to March in the northern part. The Lake Nasser/Nubia area is by far the driest part of the entire area with as little as 5 mm of rain at Dongola and at the Aswan High Dam. Mean annual spatial distribution of precipitation in the Eastern Nile is shown on Figure 3-1.

Figure 3-1 Mean Annual Rainfall Spatial Distribution, Abbay/Blue-Main Nile Basin (OSI, 2007)



Temperature and evaporation are well correlated with altitude in the Abbay/Blue Nile basin. In the upper part of the basin, evaporation is lower due to the high altitudes and cooler temperatures. Mean annual evaporation ranges from about 1,500 mm in the Highlands of the basin to more than 6,800 mm around Khartoum (OSI, 2009). At Aswan High Dam (AHD), on the Main Nile, it is estimated at 2,600 mm per year (OSI, June 2009).

Table 3-1 Estimated Evaporation in the Main Reservoirs of the Blue and Main Nile

Reservoirs	Evaporation (MCM/year)	Source
Roseires	410 (2002) 750 (raised in 2012)	Norplan, Norconsult, Lahmeyer International, 2006
Sennar	325 300	Norplan, Norconsult, Lahmeyer International, 2006 EDF, Scott Wilson, 2007
Merowe	1920 1550 (in 2012)	Norplan, Norconsult, Lahmeyer International, 2006 EDF, Scott Wilson, 2007
Lake Nasser/Nubia MFL 182m (1) FSL 178m (1) - - 175 m (1) Average	 17,000 14,900 13,300 10,000	 Norplan, Norconsult, Lahmeyer International, 2006 EDF, Scott Wilson, 2007

(1): That would be theoretical assuming a level constant all over the year for comparison purpose.

Climate Change will affect temperature and precipitation. There is a relatively wide range of climate change predictions for the Eastern Nile countries according to emission scenarios and climate change models. It is expected that temperatures will increase by 3 to 4°C between 2020 and 2100 with higher values in desert regions (IPPC, 2007).

The climate change models with given emission scenarios all agree on a warmer future; however there is much more uncertainty for changes in the precipitation patterns in magnitude and direction of the change, especially for south Sudan and Ethiopia. Changes in the total annual precipitation predictions vary between −15% to +14% for the Abbay/Blue Nile basin with most models predicting a variation of less than 5% (Elshamy *et al.,* 2008). For the basin more models report reductions than models reporting increases (IPPC, 2007a). The resulting runoff typically shows an even larger uncertainty range.

While it is relatively safe to assume that the probable warmer temperature will increase evaporation from the drier and hotter parts of the basin, the ambiguity over the precipitation inevitably leads to a greater degree of uncertainty as there is no clear indication of how runoff for the Eastern Nile basin will be affected (Eltahir, 2009). In addition to changes in mean temperatures and precipitation, climate change is also expected to increase extreme events such as the duration and severity of droughts and frequency and intensity of floods (Christensen *et al*., 2007).

3.1.2 Surface Water Hydrology

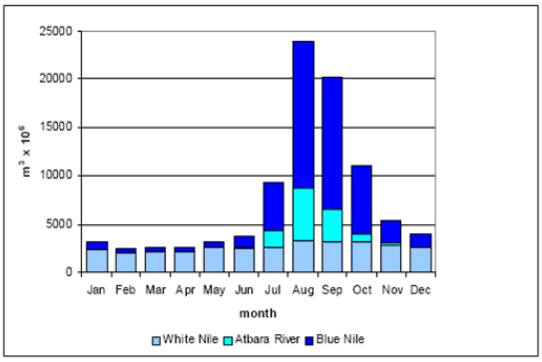
Due to high precipitation in the Ethiopian Highlands the Abbay basin is extremely important to the Eastern Nile system as it generates some 50 percent of the total water runoff in Ethiopia or 51 billion m^3/y (BCM) on average.

1.1.1.1 Overall, it is estimated that the Abbay contribution to the Main Nile discharge into Lake Nasser/Nubia is around 62% and the total Ethiopian contribution to the Nile waters is around 86% (Arsano, 2007).

Figure 3-2 drawn from the Karadobi Initial Environmental Assessment (Norplan, *et al.*, 2006) illustrates the importance of the Abbay/Blue Nile to the Eastern Nile basin. It shows that the waters coming from the Ethiopian Highlands, Abbay/Blue Nile and Atbara are largely responsible for the peak flows during July to October, while flow of the White Nile remains relatively unchanged throughout the year.

Determining an accurate water balance on a system such as the Abbay/Blue Nile and Main Nile is not an easy task due to the spatial and temporal variability of climatic conditions over such a large geographical area.

Figure 3-2 Relative importance of the Abbay/Blue Nile



Precipitation, evaporation, groundwater recharge, and abstraction are the main elements affecting the water balance. Table 3-2 presents the long-term estimated average water flows and abstractions (mostly irrigation) at various points along the Abbay/Blue Nile and Main Nile (OSI, 2009). The quantity of water that is abstracted for small-scale irrigation is unknown.

Table 3-2 Flows and Abstractions along the Abbay/Blue and Main Nile (OSI, 2009)

Node	BCM/year Average[1]
Abbay at the Ethiopia – Sudan Border	51.0
Blue Nile at the Roseires Dam	49.3
Abstraction between Roseires and Khartoum for irrigation	- 6.3
Rahad and Dinder contribution	4.0
Blue Nile at Khartoum (long-term average)	48.7
White Nile at Khartoum	25
Total Main Nile Khartoum	74
Tekeze – Setite - Atbara contribution	12
Main Nile at Atbara	86.3
Abstraction for irrigation in Sudan between Atbara and Dongola	- 1.2
Mean inflow reaching Lake Nasser/Nubia	85.1
Discharge at the AHD	55.5
Abstraction between AHD and Cairo	-17.5
Flow passing Cairo	35
Abstraction between Cairo and Delta Barrage	- 17.4
Abstraction Between Delta barrage and Edfina and Farascour Barrages at the mouth of the Main Nile	- 15.6

1) Does not take into account evaporation.

3.1.3 Water Storage

The total water storage capacity in the Abbay/Blue Nile and Main Nile in the Roseires, Sennar, Merowe and Aswan reservoirs is estimated at 161.5 BCM, with the Aswan reservoir representing 85 percent of the storage capacity (Table 3-3). The total storage capacity will increase by about 5.5 BCM when the heightened Roseires dam is completed in 2013.

Table 3-3 Current Storage Infrastructure on the Eastern Nile

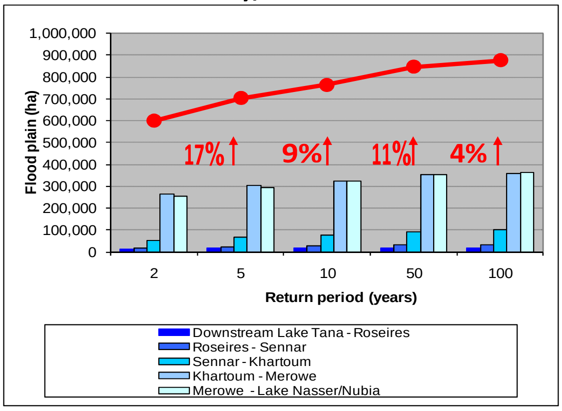
Name	River	Year Completion	Initial Storage (BCM)	Estimated Storage remaining in 2005 (BCM)	Installed Hydropower Capacity (MW)	Source
Roseires	Blue Nile	1996	3.3	1.94	280[1]	Blackmore and Whittington, 2008 1)http://diu.gov.sd/roseires/en/raising_project.htm
Roseires elevated	Blue Nile	2013	7.4	7.4	280	http://diu.gov.sd/roseires/en/raising_project.htm
Sennar	Blue Nile	1925	0.9	0.64	65	Blackmore and Whittington, 2008
Khasm El Girba	Atbara	1964	1.3	0.6	10	Blackmore and Whittington, 2008
Gebel Aulia	White Nile	1937	0.8	1.75	17	Blackmore and Whittington, 2008
Merowe	Main Nile	2009	12.5	12.5	1250	http://globalenergyobservatory.org/form.php?pid=40395
Aswan High Dam	Main Nile	1970	137.3	Almost all	2100	Blackmore and Whittington, 2008

3.1.4 Flooding

Floods occur every year during the tail of the rainy season, usually peaking in August, with varying intensity.

Flooded areas were estimated for return periods of 2, 5, 10, 50 and 100 years (Figure 3-3). Estimations were made using the HEC-RAS hydraulic model with data flow drawn from the Flood Risk Mapping Consultancy for Pilot Areas in Sudan (Riverside, January 2010). For simplicity, it was assumed that flows discharged at the Roseires, Sennar and Merowe dams were equal to flood flows. Data shows that the largest increase in total flooded area occurs between the 2 and 5 year return periods, representing an increase of 17% in flooded area.

Figure 3-3 Flooded areas along the Abbay/Blue and Main Nile



Flooding is a mixed blessing as it results in both positive and negative consequences. Flooding, when it exceeds the level necessary to sustain recession agriculture and seasonal wetlands, has consequences that could be complex and far-reaching, inflicting direct damage to property and structures, disrupting economic activity, affecting and displacing people with various degrees of economic consequences.

The Sudanese Ministry of Irrigation and Water Resources has already identified various levels of flooding that can range from beneficial to detrimental (Table 3-4) adapted from EDF *et al*., 2007). From this Table, it appears that permanent residential areas are flooded about once every two years at El Deim, once every eight years at Wad Medani, once every four years at Khartoum, once every 4.5 years at Shendi, never at Atbara, and once in five years at Dongola.

Table 3-4 Flood Control Levels along Blue and Main Nile and Frequency of Events (%)

Control Level	El Deim	Wad Medani	Khartoum	Shendi	Atbara	Dongola
Normal: Flow confined within the banks of the river						
	< 10.8 0%	<18.4 22%	<15.0 7%	<16.1 7%	<14.2 -	<13.5 7%
Alert: Flow tops over the banks of the river and floods part of the farm lands and agricultural areas adjacent to the river						
	10.8-11.8 14%	18.4-19.4 46%	15.0-16.0 43%	16.1-17.1 45%	14.2-15.2 -	13.5-14.7 45%
Critical: All the flood plain and cultivated areas are flooded						
	11.8-12.3 31%	19.4-19.9 20%	16.0-16.5 26%	17.1-17.6 26%	15.2-15.8 -	14.7-15.2 29%
Flooding: Permanent residential areas near the river are affected						
	>12.3 55%	>19.9 12%	>16.5 24%	>17.6 22%	>15.8 -	>15.2 19%

The average annual damage resulting from flooding along the Blue and Main Nile is estimated at USD $52M, and at USD $527M for a 1:100 year return period (Cawood & Associates, 2005). Additional estimates of flood damages are provided in Table 3-5.

Table 3-5 Estimated Flooding Costs for Selected Locations

Total cost per sector	Cost by Flood Magnitude (MUSD)	
	1:100 year	1:20 year
Abbay Sub-basin	26. 5	9.6
Riparian Villages, Blue and Main Nile	215.4	132.3
Dongola area, Sudan	25.2	4.5

Source: SMEC, FPEW Project Preparation, Vol. 2 Appendices, July 2006.

3.1.5 Groundwater

Groundwater in the Eastern Nile region is important as it used by a large portion of the population to satisfy drinking and irrigation water demands; it also has a fundamental importance in terms water security. Available quantities of groundwater are not well known and the recharge mechanisms are poorly understood.

In the highlands of Ethiopia, groundwater is almost exclusively confined to consolidated rocks where the retention capacity is low and groundwater is confined to fractures. The recharge is generally restricted. In addition, the presence of deep gorges along the Abbay escarpment provides relatively free drainage for the aquifers, which may emerge as springs in the lower slopes, thus drawing the groundwater table down and further reducing their potential storage ability.

Groundwater is found under about 50% of Sudan. The Nubian Sandstone Aquifer, shared by Sudan, Egypt, Libya, and Chad, is the most important aquifer in the region. The depth of this aquifer is up to 1,500 meters (FAO, 2005). The recharge usually occurs from irrigation and wetlands as well as from flooding during and after the rain season. The floods are important to the recharge of the aquifer associated with the flood plains. Eldaw (2003) has estimated that the total annual recharge in Sudan is around 4 BCM.

In Egypt, groundwater is extensively used in the delta area for irrigation purpose. Just as in Sudan, groundwater in the Nile aquifer in Egypt cannot be considered a separate source of water because it is recharged by seepage losses from the Nile, the irrigation canals and drains, and percolation losses from irrigated lands, wetlands and seasonal flooding. The current abstraction from the Nile aquifer was estimated at 7.0 BCM in 2009 (MoWRI, 2010).

In addition to the rain, seasonal flooding and irrigation are the most important mechanisms in recharging the upper aquifers along the Blue and Main Nile.

3.1.6 Water Security

Water security may be defined as sustainable access on a watershed basis to adequate quantities of water, of acceptable quality, to ensure human and ecosystem health (World Economic Forum, 2009).

Several indices have been devised to describe water security. The widely used Falkenmark Water Stress Indicator defines 1,700 m^3/capita/year as the threshold above which water shortage occurs only irregularly or locally. Below this threshold, water scarcity appears in deferent levels of severity. For example, below 1,000 m^3/capita/year water limits economic development and human health and well-being, while a level below 500 m^3/capita/year is a constraint to life. According to the FAO (2010), Egypt is below the threshold of 1,000 m^3/capita/year with an index of 702 m^3/capita/year in 2008. Sudan and Ethiopia are below 1,700 m^3/capita/year, at 1,650 and 1,512 m^3/capita/year respectively for the same year.

Egypt with the lowest ratio of renewable water resources per capita per year is a water poor country with 97% of its renewable water coming from the Nile (MoWRI, 2005). Ethiopia and Sudan are considered richer in water resources; however water security is a challenge as rainfall is erratic both spatially and temporally. In addition infrastructure is lacking to effectively distribute the water country-wide. Some areas have abundant supply of water while other regions are severely deprived. For example, in Ethiopia a widely distributed network of small dams on tributaries of the Abbay and other large rivers might achieve higher water security for local people than one or more large dams and reservoirs that would be built mostly for energy generation and maybe some irrigation. This example represents well the two aspects of water security linked to storage capacity for water and means of delivering the water to regional and local centers of population.

The situation in the region is critical, especially in cases where greater than 40% of the available water is used for agricultural to feed the population (Perveen and James, 2010). Based on data for 2000 to 2002, Egypt is withdrawing close to 60% of its water and Sudan 37% for agriculture (Table 3-6). To address this situation Egypt is investigating various alternatives such as more efficient use of water, groundwater exploitation in the Western desert, and desalination of brackish water or seawater (MoWRI, 2005).

Table 3-6 Percent of Renewable Water Used for Agriculture (2000 – 2002)

Country	Proportion of Water Used for Agriculture (2000 – 2002)
Egypt	59%
Sudan	37%
Ethiopia	5%

Source: http://fao.org/nr/aquastat/ Visited 25 January 2011.

3.2 ACCESS TO WATER AND LIVELIHOODS

Throughout the Nile basin, rural livelihoods depend on access to and exploitation of land, water and other natural resources. The principal livelihood activity, agriculture, includes various types of rain-fed and irrigated farming, as well as semi-nomadic and nomadic pastoralism. A range of natural resources complement agricultural activities, and provide households with goods and services for consumption and income generation. Recession agriculture, pastoralism and agro-pastoralism are distinct livelihood systems in the Nile basin that are integrally linked to the available natural resources of the basin.

3.2.1 Recession Agriculture

The Eastern Nile floods its banks every year due to the rainy season in Ethiopia from June to September. Flooding occurs in Sudan and Egypt with major floods between August and October. The flooding provides moisture and new fertile soil to the fields. Historically this annual flood supported the sustainability of agriculture along the Nile with the deposition of fertile alluvial soil containing mineral material and organic debris brought down from the highlands. This productive land lays in long narrow strips along each side of the river in Sudan and Egypt (Hugues, 2004).

People living in the Abbay, Blue Nile and Main Nile basins have taken advantage of these annual floods for centuries and still practice different forms of recession agriculture, relying on the soil moisture that follows annual floods to cultivate crops. The estimated area under recession agriculture may exceed 370,000 ha (Table 3.7) but varies widely according to available sources and from year to year depending on the extent of seasonally flooding.

Table 3-7 Flood Plain and Recession Agriculture along the Eastern Nile

River Stretch	Length (km)	Total Flood Plain for a 2-year return (ha)[3]	Flood plain ratio for a 2-year return period (ha/km)[3]	Recession Agriculture (ha)
Lake Tana – Roseires	930	13,211[3]		300[1] 2,400[4]
Roseires – Sennar	244	67,461[3]	71[2]	18,250[2]
Sennar – Khartoum	287	39,680[2]		83,800[1]
Khartoum – Merowe	730	265,348[3]	10[2]	169,000[1]
Merowe – Lake Nubia	1050	254,148[3]		110,900[1]
White Nile upstream Khartoum to Jebel Aulia	44		144[2]	6,300[2]

1) EDF et al., 2007 - Mandaya EIA.
2) Norplan *et al*., 2006 - Karadobi EIA.
3) Estimated from DEM and 2-year return period flows.
4) EDF et al., 2007 – Border EIA.

In Sudan, people living along the Blue Nile and the Main Nile rely on annual floods to grow crops. The most common method is based on the cultivation of rapidly maturing crops on highly fertile lands (gerouf) of the lower terraces along the river. With widths of 50-200 m these terraces are farmed after the annual flood recedes. In northern Sudan, the prevailing agricultural system combines small-scale subsistence farming with commercial crop production. The agricultural cycle involves the gerouf season, plus two irrigation seasons (EDF *et al.*, 2007 - Dal EIA). The main irrigated crops include wheat, vegetables, legumes and spices that are grown in the winter and sorghum and maize in the summer. The gerouf crop is primarily used for fodder. Throughout northern Sudan, date palms are the main cash crop and households own, on average, 30 date palms. In addition to being a source of cash income, they are highly valued as a symbol of wealth.

It is not known how many people depend on recession agriculture, but it is an important part of the traditional culture and represents a significant economic value. In Ethiopia, the environmental impact assessment conducted for the Border project estimated the value of 2,400 hectares of recession agriculture that could be inundated by the reservoir at ETB 64,836 million (about USD 3.5M). This value was based on compensation for ten years of lost production (EDF et al., 2007). The value of recession agriculture between Roseires and Khartoum is estimated at USD 2.5M (Norplan *et al.*, 2006).

3.2.2 Fisheries

Subsistence and artisanal capture fisheries help to sustain communities throughout the Eastern Nile basin.

In Ethiopia, these activities are not much widespread and not very efficient. Nationally, 15,000 fishermen fish from 2,350 boats, the majority of which are reed or raft vessels. They use basic gear and the annual per capita fish production is less that 240g (FAO, 2003). There were no data available regarding subsistence fisheries activities along the Abbay mainstream and tributaries, although it is probable that some households living on or near the water engage in subsistence fishing.

Farther downstream, subsistence and artisanal fishing are important sources of animal protein for riverside communities along the Blue and Main Nile basins in Sudan, and in Egypt. In Sudan, 95% of the annual catch comes from the Nile and its tributaries and swamplands. Over 100 fish species have been reported. Reservoir fisheries are important sources of livelihoods, including Roseires reservoir with a potential of 1,700 tons/year and fish landings of 1,500 tons/year, Sennar reservoir with an estimated fish capacity of 1,100 tons/year and actual yield of 1,000 tons/year, and the Sudanese portion of Lake Nasser/Nubia with a potential of 5,100 tons/year and current production of 1,000 tons/year (Table 3-8). Other locations along the Eastern Nile in Sudan have an estimated production of 4,000 tons/year (FAO, n.d.). The fishery on Lake Nasser/Nubia is primarily commercial although in the *khors* and near the shoreline, local ethnic groups and communities carry out subsistence fishing activities.

The yield from commercial fisheries in the Abbay River basin of Ethiopia has been estimated at 18,200 tons/year (Ministry of Water Resources, 1998). Of this, Lake Tana accounts for 15,000 tons, reservoirs 1,200 tons and the Abbay and its tributaries some 2,000 tons. The main catches from rivers are from inflowing rivers to Lake Tana. The fishery in the gorge section of the Abbay is considered to be insignificant. The fish fauna and fishery activities that are presumed to be taking place along the Abbay/Blue Nile tributaries are not well researched and not well understood. However, sporadic information and observations (personal communication Getahun, 2011) suggest that there is only small scale traditional fishery activity in the Abbay/Blue Nile tributaries using hooks and lines, and traps made of local materials.

In the upper course of the Blue Nile basin the potential is limited and fishing is carried out on a subsistence basis only. In central and northern Sudan, several lakes and reservoirs have been formed by the damming of the river and its branches such as the 180-kilometer section of Lake Nubia on the main Nile in Sudan, the Jabal al Awliya Dam on the White Nile, and the Khashm al Qirbah Dam on the Atbara River tributary of the Main Nile. These bodies of water account for some 11,000 tons of fish and have an estimated potential of about 29,000 tons (Chapin Metz, 1991). According to FAO (2001), Lake Nubia's potential in Sudan is 5,100 tons/year, but currently is able to produce only 1,000 tons of fish annually.

Fishing is an important industry for Lake Nasser. According to Bishai et al. (2000) there are some 10,000 fishers organized in five associations around Lake Nasser. Many of the fishers are unqualified and use unsuitable, illegal or damaging fishing techniques. The maximum fish landing was recorded at 34,206 tons in 1981. The potential of Lake Nasser appears to be much higher but catches have been decreasing steadily. It is difficult to develop a clear picture as the number of poaching or illegal catches is reported to be 4 to 5 times larger than the official reported catch (Bene *et al*., 2008).

The most important species in the fish landings are cichlidae with *Tilapia nilotica* and *Tilapia galilaea* forming about 90 % of the total catches.

Table 3-8 Commercial Fisheries Potential along the Abbay/Blue and Main Nile

Water Body	Fish landings (t/y)	Potential (t/y)	No of Fishermen
Lake Tana	3000 (2006)[6]	15,000[3]	2384[4]
Abbay and tributaries	Not significant[3]	2,000[3]	-
Sennar	1,000	1,100[2]	800
Roseires	1,500	1,700[2]	1,200
Sudan portion of Lake Nasser/Nubia	1,000	5,100[1]	-
Egypt portion of Lake Nasser/Nubia	8,000 (2000)		10,000[5]
Gebel Aulia	13,000	-	-

1) Witte *et al.*, 2009. 2) FAO, 2000.
3) Ministry of Water Resources – Ethiopia, 1998. 4) Demisse, 2003.
5) Bishai *et al*., 2000. 6) Getahun *et al*., 2008.

3.2.3 Brick-making

In Ethiopia, brick-making activities are often located in degraded wetlands that are sources of clay and fuel wood to support brick production and are located in proximity to communities that function as a market for the product. In Sudan, 83% of brick production occurs along the Blue Nile, with 9% located on the banks of the Main Nile.

The riverbank locations facilitate access to clays used to make bricks, as well as river transport of the product. Brick-making is mostly a seasonal activity during the dry season and it represents an important source of cash income**.** In Sudan, nearly 50,000 people are employed in brick-making during the dry season.

Although brick-making is recognized a good source of cash income, it also has detrimental effects on the environment and human health. Brickfields, because of rapid urbanization, are being indiscriminately developed throughout Sudan. The traditional methods to produce clay bricks use biomass fuels (fuel wood and dung cake) for brick burning; consequently, brick kilns are very high consumers of fuel wood, consuming about 51.5% of the total industrial wood consumption in Sudan (FAO, 2000). The total annual consumption of wood by the brick-making industries of the Northern States of Sudan is 183,000 t. Brick-making industries of Khartoum and Central States consume respectively 46.2% and 42.3% of the total annual consumption of wood in this sector (Ashraful, 2006). In turn, the industry is responsible for considerable deforestation.

This burning of biomass is responsible for the emissions of trace and non-trace greenhouse gasses, such as CO_2, CH_4, CO, N_2O, NOx and NO (World Bank, 1998); sulphur dioxides (SO_2) are also generated from the effect of heat on clay. So, brick-making industries are important sources of greenhouse gases and other pollutants in the Sudan. According to Ashraful (2006), the total brick-making industry in Sudan would be responsible for the annual emissions of 662,600 t CO_2, 2,900 t CH_4, 25,300 t CO, 20 t N_2O, 720 t NO_X and 470 t NO, and the total amount of carbon thus released would be 180,700 t . About 80% of that amount would come from the Blue Nile sub-basin.

Moreover, the toxic fumes emitted by brick kilns are considered harmful to eyes, lungs, throat and also stunt the mental and physical growth of children (SOS-Arsenic, 2005). A recent scientific report reveals that the combustion of clay and fuels for making bricks in the brickfields also produces dioxins and furans as by-products, which are known to be carcinogenic. They are found in the air, where the humans, birds and other animals either directly inhale them or indirectly uptake them through different contaminated pathways, both of vegetable and animal origins (Rahman, 2005). The kilns also emits particulate matter that carry these pollutants on the vegetation and soils where they also cause damages.

3.2.4 Pumped Irrigation

Pumped irrigated agriculture is applied along both the Blue Nile and the Main Nile in Sudan. A large number of pump schemes growing various irrigated crops have been developed. In the northern part of the country and up to the confluence of the Blue and White Nile at Khartoum, irrigation from the river is confined to the narrow stretches of the Nile alluvial deposits, where mostly high value crops are grown. The major crops are date palms, citrus, vegetables, wheat and various kinds of vegetables. Both high capital intensity and low capital intensity traditional farming go side by side due to scarcity of land and variation in farm size.

Along the Blue Nile, several large pump schemes have been developed covering thousands of hectares for growing specialized crops such as cotton and sugarcane. Pump irrigated agriculture is also practiced from artesian and surface wells in addition to areas along the Nile and its tributaries. This type of irrigation is not necessarily restricted to the area adjacent to the river and is scattered throughout the region in areas where there is sufficient groundwater. Farms that used this type of pumped irrigation are normally privately owned and of 5 to 25 hectares in size.

The total area under small scale pump irrigation and the number of people involved are unknown.

3.2.5 Pastures and Grazing Areas

Ethiopia and Sudan have the largest and second largest livestock herds on the African continent (UNEP, 2007). The three principal systems of pastoralism in the Nile basin are sedentary, transhumant and nomadic.

Some 70-80% of the households in the Abbay basin raises livestock as well as grows crops. In Sudan, it is estimated that 80-90% of rural households own some livestock, of which 50-65% also grows crops (Fahey, 2007).

Throughout the Abbay and Blue Nile basins, households that engage in sedentary pastoralism include traditional rain-fed farmers in Ethiopia and Sudan, as well as tenant farmers on large-scale rain-fed and irrigated schemes in Sudan.

Transhumant or semi-nomadic agro-pastoralism is a production system in which households depend primarily on livestock herding. Seasonally these households return to a home base for animal grazing to grow crops (Fahey, 2007). In the Blue Nile basin, groups such as the Baggars move their livestock (cattle, sheep and goats) north to grazing areas during the dry season and return south in the rainy season to their permanent homesteads. During the rainy season, they cultivate subsistence crops and/or engage in wage labor.

Nomads move continuously between seasonal pastures with their animals. The Beja are camel herders throughout eastern Sudan and the Abbala herd camels, sheep and goats in the arid northern region of the country. As with transhumant pastoralists, nomads have been severely affected by drought (the Beja lost up to 80% of their livestock during the 1980's), as well as government policies and expanding agricultural development. At present, there are relatively few purely nomadic groups left in Sudan that depend exclusively on livestock production for their livelihoods (Fahey, 2007). Nomadic groups however typically own the largest herds.

3.2.6 Food Security

Food security has been identified as a systemic and chronic problem in Benishangul-Gumuz (CIDA, 2005). The analysis of food demand and supply from a baseline survey in seven woredas in 2004 showed an average of 13% food gap[1] for all woredas, with gaps as high as 59% in several woredas. Woredas with large food gaps experience food shortages throughout the year.

The reasons for lack of food security in the region are diverse. The socio-economic conditions are poor; crop productivity is limited by the use of rudimentary labor-intensive tools; declining soil fertility and erratic rainfall limits food production; crops disease, pests and weeds are widespread; infrastructure such as roads and markets is poor; there is an absence of credit services; and many people suffer from malaria and other diseases (CIDA, 2005).

3.3 WATER QUALITY

3.3.1 Surface Water Quality

In Ethiopia, most of the industrial production is situated in major centers, which do not have waste treatment facilities. The main industries are associated with the production of textiles, food, and metals. One notable pollutant is chromium from the tannery industry, which is expanding, but there is no data on Chromium in surface water available. Other pollutants that have been found in the surface water include hydrogen sulphide, dyes, and caustic soda (NBI, 2005c). These sources of pollutants are usually located in large settlements usually outside of the Abbay watershed, and the 2009 OSI Summary estimates that water quality in the Abbay basin is generally adequate for most uses.

In Sudan, surveys were undertaken in the Khartoum area in 2002 and 2004 to identify sources of pollution in the Blue and White Nile. The results revealed on occasions that Biological Oxygen Demand (BOD), oil and grease, Hexavalent Chromium (Cr^{+6}), and coliforms exceeded the World Health Organization or World Bank Guidelines (NBI, 2005a). Considering that Sudan has used pesticides in agriculture since the 1930's along with some 600 agro-chemicals compounds (Hydrosult *et al.*, Sudan Country report, 2007), it would be expected that organic pollutants would be present. For example pesticides have been found in fish in Lake Nubia/Nasser (NBI, 2005b).

In Egypt, according to the OSI Appendices Main Nile Sub-basin (2009), water quality is one of the country most important environmental issues due to intensive agricultural and industrial activities. Uncontrolled discharge of human, industrial and agricultural wastes is the main source of contamination. Amongst these sources, agro-industrial, small private industries, and sugar cane industries are identified as

[1] Defined as the difference between needs and domestic consumption and imports.

important sources. Other sources affecting the surface water quality are areas of high population and industrial development. The major water quality problems are pathogenic bacteria/parasites, heavy metals, and pesticides. Other chloro-organic contaminants such as PCB have also been identified (OSI, 2009).

To understand the water quality setting and determine trends, comparable data sets over a long period of time, with consistent sampling location, period of the year, and similar analytical methods, are required. Unfortunately, these conditions are rarely met, and only a limited temporal comparison could be made for the Khartoum area for the period 1980 to 1992 using data from the United Nations Global Environment Monitoring System GEMSTAT.

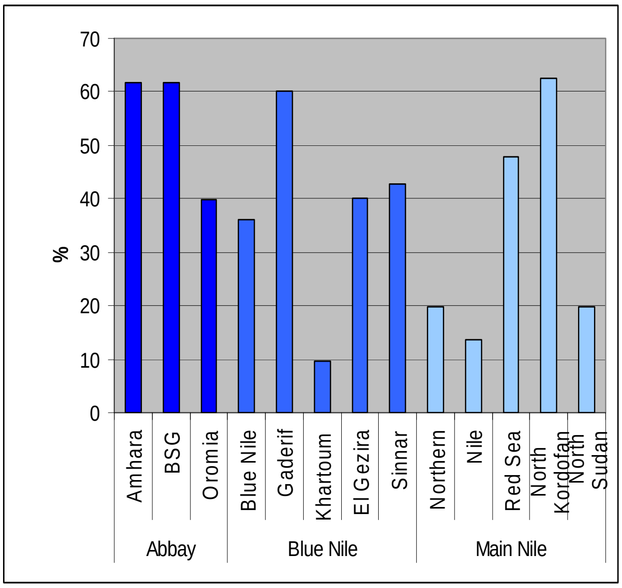
For the period 1980 to 1992, the following trends could be detected:

- Increasing Biological Oxygen Demand (BOD), Conductivity, Alkalinity, Ammonia, Total Phosphorus, Temperature, and Potassium.
- Deceasing Sulphates and Fluorides.

For the period 1991 to 2001, NBI (2005) reports that:

- BOD value of the Nile River has remained fairly stable, although 30% of the sampling points were over the Egyptian standard limit of 6mg/L.
- Nitrites concentrations are about stable, but nitrates concentrations were lower.
- Total phosphorous concentrations around Cairo were low.
- Cadmium, lead and nickel previously not detected appear to be increasing slightly.
- Some pesticides were detected at low concentrations.
- In general, the dissolved oxygen was satisfactory as all sites DO concentrations were higher than 7.0 mg O2 /L, indicating the high assimilation capacity of the River Nile.

Figure 3-4 Percent of Population without Sanitation Facility per District



Sudan: UN Population Fund & Sudan Central Bureau of Statistics (2002).
Ethiopia: World Bank, 2004; Egypt: Hydrosult et al, 2006.

It is anticipated that water quality will degrade in the Abbay/Blue Nile and Main Nile basin because of the lack of proper water treatment facilities (Figure 3-4), and the planned expansion of irrigated agriculture with use of agro-chemicals to sustain agriculture production. Both causes will be exacerbated by the anticipated population growth over the next few decades. It is noteworthy to mention that strict controls on the use of fertilizer and agro-chemicals have been implemented in Egypt close to the Lake Nasser/Nubia shore. Furthermore Egypt's Bio-organic Control Project at Aswan has developed a number of biological controls which will significant reduce the use insecticides and fungicides.

3.3.2 Groundwater Quality

Little information is available on groundwater quality in Ethiopia. In Sudan, it is thought that groundwater quality is generally good for drinking and irrigation requirements with the exception of a few isolated localities (OSI, 2009). To better understand groundwater quality ENTRO is conducting a Special Study, which will provide more detailed information for the groundwater resource.

The Nubian Sandstone Aquifer forms the largest groundwater basin in Sudan and Egypt and its quality is good to excellent with salinity values rarely exceeding 600 mg/L.

In Egypt, groundwater quantity and quality in irrigated areas was found to be decreasing because of its use for irrigation resulting in contamination from nutrients and other agro-chemicals used for agricultural production. The use of fertilizers has quadrupled between 1960 and 1988, as well as the use of pesticides and herbicides to control weeds in canals that has increased. Shallow aquifers in the Nile Delta are often heavily contaminated.

It is estimated that in Upper Egypt between 2.3 BCM (OSI, 2007) and 4 BCM (Wahaab and Madawi, 2004) of drainage water is returned to the Nile annually, either directly or indirectly. This drainage water has much higher salinity than the original water drawn for irrigation and contributes to an increase in salinity of the Nile along its course from the High Aswan Dam to the Delta. It has also been observed that there was an upward seepage of brackish/salty sea water into groundwater aquifers as the result of overexploitation of groundwater for irrigation in the Nile Delta area (OSI, 2007).

3.4 EROSION AND SEDIMENTATION

In the Ethiopian Highlands, the Abbay River and its tributaries are deeply incised into the plateau leaving a series of isolated tablelands separated by deep gorges. This contrasts sharply with the Blue Nile and the Main Nile where the relief is almost flat, with the exception of the Sabaloka gorge on the Main Nile about 80 km north of Khartoum.

Erosion and sediment loading are an important characteristic of the Abbay basin as a consequence of the steep relief, and aggravated by deforestation for agriculture expansion, overgrazing, loss of vegetation. As a result, sediment is delivered at a high rate to the main rivers during the rainy season.

In Sudan, the situation is similar, however the relief is less steep and the sediment loading in the Blue Nile is not as significant as in the Abbay in the Highlands of Ethiopia.

Several studies have been conducted to estimate the quantity of sediment in the river. The estimates vary by location and study from approximately 128 Mt/year to more than 300 Mt/year as shown in Table 3-9.

Table 3-9 Estimates of Sediment Loading at Mandaya, Border, El Deim and Roseires

Location	Estimate of sediment load Mt/year	Source	Notes
Mandaya	124	Abbay Master Plan, Phase 2, Data Collection – Site Investigation Survey and Analysis. Section III, Volume 2: Dam Project Profiles. (February 1998)	Estimate appears to be made on the basis of sediment sampled in a seven month period in one year (March to September 1961), more than 45 years ago
Mandaya	285	Mandaya pre-feasibility engineering report, 2007	Estimate based on sampling at Kessie in 2004 only, and yield of 900 t/km^2/year downstream of Kessie. Includes estimate of bed load.
El Deim	140	NBCBN/River morphology research cluster (2005) and CRA Country Report (September 2006)	Includes estimate of bed load. Based on bank-side bottle sampling, approximately 125 samples in the months of July, August, September and October in 10 individual years spanning from July 1970 to August 1994

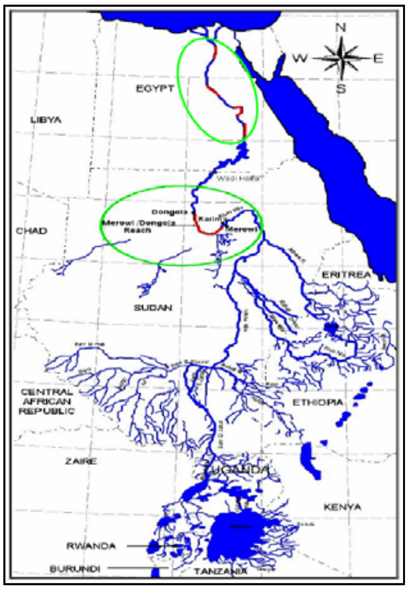
Location	Estimate of sediment load Mt/year	Source	Notes
Border	168	Abbay Master Plan, Phase 2, Data Collection – Site Investigation Survey and Analysis. Section III, Volume 2: Dam Project Profiles. (February 1998)	Assumed to include bed load and thought to be based on sediment sampling in 1961 only.
Roseires	273	Tekeze Medium Hydro Study (1998) cited in CRA Country Report (September 2006)	Mean annual suspended sediment load at Roseires
Roseires	335	Abbay River Basin Master Plan (1999)	
Border	318	Border pre-feasibility engineering report study (EDF et al., 2007)	Includes estimate of bed load
Aswan Reservoir	45 to 180	Ahmed and Ismail, 2008	

The Roseires and Sennar dams on the Blue Nile are affected by siltation. The Sudan Ministry of Irrigation and Water Resources reports that sedimentation in the Roseires Dam increased from 300 MCM in 1970 to 1,264 MCM in 2000, thus causing a loss of 38.3 percent of its storage capacity. The operation of the dams has been modified due to these high sediment loads. During the high flood peak the gates are kept open and turbines closed down to avoid excessive siltation and damage to the turbine blades, resulting in the loss of irrigation water and hydro power production.

It is estimated that 75 MCM/y (117.2 Mt/y) of sediment enters Lake Nasser during the high flow season reducing its storage capacity (Hydrosult *et al.* – Transboundary Analysis, Main Nile, 2006).

Riverbank erosion occurs naturally along the course of the Main Nile from Khartoum to Lake Nasser/Nubia and downstream to the Nile Delta (Figure 3-5). Riverbank erosion and sedimentation are exacerbated by the excavation of soil for brick-making and building material, the removal of vegetation and trees along the banks, and dumping of material into the river. In the Ed Debba-Dongola reach shifting dunes cause alters the main channel morphology, which results in riverbank erosion (Hydrosult *et al.* – Transboundary Analysis, Main Nile, 2006). The quantity of sediment originating from riverbank erosion has not been quantified.

Figure 3-5 Bank Erosion along the Blue and Main Nile



Source : NBCBN-RE, 2005.

3.5 CRITICAL HABITATS, ECOSYSTEMS FUNCTIONS AND BIODIVERSITY

The land cover in the Abbay basin has been significantly modified. According to OSI, 2009 and Hydrosult *et al.*, 2007, at least 40% of the area is either under cultivation or influenced by other types of human activity. No undisturbed forest remains in the Abbay basin and only 1% (2,300 km^2) of disturbed forest is left today. The cause of deforestation is the rapidly growing rural population need for fuel wood (estimated at about 1.8 m^3 /person/year), building materials, and agricultural land (OSI, Environmental Assessment, 2009).

The Blue Nile basin in Sudan has experienced the greatest removal of the original vegetation for the large-scale development of irrigation and the expansion of semi-mechanized farms. These developments cover some 1.32 million ha that were formerly woodlands and shrublands. In addition, overgrazing is causing land degradation, especially in areas susceptible to high soil erosion (OSI, 2009).

In the Main Nile basin, heavy grazing and low rainfall often result in an almost complete failure of annual plant growth, which affects soil erosion and the movement of sand dunes.

It is now believed that grazing, woodcutting, burning and cultivation have a greater influence than the physical environment in determining the land surface composition.

3.5.1 Flood Plains and Wetlands

Wetlands in the Eastern Nile region represent a significant micro-environment for the three countries, particularly in the flood plain along the river. They include swamps, marshes, shallow lakes, and margins of the rivers, valley and lakes, and swamp forests.

Flood plains and permanent wetlands are an important part of the environmental resource in the region. They produce several ecological and socio-economic benefits in their natural state that contribute to the well-being of rural communities. Unfortunately, wetlands are often considered as wasteland of little value and are drained to be converted into agricultural or grazing areas. This conversion offers some new benefits such as increased food production and grazing, but results in the loss of other benefits such as flow regulation, recharge of groundwater, and maintenance of habitats preserving biodiversity.

Permanent Wetlands

Ethiopia possesses a great diversity of wetland ecosystems (swamps, marshes, flood plains, natural or artificial ponds, high mountains lake and micro-dams). The Woody Biomass Inventory and Strategic Planning Project (WBISPP) land cover map of the Abbay basin estimates the area of permanent swamp at 49,943 ha. The most extensive permanent swamps are found around the shores of Lake Tana and Fincha reservoir and in the headwaters of the Dabus River. There are other wetlands in Ethiopia that are been listed (Institute of Biodiversity Conservation, 2010).

Sudan boasts a significant number of diverse and relatively pristine wetlands that support a wide range of plants and animals and provide extensive ecosystem services for the local populations. In the Blue Nile basin, the main wetlands are located on and between the Dinder and Rahad rivers and are locally known as "*mayas*" (depressions or swamps along and between the rivers dominated by *Acacia nilotica*). Most of these wetlands are found just outside the Dinder National Park and are within large to medium semi-mechanized farms. The Sudan Post-conflict Environmental Assessment carried out by UNEP (2007) found that most of Sudan's major wetlands are currently facing significant conservation threats, particularly the seasonal mayas ecosystems of the Blue Nile that are badly degraded and in continuing decline. The main cause of this decline is catchment changes due to extensive cutting of riverine forests, damage from overgrazing, wildlife poaching, and construction of the Roseires and Sennar dams (UNEP, 2007).

Egyptian wetlands are classified into two broad categories: coastal and inland wetlands. There are presently two wetlands designated as Ramsar Sites, Lake Bardawil and Lake Burullus, which are both saline lagoons. There are several other wetlands in Egypt but they are not in the study area. There is no wetland in the area of Lake Nasser/Nubia with the exception of the lake itself.

Flood Plains and Seasonal Wetlands

By definition, most of the flood plains are found along the river during the high water period and for several months afterward while they slowly drain. They can be further defined as land adjacent to an active river channel which is occasionally flooded by those bodies of water and which remain dry for varying portions of the growing season. In most cases, flood plains are conspicuous features of the landscape in contrast with the surrounding vegetation.

The total area flooded in a 2-year return period is estimated at 600,000 ha or 6,000 km^2 (Plates 1 to 5 in Appendix A) and can increase to over 875,000 ha for a 100-year return period. It is estimated that the flooded area ratio per kilometer of river is higher downstream of Khartoum than upstream.

The flood plain ecosystem supports a variety of plant species with a succession from a humid environment to a dryer environment, and they have a distinct composition from the adjacent dry lands, both in terms of flora and fauna. The ecological zones grade from the open-water and submerged vegetation of a river-lake, to floating fringe vegetation, to seasonally flooded grassland, to rain-fed wetlands and, finally, to flood plain woodlands.

In Sudan the mayas are facing significant conservation threats, particularly along the Blue Nile, and are badly degraded and in continuing decline. Some of these mayas were considered exceptionally rich (Van Noordwijk, 1984). These mayas, inundated during the flooding season, can persist for up to six months and are important for the conservation of *Acacia nilotica,* which is considered a priority species in Sudan for its products and environmental role along the Nile River banks and its tributaries (Warrag *et al*. 2002).

In addition to tree cover, the six subspecies of *Acacia nilotica* provide a range of benefits from Arabic gum to fuel wood, furniture, building material for boats and railway sleepers and tannins. Some sub-species are also known for production of ink and various local medicinal products.

Overall, the flood plain and seasonal wetlands ecosystems are considered to be more productive than the areas adjacent to them because of the periodic inflow of nutrients. Flood plains are also an essential feature of the life cycle and spawning habits of a number of fish living in the Abbay/Blue Nile and Main Nile, several of them having a significant importance in economic and livelihood terms such as Tilapia.

It is likely that other flora and fauna species also depend on the wetlands, whether permanent or seasonal, for their sustainability, but detailed inventories are lacking.

The multifunctional character of flood plains and seasonal and permanent wetlands supports a wide range of ecosystem services that contribute to fishing, recession agriculture, brick-making, and recreational opportunities (Table 3.10 and 3.11). As such, some groups of people, particularly those living near wetlands, are highly dependent on these services and are directly harmed by their degradation or disappearance.

Table 3-10 Ecosystem Services Provided by Permanent and Seasonal Wetlands in the Flood Plain

Services	Examples and Comments
Provisioning	
Food	Production of fish, wild game, fruits, grain
Fresh water	Water for recession agriculture, drinking water for people and livestock
Other goods	Arabic Gum, wood for charcoal, non-timber forest products, clay for brick-making, building material, medicinal products
Regulating	
Hydraulic regulation	Groundwater recharge, drainage
Climate regulation	Sink for greenhouse gases, carbon sequestration
Water purification	Retention, recovery and removal of excess of nutrients and some other pollutants
Supporting	
Habitats	Spawning areas for fish; pasture and grazing areas for cattle, and other species such as *Acacia nilotica,* biodiversity
Nutrient cycling	Storage, recycling, processing and acquisition of nutrients
Tourism and recreation	Eco-tourism

3.5.2 Biodiversity

3.5.2.1 Flora and Fauna

The Eastern Nile region occupies a unique position in the world with regard to plant and animal diversity.

In Ethiopia, there is a high level of endemism with 99 endemic animals and about 800 endemic plants. In fact, Ethiopia possesses some of the richest endemic fauna and flora in the African continent as a result of its immense topographic and climatic diversity.

In Sudan, the ecological diversity is reflected in the richness of biodiversity. Out of 13 mammalian orders in Africa, 12 occur in Sudan. Cave and Macdonald (1958) recorded 971 species of birds. Ninety-one genera and 224 species and sub-species of mammals other than bats were reported in the late fifties. The Sudan reach of the Nile is the home of over a hundred species of fish and the swamps are considered as a major gene reserve (El Moghraby 1982). The World Research Institution Annual Report for 1995 recorded 3,112 flowering plants in Sudan.

Egypt has a rich biodiversity with 18,000 species of flora and fauna. The natural flora and botanic cover of the areas of and around Lake Nasser encompasses a vast range of genetic resources both natural and improved by careful human management. Medicine and aromatic plants are of major importance. Lake Nasser/Nubia and the Main Nile between Khartoum and Aswan provide important habitat for aquatic flora and fauna and support an important fishery industry. Table 3-11 summarizes the main biodiversity characteristics of the three countries and the list of threatened species according to the IUCN Red List is available in a separate Baseline Report (Volume II).

Table 3-11 Biodiversity Characteristics in Ethiopia, Sudan and Egypt

Biodiversity Characteristics in Ethiopia, Sudan, and Egypt	Qty
Ethiopia	
Total known higher plants species / threatened (2002)	6,603 / 22
Total known mammals / threatened (2002)	277 / 35
Total known birds / threatened (2002)	262 / 46
Total known reptiles / threatened (2002)	208 / 1
Total known amphibians / threatened (2002)	71 / ?
Total known fish / threatened (2002) (likely underestimated)	13 / ?
Sudan	
Total known higher plants species / threatened (2002)	3,137 / 13
Total known mammals / threatened (2002)	267 / 23
Total known birds / threatened (2002)	280 / 6
Total known reptiles / threatened (2002)	161 / 2
Total known amphibians / threatened (2002)	9 / ?
Total known fish / threatened (2002)	130 / ?
Egypt	
Total known higher plants species / threatened (2002)	2,076 / 2
Total known mammals / threatened (2002)	98 / 13
Total known birds / threatened (2002)	123 / 7
Total known reptiles / threatened (2002)	108 / 6
Total known amphibians / threatened (2002)	11 / ?
Total known fish / threatened (2002)	284 / ?

Source: Earth Trends, 2003.

3.5.2.2 Fish

Lake Tana is a hot spot for fish diversity, and several families are represented by a single species. The largest fish family in the lake is Cyprinidae, with *Labeobarbus* being the most significant genus with its 15 species forming a unique species flock in Lake Tana. The cyprinid species flock in Lake Tana is the only cyprinid flock left in the world.

Only the main Abbay River and a few of the larger tributaries constitute a permanent river habitat for fish. Many of the tributaries are seasonal habitats, and most fish have to migrate from these tributary to the main river during the dry season. In the Abbay/Blue Nile tributaries, although thorough and recent surveys are lacking, it appears that about 40 species of fish have been recorded (Mishrigi, 1970). Getahun (2003) mentioned 23 fish species in the Abbay between the Blue Nile Falls ("Tis Issat") and the Ethio-Sudan border. Twenty-nine species belonging to 10 families have been recorded in the Blue Nile from Roseires Reservoir by Mishrigi (1970). About 128 species belonging to 27 families have been reported in the Main Nile and it is thought that the total number of species could reach 800 in the entire Nile Basin (Witte *et al*., 2009).

The biology of most of the species in the Nile and its associated lakes is not well known. However, it is known that most of the *Labeobarbus* spp. found in Lake Tana migrate to tributary rivers to spawn during the rainy season. Although all the tributaries of the lake are not well surveyed, and the temporal and spatial variations in their spawning migrations is poorly established, it has been confirmed that the fishes migrate to Ribb and Gumara Rivers for spawning (Anteneh *et al*., 2007 and 2008; Getahun *et al*., 2008). Similarly, some or all of the local tributaries in the 25 km of the Abbay between Boka and the proposed Mandaya dam site could serve as breeding grounds during the rainy season (OSI, 2009).

There are certain species of fish that migrate within river channels and laterally into and off flood plains. Species that are adapted to the latter include *Protopterus aethiopicus*, *Polypterus senegalus*, *Heterotis niloticus*, *Xenomystus nigri*, *Clarias gariepinus*, *Ctenopoma muriei*, and *Parachanna obscura* that are well adapted to flood plains. Tilapia, a very important commercial species, is also known to migrate to flood plains for spawning.

Amphibians and reptiles

Amphibians, especially anurans, are present in Lake Tana and all along the Abbay, Nile and tributaries, particularly in the marshy shore areas. Nile Monitor (*Varanus niloticus*) is the largest reptile in the Nile and some farmers claim that there are also pythons (*Phyton sebae*) (Getahun, personal communication). Crocodiles are very common in the Blue Nile and other tributaries of the Nile especially at altitude lower than 1500 meters.

Mammals

Hippopotamuses are present in Lake Tana and the Blue Nile River in good numbers and otters are claimed to have been seen in some water bodies (Getahun, personal communication). During surveys made in March 2007, in the Abbay reach near the proposed Mandaya site, hippos were observed to be abundant. Other important species such as leopard, lions, and various antelopes have been reported from time to time along the Abbay.

Birds

Birds are found in large numbers all along the Abbay, Blue and Main Nile. Green (2009) has recorded 205 species of non-passerine birds that are found associated with the Nile. They include several semi-aquatic birds such as geese and ducks, waders, gulls and terns, herons, egrets and rails.

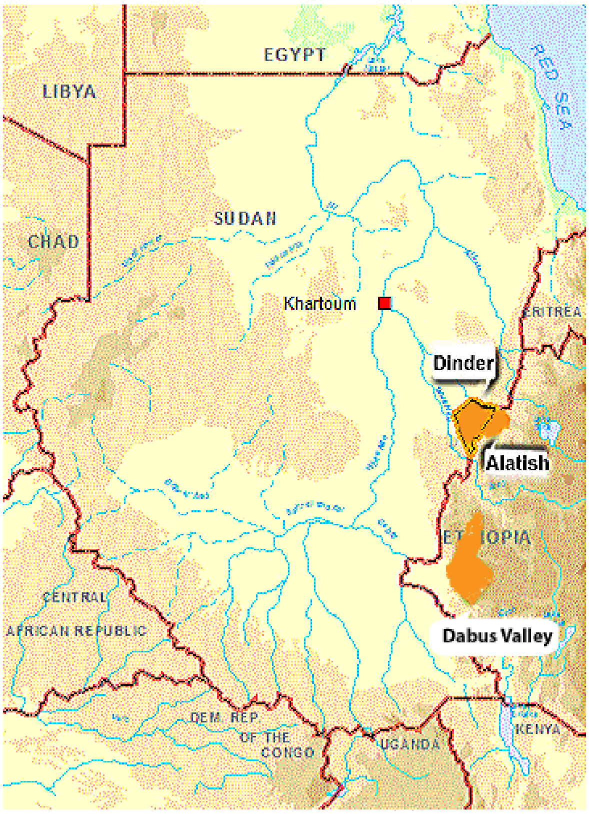
Species with Status

Ethiopia, Sudan and Egypt all have species with special status under the IUCN Red List. For the three countries taken together, over 500 species have either a status of "Critically Endangered", "Endangered", "Vulnerable", "Near Threatened" or for which data is insufficient.

None of the impact assessment study conducted at the pre-feasibility level for Mandaya, Border, Beko-Abo and Karadobi has identified with any certainty species with special status in their immediate study areas along the Abbay and in the secondary impact zone along the Blue and Main Nile. All have indicated that data was not sufficient to allow definitive assessment of the possible occurrence of threatened or endemic species and that more detailed inventories were needed. It would however be surprising that none of these 500 plus species identified in the IUCN Red List would be present in the areas to be affected by the possible dams and its infrastructure on the Abbay or its tributaries.

3.5.3 Protected Areas

Figure 3-6 Localization of Protected Areas in the Study Area



Source: NBCBN-RE, 2005.

Although Ethiopia, Sudan and Egypt have a number of protected areas, only three are found in the study area: the Dabus Valley Controlled Hunting Area, along the Dabus River in Ethiopia and the Dinder and Alatish National Parks on either side of the Sudan – Ethiopia border between the Rahad and Dinder rivers.

The Dabus Valley, a controlled hunting area in the Dabus River basin, is the only protected area directly along the Abbay River. It has been registered as a controlled hunting area by Ethiopia with the World Commission on Protected Areas (WCPA), which maintains a world database of protected areas. The Dabus Valley covers 1,227 km^2.

There is limited recent information on the fauna and flora of the Dabus Valley, but the presence of elephants and lions has been reported. The Dabus Valley was also listed in 1996 as a tentative candidate to become designated as an Important Bird Area of Ethiopia. A decision on promoting Dabus Valley as a designated Important Bird Area continues to be deferred until such time as surveys are conducted and a proper assessment made.

In Sudan, the Dinder National Park was proclaimed in 1935 and was designated a Ramsar site and UNESCO Biosphere Reserve in 2005. The park, covering an area of 8,960 km^2, is a very large complex of about 40 wetlands, or "mayas", and pools formed by meanders and oxbows that are part of the Rahad and Dinder river drainage systems bordering the frontier with Ethiopia in south-eastern Sudan. The wetlands are vital as a source of water and nutritious grasses for herbivores, especially during the severe part of the dry season. A large number of animal species are supported, some of which, like the Tiang (*Damaliscus korrigum)*, are endangered. Located in the center of migration routes among three continents, the site is visited by a large number of migratory bird species, and many of the mayas contain significant quantities of fish throughout the dry season. In 2006, the Amhara Regional State designated an area of 2,665 km^2, immediately across the border within Ethiopia and adjacent to the Dinder Park, as the Alatish National Park.

There are three groups of people who have an interest in the Dinder and likely also in the Alatish Park. The first is constituted of the original inhabitants of the areas, a small group of Maganu people who continue to live in the south-eastern part of the Dinder Park. This community depends on subsistence farming in the rainy season and supplements its diet by collecting fruits and wild honey. In the dry season they move further inside the Dinder area for fishing.

The second group is constituted of pastoralists and agro-pastoralists, which enter the park in the dry season looking for forage and water. Included in this group are the Um Barrarow or Falata who use the park in the dry season along the Dinder River and move into Ethiopia during the wet season.

The Gumuz people have settled to the south of the Dinder Park and practice poaching and fishing along the Dinder River. Around the park there are a considerable number of Internally Displaced Peoples who took refuge from the war in Darfur. They enter the park for fishing, fuel wood and honey collection but also for illegal hunting. It is estimated that 100,000 people live around the park in 36 villages.

Important Bird Areas

According to BirdLife International, there are 69 Important Bird Areas (IBAs) in Ethiopia, 22 in Sudan, and 32 in Egypt. Of these, about a dozen are located on or along the Abbay/Blue Nile, Main Nile and the Roseires, Sennar, and Aswan reservoirs, and one is reported to be located near the proposed Karadobi reservoir (Norplan *et al*., 2006). These areas are recognized as globally important habitat for the conservation of bird populations.

3.5.4 Invasive Species

The introduction of alien species has largely been responsible for aquatic weed infestation. Water Hyacinth (*Eichhornia crassipes*) is the most common aquatic weed. It was introduced into Africa through Egypt between 1879 and 1882. It was first seen on the White Nile in 1958 and has subsequently spread by flooding, wind and boat. Water hyacinth forms dense plant mats that degrade water quality by lowering light penetration and dissolved oxygen levels, and has direct consequences for primary aquatic life. The weed also leads to increased water loss through evapotranspiration, interferes with navigation and fishing activities, and provides a breeding ground for disease vectors such as mosquitoes and the vector snails of schistosomiasis. In all fairness, the water hyacinth can only thrive at infestation levels if it has sufficient nutritive elements to fuel its growth, and by doing so filters the water and removes large amounts of nutrients from the water column for its needs. Large quantities of water hyacinth are usually associated with leaching of fertilizers from areas under agriculture or discharge of untreated domestic wastes.

The presence of water hyacinth in Ethiopia has been documented by the Institute of Biodiversity Conservation (2005). It was first reported in 1965 in the northern Ethiopia in the Koka Reservoir and the Awash River. Other infestations in Ethiopia include many water bodies in the Gambela Region, the Abbay from below Lake Tana into Sudan, and Lake Ellen near Alem Tena (Fessehaie, 2005). It is also reported that the Akaki Wetland near Addis Ababa has been totally infested by water hyacinth and the surrounding mudflats, once heavily populated by waders, no longer attract these birds. Water hyacinth has been recognized as the most damaging aquatic weed in Ethiopia since its fist presence in 1965 (Fessehaie, 2005).

In Sudan, the reported northern limit of water hyacinth infestation is between Kosti and Duweim, although its presence was cited in the Jebel Aulia dam reservoir in June 2006, for the first time in seven years (Sudan Post-Conflict Environmental Assessment, 2007). Control measures initially relied on large-scale applications of the herbicide 2, 4-D, particularly in the White Nile. This practice has now ceased (Sudan Post-Conflict Environmental Assessment, 2007). Recent biological control methods have shown excellent results and some 350 km of the infested area are permanently free of water hyacinth (NBI, 2005a).

Although water hyacinth was introduced in Egypt since the 1890s, it did not become a menace in the Nile until recent times. The construction of AHD has subjected the Nile system to several ecological changes such as the permanent presence of water throughout the year and low current velocity in the Nile. These factors and the use of fertilizers have encouraged the growth of the water hyacinth within the Egyptian Nile. The situation was qualified as alarming by El-Shinnawy *et al*. (2000).

According to the Ministry of State for Environmental Affairs (2008), the infected areas in Egypt amounted to 487 km^2 covering most of the irrigation canals, and about 151 km^2 in lakes. Water loss resulting from evapotranspiration in the infected areas amounts to 3.5 billion m^3 annually. This quantity of water loss is considered adequate to irrigate 432 km^2 annually.

Egypt initially relied on chemicals to control water hyacinth. It stopped chemical control in 1990–91, because of environmental concerns. Since 1991 Egypt has depended exclusively on physical methods to control water hyacinth (Phiri *et al*., 2000). Egypt has considered biological control but has not fully implemented this method of control.

The watercourses of Sudan are also afflicted with mesquite (*Propopis spp*. particularly *Propopis juliflora*) another invasive species, which has infested many of the seasonal khors and canals of northern Sudan (Sudan Post-Conflict Environmental Assessment, 2007).

Pistia stratiotes L. and *Nymphea lotus* have been reported in the Blue Nile on the mud flats of the Sennar reservoir (El Mograby *et al*., 1986) as well as *Parthenium hysterophorus*, a weed that can degrade natural ecosystems and can produce serious allergenic reactions in humans. Parthenium aggressively colonizes disturbed sites and has a major negative impact on pasture and cropping industries (Ethiopian Institute of Agricultural Research, 2004). *Myriophyllum spicatum* has been invading Lake Nasser for over a decade and has replaced the originally dominant submerged macrophyte *Najas marina* (Ali and Soltan, 2006).

3.6 SOCIAL SYSTEMS

3.6.1 Demographics

The total population living in areas of Ethiopia, Sudan and Egypt drained by the Nile from Lake Tana to the Aswan High dam is estimated to be 45 million people. Nearly two-thirds are Ethiopians living along the Abbay River and its tributaries, over one-quarter are Sudanese in the Blue Nile and Main Nile basins, and the remainders are Egyptians living in the Lake Nasser vicinity. Moreover, it is estimated that about 95% of Egypt's total population lives within 20 km from the Nile. That would add approximately another 70 to 75 million Egyptians living along the Nile between AHD and the delta for a total of about 115 to 120 million inhabitants living along the Abbay, Blue and Main Nile in the three countries.

Population Levels

The Abbay River in Ethiopia passes through three regions: Amhara, Oromia and Benishangul-Gumuz (BNG). In 2002, the number of Ethiopians living in these three regions, situated in the Abbay basin, was 26.3 million people. The average density in the Abbay basin was 80 persons/km^2 and varied from 10 persons/km^2 in the more sparsely populated region of BNG, to 250 persons/km^2 in the densely populated Oromia. In the period 2002-2007, the population of the Abbay basin increased by an estimated 12.8% based on the average annual growth rates in the region. The estimated 2007 population of the Abbay basin is about 30 million people (FAO, 2011).

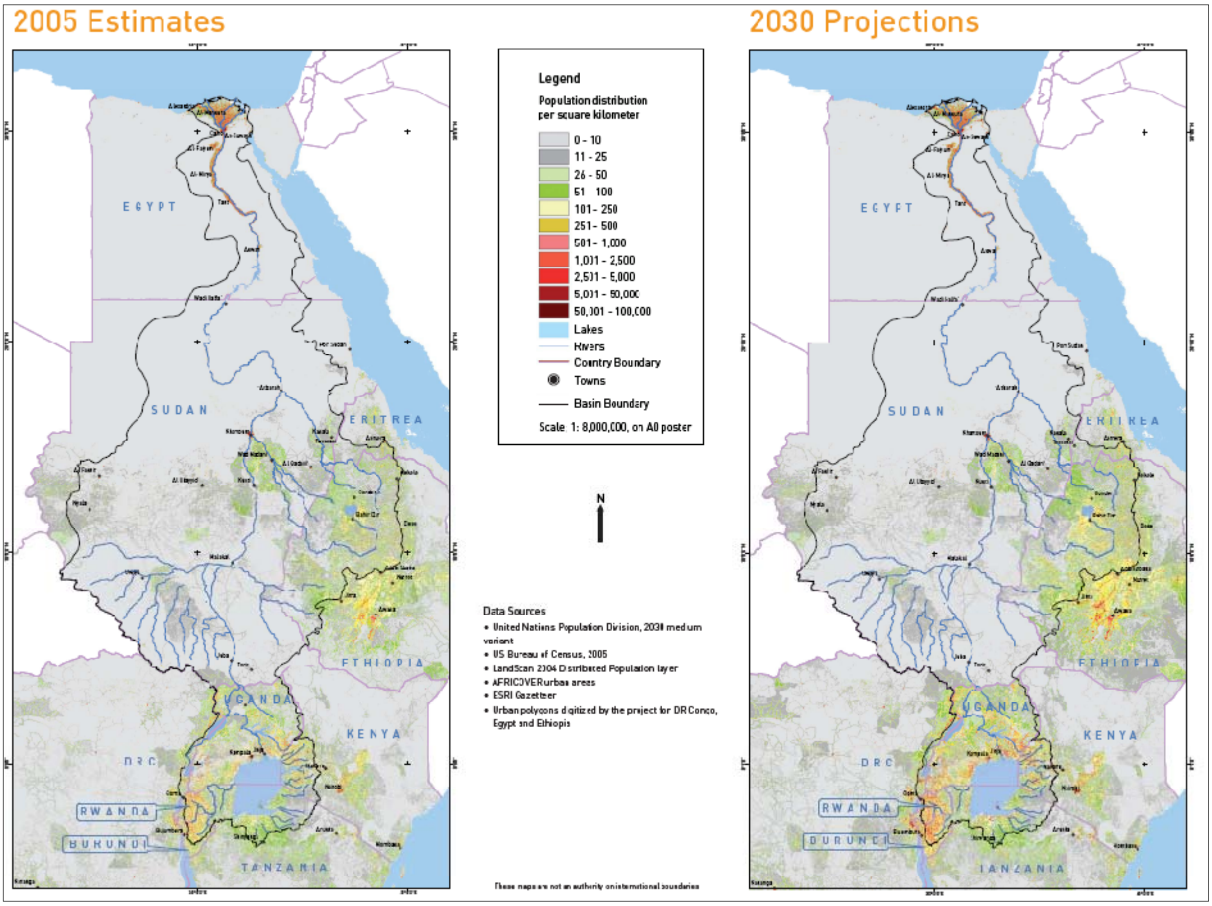
In 2002, 6.6 million Sudanese lived in the Blue Nile basin for an average population density of 60/km^2. Density ranged from 18 persons/km^2 in the Blue Nile State, to more than 300 persons/km^2 in Khartoum. Between 2002 and 2008, the population of the Blue Nile basin grew by an estimated 21.7% based on the average annual growth rates in the Blue Nile basin. In addition to rural-urban migration to the capital, Khartoum, a significant portion of this rapid population growth included people fleeing conflicts in other parts of Sudan. As a consequence the estimated 2008 population in the Blue Nile basin was 8 million people.

In 2002, the total population living in the Main Nile basin from Khartoum to the Aswan High Dam was 5.4 million people, of which over 70% lived in Sudan[2]. The population density ranged from under 10 persons/km^2 in the desert areas of northern Sudan and Aswan Governorate in Egypt, to 36 persons/km^2 in the urbanized Red Sea Governorate. Between 2002 and 2008, the population of the Main Nile basin grew by an estimated 13% based on the average annual growth rates in the states and governorates. In Egypt alone, the population increased an estimated 36.7% during 2002 to 2008. The estimated population is 4.2 million people living in Sudan in the Main Nile basin and 2 million people in Egypt in the vicinity of Lake Nasser. To this, the people living along the Main Nile between AHD and the delta would add another 70 to 75 millions.

Based on FAO projections, the 2030 population of the Nile basin will exceed 200 million people (FAO, 2011). Half of this population will be living in Egypt along the length of the Nile from Lake Nasser to the delta. The remainder will be divided approximately equally between Ethiopia and Sudan.

[2] To date, it has not been possible to ascertain the 2002 population in the portion of North Kordofan State situated in the Main Nile basin. This information, when available, may alter slightly the distribution of population within the basin, as well as the estimates of population increase in the 2002-2008 period.

Figure 3-7 Population Densities in the Nile Basin 2005 – 2030 (FAO)



Urban/Rural Distribution and Settlement Patterns

In the Ethiopian Abbay basin, almost 90% of the population lives in rural areas. The settlement pattern consists largely of dispersed homesteads or small clusters of houses surrounded by agricultural fields. Settlements are widely scattered, often located several hours of walking distance from one another. Larger villages develop along roads in the vicinity at the local administrative offices.

In the Blue Nile basin in Sudan, 70-80% of the population lives in rural areas with the exception of the State of Khartoum where 80% of the population is urban. Less than 1% of the population in the Blue Nile basin is classified as nomadic. The basin population is concentrated on the west side of the river, attracted by the El Gezira Irrigation Scheme and the presence of a main road. Other concentrations are found near the Rahad Irrigation Scheme in the Dinder Valley and along the Sennar-El Kaferif road. Most people in the basin live in villages and towns, a direct consequence of the allocation of large tracts of land for mechanized and irrigated farming. The Sudanese portion of the Main Nile basin is predominantly rural except in the State of Red Sea. At the same time, the proportion of nomads is significantly higher in Red Sea State as well as in the State of North Kordofan. The main areas of high population density in Sudan are along the river near Khartoum and in the areas around the towns of Kassala, Karima, Dondola and El Obeid.

In Egypt people living in urban areas account for 40-50% of the population in the governorates of Aswan and New Valley and 95% of the population of Red Sea Governorate. Nearly all of the population living in the immediate area of Lake Nasser/Nubia is outside of the 6-10 km buffer zone surrounding the lake (Figure 3-7).

Population Movements

Within the Abbay basin, population movement occurs for a variety of reasons with the dominant trend being rural-to-rural migration. In Ethiopia, the 1980's Resettlement Campaign resulted in many people being resettled from severely drought-affected highlands to lowlands areas such as the Benishangul-Gumuz (BSG) Region. Since 2003, the Government's voluntary resettlement program is limited to intra-regional movements.

Sudan has the largest population of displaced persons in the world today. After the civil war, over five million internally displaced persons (IDPs) and international refugees were living in rural camps, informal settlements, and urban slums in Sudan (Sudan Post-Conflict Environmental Assessment – Population Displacement and the Environment, 2007). Between November 2010 and January 2011, some 200,000 Southern Sudanese IDPs living in the north returned to the south and the Internal Displacement Monitoring Center (IDMC)[3] estimates that in January 2011, there were still 1.7M IDPs in Khartoum and 68,000 in Kessala.

The predominant livelihood for the rural majority in Sudan is agro-pastoralists. According to the 1993 census, Gaderif State bordering Kassala, Gezira, Blue Nile, Eritrea and Ethiopia, had a population of 1.6 millions agro-pastoralists as these areas represents the southern destination of the nomads and pastoralists. Also a number of the population move seasonally from the Blue Nile and the South of Sudan to the Butana area in the north east in time of water shortage, diminishing natural pastures as a result of the expansion of the mechanized farming, and increasing competition over the natural grazing.

Ethnicity and social organization

There are numerous ethnic groups in the region. Sudan in particular has a rich ethnic history, with somewhere between 500 and 600 ethnic groups. The main groups are briefly presented in Table 3-12. Several of these groups have a pastoral/agro-pastoral tradition where wage labor is a major feature of their livelihood.

Table 3-12 Main Ethnic Groups in the Eastern Nile Basin

Sub-basin	Ethnic Group	Particularities
Abbay	Amhara Oromo	Amhara and Oromo count for 90% of the population in Amhara and Oromo
	Jeblawi	Jeblawi Amhara, Oromo and Gumuz count for 80% of population of BSG. Population is mostly clan-based societies that manage land collectively, with the allocation of plots equally to all members.
	Gumuz	Gumuz and Amhara are main groups in proposed locations of Mandaya and Border projects
Blue Nile	Gumuz Berta	The Gumuz and Berta have traditional territories bridging between the Abbay and Blue Nile sub-basins
	Funj Baggars	The Funj is a warrior society that established a sultanate in the 1500's in what is now the state of Sennar and Arabic-speaking groups such as the Rufa'a al Hoi
	Kenana and Fulani	Kenana and Fulani have traditionally practiced transhumant pastoralist livelihoods throughout the Blue Nile Sub-basin
	Beja	Beja are nomadic tribes that live mainly in the Red Sea Hills of the Sudan, although they are found throughout the region

[3] http://www.internal-displacement.org/idmc/website/countries.nsf/(httpEnvelopes)/0026B2F86813855FC1257570006185A0?OpenDocument

Sub-basin	Ethnic Group	Particularities
Main Nile	Nubians Danagla Bedirya Rekabia Gaa'lian Shaigia Kawahla Kababish Hassaniya	Gaa'lian, Shaigia, Kawahla, Kababish and Hassaniya live on both banks of the Nile. Most are mainly pastoralists but also cultivate sorghum along the wadis.
	Hawaweer	Living mainly along the Wadi Muqadam and, more recently, along the Nile below Korti.
	Baggara	The numerous Baggara tribes of northern Sudan share many cultural characteristics and claim a common ancestry. These Baggara tribes live in the plains of Sudan's Darfur, North Kordofan, and South Kordofan states. The region is well suited for grazing cattle and most of the Baggara are herdsmen. Their herds are comprised primarily of cattle, although they also raise sheep and goats, and camels are kept for riding and as pack animals. Most Baggara tribes are nomadic although there are some that live in farming communities or towns. Grazing land is usually shared, but farmland is owned individually.
Lake Nasser Watershed	Ababda Bishari	The Ababda are more numerous, and make up about two-thirds of the population. The Bishari are more recent arrivals, and make up the other third of the population. Originally nomadic herdsmen, both ethnic groups are becoming increasingly sedentary and share similar livelihoods with economies based on, in descending order of importance, charcoal production, sheep herding, camel herding, collecting medicinal plants and residual moisture cultivation

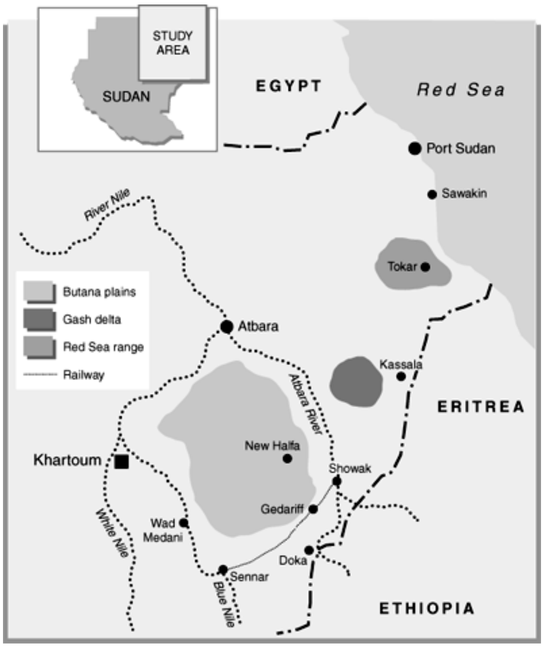
3.6.2 Vulnerable Groups

Vulnerable groups are characterized by limited resilience to avoid poverty and few opportunities to escape chronic poverty. Their limited resilience and opportunities make them especially exposed to further impoverishment in risky environments (Hoogeveen, 2004). Although poverty is widespread in the Eastern Nile Region, there are several groups that may be characterized as particularly vulnerable to further impoverishment, due to current economic development or policy trends, the presence of conflict and instability, or simply due to limited access to infrastructure and services.

One such vulnerable group is the considerable number of internally displaced people (IDP) in Sudan. The availability of work on irrigated and semi-mechanized farms has attracted many IDPs from Darfur to the eastern region of the country. Of the approximately 600,000 people associated with agricultural laborers working on the El Gezira Irrigation Scheme, 70% are Darfur IDPs (World Bank, 2000). In 2005, approximately 3 million IDPs from Southern Sudan and Darfur were still living in the provinces drained by the Blue Nile and Main Nile (UNEP, 2007). Many of these IDPs have settled in what have become slum areas around towns and major villages and 1.7M are still living in Khartoum. In addition to displacements as the result of conflicts and security issues, government-sponsored development schemes, specifically mechanized rain-fed agricultural schemes, such as the El-Gezira, Aswan dam and the new Merowe dam attract people looking for better living opportunities. In these cases, displacement takes the form of organized resettlements and land allocation for new agricultural schemes.

Another vulnerable group is the nomads and pastoralists of Ethiopia, close to the border of Sudan, as well as those found along the length of the Nile in Sudan. During the rainy season, the pastoralists usually move with their herds to the Butana Plains, where they stay for two to three months before they are forced to move south to stay near the Rahad River due to a shortage of water. Their presence along the river causes many problems as they compete with the people who live in the same area for the meager water resources available. This is especially prevalent when the summer season advances and the river forms only small-scattered ponds (Sharing, 2008).

Figure 3-8 Location of Butana Plains



Similarly, the Gumuz and other ethnic groups in the western lowlands of the Abbay basin continue to practice extensive shifting cultivation and animal husbandry within communities that uphold traditional systems of land tenure as well as traditional social and local political systems. In eastern Sudan, the ethnic groups that continue to engage in nomadic pastoralism and semi-nomadic agro-pastoralism represent particular cultural and livelihood systems that have evolved over thousands of years in the environmental context of the region. These groups have been under pressure for more than 60 years due to expanding large-scale agricultural development and increasing environmental degradation and desertification. In the region of Wadi Allaqi in the Lake Nasser vicinity, Ababda and Bishari are ethnic groups that constitute the majority of the population in the immediate region and have social and livelihood systems that emanate from their cultural origins.

3.6.3 Land Tenure and Security

In Ethiopia, ownership of land is vested in the State. Rural households have usufruct rights to land that they may lease and bequeath to immediate family members, but they are not permitted to alienate the land through sale or mortgage. Although land registration programs have been initiated in some regions, there are several aspects of land policies that lead to tenure insecurity for rural people (Hydrosult *et al*. Abbay/Blue Nile, 2006).

- The Regional Investment Bureau allocates land for commercial agricultural development. This process does not require a formal cadastral survey, environmental assessment or monitoring of subsequent land development.
- In Amhara, the regional government has the right, contingent on community demand and a scientific assessment of the impacts on productivity, to redistribute land as part of an initiative to allocate land to land-poor households (CAPRI, 2008). In Oromia, redistribution of rain-fed land is not permitted although this restriction does not apply to irrigated land.
- When the Government builds a medium- or large-scale irrigation scheme, land is redistributed to ensure that farmers have, on average, 0.25 ha. The design of the Koga Scheme was based on 1.5 ha per farmer. Households that loose productive land due to the construction of irrigation systems or redistribution of land are generally provided with irrigated land.
- In Oromia, another issue that leads to tenure insecurity is the expectation that land will be shared among family members. Also, due to the inability of formal institutions to address the needs of landless people (i.e., the restriction on redistribution of rain-fed land), farming households and communities are resorting to customary arrangements to access land, for example, through sharecropping.
- In BNG, the clan-based societies in this region have traditionally relied on a system of communal ownership of land and other natural resources. That is, the clan as a whole "owns" the land to which individual members have a usufruct right. Due to the remoteness of this region and the sparse population, these customary rules continue to take precedence among these societies; the statutory rights and formal institutions have had little or no influence on the indigenous land tenure systems (Hydrosult *et al*., 2007).

In Sudan, traditional forms of community and tribal-based land tenure systems developed among nomadic pastoralists and sedentary agriculturalists are based on communal access and use of rural land. The practice of individual land ownership has tended to exist only in and around major settlements and urban centers. Women are prohibited from owning land under traditional land tenure systems.

The 1970 Unregistered Lands Act designated all untitled land as government property. This enabled the Government to claim vast areas of pasture land, rangeland and migration routes for the development of rain-fed and irrigated agriculture.

Traditionally, Sudanese legislation regulating land and other natural resources has favored individual rights over community rights, and has promoted large-scale commercial agriculture over traditional land use systems (Fahey, 2007). As a consequence, competition over land has existed for centuries. More recently, the conflicts have been more frequent and severe as land degradation and scarce water resources have combined with increasing numbers of people and livestock; the discovery of oil and ongoing political conflicts have triggered land-related conflicts among different ethnic groups and between indigenous groups and Sudanese authorities.

At present, there are four main land tenure systems along the Blue Nile River: (i) private freehold ownership, (ii) Government land with community rights organized by customary rules, (iii) Government land with no community rights and (iv) Government leases. In the Main Nile sub-basin in northern Sudan, most of the land is government-owned, subject to usufruct use rights. Locally, the land is managed in accordance with the traditions of the different ethnic groups regarding access to and use of cultivated and pasture lands.

In Egypt, the 1992 Law 96 reversed the land reforms of the Nasser era that limited the size of landholdings and gave legal rights and security of tenure to rural tenant farmers. As a result, large landowners regained assets they had lost during the reform; and, tenant farmers lost their land tenure security and were required to pay market rents for the land they used. Prior to the law, tenants paid rents equal to seven times the land tax; in 1997, rents in most areas were equal to or greater than 22 times the land tax. Landowners could also legally dispose of land without informing their tenants.

Land reclamation programs carried out by the Egyptian Government in the 1980's and 1990's were premised on the allocation of land to smallholder farmers. However, no information is available about land tenure under these programs, nor about more recent agricultural development and land reclamation programs proposed in the Lake Nasser vicinity.

3.6.4 Gender

The roles and contributions of women in the Nile basin to household economies and community development are undervalued and frequently undercounted. Throughout the Abbay basin women contribute widely to agricultural production as well as assuming the primary responsibilities for household management. In addition to food preparation, child rearing and domestic chores, women are responsible for land preparation, planting and weeding. Due to intermittent droughts and deforestation, the time required for these tasks has increased fourfold over the past decade. In the Blue and Main Nile basins, women's participation in agriculture is confined to their households where they are responsible for keeping poultry and fowl, as well as participating in the threshing, drying and storing of farm produce. Outside the compounds, young girls assist to pasture goats and sheep and elderly women weed or glean open fields for livestock fodder.

3.6.5 Infrastructure and Health Issues

Key health indicators such as access to potable water and sanitation as well as the incidence of water-borne diseases are the principal health issues related to development of water resources in the Nile basin. Overall, these health indicators reflect poor conditions throughout Ethiopia and Sudan which contrast with much better conditions in Egypt. In the upstream countries of the Nile basin, life expectancy is low due to high infant mortality and child malnutrition rates. Children are among the most vulnerable groups due to food shortages and poverty. In Egypt, people live, on average, 35-40% longer than people in the upstream countries. The national rates for infant mortality and child malnutrition are

25% and 15% of the rates in Sudan. The incidence of child malnutrition is negligible in two of the three governorates in the Lake Nasser vicinity.

Potable Water and Sanitation

In Ethiopia and Sudan, the national averages of the population with access to improved water sources are 68.5% and 70%. Safe water sources include public and private taps and deep wells as well as piped water to the house. In Egypt, nearly the entire population is connected to reticulated water supply systems providing them with piped water to their houses (World Bank, 2000).

In the Abbay basin, there is no piped water to houses and the proportions of households with access to safe water are generally below the national average of 25% for rural areas. In fact, the majority of households rely on unsafe sources such as shallow wells and water from rivers and streams.

In Sudan, the proportion of households in Blue and Main Nile basins with access to safe water vary widely from low levels in states such as Blue Nile and conditions equal to or better than the national average nearer to Khartoum. In the case of El Gezira State, for example, the high proportion of people with access to piped water is due, in large part, to the fact that within the Gezira Irrigation Scheme 75% of the residents are connected the reticulated water supply systems (World Bank, 2000).

Sanitation conditions are poor to non-existent throughout the Abbay and Blue Nile basin. The most common type of sanitary facility is a traditional pit latrine. Up to 60% of households in some parts of the basin have no sanitary facilities. In Egypt, in comparison to the availability of safe water, far fewer people have access to improved sanitary facilities, particularly in the rural areas.

Water-Borne Diseases

Schistosomiasis and malaria are serious public health risks that are endemic throughout the Abbay/Blue Nile and Main Nile basin. Other water-borne diseases include Onchocerchiasis (river blindness) and Trypanosomiasis (human sleeping sickness), as well as acute dysentery and diarrheas, intestinal parasites, scabies, due to poor water supply and sanitation conditions.

Schistosomiasis, a potentially debilitating disease caused by parasitic flatworms, infects more than 200 million people mostly in sub-Saharan Africa (Steinmann, et al., 2006). The incidence of Schistosomiasis has been reported at levels of 90% in the Lake Tana region and other areas of the Ethiopian highlands where there are small lakes and ponds. The breeding of the snails that are the vector for Schistosomiasis and its transmission to humans is closely linked to irrigation systems.

In Ethiopia, 68% of the population lives in malaria-prone areas. The only exception is the people living in the highlands. Studies conducted at the Koka Reservoir in 2007 and recently in the Gilbel Gibe III reservoirs confirmed that the transmission of malaria is highly correlated with proximity to these reservoirs, and is particularly true for children (Yewhalaw et al., 2009). In Sudan, malaria is the major public health issue. On an annual basis, there are 7-8 million cases that result in 35,000-40,000 deaths (Nile Basin Initiative, 2007). Health experts believe that the problem is far more serious than reported, particularly in rural areas. The annual Nile floods are a primary contributing factor to the incidence of malaria, creating conditions favorable to the number of breeding sites and the density of mosquitoes.

3.7 ECONOMIC SECTOR

3.7.1 Agriculture

Traditional Rain-fed Agriculture

Traditional rain-fed agriculture is the dominant form of farming throughout the Abbay and Blue Nile basins (Figure 3-9). This is the primary farming system throughout much of the Abbay basin in Ethiopia. In Sudan, 70% of farming households practice traditional rain-fed agriculture.

In Ethiopia, rain-fed farming systems are divided between those found in the highlands and those in the lowlands, with the dividing line being 1,500 masl. Rural Ethiopian households generally have small, fragmented land holdings. The national average for the area of cropped land per household is 0.8 ha, divided into 3.2 parcels. Within the Abbay basin, the sizes of cropped land tend to exceed the national average, although one half to two thirds of households has less than 1 ha. Farmers engage in a combination of farming and raising livestock. Cultivation is undertaken with oxen using the tine plough (maresha). The main crops are teff, sorghum and maize at lower altitudes with wheat and barley taking their place at higher altitudes. In the Western Highlands at elevations below 2,000 masl, farmers are able to grow coffee as a cash crop. The Gumuz, Berta and other ethnic groups that live in the western lowlands practice shifting cultivation. The principal crops are sorghum, maize and beans, although households frequently have sheep and goats.

In Sudan, there are several systems of rain-fed agriculture. In the Blue Nile basin, this includes sedentary agriculture and shifting cultivation, both of which also involve raising livestock. The rain-fed sector is responsible for 100% of the production of millet in Sudan, 11% of sorghum, 48% of groundnuts and 28% of sesame (UNEP, 2007).

Land resources are held under individual use rights for cropping and communal use rights for grazing and fuel wood collection. Households have small landholdings ranging from 2 ha to 30 ha that they cultivate using labor-intensive methods with hand tools. The household economy relies on mixed cropping and livestock production, and is basically oriented towards subsistence production and food security.

Mechanized Rain-fed Agriculture

Mechanized rain-fed farming is a farming system that is unique to the Blue Nile basin. In Sudan, about 10,000 farmers are involved in semi-mechanized rain-fed agriculture, which covers a total area of 5 million ha.

The area of semi-mechanized farming in the Blue Nile basin is 1.32 million ha, located primarily in the states of Sennar and Gaderif and, to lesser degrees, in the Blue Nile and El Gezira states. In general, farm sizes are 400-850 ha, although there are some large companies with holdings of more than 10,000 ha. The semi-mechanized rain-fed agriculture system was adopted by the Government in the mid-1940's, to cultivate soils that were not amenable for cultivation by hand or with oxen. Land is leased by the State to individual investors under 25-year leasehold tenure. Schemes are managed by both private and government sectors. The principal crops are sorghum and cash crops such as cotton and sesame. The use of improved inputs such as fertilizer and improved seeds is minimal and organized crop rotation and fallow periods are very limited.

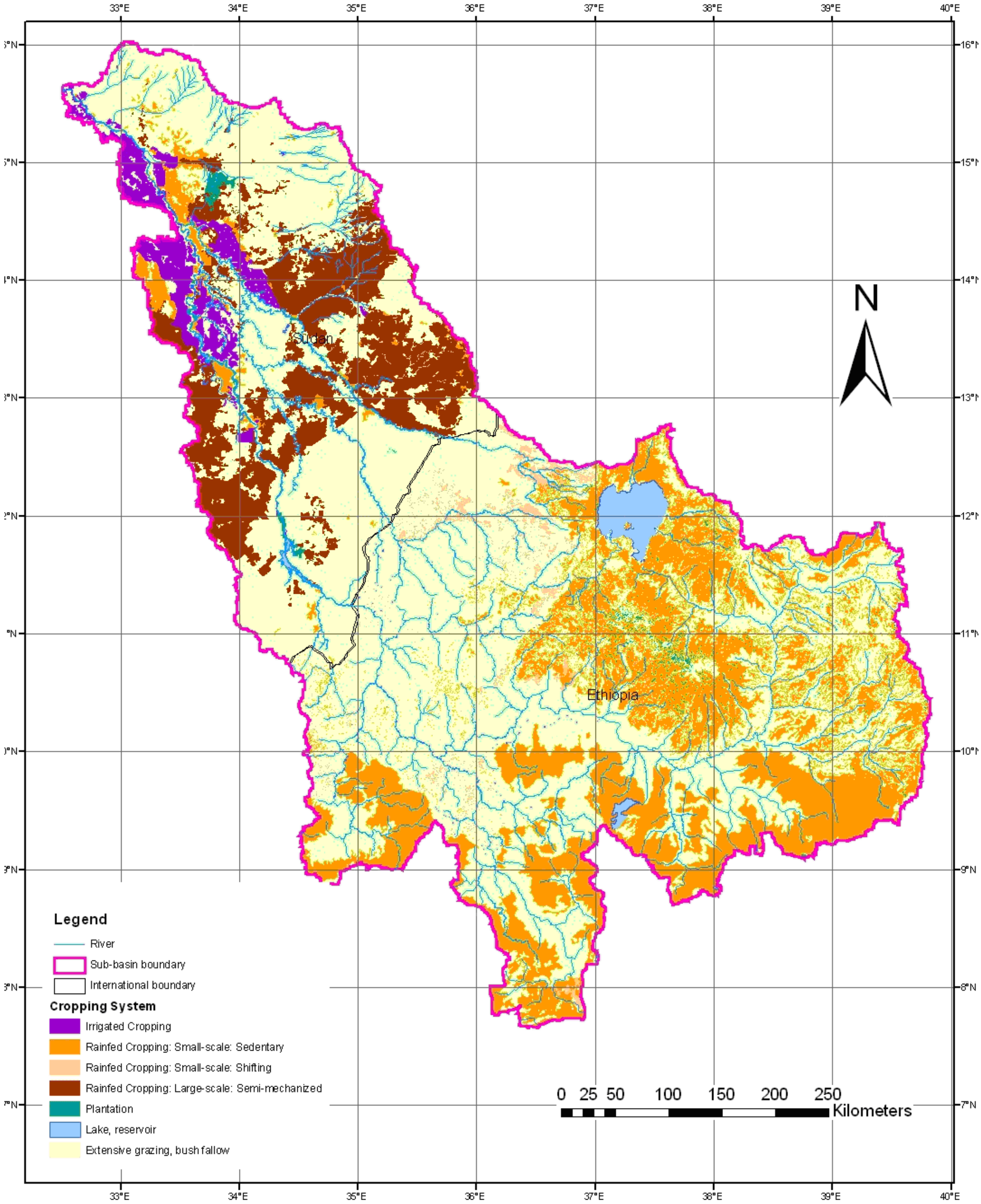
Crop yields from semi-mechanized farming have declined dramatically. This farming system has been criticized as being a major cause of environmental degradation, contributing to the deterioration of grazing resources, forest resources and soil fertility and the expansion of desertification. The evolution of mechanized rain-fed agriculture has focused on horizontal expansion and has been described as a crude form of extensive shifting cultivation with a tractor (UNEP, 2007). Mechanized rain-fed agriculture has been a major factor in the decline of transhumance in the Blue Nile basin.

Traditional and Small-scale Irrigation

Traditional and small-scale irrigation schemes are generally developed by individual farms or small community groups. They are common in the Abbay and Blue Nile basins and constitute the principal farming system along the Main Nile in Sudan downstream of Khartoum. Within the Abbay basin, there are a total of 60,000 ha of small-scale traditional irrigation schemes that range in area from 1 ha to 100 ha.

In Sudan, small-scale farmers living along the Blue Nile and the Main Nile irrigate their land using a variety of methods. Many farmers pump water directly from the river. The use of pumps has almost entirely replaced more traditional methods based on hand-operated water levers (shaduf) and animal-driven water wheels (saqia) (UNEP, 2007). Public and private small-scale pump schemes irrigate 153,000 ha along the Blue Nile and 88,000 ha along the Main Nile (BRL, 2008).

Figure 3-9 Farming Systems, Abbay and Blue Nile Basins



Source: Hydrosult et al. Abbay/Blue Nile basin. 2007.

Along the Main Nile downstream of Khartoum, the topographic conditions of the flood plain also permit spate irrigation, which is the collection of seasonal run-off water in basins and redirection to agricultural fields. On upper terraces beyond the flood plain but within 15 km of the river, farmers are increasingly relying on shallow irrigation wells (mataras) to abstract groundwater. The basic food crops grown in the Blue and Main Nile basins include maize, grown in the summer and the winter crops of wheat and vegetables. Dates along with sorghum, which is grown in the summer, are the principal cash crops. Large areas of alfalfa are also grown as livestock fodder, with up to ten cuts per year.

Raising livestock is also an integral part of the livelihood of these farmers. The animals are an additional source of income as well as a "safety net" against shocks such as droughts. In the Highlands, animals are also a valuable source of soil nutrients and fuel in fuel wood-scare areas.

Medium-scale and Large-scale Modern Irrigation

Medium-scale and large-scale modern irrigation farming systems based on the development of medium- and large-scale modern irrigation occurs in different regions of the Nile basin. In the Abbay basin, development is presently limited to several medium-scale schemes. In Sudan, there are a total of six public large-scale irrigation schemes in the Blue Nile basin providing water to over 1 million hectares. In the Lake Nasser watershed in Egypt, all agriculture relies on irrigation.

The Gezira Scheme in the Blue Nile basin is an example of agricultural livelihoods associated with irrigation. It is Sudan's oldest and largest gravity irrigation system, located between the Blue Nile and the White Nile. Tenant farmers farm the Gezira Scheme. It is the model for all public large-scale schemes in Sudan, namely a tenant farmer is allowed to own only one tenancy, although other members of the immediate family (e.g., sons, wife) can own tenancies in their own rights. A tenant farmer cannot sell or rent the tenancy without government consent but can bequeath the tenancy to an heir. However the tenancy can only be fragmented to half of the designated full size. In 2000, only 13% of the tenancies were owned by women (World Bank, 2000).

Soils in the Lake Nasser/Nubia vicinity are generally of poor quality, with low water-holding capacity and are highly susceptible to erosion by wind and water. Throughout this region, agriculture is not possible without irrigation. The Egyptian Government has proposed a major land reclamation program with the introduction of major irrigation schemes and the resettlement of up to 1.5 million people. The Lake Nasser Development Authority is responsible for the development of the watershed.

Table 3-13 Farming Systems, Abbay and Blue Nile Basins

Main Category	Scale of operations	Tenure type	Main Components	Location
RAIN-FED CROPPING	Small-scale traditional; sedentary	State land: Individual and Communal use rights	Cropping (Cereals, pulses, oil seeds) Small Livestock holdings (Communal grazing, crop residues)	Ethiopia: Highlands
	Small-scale traditional; shifting	State land: Individual and Communal use rights	Cropping (cereals, pulses): Small livestock holdings (Communal grazing, crop residues)	Ethiopia & Sudan: Lowlands
	Large-scale: Semi-mechanized	State land: Medium-term Leases	Cropping (Sorghum, cotton, sesame)	Ethiopia & Sudan: Lowlands
IRRIGATED CROPPING	Small schemes Small-scale operations (< 1.0ha) Gravity:	State Land: Individual use rights: additional to rain-fed land	Cropping (cereals, vegetables)	Ethiopian Highlands
	Small-scale: (<20 ha) Pump	Individual Freehold	Cropping: Sorghum, wheat, Alfalfa	Blue and Main Nile; Lake Nasser
	Large schemes Small-scale (< 1.0ha) Gravity:	State Land: Individual use rights: additional to rain-fed land	Cropping (cereals, vegetables)	Ethiopian Highlands
	Large scheme: small-scale operations (<40 feddan) Gravity	State land: Individual long-term leases	Cropping: Cotton, Sorghum, wheat Small-livestock holdings	Sudan: Gezira and Rahad Schemes
	Large scheme: large-	State land	Cropping: Sugar	Ethiopia: Fincha'a

Main Category	Scale of operations	Tenure type	Main Components	Location
	scale operations			Sudan: Sennar and Guneid Sugar Schemes Lake Nasser
LIVESTOCK	Small-scale: Extensive Pastoral Transhumant	State land: Communal use (grazing, water) rights	Cattle, small-ruminants	Sudan
	Small-scale: Extensive Agro-pastoral Transhumant-sedentary	State land: Communal use (grazing, water) rights	Cattle, small-ruminants Small-scale cropping	Ethiopian Highlands Sudan

Source: Hydrosult *et al.*, Abbay/Blue Nile basin, 2007.

3.7.2 Other Activities

Industrial Activities

Outside of Khartoum, there are no major cities in the Abbay, Blue Nile, and Main Nile basins. Industrial development is not significant and consists primarily of agro-processing (sugar factories), utilities (energy production) and construction materials (cement factories). However, the exploitation of oil reserves in central and southern Sudan (now South Sudan) is leading to the development of a wide range of upstream and downstream industries.

Gold Panning

Gold panning is practiced by households and communities along the Abbay mainstream and tributaries from the proposed Mandaya dam site to the Sudan border, particularly during the three-month dry season. It constitutes a key aspect of the livelihoods of Gumuz and other ethnic groups living in the western lowlands of the Abbay basin. The estimated value of gold panning in the main Abbay channel is ETB 21.6 million.

Transport and Navigation

In Ethiopia, 42-48% of households in the Abbay basin live within five kilometers from the nearest all-weather road (2004 Welfare Monitoring Survey as cited in Hydrosult *et al.*, 2007). People living along the Abbay River cross it for many reasons. They move their animals to pasture on both sides of the river. Trade is a common reason to cross the river and often the nearest schools, clinics or other social services are on the other side of the river. During the dry season people can often walk across the river and during the wet season ferry services using small boats (feluco) allow people to cross the river.

In Egypt, according to the National Water Resource Plan 2017 (MoWRI, 2005), the main inland waterways consist of the Nile (Aswan – Qanater) and other canals in the Delta. Inland waterways are used by traditional sailing boats for the transport of building materials, river barges and hotel boats (cruise ships) mainly between Luxor and Aswan. There are also a number of organizations offering cruises and excursions on Lake Nasser, and ferries are active at all times of the year, with extensive boat and ferry service to move cargo and passengers between Aswan and Sudan.

All navigation downstream of the AHD depends on the water level maintained by releases. On Lake Nasser, navigation conditions vary considerably as the result of seasonal water levels varying between 5 to 10 m.

Ecotourism

Ecotourism promotes travel to natural, cultural and historic resources in a manner that conserves the environmental integrity of these resources and improves the well-being of local people. This is a relatively new activity in Ethiopia and Sudan, which as yet do not benefit from strong networks of infrastructure and services.

In Egypt, a more dynamic ecotourism market exists as the result of its longer history of tourism to archaeological and cultural sites and supported by more extensive infrastructure. Tourism is among Egypt's five main sources of hard currency (MoWRI, 2005) and provides an important source of direct and indirect jobs.

The primary objective of the Tourism Strategy for the Government of Ethiopia is to make the country one of the top ten African destinations by 2020 with an emphasis on sustained socio-economic development and poverty reduction, namely tourism that improves the well-being of local people (World Bank, 2006). There are seven UNESCO World Heritage Sites and four important national parks in Ethiopia that constitute major attractions.

The Nile holds tremendous allure as a tourist attraction and the Blue Nile and Main Nile basins in Sudan and southern Egypt have been at the crossroads of dynamic and highly significant cultural forces and exchanges. Throughout these basins, there are a number of important bird sanctuaries including Sennar reservoir, Roseires reservoir, Lake Nubia/Nasser and the wetlands of Dinder/Alatish National Parks. The Dinder Park is designated as a RAMSAR site and a UNESCO-Man and the Biosphere biodiversity reserve, and provides habitat for a range of large and small mammals.

The main challenge with wildlife tourism in Sudan is that it does not exist on a commercial scale. In 2005, the total number of foreign visitors to Dinder National Park was less than 1,000 (UNEP, 2007).

In Egypt, Wadi Allaqi is also designated a UNESCO-MAB Biodiversity reserve based on its importance for bird migrations as well as the presence of ethnic groups such as the Ababda, and Bishari with their traditional lifestyles and crafts. The Nubian monuments from Abu Simbel to Philae are designated as UNESCO World Heritage Sites. Ecotourism is more developed in Egypt in and around the Lake Nasser region and includes fishing, lake cruises, caves and cave paintings and desert safaris, as well as bird watching and wildlife sightings such as the giant Nile crocodiles.

4 SCOPING OF KEY ISSUES

This chapter sets the scope for the selected key issues, identifies the main drivers and threats, and assesses their likelihood of occurrence and severity. The threats include climate change, effects on water quality, change in water demand, loss of livelihoods, increased water stress, and loss of biodiversity.

For the purpose of the Scoping task, the water resources development of the Eastern Nile has been defined as a range of joint investments in infrastructure and relatively small dams on the Abbay tributaries and/or larger multipurpose dams on the Abbay.

4.1 WATER SECURITY

Water security is a serious concern in the Eastern Nile basin. All three countries are suffering from water scarcity. Egypt is particularly vulnerable because precipitation is extremely rare with most of its water originating from outside of its borders, conjugated with a demand largely outstripping water availability. In 1999, it was projected that Egypt would be in a situation of *absolute water scarcity* by 2025 with less than 500 m^3 of water per person per year (Seckler *et al.*, 1999).

For Sudan and Ethiopia, the scarcity is attributed to institutional or financial causes restricting water accessibility despite sufficient quantities existing to meet the population needs (FAO, 2007).

With a predicted population increase of over 40% during the next 20 years, the scarcity of water will become extremely serious. The forecast for 2025, assuming a medium population growth scenario, predicts that even Ethiopia will reach a *critical water scarcity* level (Seckler *et al.*, 1999).

Temperature is largely expected to increase in northern Sudan and Egypt due to climate change, thus potentially increasing evaporation. Illustrating the uncertainty of the forecasts, some other studies however forecast a modest impact of less than 0.29% increase by 2050 (Badawy, 2009) representing 0.5 BCM by the end of 2017 (Dawod and El-Rafy, 2006).

Precipitation changes in the eastern part of the basin due to climate change are very uncertain. The range of change in precipitation for the Abbay/Blue Nile varies between a 15% decrease to a 14% increase (Elshamy *et al.*, 2008). This could represent some 10 BCM of water per year if it is simplistically hypothesized for the sake of the exercise that 15% additional precipitation could translate into 15% additional water in the Abbay and the other large rivers in the Ethiopia Highlands discharging into the Blue or Main Nile (Rahad, Dinder, Atbara).

The temperature and precipitation changes would also affect the frequency, duration and severity of extreme events such as droughts and floods.

Figure 4-2 Renewable Water/Capita/Year (1975-2025)

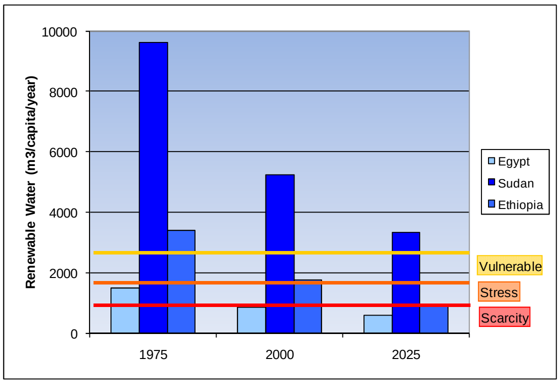
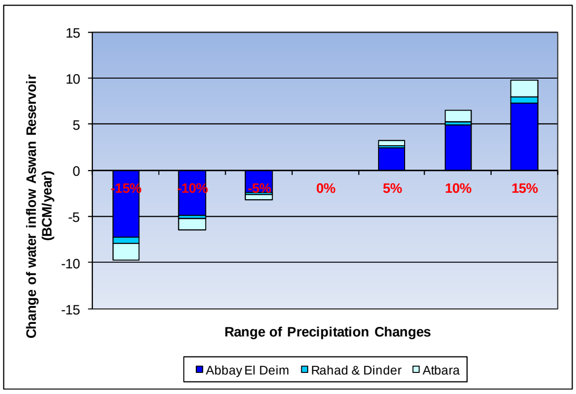


Figure 4-1 Inflow Variations from the Ethiopian Highlands under Climate Change Scenarios



Drought is a severe environmental and social problem in the region and will be exacerbated under the expected climate change scenarios. Peasants living in the Abbay basin area remain the poorest in Ethiopia due to virulent and repeated droughts and the famines associated with these events (Dessalegn, 2003). A century ago Ethiopia suffered a drought every 10 to 15 years; today droughts occur with alarming regularity every five years or less (Jeffrey, 2000). According to Asheber (2010), there have been 35 incidents of drought in Ethiopia between 1970 an 2008 where over 1.2 million people died and over 11 million were affected. Under a scenario of decreased precipitation of 15%, it is expected that drought frequency, severity and duration would increase in the region (Medany, 2008; Elasha, 2010).

Flooding is a mixed blessing as the balance between positive benefits and negative impacts shifts according to the severity of the flood. The negative impacts of flooding are economic, social and environmental and include:

- Destruction or damage to houses and public facilities, leading to loss of basic services and population displacement.
- Damage to productive assets and resources, such as agricultural land, crops, irrigation systems, loss of livestock and capital.
- Physical isolation during the flood.
- Average annual loss of productive land to river bank erosion (haddam) estimated at 20-40 meters.
- Deterioration of social and health services resulting in sanitation problems, pollution of drinking water, and the spread of diseases such as rheumatism, hypothermia, coughing and diarrhea.

As cited in the Mandaya studies (EDF *et al.*, 2007), the costs of mitigating flood damages for a 100-year flood are estimated at US$ 527 million, with an average annual damage estimate of US$ 52 million.

Flooding has also positive benefits by supplying nutrient rich silts to flood plains, material for brick-making along the Blue Nile in Sudan and by recharging seasonal wetlands that provide critical habitat for many plant and animal species, an essential part of several livelihoods and healthy biodiversity.

Flooding events will be affected by any increase in precipitation. Table 4-1 illustrates the changes in peak flows at three locations in the basin that could result from an increase of 15% in precipitation. Based on HEC-RAS hydraulic simulation, an increase from 0.5 m to almost 1.0 m in the water level along the Blue Nile is expected for a 1:100 return period. This increase in flow and the corresponding water level would have significant economical, social, and environmental consequences.

Table 4-1 Estimated future Mean and Peak Flows with a Precipitation Increase of 15% over the Ethiopian Highlands

Location		El Deim		Khartoum (Blue Nile)		Aswan High Dam	
River station		2317.45		1535		60	
Parameter		Flow (m^3/s)	Water level (m)	Flow (m^3/s)	Water level (m)	Flow (m^3/s)	Water level (m)
Historic flow	Mean	1530	489.32	1530	379.27	4890	179.02
	1:100	12386	497.78	12386	385.87	18283	179.26
	1:1000	15331	499.13	15331	386.66	22408	179.39
Future flow with increase of 15% precipitation	Mean	1759	489.69	1759	379.82	5624	179.02
	1:100	14244	498.65	14244	386.39	20886	179.34
	1:1000	17631	500.06	17631	387.20	25629	179.51

Evaporation is a key consideration and has significant influence on water availability. The Scoping Study identified that about four BCM of water could be saved if water were to be stored upstream in the Ethiopian Highlands where evaporation is less important and the Aswan reservoir operated at lower levels reducing its surface area (Blackmore and Whittington, 2008). Egypt's has however raised several concerns with the results of the Scoping Study, which are under continued discussion.

This potential to save a quantity of water is discussed further during the assessment of development options in Chapter 6.

Flow regulation as the result of the construction of dams and reservoirs on the Abbay would provide increased water management options.

- Upstream storage capacity would allow greater flexibility to provide releases for downstream needs and a water reserve in case of drought.
- It would provide flow regulation capacity to attenuate flooding and limit economic and social impacts.
- Downstream water availability may be decreased during reservoir filling, however the effect could be mitigated through the development coordinated operating rules.
- Furthermore the construction of these dams would trigger several of the World Bank's Safeguards Policies: 4.01 Environmental Assessment; 4.36 Forest, 4.37 Safety of Dams, and 7.50 Projects in International Waterways, which would require a cooperative approach.

4.2 ACCESS TO WATER AND LIVELIHOODS

Throughout the Nile basin, households and communities rely on a range of ecosystem goods and services provided by the Abbay/Blue Nile and Main Nile. Along the flood plain of the Eastern Nile basin, several of these ecosystem goods and services are provided by the annual floods. In addition to the fish derived directly from the river, an important livelihood in the basin depends on the crops grown under recession agriculture practiced after flooding. The annual floods provide fertile soil as deposited sediment, known as alluvium, and have an important role in maintaining livelihoods along the river. The residual moisture after a flood provides water for crop growth and for maintaining pastureland for grazing herds.

Recession agriculture occurs along the Blue Nile and Main Nile basins in Sudan, around Lake Nasser in Egypt, and to a much lesser degree in areas along the mainstream and tributaries of the Abbay River in Ethiopia. It is estimated that about 364,000 ha are under recession agriculture (EDF *et al*., 2007 Mandaya EIA). Farmers practicing recession agriculture are seldom wholly dependent on recession crops for subsistence and are also employed as fish catchers, brick-making, herders, or dry land cultivators. The balance between these subsistence options is variable within the region and ethnic groups (Adams, 2000). Regardless of complementary subsistence activities, recession agriculture provides an essential source of food. In years of low flow or drought, with minimal or no flooding there have been devastating food shortages and food insecurity in the region, whereas in years of high precipitation, flood damage may occur but food security is vastly improved (FEWS, 2010). The regulation of floods and the resulting effectives on recession agriculture is an important issue.

The cultural traditions of different ethnic groups have a strong influence on how various communities use natural goods and services. Communities such as the Gumuz in the western lowlands of Ethiopia and the various pastoralist groups in the Blue Nile basin continue to place high importance on the communal use and management of land and other ecosystems services. In remote rural areas, poor households survive because they are able to access and use these natural goods and services that complement fixed agricultural and other economic activities.

The development of large infrastructure on the Abbay has the potential to completely regulate river flow and eliminate flooding. As a consequence these developments may affect the households and communities that rely on recession agriculture. These 364,000 ha that are cultivated following the annual floods would be at risk of disappearing with complete flow regulation unless a suitable seasonal flood and environmental flood regime is maintained; otherwise recession agriculture will be affected, increasing the risk of impoverishment and the degree of food insecurity.

Pastoralism is concentrated in the Blue Nile basin in Sudan where nomadic and semi-nomadic communities rely primarily on raising livestock for their livelihoods. Also a number of the ethnic groups living in the western lowlands of Ethiopia practice extensive forms of animal husbandry in conjunction with shifting cultivation activities. Pastoralists' access to water, for both human and animal consumption, is a major influence on their livelihoods and the availability of pastoral natural resources such as pasture, land, and trees (Gomes, 2006).

The livelihoods of pastoralist groups in the Blue Nile and Main Nile basin have been under pressure for a number of years. These threats include, among others, environmental pressures due to increased water scarcity, reduced grazing land and obstructed migration routes as a consequence of the expansion of large-scale agriculture. Pastoralism is not considered a viable way of life and crop cultivation is the only rural economic activity recognized as productive and contributing to the national economy (Kandagor, 2005). This has precipitated significant changes in the livelihoods of tradition pastoralists and a large number have abandoned traditional pastoralist livelihoods in favour of other forms of agricultural and raising livestock.

Although reliable information on the number of families dependent on pastoralism is very limited, it is suggested that pastoralists throughout the basin would be affected by developments on the Eastern Nile.

It is estimated that about 3,000 households would be physically displaced from the Abbay portion of the basin in Ethiopia by the Border Dam. A large number of these household belongs to ethnic groups that manage communal grazing lands.

In Sudan, disruption of annual floods would reduce grazing areas on which sedentary, transhumant and agro-pastoralists depend and may restrict the movement of herds across the river by obstructing animal migration routes.

Brick-making is recognized a good source of cash income. The traditional method is to produce clay bricks using biomass fuels (fuel wood and dung cake) for brick burning. The brick-making industry is a major consumer of fuel wood representing 51.5% of the total industrial wood consumption in Sudan (FAO, 2000). The total annual consumption of wood by the brick-making industries of the Northern Sates of Sudan is 183,000 tonnes. As such the industry is responsible for considerable deforestation. In addition traditional methods of producing bricks has negative consequences for limited natural resources, the environment, results in poor air quality, and affects human health.

Brick-making is mainly concentrated along river banks and results in erosion (Haddams) and damage to arable lands. However most of the lost arable lands are recovered with the deposition of river sediments during the annual flood. In Sudan nearly 50,000 people are employed in brick-making during the dry season. The development of large infrastructure on the Abbay and the regularization of river flows may reduced access to clays as well as reduced deposition of sediment. However the major risk for brick-making is the lack of available fuel wood or other biomass materials to fire kilns.

> The flood plain provides a large number of ecological services that in turn would have social impacts on the livelihoods of those who depend on the flood plain. The development of large infrastructure on the Abbay has the potential to completely regulate the river flow and eliminate flooding. As a consequence these developments may affect the households and communities that rely on the annual flood events. However, it would be possible to establish a seasonal flood regime for flood plain management and to support most of the dependent ecological functions. As well mitigation measures for the loss of subsistence activities such as recession agriculture, pastoralism, or brick-making may be considered and implemented in advance of any changes in flow regime.

4.3 WATER QUALITY

Human activity in the Abbay/Blue Nile and Main Nile basins significantly affects the systems water quality and the health of the aquatic ecosystem. Agricultural practices and the use of agro-chemical products such as fertilizers and pesticides as well as the wastewater discharge from large urban areas, such as Khartoum, and industrialized areas in Egypt provide a source for organic and heavy metals contaminants.

Percolating water from irrigated areas has increased salinity in surface and groundwater. It is estimated that between 2.3 BCM (OSI, 2007) and 4 BCM (Wahaab and Madawi, 2004) of agricultural drainage water is returned to the Nile annually. The use of fertilizers, mostly nitrates and phosphates, is causing eutrophication concerns in drainage canals and water bodies. The proliferation of invasive weeds is of concern (NBI, 2005b).

Surface and groundwater quality is relatively good in the Abbay/Blue Nile and the Main Nile except near urban centers. Surface water quality is deteriorating in the Khartoum area and is considered a serious environmental issue in Egypt downstream of the Aswan dam (OSI, 2009). Groundwater quality is generally good in Sudan and is deteriorating in Egypt due to the leaching of nutrients and other agro-chemicals used in irrigated areas.

The pressure to expand irrigated areas to increase agricultural outputs will result in the increased use of agro-fertilizers and agro-chemicals. Water quality concerns are expected to increase unless measures are taken to treat industrial and urban wastewater and to improve agricultural practices.

Since several causes of poor water quality in terms of organic and heavy metals contamination are generally localized it is believed that mitigation measures by each country at the local level are necessary.

Diffuse agricultural pollution, from agro-fertilizers and agro-chemicals, is at a much larger scale and improvement of basin-wide practices would be necessary to maintain water quality. For example, Egypt has implemented strict controls on the use of fertilizer and agro-chemicals close to the Lake Nasser shore. The Bio-organic Control project at Aswan has developed a number of biological controls of plant pests that remove the need to use insecticides and fungicides.

A broader coordinated approach including information and knowledge sharing would ensure an effective basin-wide approach is implemented as the construction of dams and reservoirs upstream in the basin could have some downstream water quality implications during the filling and initial operation of reservoirs.

> Surface water and groundwater quality is generally decreasing from upstream to downstream due to agriculture and industrialization. It is a serious concern in Egypt. Mitigation measures by each country at the local level are necessary for pollutants from urban centers and industrialized areas. A basin-wide approach is necessary for diffuse agricultural pollution and to take into account impacts on water quality of the construction and filling of upstream reservoirs.

4.4 HYDROPOWER DEVELOPMENT

Harnessing the potential of the Eastern Nile in order to meet the projected energy demands of the Eastern Nile Basin in a sustainable manner is an issue of central importance in the region. Given current population growth and the current rates of electrification in Ethiopia, Sudan and Egypt, a significant source of energy must be developed to have any hope to sustain economic growth and alleviate poverty, particularly in Ethiopia and Sudan. In order to meet the energy demands in the Eastern Nile Basin, Ethiopia Sudan and Egypt, respectively have all developed Generation Expansion Plans based on projected needs, available resources and industrial development, which span a range of options including thermal and nuclear generation, as well as hydropower(Appendix C).

Although thermal and nuclear energy production feature prominently in the generation expansion plans of Egypt and Sudan, there is an advantage in developing renewable energy alternatives which would avoid GHG emissions and other pollutants and promote long-term sustainable growth. Among renewable energy alternatives, such as wind, solar and geothermal, hydropower shows the most potential for large-scale generation at present, which can help to meet a significant proportion of energy demands over a medium time horizon. Although hydropower development remains limited on the Eastern Nile, with the current total capacity for the Abbay/Blue –Main Nile down to Aswan, at just over 4,000 MW, the topography in the Eastern Nile Basin makes the Abbay River the area with one of the largest hydropower potential in Africa.

Power demands across the region are increasing very rapidly and an initial estimate of required power generation growth over the period to 2030 has been estimated from information available in the Final Report for the "Eastern Nile Power Trade Program Study" by EDF-Scott Wilson (2007), and is presented below in Table 4-2.

Table 4-2 Required Growth in Power Development in the Eastern Nile Region

Feature	Egypt	Sudan	Ethiopia
Installed capacity in 2009 - MW	26,382	4,121	1,855
Required capacity in 2030 - MW	77,951	16,535	11,951
Average annual percentage increase	6.8%	5.3%	9.3%
Main generation resources used	• Combined cycle • Coal and oil-fired Steam • Nuclear	• Some hydro • Remainder mostly combined cycle and thermal	• Almost all hydro • Less than 1% from 1 coal plant

As mentioned previously, regional studies have shown that water storage facilities on the Abbay/Blue Nile Sub-basin would not only generate large amounts of hydropower but could also provide important multipurpose benefits to downstream riparians, including flood control, sediment management, and improved navigation. Sediment management itself would have a significant effect on improvement of downstream power generation and irrigation efficiency. Furthermore, water storage and hydropower generation facilities in this sub-basin could be complemented by investments in watershed management and irrigated agriculture, making an important contribution to maintaining the health of the river basin and those who depend on its resources. Finally, there also exists an important potential to achieve water savings in the Eastern Nile Basin system by creating reservoirs in upstream highland areas were loss of water due to evaporation would be smaller than in much drier and hotter lowland areas.

Table x.x shows that, over the next 21 years, about 74,000 MW of additional capacity will be needed in the region and most of it (about three quarters) would be from thermal sources, as indicated in the respective national development plans for Egypt and Sudan. Almost all of Ethiopia's energy needs in the next 2 decades will be met through the development of hydropower and these developments, if pursued jointly have the potential to address larger energy needs in the region while also addressing important aspects of transboundary water management

Four principle hydropower developments have been studied for development on the Abbay in Ethiopia. These are described below in Table 4-3.

Table 4-3 Characteristics of Main Abbay River Projects

Project	Catchment Area (km^2)	Reservoir Area (km^2)	Full Supply Level (m)	Gross Storage (MCM)	Live Storage (MCM)	Installed Capacity (MW)	Energy Output (GWh/Year)
Karadobi	82,300	445	1146	40,200	17,000	1,600	9,708
Beko-Abo	88,890	420	906	37,500	20,000	800-1,000	11,200
Mandaya	128,729	574	800	49,200	24,600	2,000	12,119
Border	176,918	574	580	14,470	8,500	1,200	6,011
Total	**176,918**	**2,013**	**-**	**141,370**	**70,100**	**±5,700**	**39,038**

If a full range of joint investments were to occur on the Abbay River and all four of the above described dams were built, this additional 5,700 MW could more than double the current total of 4,000 MW currently generated along the entirety of the Abbay/ Blue and Main Nile up to Aswan. It should be noted that the production from the four large dams of 5,700 MW is about 8% of the total new power requirement to 2030 of 74,000 MW. The production from the construction of five smaller dams of 729

MW on Abbay tributaries (and no major development on the Abbay) is less than 1% of total new power requirement. Considering that about 74,000 MW of additional capacity will be needed in the region over the next 21 years, a full range of joint investments along the Nile could constitute a significant contribution to satisfy regional demand.

Furthermore, as most of the plants planned in Sudan and Egypt would be thermal or nuclear, purchasing hydropower and at least delaying thermal and nuclear development have measurable social and environmental impacts.

> The issue of hydropower development is considered significant at the region scale given power demand growth and the potential for multipurpose benefits. Jointly planned investments have a greater potential to maximize multipurpose benefits such as increased downstream generation, flood control, irrigation efficiency improvement and expansion, and downstream navigation. Given the presence of a several very complex intertwined downstream impacts both positive and negative a cooperative approach is the best way to ensure that the three countries benefit from hydropower development.

4.5 EROSION AND SEDIMENTATION

High sediment loading is a significant regional issue with environmental and economic implications. The main cause is soil erosion from the Ethiopian Highlands, bank erosion and dune shifting. Sediment accumulates in reservoirs and irrigation infrastructure in Sudan and in Lake Nasser and has significant economic consequences due to cost of dredging and maintaining irrigation and hydroelectric infrastructure. In addition, high sediment loading is responsible for a loss of hydro energy during peak flow periods as water is flushed through the reservoirs to avoid sedimentation in the reservoir and loss of storage capacity.

For the Roseires reservoir, the dredging and maintenance of infrastructure cost some US$ 7.5 million per year (EDF *et al*., 2007). It is estimated that if sediment loads could be reduced it would generate US$ 88 million yearly in additional electricity production with one large reservoir on the Abbay trapping most the sediment (EDF *et al*., 2007, Mandaya EIA), and more with a second reservoir (EDF *et al*., 2007, Border EIA).

Bank erosion is a concern on the Main Nile in the northern part of Sudan. The available cultivated land in northern Sudan and Egypt extends only for a few hundred meters along the riverbanks, and is susceptible to bank erosion (NBCBN-RE – River Morphology – River Cluster, 2005). For example, due to bank erosion, the Nuri scheme in northern Sudan has lost 5% of its productive land between 1970 and 1980.

> The issue of sediment loading is considered significant at the region scale with economic and environmental consequences. Reservoirs on the Abbay would have the potential to trap sediment upstream, reducing the loading downstream with significant positive economic impacts.

4.6 CRITICAL HABITATS, ECOSYSTEM FUNCTIONS AND BIODIVERSITY

The flood plain of the Blue Nile and Main Nile supports a large number of human and ecological needs and as such is critical. The estimated total flood plain extent along the Abbay/Blue Nile and Main Nile is some 6,000 km^2 for a 1:2 return period. It can increase to 9,000 km^2 for a 1:100 return period. The flood plain along the Abbay and its tributaries is almost non-existent due to the very step gradients.

The flood plain provides other ecological services such as the provision of goods (food and fresh water), regulating services supporting the recharge of groundwater and carbon sequestration, and support services such as nutrient cycling, the provision of habitats critical for fish and the grazing of cattle. The flood plain is important in every aspect of the human and ecological tissues along the Blue Nile and Main Nile.

In addition to recession agriculture practiced on some 364,000 ha along the river, seasonal wetlands and flood plains are an essential feature supporting the life cycle and spawning habits of a number of fish species living in the Abbay/Blue Nile and Main Nile basins. Several of these fish species such as Tilapia are of significant importance providing economic and livelihood benefits

Seasonal water levels fluctuations in Lake Nasser/Nubia are an important feature of the habitats found in the littoral zone around the lake and the Khors where most fish are found. The water levels fluctuate generally between 5 to 10 m every year (BirdLife International, 2010; Hassoup, 2002), but may reach up to 25 m (International Lake Environment Committee, 2011). Variations of water level greater than 10 m may not be able to sustaining fish populations as it would prevent the growth of submerged macrophytes habitats, which support these fish populations (Bernacsek, 1984).

Ethiopia, Sudan and Egypt all have species designated with a special status under the IUCN Red List, with over 500 species having either a “critically endangered”, “Endangered”, “Vulnerable”, or “Near Threatened” status. All development options, depending on their scale, have some potential to change the characteristics of the aquatic (river flow), terrestrial (reservoirs and construction sites), and semi-aquatic habitats (wetlands, food plain and seasonal wetlands), which will affect a number of these ‘‘at risk” species.

The development of large infrastructure on the Abbay has the potential to completely regulate river flow thus eliminating seasonal flooding. The ability to regulate the river flow would provide economical benefits by reducing flood damages and by adding storage capacity enabling greater flexibility for drought mitigation. Unless a provision for some seasonal flood regime is incorporated into the annual operations of these large infrastructure projects, there would be consequences for people relying on recession agriculture, on the flood plain fauna and flora resulting in decrease in biodiversity, and a potential increase of invasive macrophytes such as the water hyacinth (Bernacsek, 1984).

Of the two Protected Areas in the study area, only the Dabus Valley Hunting Area would be directly affected if one large reservoir were to be built in the Border area. A reservoir with a FSL of 580 masl would inundate the lower few kilometers of the 574 km^2 Dabus Valley Area, representing well less than 1.0% of the total controlled hunting area; a larger reservoir would inundate more. The construction of other small or large reservoirs would affect some Important Bird Areas along the Abbay, however the new reservoirs would create new habitat for birds. The Dinder and Alatish national parks could be indirectly affected by people moving there due to flood plain grazing areas reduction and expansion of irrigated agriculture.

> The existing flood plain habitat provides a large number of social and ecological services. The development of large infrastructure on the Abbay has the potential to completely regulate the river flow eliminating extreme flooding events that cause significant damage, but also reducing the flood plain sustaining these services. It would be advisable to preserve some level of environmental flows critical for the preservation of a “normal” flood plain, keeping intact its social and ecological functions.

4.7 VULNERABLE GROUPS AND RESETTLEMENT

Vulnerable Groups are characterized as those prone to impoverishment due to current economic development trends. As previously noted poverty is widespread in the region and members of vulnerable groups may be subjected to further risks with the development of infrastructure on the Nile.

One of the most vulnerable groups in the Blue Nile basin is the internally displaced people (IDPs) and refugees. The number and dispersion of IDPs within Sudan is in a constant state of flux, with a significant movement of IDPs towards the south due to the 2010 referendum. However there remains a large number of IDPs in the Khartoum area and along the bank of the Blue Nile employed by the large irrigation schemes. The majority of agricultural labourers working on large scale irrigation schemes such as Gezira tend to be IDPs from Darfur and other conflict areas. The presence of a large number of IDPs in the basin creates pressure on the limited environmental resources, as well as social services, especially health and education. It also puts pressure on the economy leading to high rates of unemployment.

Indigenous People and certain Ethnic Groups rely strongly on traditional resource-based livelihoods and, for this reason, may be more vulnerable to the changes associated with proposed water resource developments. These include the Gumuz, Berta, and other ethnic groups that are located primarily in the western lowlands of the Abbay basin. These groups, which maintain traditional social organizations based on clans, manage and use land resources collectively, and their livelihoods are based on shifting cultivation and extensive grazing of livestock on communal lands.

Throughout the Blue Nile and Main Nile basins in Sudan, there are numerous ethnic groups that have traditionally practiced nomadic and semi-nomadic pastoralism. While their systems of social organization have evolved, in part in response to the migratory patterns of their livelihoods, a number of forces have led members of these ethnic groups to adopt more sedentary agro-pastoral livelihoods; these groups still rely strongly on access to water and related resources such as pastureland, which may be threatened by changes to the flow regime.

The Ababda and Bishari, the ethnic groups in the Wadi Allaqi region and on the eastern shores of Lake Nasser, have traditionally been nomadic herdsmen migrating with their herds of camels and sheep. Their livelihoods have also evolved, with many now spending a portion of the year cultivating crops. Access to water and related resources will be affected by changes in the level of Lake Nasser as the result of large infrastructure developments on the Abbay, particularly during the filling of the reservoirs, but also during operation of AHD if lower operating levels are maintained to reduce evaporation.

Large-scale infrastructure investment such as the construction of hydropower dams carries with it high risks of population displacement as well as in-migration to the project site. The scale of involuntary resettlement and in-migration depends very much on which projects are chosen for development and the planning which takes place in regards to these developments and the mitigation measures put in place. It is clear that large-scale developments on the Abbay would result in the physical and economic displacement of people and communities in the vicinity of the proposed dam sites; the extent of displacement varies considerably among sites. One or both forms of displacement will occur in Ethiopia in relation to the dams and may occur in Sudan if there is loss of recession agriculture or other livelihoods.

Preliminary data, drawn from the pre-feasibility studies, are available for three of the four large dams, as well as estimates of the displacement caused by the dams on Abbay tributaries. Table 4-4 shows the maximum physical and economic displacement that would occur if the full JMP development were to occur (maximum investment level leading to four large dams on the Abbay) vs. if all dams on Abbay tributaries found in Ethiopia's national developments plans were built under unilateral or joint alternative (with no large dams on the Abbay).

According to the pre-feasibility EIAs conducted respectively by Norplan et al. (2010) and Norplan et al. (2006), there is no physical displacement of people from the reservoir areas of Karadobi and Beko-Abo. Some displacement would occur do to the reservoir created by the Mandaya project and considerable displacement would occur due to the creation of the Border Dam project. Table 4-5 summarizes the displacement by project (these figures would need to be confirmed with a detailed EIA).

In the case of the Border dam, there is potential for social conflicts between the Gumuz ethnic groups and newcomers, based on different systems of social organization, land use, and agriculture.

An international safeguard that would be triggered by the construction of dams and reservoirs on the Abbay is the World Bank Policy on Involuntary Resettlement (OP 4.12). This policy has as its objective to assist the people and communities affected directly by physical and economic displacement caused by development investments. The goal is to assist project-affected people to improve or at least to restore their living conditions, livelihoods and income levels to the existing conditions prior to the project. The implementation of the World Bank policy is based on the development and implementation of two tools, the Resettlement Policy Framework and the Resettlement Action Plan.

Table 4-4 Number of Potentially Affected People under Development Alternatives

	Maximum Development on the Abbay (4 large dams)[1]	Dams on Abbay tributaries[2]
Total number of affected people (physical and economic displacement)		
Affected households (no.)	8,046	5,403
Affected people (no.)	45,505	27,063
Affected communities (no.)	28 [3]	63
Physical displacement		
Affected households (no.)	3,161	224
Affected people (no.)	15,525	1,118
Affected structures (no.)	9,500	Not available
Loss of resources causing economic displacement		
Loss of arable land (ha)	10,950	12,678
Loss of grazing land (ha)	28,600	
Loss of access to natural resources	Yes, but loss not quantified	Yes, but loss not quantified

1) EDF *et al*., 2007; Norplan *et al*., 2006, Norplan *et al*, 2010.
2) Estimated by the Consultant based on aerial photos and GIS techniques
3) Data available only for Border

Table 4-5 Physical and Economical Displacement for large Dams on the Abbay

Extent of Physical and Economic Displacement	Border	Mandaya	Beko-Abo	Karadobi
Number displaced people	13905	1620	0	0
Number affected people	13905	3000	0	28600
Affected people per MW produced	12	2	0	18
Affected people per Live Storage	1.6	0.1	0.0	1.7

Sources: EDF *et al*., 2007; Norplan *et al*., 2006, Norplan *et al*, 2010.

The socio-political risks of population displacement include:

- High risks of further impoverishment of people and groups who often are already vulnerable due to poverty and other reasons,
- The resource and institutional limitations to carrying out successful resettlement programs; and,
- The increasing opposition to resettlement by project-affected people as well as international NGOs and civil society.

Physical and economical displacement due to the construction of dams on the Abbay or its tributaries is a very distinct possibility, the number of affected people depending on the dams selected. If physical and economic displacement is unavoidable, mitigation measures should be carefully put in place following detailed studies and plans, in order to avoid the further impoverishment of project affected people and jeopardizing the sustainability of water resources developments in the Eastern Nile Region.

Resettlement and physical displacement represent risks, and have the potential of generating controversy. It is best to avoid resettlement, or if unavoidable, to at least minimize the resettlement needed.

World Bank Safeguards on Vulnerable groups (OP 4.10) and Involuntary Resettlement (OP 4.12) would be triggered.

4.8 DAM SAFETY

Any dam built on the Abbay or its tributaries is considered as a large dam, although the dams on the Abbay are much larger than the smaller on the tributaries. Up to four large dams may be considered for full development of the Abbay, although it is more realistic to consider that two or three could be built during the time horizon set for this study.

Roller compacted concrete (RCC) gravity dams as proposed for the Abbay river are considered among the safest types of dams, although very few as large as those considered for the Abbay have been built (three have a height between 200 and 280 m).

The failure of the dam structure itself, the failure or malfunction of other structures (e.g., spillway gates), as well as the failure of warning systems, or unforeseen spillover due to extreme precipitation increase induced by climate change has the potential to cause important negative environmental, economic and human impacts downstream, including potential loss of lives. Communities near the dams or the cascade of dams and reservoirs would be seriously affected, as would downstream communities along the Blue Nile and Main Nile. Lives and livelihoods may be lost.

The World Bank Safeguard on Safety of Dams (OP 4.37) would be triggered by any of the large dams on the Abbay or the smaller dams on its tributaries. One of its provisions includes a review by an independent Panel of Experts. This independent Panel of Experts will be charged with reviewing design and design changes, prequalification of bidders, inspection of construction works and periodic safety inspections following construction of the dam. The Panel of Experts would also review engineering operation and maintenance plans and oversees hazard plans including those for flood forecasting and flood warning.

> World Bank OP 4.37 would be triggered by the construction of any large dams on the Abbay as well as by the construction of smaller dams on the Abbay tributaries or elsewhere in the basin as these smaller dams will still be higher than 15 m and will be considered as large dam under OP 4.37. Failure of these dams, particularly under a cascade scenario could have significant negative impacts on downstream communities and environment.

4.9 CLIMATE CHANGE

4.9.1 Effects of Climate Change

Climate change will directly affect the three countries by changes in temperatures and precipitation. The changes in precipitation and temperature resulting from climate change will be increasing runoff under the increased precipitation hypothesis, or will increase drought frequency and severity under the lower precipitation hypothesis.

Under a unilateral development scenario, the flexibility to adapt to the changes on a regional scale will be restricted as tools such as flow regulation and upstream storage capacity would be limited.

- For example, under severe basin-wide drought conditions/water scarcity, the value of water for irrigation would be higher than for hydropower, and so the priority for JMP 1 reservoir operation could be switched to support irrigation/food security.
- If temperatures increase further in the north, evaporation losses from the AHD will also increase, making it more desirable to store water in the Ethiopian highlands.

Under the JMP 1 scenario, cooperative action would facilitate these adaptations to lessen the vulnerabilities, especially in agriculture and water management with a more stable water supply for irrigation, the population and livestock as well as provide flood control and controlled flood flow regime to sustain critical flood plains.

4.9.2 GHG Emissions

Ethiopia is largely an agricultural economy where traditional practices are still much in use. Its GHG emissions are due to a large extent to the use of traditional energies such as biomass. Electricity generation is dominated by hydroelectricity (85%). The national Ethiopian Electric Power Corporation (EEPCO) is rapidly expanding generating capacity and total installed capacity is expected to grow by more than 9% per year between 2009 and 2030 from 1,798 MW to 9,166 MW (Appendix C). Most of the added capacity would be hydropower, with some wind and geothermal sources.

Sudan is also a largely agricultural economy, which has undergone very rapid economic growth due to the development of its oil and gas industry over the last few years. This rapid economic growth will require increased electricity capacity, which is expected to reach 16,535 MW in 2030, or an average annual increase of 5.3%. In 2009, the total capacity was 4,121 MW and it is expected that most of the additional capacity will be composed of thermal plants (Appendix C).

The economy of Egypt is far bigger than Ethiopia and Sudan and has a much higher level of development in terms of GDP per capita, relying to a lesser degree on agriculture. Its energy demand is much more significant and growing. The generation expansion plan for Egypt to 2030 as per the Power Trade study shows a planned increased in capacity of about 52,000 MW between 2009 and 2030. The increase is largely composed of combined cycle gas turbine and steam turbine plants with some nuclear and wind power included (Appendix C).

The development plans for Egypt and Sudan clearly shows that under unilateral development, GHG would increase as Sudan and Egypt would satisfy their growing demand mostly from fossil fuel sources. Whereas under large joint investments, electricity exports from Ethiopia would partially satisfy these demands avoiding or delaying new plants in both Egypt and Sudan and reducing GHG emissions. It would replace steam plants burning crude oil in Sudan, and in Egypt it could replace steam plants and CCGT using natural gas.

> Climate Change may very well increase the frequency of extreme events, their extent and their duration with significant economic and environmental consequences. Flooding and droughts are expected to be more severe and common.
>
> A cooperative approach is viewed as an adaptation tool to address some of hydrological vulnerabilities in the region by ensuring more stable water supply for food production, sustaining populations and livestock, protecting ecosystems and providing flood control.
>
> Hydropower generation in the Abbay from large reservoir would partially satisfy these demands avoiding or delaying new plants in both Egypt and Sudan and reducing GHG emissions.

5 INSTITUTIONAL AND REGULATORY ASSESSMENT

The institutional and regulatory assessment detailed in this chapter provides an evaluation of country specific responsibilities with respect to each of the Key Strategic Issues. Existing bilateral, multi-lateral, and international instruments applicable to the Key Strategic Issues are identified. Proven instruments for overcoming institutional deficiencies are identified as well as the associated funding responsibilities of each party.

Detailed information of existing country, bilateral, and international institutions pertinent to the evaluations presented in this chapter is available in Appendix D.

To be effective, the three Eastern Nile countries must jointly address the nine issues discussed in Chapter 4. These issues are discussed below and additional information on each country institutions and policies is available in Appendix E. Furthermore, the Key Strategic Issues are of a nature that requires effective formal institutions be in place from the onset.

5.1 WATER SECURITY

All three Eastern Nile countries have legislation and agencies responsible for the management of their available water resources in a manner to serve their people. Egypt has the most comprehensive institutions ranging from data collection to a program of updating their national water plan. Ethiopia has limited institutional means to affect its existing legislation. Sudan has suitable legislation and agencies assigned for the management of their available water resources. It was found that the existing level of institutional capacity in the three Eastern Nile countries reflects the scarcity of water with the legislation and institutional capacity more developed in countries with less available water.

Though the existing institutions in all three Eastern Nile countries provide a suitable basis for expansion in response to additional responsibilities they will benefit from strengthening as the issue of water security within the East Nile Region remains of immediate concern.

Potential Safeguard Triggers:

- WB - OP 7.50 Projects on International Water Ways

5.2 ACCESS TO WATER AND LIVELIHOODS

Provisions in the constitutions of Ethiopia and Sudan appear to be similar to constitutional provisions of India, USA, and Germany. These constitutions grant their citizens ownership of the water resources and assign the government the responsibility to manage the resource in a manner to benefit all citizens. The content of Egypt's constitution is not known, however Egypt's Ministry of Water Resources and Irrigation is responsible for managing the country's water resources.

In the three Eastern Nile countries government responsibilities are executed through agencies in accordance with legislated policies, programs, and budgets. Access to water and employment are sovereign issues that institutional responses would be tailored to the specific situation, consistent with the government's basic policies. The primary activity under JMP would be to encourage better environmental and social policies and programs and to seek sources of external funding for the individual country efforts.

Potential Safeguard Triggers:

- WB-OP 4.01 Policy on Environmental Assessment
- Equator Principle Financial Institutions 3: Applicable Social and Environmental Standards
- Equator Principle Financial Institutions10: EPFI Reporting

5.3 WATER QUALITY

All three Eastern Nile countries have government agencies responsible for monitoring and regulating water quality in accordance with legislation. Environmental agencies in all countries have defined authority in the water sector; however Egypt places specific responsibilities for water quality with the Ministry of Water Resources and Irrigation.

Water quality management is primarily an in-country function; however the development of large-scale infrastructure on the Abbay will entail the development of transboundary water quality objectives to protect downstream interests. This will require an expansion of each country's pollution and water quality programs requiring additional legislation support with budget and staff increases.

The exiting institutions provide an adequate base for such modification. However, a Transboundary Organization (TO) would provide transparent monitoring of water quality and compliance according to agreed upon transboundary water quality objectives.

Potential Safeguard Triggers:

- WB - OP 7.50 Projects on International Water Ways

5.4 HYDROPOWER DEVELOPMENT

All three countries produce hydroelectricity and have dedicated agencies and/or ministries to handle the construction hydroelectric plants and the distribution of electricity. In Egypt, the responsibility is shared for hydropower between two ministries due to the central role of the Nile. In Sudan, there have been changes over the last few years and the National Electricity Corporation appears to have been dissolved recently.

Each country possesses the ability to built unilaterally hydroelectricity plants on its national rivers, but must respect international treaties and agreements for which they are signatory in the case of transboundary rivers.

Potential Safeguard Triggers:

- WB - OP 7.50 Projects on International Water Ways
- WB-OP 4.01 Policy on Environmental Assessment

5.5 EROSION AND SEDIMENTATION

Erosion and sedimentation issues exist in the upper Blue Nile and along the Main Nile. The degradation of agricultural, forest, and rangelands in Ethiopia is the primary source of sediment in the Blue Nile. Ethiopia's legislation calls for erosion control and soil conversation in agriculture; however its agricultural agency is constrained by inadequate budget and field staff to effectively assist farmers throughout the affected areas.

The situation in Ethiopia is a pressing concern for the Eastern Nile Region. Forty percent of the reservoir storage in Roseires, built in 1996, was lost over eleven years due to sedimentation. The risk of sedimentation to any large-scale infrastructure development is significant and institutional strengthening will be required to address the issue. Effective actions will entail farmer education programs regarding tillage practices, crop selection, and land preparation together with construction of stable drainage systems. Financial incentives to farmers will be required. The World Bank's program in the loess soils areas of China, the principle sources of the silt load in the Yellow River, provides a useful legislative and institutional model.

Soil conservation and watershed improvement programs are of immediate priority and a watershed management component is integrated into the JMP 1.

5.6 CRITICAL HABITATS, ECOSYSTEM FUNCTIONS AND BIODIVERSITY

Ethiopia has policies that address all elements of biodiversity and the existing agencies are suitable for absorbing JMP related tasks. As well, Sudan has policies and programs for addressing biodiversity and has existing agencies with the capacity to undertake JMP related tasks. The Environmental Affairs Agency in Egypt is the responsible institution and has broad legislation and polices to address biodiversity issues. Egypt's Ministry of Water Resources is responsible for water protection.

The responsibility and authority to address biodiversity issues with the management of land, water, and other natural resources are a matter of sovereignty. However, it is suggested that actions related to biodiversity under JMP would be best mandated under a Transboundary Organization as part of a basin-wide agreement. The extent of a JMP basin-wide program would depend upon the source and amount of available funding; long-term grant funding would however be essential.

Potential Safeguard Triggers:

- WB - OP 4.01 Policy on Environmental Assessment
- WB - OP 4.04 Policy on Natural Habitat
- WB - OP 4.11 Physical Cultural Resources
- WB - OP 4.36 Policy on Forests
- AfDB - 2004 Policy on Environmental Assessments and Environmental and Social Management Plan
- Equator Principle Financial Institutions 2: Social and Environmental Assessment

5.7 VULNERABLE GROUPS AND RESETTLEMENT

Ethiopia has established procedures for compensating people when they are evicted and for any associated loss of personal property.

Sudan's legislation provides compensation for the expropriation of private property. Sudan must compensate and must resettle populations as the result of dam construction.

Egypt has legislation that provides compensation for all property expropriated by the government and must assist in resettlement for specified projects.

International agencies financing JMP activities require the preparation of detailed plans that include compensation and resettlement packages for people affected by the taking of land for constructing dams and reservoirs. It is expected that the owner will be held responsible for executing the program including the longer term monitoring of results and any remedial measures, with oversight provided by a Transboundary Organization.

Potential Safeguard Triggers:

- WB - OP 4.10 Indigenous Peoples
- WB - OP 4.12 Policy on Involuntary Resettlement
- AfDB - 2004 Policy for Environmental and Social Management Plan ESMP, EA, Resettlement and Compensation Standards
- Equator Principle Financial Institutions 5: Consultation and Disclosure
- Equator Principle Financial Institutions 6: Grievance Mechanism
- Equator Principle Financial Institutions 10: EPFI Reporting

5.8 DAM SAFETY

It is not clear if Ethiopia has an agency responsible for dam safety and it may require new legislation and the establishment of an appropriate institutional mechanism. It is suggested that the dam safety must be independent of line agencies, particularly those engaged in activities related to the construction and operation of dams.

Sudan assigns dam safety design to a unit reporting directly to the President. Egypt assigns the responsibility to Ministry of Water Resources and Irrigation.

It is suggested that a Transboundary Organization receive regular reports of dam safety inspections and have authority to independently inspect facilities.

Potential Safeguard Triggers:

- WB - OP 4.37 Dam Safety

5.9 CLIMATE CHANGE

All three Eastern Nile countries have various bodies studying climate change. At this time the extent of formal climate change studies is difficult to assess.

Due to the global nature of the climate change issue and the continuing global studies that are underway it is suggested that a Transboundary Organization be given the responsible for gathering and sharing relevant information as the result of recognized international climate change studies to the Eastern Nile countries. Alternatively, the possibility of linking existing national agencies and adding functions to existing international organizations should be considered.

Potential Safeguard Triggers:

- AfDB- 2004 Policy on Climate Change

5.10 FUNDING AND SOVEREIGNTY IMPLICATIONS

The development of large-scale infrastructure on the Abbay raises a number of sovereignty and funding questions. The three parties have discussed the undertaking for several years and have outlined a program of actions, which identifies benefits to each of the parties. However sovereignty related questions such as ownership of the sites and the completed facilities, the principles for assigning reservoir use, and the sizing and operation of the infrastructure need to be further discussed.

The magnitude of the project may require external financing whether the work is undertaken by an individual country or as a basin-wide action. A Transboundary Organization would provide significant opportunities for cooperation and coordination as well as information sharing due to the basin-wide nature of the project. The responsibilities and roles of ENTRO and the Transboundary Organization will require careful consideration. Specifically, ENTRO will need to package any large-scale development actions in a manner that satisfies the requirements for international and bilateral financing.

In summary the JMP is a multi-purpose and multi-ownership undertaking to which well-established cost and funding allocation principles apply. The institutional measures necessary to address the nine Key Strategic Issues are highlighted in the following:

- Water Security - Requires a transboundary agreement for water sharing and compliance with a Transboundary Organization to oversee the agreement.
- Access to Water and Livelihoods - Encourage better environmental and social policies and programs with a Transboundary Organization to seek sources of external funding for the individual country efforts.
- Water Quality - Requires the establishment of water quality objectives to protect downstream countries with a Transboundary Organization to oversee the compliance.
- Hydropower - Requires a transboundary agreement for projects on transboundary rivers.
- Erosion and Sedimentation – Watershed management component is included in JMP 1.
- Critical Habitats, Ecosystem Functions, and Biodiversity – Establish a basin-wide agreement with a Transboundary Organization to oversee coordination.
- Vulnerable Groups and Involuntary Resettlement - Encourage better environmental and social policies and programs with a Transboundary Organization to seek sources of external funding for the individual country efforts.
- Dam Safety – Establish country specific Dam Safety institutions with a Transboundary Organization responsible for oversight and cooperation.
- Climate Change – Establish a Transboundary Organization for gathering and sharing information based on recognized international climate change studies; or alternatively consider the possibility of linking existing national agencies and adding functions to existing international organizations.

6 ASSESSMENT OF DEVELOPMENT ALTERNATIVES

This chapter will explain and highlight the benefits and impacts for a range of investment from no dam to the full cascade development on the Abbay, recognizing that it would be unlikely that four large dams be built during the time horizon of 2030. It is believed over the next 20 years that two and at most three large dams could be built.

The discussion looks at how the Key Strategic Issues would be affected by the range of investments various developments focusing on the main characteristics of these developments such as storage capacity, areas inundated and energy produced. The discussion avoids as much as possible site-specific issues for projects such as Karadobi, Beko-Abo, Mandaya, and Border but will use the findings of these studies to support the discussion.

As mentioned earlier, in light of the growing population pressure in the Nile basin, actions to better use the Nile waters such as collaborating on joint multipurpose investments to increase water security and access to water in the basin are highly advantageous, if not essential. Reducing the environmental degradation caused by increasing population pressures and accelerated economic growth is only possible by means of an integrated water resources management in the basin, transcending geopolitical boundaries. Furthermore, developing sustainable energy sources at a time when the risks of climate change have become increasing palpable and may have unpredictable and serious effects on water availability and food security in the Nile basin is important. Accordingly, an initial set of cooperative investments has the potential to spur regional, multipurpose benefits for all three Eastern Nile countries without eliminating future development options. Not only could a joint multipurpose project on the Eastern Nile generate large amounts of hydropower, it could also provide important multipurpose benefits to downstream riparians, including flood control, sediment management, and improved navigation.

6.1 DEFINITION OF RANGE OF COOPERATIVE DEVELOPMENT

The purpose of the Stage 1 SSEA is to identify environmental and social impacts and risks, which might arise from a range of cooperative action from “No-dam” to “Full Cascade Development” on the Abbay/Blue Nile and Main Nile.

At one end of the spectrum, the No-Dam development assumes that no large dams will be constructed on the Abbay and that no smaller dams will be constructed on the tributaries.

At the other end of the spectrum, the “Full Cascade Development” is defined as a range of joint investments in infrastructure of several large dams on the Abbay and/or smaller dams on the tributaries with a cumulative live storage capacity that could be up to approximately 100 BCM.

More specifically under a Full Cascade Development scenario up to five projects are considered on the Abbay tributaries and four larger projects on the Abbay, representing a range of investments defined as full development of the Abbay. Figure 6-1 shows the locations of the projects that have been considered at the time of preparing this report and their main characteristics are summarized in Table 6-1.

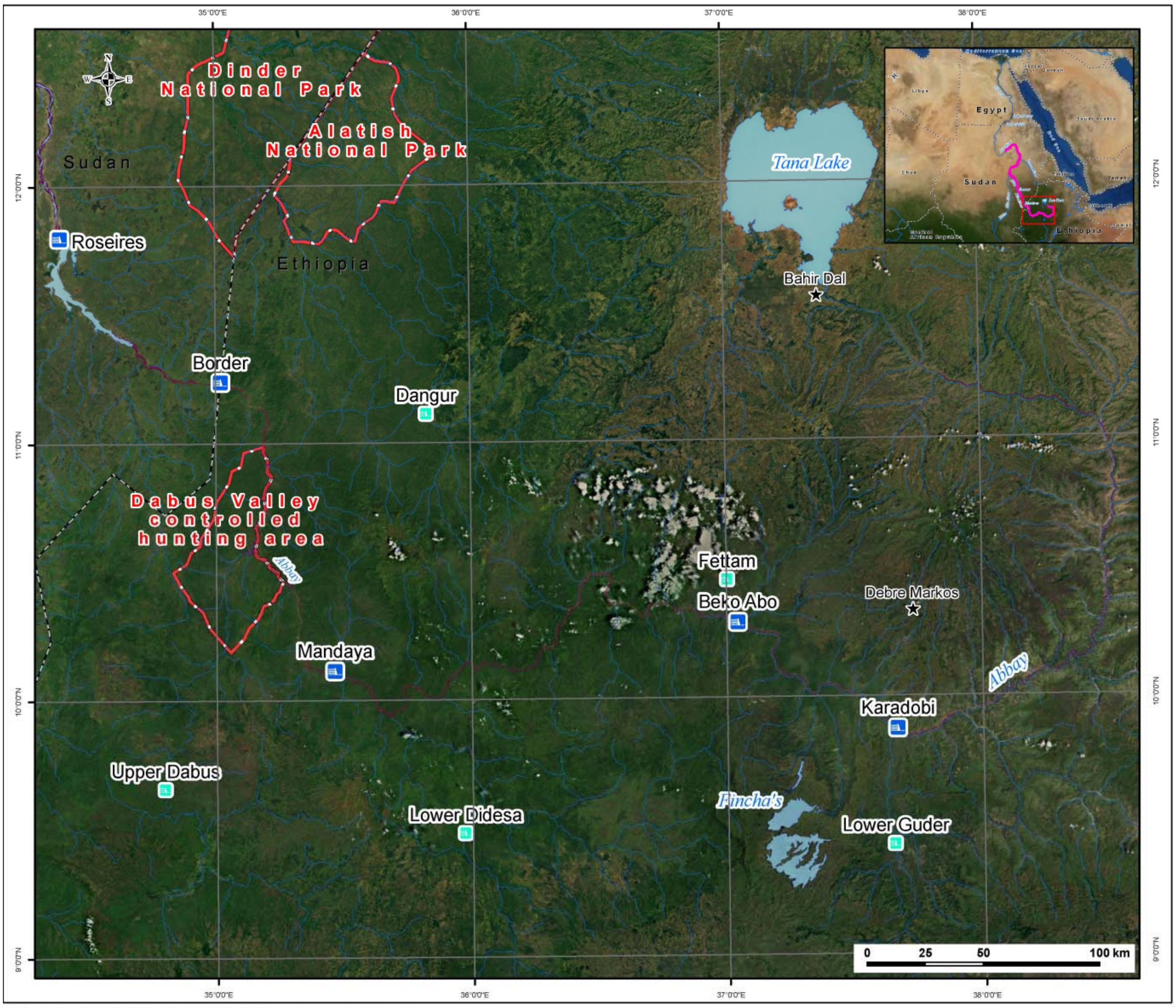
6.2 WATER SECURITY

6.2.1 Water Availability

Water security involves the sustainable use and protection of water systems, the protection against water related hazards (floods and droughts), the sustainable development of water resources and the safeguarding of (access to) water functions and services for humans and the environment (Unesco, 2007).

In Egypt, Lake Nasser generates hydropower in addition to providing flood protection and releases water through the year to ensure sufficient water is available to satisfy the country’s irrigation demands. However, it is projected that Egypt will approach the limits of its available water supply within the next decade.

Figure 6-1 Projects on the Abbay and its Tributaries



Sudan has access to sufficient water on a yearly basis to satisfy its needs but lacks sufficient infrastructure to optimize the available water. Due to sedimentation concerns, Sudan's reservoirs cannot be operated to maximize the production of electricity or water storage for irrigation. The Roseires and Sennar reservoirs on the Blue Nile do not have the flow regulation capacity to prevent damaging floods and cannot store sufficient water to ensure a secure water supply during times of drought. The heightening of the Roseires Dam will offer some improvement by providing additional water for irrigation and will enable increased electricity generation, but it will not provide sufficient capacity to avoid damaging floods or to satisfy downstream water needs during times of drought.

In Ethiopia, the Abbay basin supplies in theory sufficient water to satisfy the needs of its population, but Ethiopia does not have the infrastructure network to carry the water in other parts of Ethiopia where there is a water deficit. In addition, it does not have the means to store water for drought periods or to regulate the Abbay providing downstream flood protection on the Blue Nile and operational flexibility for Roseires, Sennar and Merowe.

With no dam and no storage capacity added to the current situation, the total quantity of water available in the Eastern Nile would not increase in the short term. Total water available may even decrease slightly in the short and medium terms due to higher evaporation rate in the Roseires Reservoir after the heightening of the dam (from 410 to 750 MCM/year, Norplan *et al*, 2006). Over the long-term water quantity may increase, if the climate change scenario with higher precipitation on the Ethiopian Highlands were to materialize, with all the uncertainty surrounding climate changes predictions.

Table 6-1 Main Characteristics of Possible Hydroelectric Projects on the Abbay and its Tributaries

Project		Tributaries					Abbay			
Characteristic	Unit	Beles Dangur	Fettam	Lower Didessa	Lower Guder	Upper Dabus	Karadobi	Beko-Abo	Mandaya	Border
Installed capacity	MW	104	126	295	52	152	1600	2100	2000	1200
Energy output	GWh/y	455	553	1292	228	666	9708	11200	12119	6011
Gross storage	MCM	n.a.	n.a.	n.a.	n.a.	n.a.	40200	37500	49200	14470
Live storage	MCM	2530	312	5510	1606	423	17000	20000	24600	8500
Cost per live storage unit	MUSD/MCM	0.115	0.641	0.069	0.063	0.648	0.144	0.157	0.117	0.191
Catchment area	km2	9092	648	17799	4774	8463	82300	93490	128729	176918
Reservoir area	km2	117	46	103	70	37	445	420	574	574
Reservoir length	km						150	150	300	150
FSL	m.a.s.l.	830	1960	990	1380	1365	1146	800	800	580
Dam height	m	110	25	100	103	40	250	280	200	90
Capital cost	2009 MUSD	291	200	380	101	274	2452	3133	2872	1620
Cost per MW	MUSD	2.80	1.59	1.29	1.94	1.80	1.53	1.49	1.44	1.35
Environmental mitigation costs	MUSD	n.a.	n.a.	n.a.	n.a.	n.a.	59	61	22	130
Number displaced people		n.a.	n.a.	n.a.	n.a.	n.a.	0	0	1620	13905
Number affected people[1]		2573	16142	690	0	7658	28600	0	3000	13905
Affected people per MW produced	nb/MW	25	128	2	0	50	18	0	2	12
Affected people per Live Storage	nb/MCM	1.0	51.7	0.1	0.0	18.1	1.7	0.0	0.1	1.6
Evaporation	MCM						277		580	939
Sediment trapping	%	n.a.	n.a.	n.a.	n.a.	n.a.	87	86	100	95

1) Estimations by the Consultants for the tributaries, and taken from individual EIAs for the projects on the Abbay

Reserve storage would increase water security for Ethiopia and also for Sudan and Egypt with appropriate operating rules to allow Sudan to operate the Roseires, Sennar and Merowe dams and reservoirs to optimize available water. In turn benefits would also be felt in Egypt during the operation phase. During the construction phase and filling of the reservoirs, great care and cooperative management will be needed to preserve Egypt's water availability.

To satisfy human needs in the Eastern Nile Basin, it is estimated that some 6.3 BCM is abstracted between Roseires and Khartoum, 1.2 BCM between Atbara and Dongola, and 55.5 discharged from the Aswan Dam (Table 3-2 in earlier Chapter), for a total of 63 BCM. Water abstraction is expected to increase in the future as the result of higher demand from the planned expansion of irrigated schemes. The amount will depend on total added irrigated area as well as crop type and climatic conditions.

Needs for Future Irrigation

Irrigation infrastructure development is part of each country's development plan. Ethiopia has several planned irrigation schemes in the Abbay basin for the 2005-2020 horizon: Lake Tana sub-basin (115,260 ha), Dedissa sub-basin (58,471 ha), Beles sub-basin (148,000 ha), and Angar sub-basin (26,563 ha) for a total potential of 348,294 ha (Hydrosult et al., 2006a).

In Sudan irrigation development is planned for the Gezira and Rahad areas as well as near Merowe. This is in addition to proposed increase in pumped irrigation along the Blue Nile and Main Nile. Rahad-2 (210,000 ha) and Great Kenana (420,000 ha) are committed, and other development are expected to follow (Hydrosult *et al*., 2006b).

For the Blue Nile basin, the increased demand for irrigation is estimated to be between 5.3 BCM (Norplan *et al*., 2006 – Karadobi EIA) and 9.2 BCM (EDF *et al*., 2007 – Mandaya Pre-Feasibility). For the Rahad area, it is estimated that each additional hectare of irrigated agriculture, with a typical crop pattern of sorghum 22% (summer), groundnuts 22% (summer), sunflower 22% (winter), maize 22% (winter), and vegetables 12% (winter), will require an additional 15,197 m^3/ha/y of water (SMEC, 2010).

Egypt has several large irrigation projects underway or planned under its Horizontal Expansion Programme (MoWRI, 2005). The West Delta (37,000 ha) and three projects in the Qanater area (840,000 ha) are to be completed in the very near future

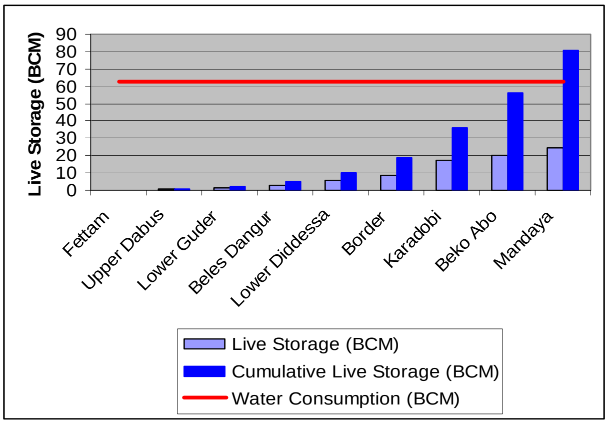
Under a Full Cascade Development scenario the total quantity of available water could increase by a few billion cubic meters if some water storage was displaced from Lake Nasser and held in the Ethiopian Highlands where evaporation is lower. Although the exact amount depends on a number of factors the potential increase in water available in a water scarce settings is worthy of consideration. It has been estimated at 4 BCM in the Scoping Studies (Blackmore and Whittington, 2008). These findings are disputed by Egypt which commented that the Scoping Study did not take into account critical scenarios such as effects of filling the new dams on the downstream flows, drought periods, and variable initial conditions of the levels of Lake Nasser, thus having a high probability of increasing water deficits for Egypt (Comments on the Scoping Study of the Joint Multipurpose Program (JMP), 2008). Other researchers have provided figures in the range of 4 BCM to up to 7 BCM (Block and Strzepek, 2010; Guariso and Whittington, 1987).

Capacity to Alleviate Droughts

Presently, there is no storage capacity on the Eastern Nile able to alleviate droughts. It is thought that adding storage capacity could provide an interesting adaption mechanism to climate change and play an important role in increasing food security in the region.

Figure 6-2 shows that the live storage capacity of the possible reservoirs on the Abbay tributaries would not have any significant capacity to alleviate a severe drought. Cumulatively, the five tributary reservoirs would account for some 19 BCM or about 16% of the total demand estimated at 63 BCM, slightly more than the Border project, the smallest large dam proposed on the Abbay.

Figure 6-2 Live Storage Capacity under Full Cascade Development



The total estimated capital cost of the five dams on the tributaries is close to the estimated capital cost of Border (MUSD 1,249 vs. MUSD 1,620), but twice as many people would be affected (27,063 vs. 13,905) and only 60% of the energy produced (729 vs. 1,200 MW). Any two large reservoirs would meet between 41% and 71% of the total demand and three large reservoirs would approach the total demand of 63 BCM.

6.2.2 Flooding

Flooding is a mixed blessing as it has both positive and negative effects. The negative effects are associated with large to extreme flood events with dramatic economic, environmental and social consequences; whereas the benefits of moderate floods supply moisture, nutrients and silt for recession agriculture and brick-making, sustain seasonal wetlands and semi-aquatic habitats that are critical for sustaining ecological services and recharge the groundwater.

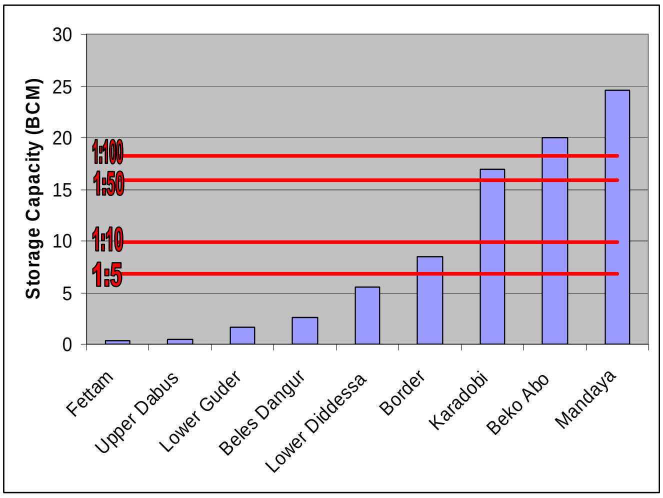
The levels defining beneficial and damaging floods have been studied by the Sudan Ministry of Irrigation and Water Resources and reported in EDF *et al*. (2007). This information is shown in Table 3-4. EDF *et al*. (2007) in their Environmental Impact Assessment of the Mandaya Project concluded that:

> *"Critical" years, occurring in about one year in four, are good for all – all the flood plain is flooded and receiving a dressing of silt as a fertilizer; (the word "critical" here refers to potential imminent flooding of properties and breaching of dykes in the flood warning sense of critical levels; for future agricultural production on the flood recession and for future water supplies from recharged groundwater and mataras, the situation is not critical but welcome and perhaps almost "ideal").*

The volume required to store volume equivalent to floods for return periods of 5, 10, 50 and 100 has been estimated based on the 100 year flood hydrograph derived by the Study Flood Risk Mapping Consultancy for Pilot Areas in Sudan (Riverside, January 2010). The proposed capacity of each reservoir is plotted against the volume of the water generated for each flood return period and is shown by Figure 6-3.

The analysis demonstrates that none of the reservoirs on the Abbay tributaries would have sufficient storage capacity to retain the 1:5 year flood. Border has sufficient capacity for the 1:5 year flood, but not for the 1:10 year flood.

Figure 6-3 Reservoirs Live Storage Capacity vs. Return Period Volumes



The analysis shows that a storage capacity of about 10 BCM could control a 1:10 flood, but would not have any significant effect for 1:20, 1:50 or 1:100 return periods. Since, it is predicted that extreme events are likely to increase in frequency and intensity, it is suggested that a storage capacity of about 20 BCM and more would be needed to offer protection against large flood that have the potential of bringing negative impacts. Table 6-2 presents some combinations of reservoirs that could control a 1:100 year flood and the corresponding economical and social characteristics.

Table 6-2 Combinations of Reservoirs Controlling a 1:100 Flow and Main Economic and Social Characteristics

Combinations of Reservoirs	Capital Cost MUSD	MW Produced	Person Affected	Cost per MW (MUSD)	Persons affected per MW
All 5 reservoirs on tributaries plus Border	2,866	1,929	40,968	1.48	21.2
Border plus any large reservoir	4,072 – 4,753	2,800 – 3,300	13,905-42,505	1.44-1.45	7-12.8
Karadobi plus Lower Gudder	2,553	1652	28,600	1.54	17.3
Beko-Abo	3,133	2,100	0	1.49	0
Mandaya	2,872	2,000	3,000	1.44	1.5

6.2.3 Groundwater Recharge

In the Lake Tana area some 30% of groundwater recharge may be due to seasonal flooding. For the Blue and Main Nile basins groundwater is recharged by seepage from the Nile, irrigation canals, leaching from irrigated lands and the flood plain (MoWRI, 2005).

The critical areas for groundwater recharge along the Abbay/Blue Nile and Main Nile are poorly understood, and the effect of a reduction in the seasonal flooding along the Eastern Nile cannot be quantified with any degree of certainty at this time. The assumption is that groundwater levels would decrease with a decrease in seasonal flooding, but at an unknown rate.

Under the no development alternative, groundwater recharge along the Blue and Main Nile is not expected to be affected as there would be no reservoir to modify the surface water flow and groundwater recharge.

Small dams and reservoirs on the Abbay tributaries would not modify the surface flow significantly at the basin level and would only have a localized impact on the groundwater; they could affect the livelihoods of local populations to the extent that these populations are relying on groundwater for their livelihoods. At the other end of the spectrum, only one very large reservoir of about 7 or 8 BCM on the Abbay would have the potential to achieve flood control for a 1:5 return period and have the potential to affect downstream groundwater recharge. A reservoir or a set of reservoirs of 20 BCM or more could easily regulate a 1:100 year flow and have the potential to affect downstream groundwater recharge and livelihoods. Groundwater recharge could be largely maintained and negative impacts avoided if seasonal flooding at a beneficial level equivalent at a 1:4 return period are maintained.

6.3 ACCESS TO WATER AND LIVELIHOODS

Livelihoods of those along the Abbay/Blue Nile and Main Nile depend on access to water and related ecosystem resources. The range of developments that may occur on the Nile from presents a wide range of risks and opportunities for those that depend on the Nile for their livelihoods.

6.3.1 Recession Agriculture

Recession agriculture occurs along the Blue Nile and Main Nile basins in Sudan, around Lake Nasser in Egypt, and to a much lesser degree in areas along the Abbay River and its in Ethiopia. Under the no development scenario the existing situation is not expected to be affected on the short term. A range of impacts may be felt on livelihoods in the basin depending on the range of investments implemented.

It is clear from previous pre-feasibilities studies and associated EIAs conducted for specifically proposed projects in the Abbay that one major dam on the Abbay would have an impact on recession agriculture. The cumulative impact are not well understood but livestock may be affected in terms of reduced vegetation for grazing, lost crop residues, less dung as manure for subsequent cropping, etc. Also, the deposition of silt on farmlands, which acts as a crucial necessary fertilizer for crops, could be reduced (EDF *et al*., 2007- Mandaya Pre-Feasibility EIA).

The water levels in Lake Nasser/Nubia may drop during the initial filling of JMP reservoirs on the Abbay. For example, levels in Lake Nasser may drop by 2 m during the initial filling of the Border reservoir, which is estimated to span two wet seasons. The larger storage capacity of the Mandaya reservoir may result in a drop in water levels under an extreme filling scenario of up to 18 m. As a reference, seasonal fluctuations are typically between 5 and 10 m.

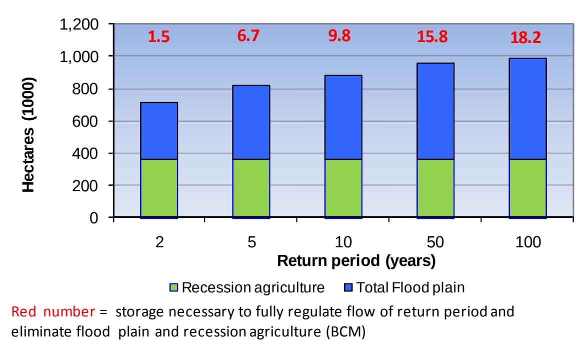
There are an estimated 1,000 farmers that cultivate land in the drawdown areas along the shores of Lake Nasser. The numbers of people potentially affected around Lake Nasser/Nubia are much higher in Sudan than in Egypt, although specific data are not available. There will be increased risks for these farmers.

There are relatively few people who practice recession agriculture along the Abbay River. Downstream of the gorge in the area proposed for the Border dam, there are some 2,400 ha of riverbank land that is cultivated after the annual flood. Data are not available, but it is believed that there is some recession agriculture along the tributaries. The construction of the dams and the impoundment of water would ultimately eliminate opportunities for recession agriculture along 700 km of the mainstream of the Abbay and those portions of tributaries that are inundated.

About 364,000 ha of recession agriculture are cultivated following the annual floods in Sudan along the Blue and Main Nile (EDF *et al.*, 2007) and would be at stake. Traditional recession agriculture is also practiced in the drawdown areas of Lake Nasser/Nubia and it could be affected during the initial filling periods of the Abbay reservoirs, and possibly during operation depending on the operation rules.

Figure 6-4 presents the area under recession agriculture proportional to the total flood plain with 2, 5, 10, 50 and 100 return period that could be at risk. The total average area of recession agriculture has been maintained constant as it would not increase very much in case of extreme floods, rare by definition, and because recession agriculture would be practised close to the river where flooding is regular and expected. It is assumed that local communities would not have the capacity to really take advantage of larger and unpredictable and irregular floods, although it is recognised that these may fluctuate for 3, 4 and 5 year return period. The figure also shows in red numbers what would be the minimal live storage capacity of dams and reservoirs on the Abbay or the tributaries to fully regulate the flow and eliminate the floods for each return period.

Figure 6-4 Minimal storage capacity to regulate flow per return periods and potential loss of recession agriculture



For the sake of discussion, assuming that the storage capacity is completely used to regulate the flow, three projects on the tributaries would have the potential to significantly reduce flooding and recession agriculture for a 2 year return period. None would have enough storage capacity to regulate a 5 year return period of more, although this could be achieved by several small dams on the tributaries or any larger dam on the Abbay. Three larger dams, Karadobi, Mandaya and Beko-Abo have the potential to regulate a flow with a 100 year return period.

Storage capacity of about 7 BCM provides the ability to completely control flows with 1:5 return period and has therefore the potential to eliminate the recession agriculture that is currently practiced by people living in these areas, depending whether or not minimal flows are maintained to preserve the critical flooding level beneficial for everybody.

The regularization of river flows presents the opportunity to expand the use of pumped irrigation to cultivate two crops per year. The Ministry of Irrigation and Water Resources in Sudan plans to implement more irrigation schemes in flood recession areas in order to produce crops in the non-flood summer season. This transition will facilitate two crops a year and involve 121,000 feddans (58,080 ha).

According to EDF *et al*. (2007-Mandaya Pre-Feasibility EIA), with one large dam on the Abbay, and with conjunctive use of Roseires reservoir, the regulated flows would be more than sufficient for irrigating the whole of the Blue Nile's alluvial strip throughout the year, even in drought years. The expansion of pumped irrigation schemes and ability to produce two crops every year offer significant benefits even if the annual energy required for pumping would amount to about 0.5% of the average annual energy generated at one reservoir such as Mandaya (EDF *et al*., 2007 Mandaya Pre-Feasibility EIA). Detailed economic studies will be necessary to assess the net benefits, taking account other elements such as reduction of damages due to flooding.

The Table 6-3 presents the implications resulting from the conversion of land under recession agriculture to irrigated agriculture, using the Mandaya dam as an example. The water demand is based on delivering 1,750 mm per year. The estimated capital and annual energy costs are US$ 1.74 million and US$ 2.9 million. According to this estimation, close to 3 BCM would be required for this conversion. This amount is important and of the same order of magnitude than the potential evaporation savings that could result from storing water in the Ethiopian Highlands rather in the lake Nasser and the effects and consequences must be investigated thoroughly with specific areas to be converted, full knowledge of future crops and full water balance taking into account abstraction, evapotranspiration and leaching to groundwater with eventual discharge into the Blue or Main Nile.

Table 6-3 Recession Agriculture, Blue/Main Nile Sub-basin

	Riverside agricultural area (feddan)	**Riverside area, assumed dev'd irrigation** (feddan)	**Balance of area, vulnerable to reduced flooding** (feddan)	**Water demand to convert vulnerable area to irrigation** (Mm^3/year)
Blue Nile	200,700 (84,294 ha)	0	200,700 (84,294 ha)	1260
Main Nile	666,000 (279,720 ha)	432,000 (181,440 ha)	234,000 (98,280 ha)	1722
Total	866,700 (364,014 ha)	432,000 (181,440 ha)	434,700 (182,574 ha)	2,982

Source: EDF *et al.* 2007 Mandaya EIA

It is important to note however, that changes from traditional cultivation methods to alternative systems of agriculture take time, capital investment, comprehensive extension services, maintenance and monitoring over time. A thorough survey of affected people should be carried out well in advance of project planning activities and measures for compensation and livelihood transition would have to be provided before any changes to the flow regime occur, in order to for such mitigation measures to feasibly avoid potentially devastating consequences on local livelihoods.

6.3.2 Pastoralism

Pastoralism, whether nomadic, semi-nomadic or practiced in combination with fixed agriculture, continues to be prevalent in some areas of the Abbay/Blue Nile basin.

Under the no-development scenario the livelihoods of pastoralist groups in the Blue Nile and Main Nile basins will continue to feel the pressure from various sources, including reduced grazing land and obstructed migration routes as a consequence of the conversion of land to large-scale agriculture.

Depending on the extent of the developments under a JMP scenario, a range of additional impacts could be felt by pastoralists in the basin. Dams on Abbay tributaries would likely result in little or no change in baseline conditions for pastoralist activities in the Blue Nile and Main Nile basins, or to extensive livestock raising activities in the western lowlands of Ethiopia.

Their livelihoods would however be at an increased risk as a result of large dams built on the Abbay. In particular, the potential reduction of annual floods in the Blue Nile and Main Nile basins would result in the loss of dry season grazing areas in the flood plain wetlands. Moreover, increased water levels particularly during the dry season would impede the movement of animal herds across the river. Also, the potential for expansion of existing irrigation schemes in the Blue Nile basin would also increase the conversion of grazing land into large-scale agriculture schemes and further obstruct tradition animal migration routes. There is a strong possibility that some of these pastoralists along the Blue Nile will tend to migrate north into the Dinder Park with a risk of conflict with local people.

In Ethiopia, the households and communities living in areas inundated by the proposed Border dam reservoir are at risk of losing grazing lands despite that the preliminary environmental studies for this project have not specifically identified grazing land as a possible loss associated with water impoundment. Nonetheless, there are an estimated 3,000 households that will be physically displaced by the project and several have some cattle. Some or all of these households are likely to be resettled to a series of "resettlement villages" established by the regional government. However, many of these people belong to ethnic groups that continue to manage land resources in a communal manner, including those used to graze animals. Therefore, there may be risks to their extensive livestock raising activities that will need to be confirmed during detailed studies for the project. In addition, there may be other households that are affected as a result of allocation of land to relocate the displaced people.

In Sudan, the risks for pastoralist communities are both direct and indirect, and are potentially serious for the long-term viability of nomadic and semi-nomadic livelihoods. Pastoralist movements and seasonal grazing areas are organized, in part, to synchronize with the annual floods that promote the growth of grasses along riverbanks. Traditional migration routes between dry and wet season grazing areas have included moving animals across the Nile during the low-water season. The regularization of river flows through the Blue Nile and Main Nile basins could largely eliminate the annual floods as well as low water levels for river-crossing, unless measures are taken to reproduce seasonal flow variations patterns. The maintenance of critical seasonal flooding would provide a number of benefits for recession agriculture, brick-making, grazing areas, and groundwater recharge. Maintaining low water levels during the dry season would be more complicated as it would interfere with navigation. These issues need to be carefully considered.

In discussing the loss of dry season grazing in flood plain wetlands that could occur as a result of reduced flooding, Norplan *et al*., (Karadobi EIA, 2006) estimate that it would have a value of US$ 450,000 to US$ 800,000 per year for pastoralists in the area between Roseires Reservoir and Khartoum. Unfortunately, data is not available to estimate the actual number of pastoralists that may be directly or indirectly affected by large scale infrastructure on the Abbay. Detailed studies are required in order to determine the number of pastoralists which depend directly on the flood plain and the loss of revenue associated with the loss of flood plain services.

6.3.3 Subsistence Fisheries

The development of dams on the Abbay may pose some risks for the local people who practice subsistence fishing, although these risks will be minor due to the low population density in the areas of the proposed dams. This risk is offset by the significant potential increase in subsistence and commercial fisheries as the result of development of a dam or series of dams on the Abbay, which could create conditions and opportunities for enhanced fish rearing. The potential exists to develop a commercial fishery on the reservoirs under certain drawdown conditions, but it depends on annual water level fluctuations as fish population do not do well with drawdowns higher than 3.5 m (Bernacsek, 1984). Then better access to existing markets and commercialisation infrastructure such as wharehouse and refrigeration facilities would be needed.

In the Blue Nile and Main Nile basins, the regularization of river flows will support increased fishery activities in the existing reservoirs and the river. For Lake Nasser/Nubia the lower water levels may lead to reduced subsistence fishery yields in the khors that border the lake.

In Ethiopia, at the household level, a local fishery would represent a valuable source of animal protein and cash income. A commercial fishery would support the development of small and medium enterprises and create employment in existing and new communities near the reservoirs. Roseires and Sennar reservoirs have annual yields of 1,500 and 1,000 tons. Norplan *et al*., (Karadobi EIA, 2006) estimate that the potential yield of a reservoir fishery may be 30 kg/ha, or 520-1,250 tons per year. However, further studies will be required to determine the suitable fish species for the Abbay reservoirs and the potential yields.

6.3.4 Brick-Making

Brick-making is mainly concentrated along river banks, especially along the Blue Nile where about 83% of the Sudan estimated 50,000 people engaged in brick-making are located (Alam, 2006). In Ethiopia, brick-making activities are mostly located in degraded wetlands that are sources of clay and fuel wood to support brick production, particularly when these resources are located in proximity to communities that function as a market for the product.

Since brick-making is mainly concentrated along river banks, it causes erosion (*Haddams*) and damage to the arable lands in these areas, although most of the lost arable lands are partly recovered annually after the flood period of the river by deposition of river sediment; but burnt clay soil is permanently destroyed and changed to an unrecoverable state.

With no dam construction on the Abbay and its tributaries there will be no effect on brick-making. Any impact would depend on the capacity of dams to regulate the flow, eliminate the flooding, or reduce the sediment concentrations. The impact of dams and reservoirs on the Abbay tributaries would only be felt locally and given the low population and remoteness of the areas that could be inundated by the reservoirs, would not be significant in Ethiopia. In Sudan along the Blue Nile, because of the limited capacity of these dams on the tributaries to significantly alter the flow regime and reduce sediment loading, no impact is expected.

On the other hand, only one large dam on the Abbay, or about 10BCM in storage capacity, would have the capacity to regulate 1:10 year event and could eliminate the brick-making industry by preventing annual regeneration of silt and clay necessary to make bricks. The extent of the impact would be dependent on the operating rules adopted and whether or not environmental flows are maintained to ensure flooding at the “critical” level of about 1:4 return period.

In Sudan, notwithstanding the development investments considered on the Abbay, the major risk for brick making activities is the lack of available fuel wood or other biomass materials to fire kilns. The elimination of the flooding cycles due to flow regulation or a drastic reduction in the sediment carried by the river during flooding due to large reservoirs upstream would reduce access to clays, further threatening the industry and adding to the precariousness of this livelihood.

On the other hand, because of the detrimental effects on the environment of the traditional methods of producing bricks, it might be timely to consider the opportunities offered by a joint investment on the Abbay to modernize the industry and look at alternative fuels as main source of energy. Consequences of such a shift would be felt on the environment, air quality, decreased pressure on natural resources, and on human health.

6.3.5 Other Ecosystems Goods and Services

Large-scale development on the Abbay will inundate large areas upstream along the Abbay River, transforming nearly 2,200 km^2 into a series of reservoirs. The loss of forest resources constitutes serious risks for the resource-based livelihoods of the communities living along the river. A major source of cash income for these communities is the harvest of various resin-producing trees. Households also collect fuel wood for their own needs. There are other non-timber forest products that are used by local communities to meet their needs or generate income such as artisanal mining, which is common along the mainstream and tributaries of the Abbay.

Under the JMP development scenarios, opportunities related to navigation and eco-tourism may be created. The impoundment of water in the reservoirs may encourage the introduction of ferry transport. This can create employment as well as compensate for the loss of direct access across the river for people and herds during the dry season. The regularization of river flows in the Blue Nile and Main Nile basins would increase the duration of river transport beyond the wet season to year-round. The presence of the reservoirs, the improved navigability of the Blue Nile and Main Nile, and the location of significant archaeological sites on the banks of the Main Nile provide potential for eco-tourism development.

6.4 WATER QUALITY

As noted in Chapter 3, causes of poor water quality are often localized, punctual and associated with settlements and industrialization. Mitigation measures by each country at the local level are necessary to reduce pollutants loading from these sources. There are also sources of contaminants that are largely regional and of a more diffuse nature, such as agricultural runoff. In this case, fertilizers and pesticides can find their way to the river via surface runoff water (irrigation or rain) and leaching in the groundwater. These sources are much harder to control and need a concerted regional approach.

The establishment of reservoirs in the Abbay or its tributaries would not play a significant role on the pollutants resulting from large settlements or industrialization as these sources are located downstream of any future reservoir. They could however play a role in trapping some of the pollutants from the diffuse sources located upstream, particularly organic contaminants and heavy metals often adsorbed to clay and silt particles. This benefit will be partially or totally eliminated by the decomposition of the vegetation and organic material left in place during reservoir filling, and its subsequent decomposition. The net result would depend on the initial concentration of relevant pollutants at a given location, the quantity of vegetation left in place before reservoir filling, and the operating rules implemented at the dam during peak flows. To be effective in trapping pollutants, the flow has to be slow enough to allow sedimentation of fine particles. Section 6.6 contains a more detailed discussion on the topic of sediment trapping.

With no dams on the Abbay or its tributaries, no change from the present baseline situation and trends is expected. Actions to improve water quality would be local and only target the source of contamination. For diffuse pollution, without local remedial actions to limit the quantities of agro-chemicals and increased recirculation of runoff water, the anticipated expansion of irrigated agriculture schemes and use of agro-chemicals will continue to affect water quality. The increased use of fertilizers is expected to amplify the proliferation of invasive weeds, particularly water hyacinth.

The creation of reservoirs on the Abbay and its tributaries could have a negative effect on water quality due to decomposition of biomass during reservoir filling, releasing nutrients and metals. The expected flooded area for each reservoir is presented in Table 6-4.

Table 6-4 Area flooded by Small and Large Dams Reservoir Filling

Reservoir on Abbay Tributaries	Flooded Area (ha)
Beles Dangur	11,700
Fettam	4,600
Lower Didessa	10,300
Lower Guder	7,000
Upper Dabus	3,700
Total	**37,300**
Large Reservoirs on the Abbay	**Flooded Area (ha)**
Karadobi	45,500
Beko-Abo	45,500[1]
Mandaya	73,600
Border	57,400
Total large Dams	**222,000**

1) Presumed to be about the same as Karadobi

The table shows that the total area inundated by the five tributary reservoirs is smaller than the area inundated by any of the large Abbay reservoirs. This suggests that the effect on water quality would be smaller for the tributaries reservoirs than for the Abbay larger reservoirs. Based on the little water quality data available on the Abbay, which are within acceptable range (Section 2.1.4.1 0 Volume II – Baseline), it is likely that the negative impact from biomass degradation in flooded reservoir(s), if not removed, would be larger than the benefits of trapping pollutants adsorbed to sediment, already in low concentrations. To properly quantify the net impact, a detailed analytical program at regular intervals during the year, and estimation of the nature and quantity of biomass susceptible to be flooded and degraded are necessary.

The scenarios described in the Scoping Study (Blackmore and Whittington, 2008) predicted that the water stored in Lake Nasser may vary from the reference situation of 133 BCM to a quantity between 93.2 and 50.4 BCM depending on the scenarios. These findings are based on data from 1913 to 1976. Alternatively, by extending the period to 1990 to capture the drought period of the 1980's, the stored water in Lake Nasser may vary between 50.1 and 40.4 BCM from a reference situation of 69 BCM (Summary of Egypt's comments on the Scoping Study, 2008). Even if the approach is simplistic and purely arithmetic, Table 6-5 gives an idea of the potential effect on Lake Nasser water quality that would be due to a reduction of the volume of water in the lake under various scenarios and assuming that the loading of contaminants would remain constant. It shows that concentrations of contaminants could increase significantly.

Table 6-5 Potential Contaminants Concentrations Increase under Various Water Storage Levels in Lake Nasser

Average End Storage (BCM)	Initial concentration (mg/L)	End Storage under Scenarios B to F of the Scoping Study	Resulting concentrations (mg/L)	Concentration increase from original (%)
Data set 1913-1976				
133.0	10	93.2 to 50.4	14.27 – 26.38	42.7 to 163.8
Data set 1913-1990				
69.0	19.27	50.1 to 40.4	26.55 – 32.92	165.5 to 229.2

6.5 HYDROPOWER

Finding a sustainable method of power generation to meet regional power demand and expansion generation needs is of central importance in the Eastern Nile Basin. Hydropower generation shows great promise as a renewable source of energy that can help to both significantly meet energy needs while providing a host of multipurpose benefits. The benefits of hydropower generation however are not without certain tradeoffs. The construction of hydropower infrastructure has a range of environmental, social and economic impacts both positive and negative, which increase with the scale and number of hydropower developments when progressing along the range of investment scenarios. The environmental and social impacts of hydropower generation are discussed throughout this report in regards to biological impacts on critical habitats and ecosystem function, the physical impacts on water quality, flooding and erosion/sedimentation as well as the social impacts on livelihoods and vulnerable people in the basin. The positive economic benefits of hydropower generation along a range of possible development scenarios are presented in this section, below.

6.5.1 Meeting Power Generation Demands and Regional Power Trade

An initial estimate of required power generation growth to 2030 was derived using information from the Final Report for the "Eastern Nile Power Trade Program Study" by EDF *et al*. (2007), and is presented in Table 6-6. This report presents projections for Egypt, Sudan, and Ethiopia.

Table 6-6 Required Growth in Power Development in the Eastern Nile Region

Feature	Egypt	Sudan	Ethiopia
Installed capacity in 2009 - MW	26,382	4,121	1,855
Required capacity in 2030 - MW	77,951	16,535	11,951
Average annual percentage increase	6.8%	5.3%	9.3%
Main generation resources used	• Combined cycle • Coal and oil-fired Steam • Nuclear	• Some hydro • Remainder mostly combined cycle and thermal	• Almost all hydro • Less than 1% from 1 coal plant

The table shows some 74,000 MW of additional capacity will be needed over the next two decades and some three quarters would be from thermal sources in the hypothesis of unilateral development. Appendix C provides the detail generation expansion plans for each of the Eastern Nile countries.

Hydropower development on the Abbay River can contribute significantly to meeting power generation demands in Ethiopia, Sudan and Egypt. In order to assess the magnitude of the contribution, it is useful to use the relative installed power generation capacity and the energy output of the minimum joint investment scenario with that of the maximum joint investment scenario as a criterion.

If no major dams were constructed on the Abbay river and only small unilateral hydropower developments occurred on Abbay tributaries a total of 729 MW would be produced in contrast with a total installed capacity of 5,700 MW for four large hydropower developments on the Abbay. In terms of annual energy output the relative values are 3,194 GWh/year (small dams on Abbay tributaries) for no major dams on the Abbay versus 39,038 GWh/year for the maximum investment scenario. Both total installed capacity and annual energy output are an order of magnitude different on either end of the investment spectrum and it can be argued that the power generation and energy output for the minimum investment alternative are insufficient to interest Egypt and Sudan in investing in the project, as power production is the driver for JMP 1.

The increased power production potential is directly related to the storage volume in the reservoirs and the increased flows during the dry season. The total live storage all four major dams on the Abbay were to be built is 70.1 BCM, compared with 10,4 BCM for the total live storage achieved with no major joint investment and only small dams on Abbay tributaries. This is an order of magnitude difference with a commensurate difference in the potential for increased power production downstream of the project area (Figure 6-6)

Figure 6-5 Total Capacity versus Live Storage Capacity

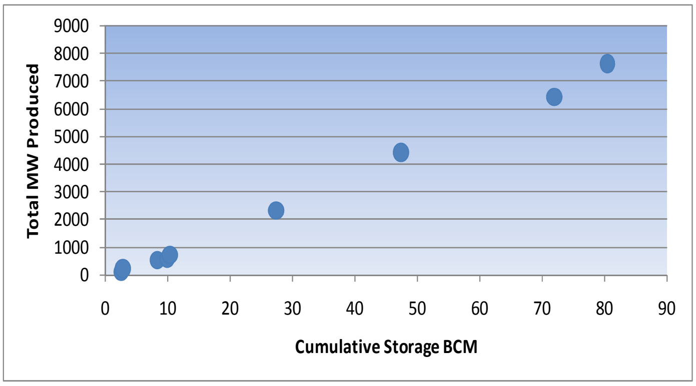


Table 6.5 shows a hypothesis for the sharing of the costs and benefits of the projects on the Abbay River:

Figure 6-6 Possible Sharing of Abbay River Developments

Year	Project on Abbay River	Installed Capacity (MW)	Share of plant outputs (MW)		
			Ethiopia	Sudan	Egypt
2022	Beko-Abo	900	675	0	225
2023	Mandaya - Partial	1000	330	170	500
2024	Mandaya - Complete	1000	490	60	450
2025	Karadobi - Partial	800	400	0	400
2026	Karadobi - Complete	800	233	342	225
2027	Border - Partial	600	500	100	0
2028	Border - Complete	600	500	100	0
	Total capacity	**5700**	**3128**	**772**	**1800**
	Percent	**100%**	**55%**	**13%**	**32%**

Regional power trade is an integral part of JMP 1, and will result in a high level of power trade activity. The level of power trade between Eastern Nile Basin countries would presumably increase with the number of hydropower generation facilities built on the Abbay in Ethiopia, producing power for export. As the available generation capacity increases, so do the opportunities for regional economic integration. As most of the power plants planned in Egypt and Sudan would be thermal or nuclear, purchasing hydropower and at least delaying thermal and nuclear development also has measurable environmental impacts.

6.5.2 Economic Benefits

The generation of significant quantities of electricity in the Abbay Sub-basin, some of which would be sold to the downstream countries of Sudan and Egypt would have direct socio-economic benefits. In the context of poverty reduction and sustainable development, electricity supplied to rural communities would replace/reduce the consumption of woody biomass that is the principal source of household energy.

Furthermore, power is required to support development in the agricultural sector (irrigation pumps, poultry, animal husbandry, preservation of products); in the commercial sector (shops, bars, and restaurants); in the development of small and medium industries (flour mills, rural water supply installations, tanneries, and coffee processing plants), in the residential sector (lighting, heating, and cooking), in education (kindergarten, elementary schools, junior secondary schools, secondary schools and technical colleges), and in the health sector (pharmacies, clinics, health centers and hospitals). In brief, it would assist in the facilitation of economic growth throughout the Nile basin and create long-term employment opportunities, with the potential of increasing income levels and reducing poverty with a renewable source of energy.

Notwithstanding these opportunities, it is important to note that access to electricity may not be achieved in the short term for the local population in much of the basin. The high voltage transmission lines that will carry electricity to Sudan and Egypt are not suited to local distribution systems where low voltage lines are required. It is suggested therefore to optimize benefit sharing, to consider the construction of substations at the dam sites for the purpose of establishing a local distribution network to supply electricity to the dam site town and other nearby communities, for example, including the resettlement areas. The geographic extent of these distribution networks would depend on the types and levels of demand for electricity, for example, for residential, commercial or industrial uses.

Induced development may occur to varying degrees throughout the Nile basin as a consequence of the investments in hydropower. In the Abbay Sub-basin, the dam construction program, as noted, will extend over a long period with significant in-migration of people into the region. New towns will be established at each of the dam sites. Commercial and trade activities may be expected to develop substantially in and around any project area because of new demand for goods and services at the dam site towns, resettlement areas and improved communications. This, in turn, will act as an incentive for other private and public sector investments in economic activities and development. The experience of hydropower development construction sites in Ethiopia shows that small construction sites can be transformed into large towns and commercial centers.

In addition to the primary economic development resulting from the construction of hydropower infrastructure, hydropower development will generate other indirect opportunities for economic development, such as the development of commercial fisheries.

Benefits to downstream hydropower generation There is the potential for increased power generation downstream of the Abbay River in Sudan and Egypt. Power production will be significantly increased at other power plants on the Blue and Main Nile due to the storage of water upstream in the Abbay Basin. The storage on the Abbay effectively increases that on the Blue and Main Nile by an amount similar to the combined storage in the Abbay system.

Estimates from the prefeasibility study of Beko-Abo suggest that Beko-Abo alone would increase the power generation capacity at Roseires and Merowe combined by 17%, or approximately 270 MW by allowing them to optimize their operation for power generation (Norplan *et al*., 2007). The similar impact on production in Egypt at Aswan is not noted.

In the Karadobi study the additional power generation capacity of 480 MW and firm energy output of 2606 GWh/year can be developed in Sudan, assuming all Sudan's planned power stations are developed. Considering only Roseires, Sennar and Merowe (existing) the increase would be 254 MW and 1,361 GWh/year, respectively.

Total estimated increased energy output attributed to Mandaya alone is 2,657 GWh/year. For Border the estimate is an uplift of 1,658 GWh/year with Roseires as it is now, and 1,992 GWh/year with the increased height of 10 meters (which will be developed in the near future).

Further analysis of the increases in power production under JMP 1 projects will be carried out during Phase II of this study and also during the concurrent feasibility studies of Mandaya and Beko-Abo.

With the construction of each respective hydropower development on the Abbay, the quantity of sediment in the Blue and Main Nile would decrease allowing optimization of operations at Roseires, Sennar and Merowe for power generation and water abstraction for various uses, including irrigation. There would also be lower maintenance costs of infrastructure and for sediment removal.

Multipurpose benefits of hydropower: Another multipurpose benefit from building hydropower generation facilities upstream in Ethiopia is to reduce water loses in the system due to evaporation. Estimates have been made for the potential savings in water availability with JMP 1. Such estimates have centered on the maximum investment scenario (four major dams on the Abbay) and are on the order 4 BCM to up to 7 BCM (Block and Strzepek, 2010; Guariso and Whittington, 1987). This water could be used to expand irrigated agriculture, which in itself would increase food security and provide opportunities to reduce poverty. Flood control and relief during droughts are also other multipurpose benefits of hydropower generation.

6.6 EROSION AND SEDIMENTATION

6.6.1 Sediment loading

It is recognized that erosion and sedimentation of the Abbay, Blue Nile and Main Nile are a serious regional issue with environmental and economic consequences. Sediment deposition in reservoirs and irrigation infrastructure in Sudan along the Blue Nile is a major problem with significant annual costs of some USD 7.5 million for clearing it every year and maintain the infrastructure. The loss of storage in the reservoirs and subsequent loss of energy production add to the negative impacts.

The negative impact of the sediment on the irrigation and energy production infrastructure in Sudan must on the other hand be put in perspective against the benefits of the sediment as fresh source of nutrients for recession agriculture and base material for brick-making (clay and silt). Reducing sediment load downstream of the Sudan - Ethiopia border would facilitate the optimization of various irrigation and energy production infrastructure and lower maintenance costs, but would negatively impact communities relying on recession agriculture and brick-making as their livelihoods.

It is understood that most of the sediment originates from the Ethiopian Highlands Plateau and is transported by the Abbay and its tributaries. Over the long term the problem must be addressed with appropriate interventions at the local watershed level to reduce erosion at the source. Yet, addressing the erosion concern in the Ethiopian Highlands would be a long process given the scale of the basin and the difficult relief. Results would take a long time to materialize.

The trapping of sediment in reservoirs on the Abbay and/or its tributaries may produce more immediate results. Table 6-7 shows catchment area and the storage capacity of the reservoirs on the Abbay and tributaries.

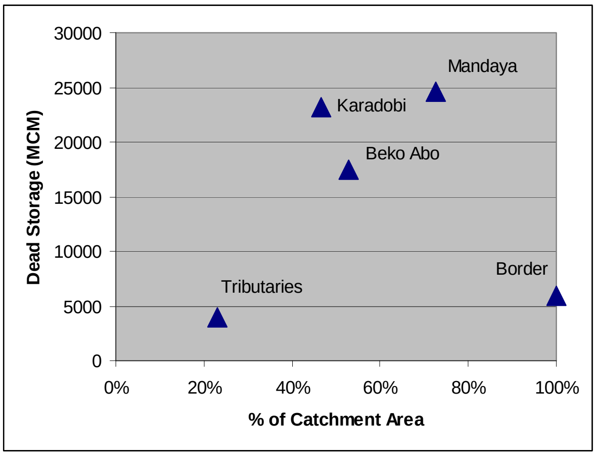
Table 6-7 Catchment Area and Storage Capacity of Reservoirs on the Abbay and its Tributaries

	Catchment Area	% of Catchment Area	Gross Storage (MCM)	Live Storage (MCM)	Dead Storage (MCM)
Beles Dangur	9,092	5%	-	2,530	-
Fettam	648	0.4%	-	312	-
Lower Didessa	17,799	10%	-	5,510	-
Lower Guder	4,774	3%	-	1,606	-
Upper Dabus	8,463	5%	-	423	-
Total Tributaries	40,776	23%	14,381	10,381	4,000[1]
Karadobi	82,300	47%	40,200	17,000	23,200
Beko-Abo	93,490	53%	37,500	20,000	17,500
Mandaya	128,729	73%	49,200	24,600	24,600
Border	176,918	100%	14,470	8,500	5,970

1) MoWR, Abbay River Master Plan, 1999

Figure 6-7 illustrates the relative performance of the reservoirs as a percentage of catchment areas controlled by the reservoir. The Border site is located just before the Ethiopian – Sudan border and has been assigned a value of 100% as it covers the entire Abbay catchment. The reservoirs located in the upper right quadrant offer the best performance in terms of potential to trap sediments while the ones at the lower left quadrant offer less potential. The graph shows that reservoirs on the Abbay offer more potential to trap sediment than all the tributary reservoirs (the dead storage for the smaller reservoirs on the tributaries has been extrapolated at pro rata).

Figure 6-7 Dead Storage Capacity vs. % of Catchment Area



Although there is significant uncertainty and variability around the estimate of the quantity of sediment carried by the Abbay, it remains that the reduction of the sediment quantities reaching Sudan would likely be greatly reduced with the addition of large dams on the Abbay, and their operation in a multipurpose framework. Let us consider the following:

- Compared to the Small Dams alternative, the catchment area of any of the large dams on the Abbay is greater than the sum of the catchment area of the small dams on the tributaries.
- This is even more obvious for Border, which by virtue of its location includes all the catchment areas of the smaller dams and the total Abbay Sub-basin.
- The dead storage capacity of 70,000 MCM of these large reservoirs is 17.5 times larger than the small reservoirs and will trap more sediment.
- The Karadobi PFS states that it is expected that Karadobi reservoir would trap about 86% of the sediment: 100% of the sand, 50% of the silt, and 25% of the clay. Beko-Abo, Mandaya and Border would also trap an undetermined portion of the silt and clay passing the first dam.

Based on these simple observations, the impact of only one large dam on the Abbay would have a very significant impact in decreasing the quantity of sediment reaching the Blue Nile. Two or more could for all intent offer complete control over the sediment transport downstream of Ethiopia, should these dams operated with this purpose and be located close to the Sudan border. Consequently, the operating rules of Roseires and Sennar, and possibly Merowe and Aswan could be modified to optimize power generation or availability of water for irrigation since avoiding sedimentation in the reservoir will be less of a priority. Significant cost reduction would be achieved in the maintenance of Roseires and Sennar reservoirs, and likely also for Merowe and Aswan; these savings would be related to dredging, canal desilting and pump replacement.

These potential savings could be used to convert areas in irrigated recession, thus reduce the need for recession agriculture in the riparian communities and compensate people relying on brick-making, perhaps in helping them moving towards more environmentally friendly brick-making production methods.

As seen in the graph in Figure 6-7, the smaller reservoirs on the Abbay tributaries offer a limited advantage from a sediment control point of view for downstream infrastructure along the Blue Nile because they cover only a small portion of the watershed. Sudan may decide to build reservoirs on the Main Nile, but these reservoirs would not provide benefit for Roseires and Sennar and evaporation losses would increase in comparison to the Ethiopian Highlands.

6.6.2 Bank Erosion

Riverbank erosion impacts river morphology. It is particularly acute in the Main Nile just downstream of the Merowe Dam, and has been somewhat reduced downstream of the Aswan High Dam due to flow regulation (NBCBN, River Morphology Cluster, 2005).

New infrastructure brings modifications to the natural flow of the river, which affects the downstream river morphology. Dams regulate and decrease the peak flows and this contributes to riverbank stability. Dams also are responsible for degradation of the downstream river bed causing changes in river morphology.

Overall, flow regulation and the elimination of extreme peak flows would offer the benefits of riverbank stabilization, but this would require at least one large dam on the Abbay or about 10 BCM of live storage for average flows or about 20 to 25 BCM for 1:100 events.

6.7 CRITICAL HABITATS AND ECOSYSTEMS FUNCTIONS

The seasonal flood plain and wetlands are important in sustaining ecosystem functions and they provide habitat for a large number of species supporting biodiversity, spawning areas for fish, and groundwater recharge.

6.7.1 Protected Areas, Species with Status and Biodiversity

The protected areas located in the study area under the proposed development (Plate 1) are:

- Dabus Valley Controlled Hunting Area, between the Mandaya and Border site locations on the Abbay, and
- Dinder and Alatish National Parks on either side of the Sudan – Ethiopia border between the Rahad and Dinder rivers

Dabus Valley Controlled Hunting Area: One dam may be constructed on the Upper Dabus River, either unilaterally or jointly. At the time of preparing this report no EIA has been conducted and as a result specific information on the Dabus River is very limited. The Dabus Valley Controlled Hunting Area is located downstream of the planned dam site, which may see an altered flow regime. The altered flow regime would affect aquatic and semi-aquatic fauna and flora; however there is not sufficient information for detailed assessment of the impact on these habitats.

According to the Border Environmental Impact Assessment (EDF *et al*., 2007), flooding of the Border reservoir at a FSL 580 masl would inundate the lower 3 to 5 kilometres of the 574 km^2 Dabus Valley area and would therefore impact the controlled hunting area to a limited extent as the area affected would represent only 0.41% of the total controlled hunting area (EDF *et al*., 2007).

If the Border dam were to be built, the EIA suggests that silt will accumulate in the lower part of the valley and form a mini delta in the Border reservoir at full supply level. The silt may be expected to accumulate and be reworked during the Dabus river flood flows. The EIA suggests that the delta formed would provide habitat for water birds and other wildlife and may support cultivation (EDF *et al*., 2007).

No direct impacts are expected on the Dinder and Alatish National Parks with the construction of large reservoirs on the Abbay or from smaller tributary reservoirs. However there is the possibility that the conflict between the pastoralists and park's interests may be exacerbated if traditional pastoral areas are lost due to expanded irrigated schemes made possible with the construction of a large dam (Ali and Nimir, 2006).

Important Bird Areas: There are two Important Bird Areas (IBA) sites that may be affected by tributary reservoirs. The Bird area located in the mid-Abbay river basin, identified in the Mandaya EIA report as the IBA ET016, could be affected by a reservoir on the Didessa River, and the IBA/Wetland ET020 known as the Fincha'a and Chomen swamps may be affected by a dam on the Lower Guder River.

Only the IBA ET016 would be affected by the construction of a large reservoir on the Abbay. According to the Mandaya EIA (EDF *et al*., 2007), the flooding of the proposed Mandaya reservoir would cause a loss of habitat. The extent of IBA 016 that would be lost is not known as the boundaries of the IBA are not defined. No other IBAs will be affected by the any of the four possible reservoirs on the Abbay.

Ethiopia, Sudan and Egypt all have species with special status under the IUCN Red List and over 500 species have a “Critically Endangered”, “Endangered”, “Vulnerable”, or “Near Threatened” status.

None of the pre-feasibility impact assessments conducted for any of the reservoirs on the Abbay has identified with any certainty an impact on species with special status, but all have indicated that data was insufficient and too restrictive to allow a definitive assessment. EAI’s have not been completed for the Abbay tributary reservoirs.

Reservoirs on the Abbay and its tributaries will change to various degrees the characteristics of the aquatic (river flow), terrestrial (reservoirs and construction sites), and semi-aquatic (wetlands, food plain and seasonal wetlands) environments. Understanding the implications for the flora and fauna will require detailed studies at the time of conducting project specific EIAs.

Proliferation of Invasive Species: Invasive species place significant pressure on habitat used to support natural species and often result in a decline in biodiversity as these natural species are displaced or eliminated by more aggressive invasive species. Aquatic weed infestation has significantly increased as a concern in the Nile basin over the last two to three decades. Enrichment by nitrogen, phosphorus and other nutrients originating from use of fertilizers, sewage discharge and sediment leaching from agricultural areas has caused proliferation of invasive species.

Water hyacinth is now present throughout the Nile system and it contributes to eutrophication, increased evapotranspiration, reduced fisheries productivity, disruption of water transport systems, accelerated spread of waterborne diseases, physical obstruction of hydropower and reduced water infrastructure. It also restricts access to water for domestic, industrial and agricultural users. It is reported that the cost of controlling weed infestation in irrigation canals can be as high as 50% of the total operation and maintenance budget of these canals.

The creation of reservoir under these conditions could favour the proliferation of floating macrophytes (water hyacinth and water lettuce). In large reservoirs it has been shown that floating mats of macrophytes can be killed by applying desiccation coupled with a large drawdown (Bernacsek, 1984). This method to control floating macrophytes would have application for the large reservoirs on the Abbay as all have a proposed drawdown of more than 15 m, but would not be very supportive if fish populations.

The ability to maintain a seasonal controlled flood flow may also restrict infestations of invasive weeds on the flood plain. This ability would require at least 10 BCM of love storage for 1:2 to 1:4 return period, but about 20 BCM for 1:100 return period.

6.7.2 Fish Spawning

Several species of fish use the Abbay tributaries and the seasonal wetlands for spawning. Dams on the tributaries close to the junction with the Abbay may prevent fish from reaching their spawning area, although fish ladders and other modifications can be considered to mitigate this restriction.

Larger dams on the Abbay would prohibit the movement of fish along stretches of the river and would have an impact on species that migrate from the river to the tributaries for spawning. The reservoirs created would however offer new habitat potential for fish species favouring such an environment at the condition that drawdown is not too important.

Fish spawning is usually triggered by higher flows that enable fish to move to their spawning grounds in tributaries or on the flood plain. Dams on the Abbay tributaries would have only localized effect on the tributaries, whereas a large dam on the Abbay would have the potential to reduce high flows and interfere with the spawning mechanism as well as potentially decrease flood plain available for spawning. The failure of a flood plain to become inundated would result in a decline of fish productivity (Bernacsek, 1984).

As previous discussed, flood plain management may be achieved to recreate normal flooding with about 10 BCM of live storage (one large dam).

Detailed studies under specific EIAs will be necessary to further the understanding of the flora and fauna species relying on the flood plain.

6.8 VULNERABLE GROUPS AND INVOLUNTARY RESETTLEMENT

Specific ethnic groups in the Eastern Nile basin may be at greater risk than others as the result of the proposed water resource developments.

The Gumuz are among the majority of the people who could be displaced by the Border dam. Their relocation to resettlement villages may result in increased social and cultural stresses as well as changes to their livelihood systems.

The ethnic groups in the Blue Nile and Main Nile basins that rely on pastoralist livelihoods are vulnerable. This is because flood control and regularized water flows from large dams on the Abbay would affect the availability and access to dry season grazing land that are essential for their herds. A single large project of 10 BCM of live storage on the Abbay has the potential of controlling normal seasonal flooding downstream and impacts ethnic groups relying on pastoralist as their livelihoods. This impact could however largely be mitigated by careful dam operation rules to allow artificial flood releases mimicking flows required to maintain critical ecosystem functions.

The lowering of water levels in Lake Nasser/Nubia that may occur as large Abbay reservoirs are initially filled may increase risks to the livelihoods of ethnic groups living near Wadi Allaqi. These groups rely on easy access to water for their herds, as well as subsistence fishing in the khors around the lake. The same can also occur depending on the operating rules put in place. The smaller dams on the Abbay tributaries do not pose this problem.

Women are also particularly vulnerable to the economic and physical displacement under any development scenario. This is due to the fact that when compensation schemes are designed for those displaced by development; gender is not traditionally considered and most often the household is treated as a single unit for compensation. Males are usually the recipient of compensation, while women, due to their limited autonomy in the household and lack of control of financial and land resources, often become further impoverished and marginalized (Mehta and Srinivasan 1999).

Population Displacement and Migration: Physical and economic displacement of people and communities is often a social impact of large-scale hydropower projects. There may be significant costs associated with compensation payments, as well as with the design, implementation, and monitoring of strategies to relocate people, restore incomes, or other initiatives to assist project-affected people.

Under the no development scenario, population displacement and in-migration is not expected. Under the range of investments possible, a number of impacts may occur depending on the choice of projects and the combination thereof. The development of dams on Abbay tributaries will have similar types of impacts related to physical and economic displacement of people and influxes of migrants.

In order to estimate the scope of physical and economic displacement associated with the Abbay tributaries dams, an analysis was conducted using recent population data. The area associated with the at-risk population is defined by the estimated limits of the proposed reservoirs plus a buffer to account for changes in the size of reservoir affected areas. Within this area, data were assembled on land use, the numbers of settlements, and their populations and is shown in Table 6-8. The analysis provides an indication of the types and extent of impacts associated with the dams on the Abbay tributaries:

- The five dams (all of those proposed in the national development plans of Ethiopia for dams on Abbay tributaries) may affect directly or indirectly a total population of some 27,000 people or 5,400 households living in 63 communities[4].

[4] Study is available only for Lower Didessa – reconnaissance Level Study. Values for the four other dams on the tributaries have been estimated by the Consultant based on GIS analyses and recent aerial photos.

- The Dangur and Didessa dams may displace small numbers of people based on the analysis of settlements located within the proposed reservoir areas. For the Dangur dam, there are three settlements in the reservoir area, with 161 households (804 people). In the area of the Lower Didessa reservoir, there are two settlements with 63 households (314 people).
- There is no settlement located in the proposed reservoir areas of the other dams, although there are nearly 60 communities within the buffer zones of these reservoirs.
- The dams will also cause economic displacement due to the loss of arable land (12,600 ha), grazing land (4,000 ha classified as grassland and 8,600 ha classified as shrub land) as well as large areas of forests, wetlands and woodland where people hunt, fish and harvest various types of forest and non-timber forest products.

The reconnaissance studies for the Lower Didessa dam have been reviewed and found to provide a different assessment of the physical and economic displacement risks associated with this small dam (MWR, 2001). A total of 2,777 people (448 households) living within five kilometres of the proposed reservoir are at risk. Of these, as many as 237 households may be physically displaced. Economic displacement includes the inundation of 680 ha of grassland that are used to graze upwards of 2,000 animals; and, 1,288 ha of forest land that provide a range of ecosystem services to people living in 12 villages. In addition, 850 beehives exploited by 270 households will be adversely affected by the impoundment of water in the reservoir.

Table 6-8 Potential Physical and Economic Displacement, Dams and Reservoirs on Abbay tributaries

	Fattem	Upper Dabus	Dangur	Didessa	Lower Guder
Population in buffer zone (no.)					
Settlements	24	25	11	3	0
Population	16,142	7,658	2,573	690	0
Households	3,228	1,532	505	138	0
Population in proposed reservoir (no.)					
Settlements	0	0	3	2	0
Population	0	0	804	314	0
Households	0	0	161	63	0
Land resources (ha)					
Rain-fed cultivation	4,300	1,875	4,985	25	-
Shifting cultivation	-	35	8	1,450	-
Grassland	840	9	2,225	936	-
Shrub land	-	143	14,500	4,000	15,000
Forest	-	1,430	-	-	-
Wetlands	3,780	56	68	145	-
Woodland	11	8,450	6,790	19,560	-

Source: Consultant – estimations based on GIS analysis conducted with land use maps and demographic data provided by previous studies.

The high population mobility in Ethiopia and other “pull” characteristics of the projects on the Abbay tributaries could contribute to in-migration of people looking for employment or wanting to take advantage of business or other economic opportunities. The in-migration to the dam areas may be significantly greater than the actual requirements of the projects, which will have social consequences.

Each of the Abbay tributaries dams will result in a small growth in the existing communities to accommodate the permanent staff for operations of the dams. However, the boom/bust social impacts associated with dam construction will be greater as people migrate and resettle at the development sites.

Land will be required on a temporary and a permanent basis for the establishment of access roads, construction and ancillary facilities, and for the impoundment of reservoirs, displacing people. Economic displacement will also occur as people or businesses lose land, income sources or other productive assets. There may also be people who are displaced due to the construction of transmission lines and, in Sudan, due to the expansion of existing irrigation schemes.

For larger dams on the Abbay, the extent of physical and economic displacement of people and communities in the vicinity of the proposed dam sites depends on the projects chosen. Preliminary analyses have been conducted for the four projects and are shown in Table 6-9. This data is based on the various EIAs conducted between 2006 and 2010, they are considered reasonably accurate as they are derived from field surveys conducted during these EIAs, but would need to be validated should one of these projects go ahead. The summary results are:

- Physical displacement will consist of the relocation of people and communities from the sites for the dam, ancillary facilities and reservoir for Mandaya (599 households) and Border (2,781 households); and the loss of house, business and community structures belonging to these people and communities (9,000-10,000 structures).
- Economic displacement will result from losses of large areas of arable land (30,000 ha) and grazing land (40,000 ha), as well as loss of access to natural resources that are harvested and used as part of people's livelihood systems.
- A total of 45,500 people are at risk of being directly affected by the construction of the dams, of which an estimated 15,500 (34%) will be displaced. Other indirect impacts that may occur relate to the relocation and integration of displaced people into host communities, as well as environmental impacts of relocation or development of new agricultural land to replace losses.

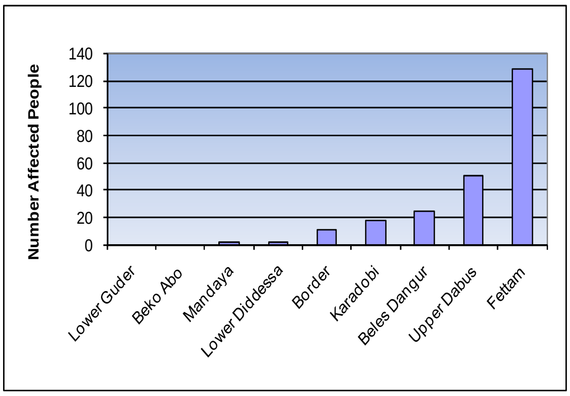
Table 6-9 Potential Physical and Economic Displacement, Large Dams, Abbay Basin

	Karadobi	Beko-Abo	Mandaya	Border
Total number of affected people (physical and economic displacement)				
Affected households (no.)	4,666	Not determined	599	2,781
Affected people (no.)	28,600	Not determined	3,000	13,905
Affected communities (no. of sub-kebele)	Not determined	Not determined	Not determined	28
Physical displacement				
Affected households (no.)	0	0	320	2,781
Affected people (no.)	0	0	1,620	13,905
Loss of structures (no.)	0	0	1,000	8,300
Loss of resources causing economic displacement				
Loss of arable land (ha)	3,511	20,700	790	6,650[1]
Loss of grazing land (ha)	28,629	12,220	Not determined	Not determined
Loss of access to natural resources	Yes but loss not quantified	Yes but loss not quantified	Yes but loss not quantified	Yes but loss not quantified
[1] The loss of arable land includes an estimated 2,400 ha of recession agriculture.				

Sources: EDF *et al*., 2007; Norplan *et al*., 2006, Norplan *et al*, 2010.

Figure 6-8 compares the number of people who would be directly affected (Project Affected People in reservoirs areas) on the basis of the number of people affected per MW produced for each project. This includes both the people who would be displaced economically and physically. The figure shows that a large dam on the Abbay compares favourably with the smaller dams on the tributaries. Taken together, the 4 large dams on the Abbay would affect 7 persons per MW produced whereas the smaller dams on the tributaries, taken together, would affect 37 persons per MW produced.

Figure 6-8 Number of PAP per MW Produced



Project-induced in-migration as the result of large-scale infrastructure projects must be considered. The risks associated with the potential influx of people can easily result in exceeding the physical, social and environmental assimilative capacities of local communities.

Within the context of a major project, these people may include, among others (IFC, 2009):

- People who have family or who previously lived in the region, returning to seek employment or take advantage of opportunities to provide goods and services,
- Temporary or permanent workers employed by the project and its contractors,
- People who want to take advantage of increased accessibility (e.g., project-related access roads) to exploit natural resources in the project region,
- Traders, entrepreneurs, small and medium enterprises (SMEs), commercial sex workers,
- Opportunistic migrants including unskilled, semi-skilled and skilled workers seeking direct and indirect employment and entrepreneurial opportunities related to the project.

It is difficult to produce a reliable estimate on how the proposed dams on the Abbay River will affect the level of in-migration. IFC (2009) suggests large-scale projects may lead to annual population growth rate of 10 to 15%. Experience with mining projects suggests that there are as many as ten people who migrate into a project area for every person employed to work on the project (IFC, 2009). It should be somewhat lower in the case of hydroelectricity projects where jobs are mostly created during the construction phase, with fewer jobs available during the operation phase.

The Border project offers the potential for social tensions as its location will attract in-migration from different ethnic groups of Ethiopia and Sudan. There is a history of conflict in the Benishangul-Gumuz region between local ethnic groups that practice extensive, shifting cultivation and previous migrants who practice a more sedentary agricultural system. The influx of migrants seeking work and other opportunities associated with the Border project may heighten tensions with local communities. There is a good probability of Sudanese people migrating to the region to work; however, many are from the same ethnic groups that are resident in Ethiopia, which may lessen tensions.

As routes are normally planned to avoid dense population settlement areas, the transmission lines required to transport electricity from the large dams to Sudan and Egypt have limited potential for physical and economic displacement. The permanent land acquisition to construct towers requires very small areas of land (often less than 100 m^2 per tower). Also, the proposed alignment of the transmission lines is largely in desert areas where there is a low risk of physical displacement of people. In other areas where different types of agriculture are practiced, structures and trees are normally removed from the rights-of-way and owners compensated, while farmers are permitted to continue cultivation of annual crops.

The key principles to resettlement programs are that (i) resettlement planning and implementation is a participatory process, involving project-affected people and other stakeholders and including activities to inform and consult them, as well as procedures for public disclosure and grievance redress; (ii) compensation for lost or affected assets is equal to the replacement cost or value based on current market prices; (iii) the lack of formal title to affected assets does not preclude affected people from being assisted; and, (iv) the needs of vulnerable groups such as ethnic minorities, the very poor, women or disabled must be explicitly addressed through relocation, income restoration and other rehabilitation strategies.

6.9 DAM SAFETY

All the dams that will be built on the Abbay or its tributaries are by all means considered as large, although the ones on the Abbay are much larger than the ones on the tributaries.

The failure of the dam structure itself, the failure or malfunction of other structures (e.g., spillway gates), as well as the failure of warning systems, or unforeseen spillover due to extreme precipitation increase induced by climate change has the potential to cause important negative environmental, economic and human impacts downstream, including potential loss of lives. Communities near the dams or the cascade of dams and reservoirs would be seriously affected, as would downstream communities along the Blue Nile and Main Nile. Lives and livelihoods may be lost.

In general risks related to dam rupture will be in direct proportion to the size of the dam, the storage volume of the reservoir as well as the number of dams built. The magnitude of the consequences of the failure of one of the dams or of a cascade will be commensurate to the volume of water stored in the reservoir(s). In the event of a complete failure, the amount of water released would be equivalent more or less to the live storage of the reservoirs, which in turn would represent flow peaks for various return periods (Table 6-10).

Table 6-10 Live storage Capacity Equivalence to Flooding Events

Storage Capacity BCM	Reservoir Combinations	Equivalent Extreme Event (Return Period)
5	Reservoirs on tributaries	1:4
10	Smaller of the large dams on Abbay	1:10
25	Combination of 2 or more large dams on Abbay	1:100
50		>1:100
100	Full development	>1:100

This Table shows that the smallest of the large dam on the Abbay could trigger a flood equivalent to a 1:10 return period and that a very large dam or any combination of two large dams would result in a flood event equivalent to a 1:100 year return period of more. Complete failure of a full cascade development would have catastrophic consequences for the entire basin, largely exceeding a 1:100 flood event.

The design of the dams and the reservoirs must also take into account the uncertainties related to climate change and possible precipitation increase as well as increase in frequency and duration of extreme events. Omission to do so could result in the incapacity of the reservoir(s) to retain additional precipitation and cause spill over or unscheduled releases with consequences similar to flooding.

A dam safety program will be required by Ethiopia and the financing organizations for all dams constructed on the Abbay or its tributaries. In the case of an exceptionally large dam infrastructure development, on the Abbay the construction of which may not have any precedent in term of similar scale and/or construction type, the construction contractor and owner of the facilities will be responsible for conducting additional in depth seismological testing to ensure that seismicity levels present in the construction zone do not present an undue risk of dam failure.

From available information collected in the Border, Mandaya and Karadobi pre-feasibility studies, these large dams appear to be located in low seismic hazard zone and located at about 200 km from any epicentres recorded between 1906 and 2003. Nonetheless, this aspect will need to be thoroughly documented and scrutinized as part of the safety program and safeguards.

The financing agencies will demand that the local government dam safety agency obtain necessary analytical, advisory and inspection services from recognized international consultants specializing in dam safety. The larger dams on the Abbay will require a more substantial program in terms of number, professional breath, technical expertise and experience of Panel members. The consultants and contractors will also prepare a program for ongoing dam safety inspections and any required remedial work during the life of the facility. The owner of the facilities will be responsible for the safety of the facilities and timely execution of all related work and services.

6.10 CLIMATE CHANGE

Climate change, with anticipated changes in temperature and precipitation, has the potential to affect the JMP investments. At the same time, if adequately planned for uncertainties inherent to climate changes, these investments may represent valuable adaption tools to alleviate negative consequences of climate changes by helping to prevent flooding or by alleviating drought consequences.

Also, although none of the three Eastern Nile countries is party to the Kyoto protocol it is important to examine the implication of these developments on Green House Gas (GHG) emission. The proposed investments have the potential to reduce GHG emissions replacing high emission energy with low emission energy. This opportunity to reduce GHG emissions may give rise to Clean Development Mechanisms credits, which in turn may influence the choice of development scenarios.

6.10.1 Impacts and Risks of Climate Change on JMP 1

Climate change will affect all of the three Eastern Nile countries through changes in temperature and precipitation averages and extremes.

In Ethiopia, agriculture, forestry, and water resources will be affected by climate change. Although quantitative assessments have not been completed, it is expected that there will be a decrease in crop yield, a change in livestock feed availability as well as changes in animal health, growth and reproduction as the result of climate change. For forests, it is expected that there will be an expansion of tropical dry forests and the disappearance of lower mountain wet forests with an increase in desertification. With respect to water resources there is the potential for a decrease in river run-off with a decrease in energy production as well as more frequent flood and drought extremes (National Meteorological Agency, 2007).

In Sudan, “climate risks pose a serious challenge to Sudan’s overriding development priorities in agriculture, forestry, and water resource management” (National Adaptation Program of Action, Sudan, 2007). Specifically, traditional rain-fed farmers and pastoralists are most vulnerable either from drought or flooding that may be translated into hunger, forced migration from rural areas, death of their livestock and destruction of property.

In Egypt, coastal areas on the Mediterranean and the Red Sea may be threatened by sea level rise. As well, fresh water supplies to the Nile will be affected by changes in rainfall patterns throughout the Nile basin. These changes in turn will impact agricultural productivity and fisheries, influencing the country's food security.

Directly or indirectly, the development of reservoirs on the Abbay and its tributaries provides an adaptation opportunity to potential changes in runoff from the Abbay/Blue Nile induced by climate change. The importance of implementing adaptive measures is highlighted by the case of the Aswan Dam that was of a tremendous importance to Egypt in successfully coping with the severe droughts ranging from 1979 to 1987. Without the dam, it is believed that the shortage of irrigation water would have caused the country serious food crisis (OSI, 2007). However, these potential investments will be directly affected by changes in mean temperature and precipitation as well as their extremes. These changes will affect electric power generation, modernization of irrigation, watershed management, flood management, flood plain sustainability and ability to sustain droughts.

In the case of precipitation decrease, large storage capacity will provide better flexibility to sustain droughts and maintain environmental minimal flow requirements to preserve the flood plain functions and services. On the other hand, in the case of increased precipitation, large storage capacity would provide the ability to better regulate the flow and avoid damage due to severe flooding conditions.

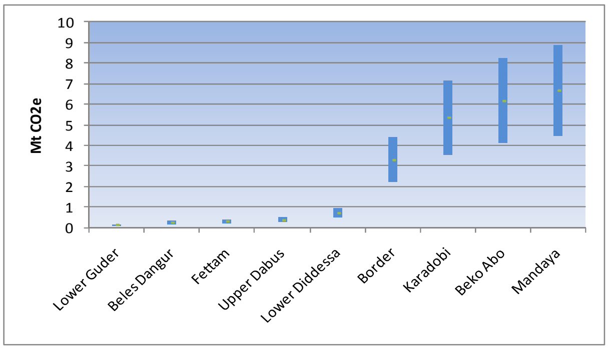
Given the wide range of climate change predictions for the three Eastern Nile countries the effects of climate change will need to be carefully considered as failure to take into consideration the possibility of extreme events in the design of the potential investments could lead to serious disastrous consequences, for example in the case of dam failure under extreme precipitation.

6.10.2 Potential GHG Emissions

The examination of each country's National Generation Expansion shows that potential electricity exports from Ethiopia would satisfy the energy needs of Sudan and Egypt, which could help these countries either avoid or delay the construction of new thermal plants.

An initial comparison of the possible effect of hydroelectricity production investment in Ethiopia shows that up to some 2,770 MW of thermal plants could be eliminated or delayed, from 2022 onward. According to Appendix C, imports from Ethiopia could eliminate the need for some 770 MW of new power plants in Sudan, while in Egypt it could replace up to 1,800 MW. The electricity imports from Ethiopia would mostly replace steam plants burning crude oil in Sudan and steam plants and CCGT using natural gas in Egypt.

Figure 6-9 Range of Potential Saved Quantities of GHG per Dam/Reservoir



The reduction of GHG will vary according to the share of production sold to Sudan and Egypt as well as the type and efficiency of the plants that hydroelectricity production will replace.

It is estimated that between 367 tCO_2e/GWh to 734 tCO_2e/GWh may be saved depending if the best natural gas combined cycle gas turbine (CCGT) or a basic heavy oil steam plant was replaced. Figure 6-9 presents for each of the reservoirs identified on the Abbay and its tributaries the expected range of equivalent CO_2 quantities that could be saved by producing energy from hydroelectricity compared to fossil fuel.

This reduction may be offset in part by the generation of GHG from decaying vegetation in the newly formed reservoirs. The amount of GHG emitted by reservoirs created for hydroelectricity production is a function of the surface of the reservoir as well as its depth. It is also a function of the measures taken during the construction of the reservoir to clear the biomass from the inundated area. Besides, additional organic matter originating upstream of the reservoir is being trapped and degrades in the reservoir, hence increasing the amount of GHG emitted from the reservoir (Svensson, 2005).

Notwithstanding the production of GHG due to biomass decomposition in the reservoirs, Tremblay et al., (2005) have estimated that emission factors for hydropower production were between one and two orders of magnitude lower than the thermal alternatives.

6.10.3 Other Emissions

Reductions of GHG under joint development would be accompanied with similar reductions in NO_x, SO_2 and particular matters thus contributing to better air quality. The amount of reduction of these gases is a function of the type and the efficiency of the plants that hydroelectricity production would replace and the nature and quality of fuel used. It is difficult to assess the amount of reduction in these gases, without detailed information on the proposed thermal plants.

6.10.4 Opportunities for Carbon Credits / CDM and CO_2 Sequestration

Large hydroelectric projects do not generally give rise to CDM carbon credits. One of the criteria to be met by a CDM project is "additionality". The concept of additionality addresses the question of whether the project would have happened anyway, even in the absence of revenue from carbon credits.

As such, only carbon credits from projects that are "additional to" the business-as-usual scenario represent a net environmental benefit. Carbon projects that yield strong financial returns even in the absence of revenue from carbon credits, that are compelled by regulations, or that represent common practice in an industry are usually not considered additional, although a full determination of additionality requires review.

A means for carbon sequestering and to compensate for GHG emissions from hydroelectric projects would be the reforestation of depleted forest in order to preserve the biodiversity and ecosystems. These reforestation projects would constitute an operation of carbon sequestration and could under appropriate conditions give rise to carbon credits. This type of intervention could also alleviate soil erosion and some level of sedimentation.

6.11 SUMMARY OF ASSESSMENT

Table 6-11 summarizes the salient points for each of the Key Strategic Issues. The table provides information on when tipping points are reached, when impacts, negative or positive, start to be felt basin-wide in relation to levels of investment represented by their footprint in terms of live storage capacity expressed in billion cubic meters (BCM). The scale of 0, 5, 10, 25, 50 and 100 BCM has been selected based on the projects considered in Table 6.1 at the beginning of this Chapter. The thresholds roughly correspond to logical increase possible with the projects considered.

The following examples are only provided to illustrate the various combinations possible for a given threshold. Other possibilities can be also considered.

0 BCM	• No investment
5 BCM	• Largest of the smaller dam on the Abbay tributaries, in this case, Lower Didessa at 5.5 BCM • The 4 other dams on the tributaries: Beles Dangur, Fettam, Lower Guder, Upper Dabus
10 BCM	• The 5 dams on the tributaries • The smallest of the large dams on the Abbay, Border in this case
25 BCM	• The 5 dams on the tributaries plus the smallest of the larger dam on the Abbay • One larger dam on the Abbay, such as Karadobi, plus Lower Didessa • One large dam on the Abbay such as Mandaya
50 BCM	• At least 2 of the largest dams on the Abbay plus 5 to 10 BCM of smaller dams on the tributaries • At least 2 of the largest dams on the Abbay plus the smallest one
100 BCM	• The 5 dams on the tributaries plus the 4 larger on the Abbay would total approximately 80.4 BCM. For all intent, this is considered as full development for discussion purpose

Table 6-11 Summary of Impact Assessment on Key Strategic Issues

Issues		Impacts			Footprint in Live Storage Capacity (BCM)						Comments
		Description	Confidence of occurrence	Significance	0	5	10	25	50	100	
Water Security	**Construction of dams and reservoirs**										
Water Security	Water availability	Increased reliability of water supply during operation	H	H	n.a.	T					With appropriate operating rules
Water Security	Water availability	Decreased reliability downstream during reservoir filling	M	H	n.a.	~					Mitigation possible with adequate reservoir filling schedule
Water Security	Water availability	Increased flexibility for drought management due to accrued storage capacity	H	H	~	T					The more storage, the better the flexibility. 60 BCM and more necessary to supply the total demand in the Eastern Nile for 1 year.
Water Security	Extreme Events	Possibility of attenuation of damages due to inundations	H	H	~	~					Extreme event defined as at least 1:100 return period. Some benefits at 10 BCM, but full control only at ± 20 BCM and more.
Water Security	Extreme Events	Diminution of groundwater recharge in flood plains	H	M	~	T					Impact can be avoided with maintenance of environmental flows to optimal flooding
Access to Water and Livelihoods	**Recession Agriculture**										
Access to Water and Livelihoods	Flow regulation	Loss of recession agriculture	H	H	n.a.	T					Impact can be avoided with maintenance of environmental flows to sustain optimal flooding
Access to Water and Livelihoods	Flow regulation	Potential to replace lost recession agriculture with irrigated agriculture	H	H	~	T					Would be limited on the tributaries. Otherwise, the more storage, the more potential for downstream irrigation
Access to Water and Livelihoods	Flow regulation	Decreased alluvium and soil fertility	H	H	~	~					Impact can be avoided with maintenance of environmental flows to sustain optimal flooding
Access to Water and Livelihoods	**Irrigated Agriculture**										
Access to Water and Livelihoods	Potential evaporation saving	Increased water availability for irrigated agriculture	M	M	~	~					The more storage, the more potential
Access to Water and Livelihoods	**Fisheries**										
Access to Water and Livelihoods	Flow regulation	Loss of wetlands and spawning habitats	H	H	n.a.	~					Impact can be avoided with maintenance of environmental flows to sustain optimal flooding
Access to Water and Livelihoods	Flow regulation	Increased potential for fisheries in existing reservoirs on the Blue Nile	M	M	n.a.	~					Would depend on operating rules (limited drawdown) of the reservoirs and level of sediment control upstream
Access to Water and Livelihoods	Construction of dams, reservoirs and infrastructure	Reduced access to spawning areas in Abbay tributaries	H	H	n.a.	T					The largest the footprint and the number of dams, the more access to tributaries is blocked. Cannot be mitigated
Access to Water and Livelihoods	Construction of dams, reservoirs and infrastructure	Increased potential for commercial fisheries in new reservoirs	M	M	n.a.	T					Increases with number of reservoirs, if drawdown is limited
Access to Water and Livelihoods	Construction of dams, reservoirs and infrastructure	Decreased fish production in Lake Nasser/Nubia during new filling of new reservoir	M	M	n.a.	~					Depends on duration and extent of water level decrease in the lake, all related to filling of reservoirs. Would stabilize during operation phase.
Access to Water and Livelihoods	Construction of dams, reservoirs and infrastructure	Local loss of some fish species not adapted to life in reservoirs	H	M	n.a.	T					Increases with number of reservoirs and increase of footprint along the Abbay and tributaries
Access to Water and Livelihoods	**Brick-Making**										
Access to Water and Livelihoods	Loss of flood plains	Decreased sediment/clay replenishment in flood plains	H	M	~	~					Impact can be avoided with maintenance of environmental flows to sustain minimal flooding
Access to Water and Livelihoods	Loss of flood plains	Loss of access to flood plains	H	M	~	~					
Access to Water and Livelihoods	**Pasture and Grazing Areas**										
Access to Water and Livelihoods	Loss of seasonal wetlands	Decreased of pasture and grazing areas	H	M	~	T					Impact can be avoided with maintenance of environmental flows to sustain optimal flooding
Access to Water and Livelihoods	Expansion of irrigation schemes	Decreased of pasture and grazing areas	H	M	L	T					With a nil footprint, expansion of irrigation schemes is possible, but limited. Potential for expansion of irrigation schemes increases in Sudan with increased storage capacity in the Abbay and appropriate operating rules of all reservoirs.
Access to Water and Livelihoods	Expansion of irrigation schemes	Migration routes are cut	H	M	L	~					
Access to Water and Livelihoods	Expansion of irrigation schemes	Increased pressure on protected areas	H	M	L	~					
Access to Water and Livelihoods	**Navigation and Transport**										
Access to Water and Livelihoods	Flow regulation	Increased difficulty to cross river at low flows for people and cattle	H	M	n.a.	T					Unlikely to be mitigated as low regulated flow will be higher than unregulated dry season flow
Access to Water and Livelihoods	Flow regulation	Increased opportunities to develop commercial services	M	M	n.a.	T					Opportunities will also increase with the number of dams and the new access roads and infrastructure
Access to Water and Livelihoods	Filling of new reservoirs	Decreased level in Lake Nasser/Nubia	H	H	n.a.	~					Impact would be during filling an depend largely on filling schedule and precipitation. The situation would stabilize during operation and even be positive with less water level fluctuations

Issues		Impacts: Description	Impacts: Confidence of occurrence	Impacts: Significance	Footprint in Live Storage Capacity (BCM): 0	5	10	25	50	100	Comments
Access to Water and Livelihoods	**Health**										
	Construction of reservoirs and increased irrigation	Increase in water borne diseases	H	H	n.a.	T					Especially malaria. Mitigation possible, but it would require widespread distribution of bed nets and large amount of pesticides to control mosquito populations.
	Flow regulation	Decrease in water borne diseases	M	L	n.a.	T					Reduction of Onchocerciasis (river blindness) possible with flow regulation and decrease of fast flowing water.
Water Quality	**Surface Water Quality**										
	Expansion of irrigation agriculture	Increased concentrations of agro-chemicals	H	M	~	T					Possibility of mitigation by recycling runoff water and improving agricultural practices
		Increased salinity due to increased run-off of irrigation water	H	M	~	~					
	Flooding of new reservoirs	Decreased water quality due to decomposition of biomass and nutrient loading	H	M	n.a.	T					Can be mitigated by removal of vegetation and biomass prior to reservoir flooding
	Groundwater quality										
	Expansion of irrigation agriculture	Increased concentrations of agro-chemicals	H	M	~	T					Possibility of mitigation by improving agricultural practices
		Increased salinity due to increased leaching of irrigation water	H	M	~	~					Possibility of mitigation by recycling runoff water and improving agricultural practices
Hydropower	**Local and regional economy**										
	Power provision	Ability to meet some generation expansion needs of one or more countries	H	H	n.a	T					Partition of benefits and replacement and or delay or other energy sources would depend on power sharing agreements
	Economic benefits/ savings	Increased possibility of development of various sectors (industrial, agricultural, commercial)	M	H	~	T					This impact would be most acutely felt in Ethiopia where the overall proportion of power available would increase most drastically.
	Multipurpose uses										
	Irrigation, sediment trapping, added generation of power	Other downstream benefits possible from hydropower generation and infrastructure	M	H	~	~					Benefits attributed to sediment control and water savings would depend on filling and operation procedures
	Climate Change	Delaying of or cancellation of thermal plants resulting in less GHG emissions downstream	M	M	~	~					Providing that electricity is sold to Egypt and Sudan
Erosion and Sedimentation	**Change in bank erosion**										
	Flow velocity	Reduction of peak flows after rain season	H	H	~	T					With appropriate operating rules
		Increased bed load lost at turbine outlets	H	M	n.a.	T					Will increase with number of dams
	Change in sediment transport & deposition										
	Sediment loading in the river	Trapping of sediment in new reservoirs	H	H	n.a.	T					No significant additional benefits after 2 large dams on Abbay, although capacity to trap sediment increases with number of reservoirs and trapped sediment would be spread amongst more reservoirs
		Diminution of sediment accumulating in existing reservoirs and economies of infrastructure maintenance costs	H	H	~	~					No significant additional benefits after 2 large dams on Abbay, especially of reservoir(s) are close to Sudan border, i.e. large catchment area.
		Increased power generation potential from existing reservoirs because of less concern for sedimentation accumulation	H	H	~	~					
Critical Habitats and Ecosystems Functions	**Flood Plain and Wetlands**										
	Flow regulation	Loss of flood plains / wetlands	H	H	~	T					Mitigation possible with environmental flows. Complete control possible for 1:100 period at ±20 BCM
		Loss of high flows as trigger for spawning	M	M	~	T					
	Reservoir impoundment	Loss of flood plain and/or wetland	H	L	n.a.	T					Proportional to total reservoirs area
	Ecosystem Functions										
	Flow regulation and loss of flood plain	Loss of provisioning services	H	H	~	T					Mitigation possible with environmental flows. Complete control possible for 1:100 period at ±20 BCM
		Loss of regulating services	H	H	~	T					
		Loss of supporting services	H	H	~	T					

Issues		Impacts: Description	Impacts: Confidence of occurrence	Impacts: Significance	Footprint in Live Storage Capacity (BCM): 0	5	10	25	50	100	Comments
Critical Habitats and Ecosystems Functions	**Protected Areas and Biodiversity**										
	Loss of wetlands	Loss of critical habitats for several aquatic and semi-aquatic species	H	H	~	T					Mitigation possible with environmental flows. Complete control possible for 1:100 period at ±20 BCM
	Construction of dams and reservoirs	Loss of terrestrial and aquatic habitat in reservoirs	H	M	n.a.	T					Proportional to total reservoirs area
	Expansion of irrigation agriculture	Increased risk of invasive species due to increased run-off of nutrients	M	M	~	T					Possibility of mitigation by improving agricultural practices
Vulnerable People and Resettlement	**Vulnerable People**										
	Expansion of irrigation schemes	Loss of land uses (grazing) for pastoralists	H	H	~	~					Increases with increased potential for irrigation
		Loss of migration routes	H	H	~	~					
	Flow regulation	Decreased possibilities to cross the river at low flow for people and cattle	H	M	n.a.	~					Mitigation possible with environmental flows. Complete control possible for 1:100 period at ±20 BCM
	Loss of wetland	Loss of livelihoods and impoverishment	H	H	~	T					Proportional to total reservoirs area
	Resettlement										
	Construction of dams and reservoirs	Physical displacement	H	H	n.a.	T					In theory, risk increases with increased flooded area, although it is recognized that it varies between reservoirs. Compensation along regulatory framework and safeguards.
		Economic displacement	H	H	n.a.	T					
Dam Safety	**Unplanned Water Release**										
	Construction of dams and reservoirs	Failure of dam structure and systems	L	H	n.a.	T					Proportional to total stored volume. Could be catastrophic with full development.
	Increased precipitation due to climate change	Overspill or unscheduled releases	L	H	n.a.	T					Confidence of occurrence is highly uncertain.
Climate Change	**Green House Gas Emissions**										
	Substitution of hydropower instead of fossil fuels	Decrease of CO_2 emissions	H	M	n.a.	~					Potential proportional to hydropower production capacity
		Increased CO_2 emissions from new reservoirs	H	M	n.a.	T					Mitigation possible by removing vegetation and biomass before flooding
	Effect of Climate Change on Hydropower Projects										
	Increased run-off and flow	Increased hydropower potential	M	L	n.a.	T					Proportional to hydropower production capacity
		Increased possibility of extreme events with impact on dam safety	L	H	n.a.	T					Extreme event defined as at least 1:100 return period. Some benefits at 10 BCM, but full control only at ± 20 BCM and more.
	Increased drought periods	Increased flexibility to manage drought events and increased food security	M	L	~	T					Flexibility increases with storage capacity
	Increase of temperature	Increased evaporation from reservoirs	M	M	n.a.	T					Mitigation only possible by transferring more water upstream if temperature increase is lower

Legend

n.a.	Not applicable	(light green)	Tipping point where positive impact starts to be felt in the entire basin. Color density indicates that impact increases with additional living storage capacity.
L	Low		
M	Medium	(light yellow)	Tipping point where negative impact starts to be felt in the entire basin, but can be mitigated. Color density indicates that impact increases with additional living storage capacity.
H	High		
~	No impact or no significantly different from baseline	(light red)	Tipping point where negative impact starts to be felt in the entire basin, but cannot be mitigated. Color density indicates that impact increases with additional living storage capacity.
T	Impact only felt locally on tributaries where dams would be built		

7 SUMMARY OF ASSESSMENT AND RECOMMENDATIONS

7.1 MAJOR FINDINGS

7.1.1 Water Security

Water security may be the most important issue that the region will face over the next few decades. The situation is particular pressing for Egypt, but all three countries are facing a significant water demand to satisfy the needs of a growing population.

With no dam and no storage capacity added to the current situation, the total quantity of water available in the Eastern Nile would not increase in the short term, and it may even decrease in the short and medium terms due to higher evaporation rate in the Roseires Reservoir after the heightening of the dam and planned expansion of irrigated agriculture.

Climatic changes, as a result of global warming, are uncertain in magnitude and direction of the change in precipitation. The worst-case scenario is that precipitation over the Ethiopian Highlands will decrease and exacerbate the water scarcity situation. It is also expected that climate change will affect extreme events such as drought and flood and that these events will increase in frequency, duration, and severity.

Flooding is a mixed blessing. It supports livelihoods for a large part of the population along the Abbay/Blue Nile and Main Nile, but it also causes severe economic and social damages when flood levels exceed critical levels. If precipitation were to increase due to climate change, then the expected increase in flood levels is estimated between 0.5 m and 1.0 m along the Blue Nile for a 1:100 year return period. This increase would have would have potentially severe economical, social and environmental consequences.

Water storage built on the Abbay would have the potential to increase water security for Ethiopia and also for Sudan and Egypt by allowing Egypt to store less water in the Aswan reservoir, thus limiting evaporation losses. Between four to seven BCM could be saved this way. Also, appropriate operating rules would allow Sudan to operate the Roseires, Sennar and Merowe dams and reservoirs in a manner that would optimize available water. During the construction phase and filling of the reservoirs, great care and cooperative management will be needed to preserve Egypt's water availability.

Large reservoirs on the Abbay by providing flow regularization capacity could significantly reduce the frequency of damage caused by large floods. It is estimated that one large reservoir of about 10 BCM could control events with a 1:10 year return period and that storage of a little less than 20 BCM could control events of a 1:100 year return period. These reservoirs could also hold water in reserve to mitigate droughts and increase food security for the region. A cascade development of about 60 BCM would provide water for all uses along the Abbay, Blue and Main Nile for one year.

Only one large reservoir on the Abbay with live storage capacity of about 10 BCM, operated within a cooperative and multipurpose framework, is enough to start addressing the region water security challenge, and provide other regional multipurpose benefits. Smaller reservoirs on the tributaries with their limited capacity to regulate flood and store water would not have this capacity; their impact would only be felt locally.

7.1.2 Access to Water and Livelihoods

Livelihoods along the Abbay/Blue Nile and Main Nile depend on access to water and related ecosystem resources. The range of developments that may occur on the Nile from presents a wide range of risks and opportunities for those that depend on the Nile for their livelihoods.

Recession agriculture is practiced intensively along the Blue and Main Nile in Sudan and around Lake Nasser in Egypt. Large reservoirs on the Abbay with the capability to completely regulate the flow could put at risk over 364,000 ha of seasonal recession agriculture, thus threatening people livelihoods, reducing food security and further impoverishing them.

People practicing **pastoralism** are still prevalent in some parts of the Blue and main Nile. They would be at risk of losing their livelihood if seasonal flooding were to be eliminated. They would lose the grazing areas necessary for their herds and could also be displaced by expansion of irrigated agriculture schemes. Their traditional migratory routes may also be cut.

Subsistence fisheries practiced along the river would be affected in Ethiopia by the construction of large dams that would impede fish migration and reproductive behavior. This impact could however be offset by the development of dams, which could create under certain conditions opportunities for fish rearing and commercial fisheries. In the Blue Nile and Main Nile basins, the regularization of river flows will support increased fishery activities in the existing reservoirs and the river. For Lake Nasser/Nubia the lower water levels during filling may lead to reduced subsistence fishery yields in the khors that border the lake. Conditions should stabilize during operation phase.

Brick –making is an important activity along the in Sudan and is concentrated along the river banks. They need seasonal floods and the sediment they carry to replenish the silt and clay they need to make bricks. This industry also faces other challenges due to the decreasing of available fuel wood and has detrimental effects on the environment.

The negative impacts due to flow regulation and the possible loss of the flood plain can be eliminated by releasing seasonal flood at a level sufficient to maintain recession agriculture, grazing areas, and brick-making activities. The seasonal flooding would need to be maintained between a 1:2 and a 1:4 year return period event to benefit most users. Damages would start to occur at higher flows.

7.1.3 Water Quality

Water quality is a concern near human settlements and industrialized areas along the Abbay and Blue Nile, and is considered to be rapidly deteriorating in Egypt downstream of the Aswan dam where several parameters have reached or exceeded international water quality threshold levels. Water quality concerns are expected to increase unless measures are taken to treat industrial and urban wastewater and to improve agricultural practices.

For punctual pollutant loading, localized by definition, it is believed that mitigation measures by each country at the local level are necessary. For regional and diffuse pollutant loading, particularly due to agricultural surface water runoff and leaching in the groundwater, a broader coordinated approach including information and knowledge sharing would ensure that an effective basin approach is implemented

7.1.4 Hydropower

There exists a pressing need to find sustainable means of meeting the rapidly growing energy regional demands. Hydropower generation on the Abbay shows great promise as a reliable and renewable source of significant energy production. Hydropower energy, which can be exported to Sudan and Egypt, could help to delay the construction of nuclear and thermal plants and avoid GHG emissions. Furthermore, water storage facilities on the Abbay/Blue Nile Sub-basin would not only generate large amounts of hydropower, but could also provide important multipurpose benefits to downstream riparians, including flood control, sediment management, and improved navigation. Sediment management itself would have a significant effect on improvement of downstream power generation and irrigation efficiency.

Water storage and hydropower generation facilities in this sub-basin could be complemented by investments in watershed management and irrigated agriculture, part of JMP, making an important contribution to maintaining the health of the river basin and those who depend on its resources. There also exists an important potential to achieve water savings in the Eastern Nile Basin system by creating reservoirs in upstream highland areas were loss of water due to evaporation would be considerable less than in much drier and hotter lowland areas.

In general the more hydropower is generated and the greater the joint investment in hydropower infrastructure in the basin, the greater the economic benefits of power trade, electricity supply for development and improved downstream power generation. Smaller dams on the Abbay tributaries would not produce enough energy for significant exportation and would not generate all these benefits. One or more large dams on the Abbay are necessary to reach the threshold that enough energy is generated and to provide enough storage capacity to start producing the expected multipurpose benefits that in turn could increase food security and alleviate poverty.

7.1.5 Erosion and Sedimentation

Erosion and sedimentation is a serious regional issue with important environmental and economic implications due to the loss of reservoir storage, cost of dredging, and inefficiencies for hydropower operations. The main cause is soil erosion in the Ethiopian Highlands and to a lesser extent soil degradation from irrigated agriculture along the Blue Nile and Main Nile as well as bank erosion and dune movement along the Main Nile.

Soil conservation and watershed improvement programs are of immediate priority and would be one of the multipurpose benefits of the JMP. All three Eastern Nile countries will directly benefit by this action.

Reservoirs on the Abbay have greater potential to trap sediment than reservoirs on the tributaries; the effect would only be felt locally for reservoirs on the tributaries. The trapping of sediment would benefit downstream riparian countries and allow for more operational flexibility of existing dams with respect to hydropower generation.

7.1.6 Critical Habitats and Ecosystems Functions

There are three **protected areas** located in the study area under the proposed development. The Dabus Valley Controlled Hunting Area, located on the Dabus River, between the Mandaya and Border site locations, is at risk of being impacted by a small dam on the Dabus River or by the flooding of the reservoir of the Border dam. Mitigation or compensation measures may be possible.

The Dinder National Park in Sudan and the adjacent Alatish Park in Ethiopia will not be impacted directly by any of the large or smaller dams. They can however be indirectly affected by pastoralists or other groups moving in the parks to look for grazing areas or other means of survival if flood plain along the Blue Nile disappears or because of expansion of irrigation schemes.

The **flood plain** provides critical habitat and natural or ecological services for wildlife and the local population**.** The total flood plain along the Abbay/Blue Nile and Main Nile is estimated at over 6,000 km^2 for a flood with a 1:2 return period. Several species of fish use the seasonal flood plain and its wetlands for spawning. Fish spawning is usually triggered by higher flows that enable fish to move to their spawning grounds in tributaries or on the flood plain.

The development of large-scale infrastructure on the Abbay has the potential to regulate river flow and eliminate flooding. By doing so critical habitats and natural services supported by the flood plain will be significantly affected. Mitigation measures are possible by maintaining critical environmental flows at specific periods of the year and managing releases to provide a controlled flood regime.

Flood plain management may be achieved reproducing normal flood with about 10 BCM of live storage (one large dam). Cooperation and coordination amongst the Eastern Nile countries would be required to successfully preserve the flood plain and ecological services that the flood plain provides.

7.1.7 Vulnerable Groups and Resettlement

It is well recognized that large dam projects often result in the displacement of people and communities and is the most important social consideration at the planning and implementation stages.

Ethnic groups who rely on traditional resource-based livelihoods may be more vulnerable to the changes associated with the proposed infrastructure development. These groups include the Gumuz, Berta, Amhara, Funj, Kenana, Fulani, Nubians, Danagla, Bedirya, Rekabia, Gaa'lian, Shaigia, Kawahla, Kababish, Hassaniya all of whom use the stretch of the Abbay/Blue Nile and Main Nile sub-basins to differing degrees.

In relative terms the large dams on the Abbay all together would affect 7 persons per MW produced compared to 37 persons per MW for all the smaller dams on the tributaries.

Expansion of irrigated agriculture along the Blue Nile would affect pastoralist's livelihoods. Pastoralists' access to water, for both human and animal consumption, is key to supporting their livelihoods. Expansion of irrigated agriculture would restrict their traditional grazing areas and disrupt their migration routes. There is a possibility that some of the pastoralists along the Blue Nile may migrate north into the Dinder Park placing additional pressure on the resources.

The development of the Border project in the lowlands of Ethiopia has the potential for increased social conflict between the Gumuz ethnic groups and newcomers. There is a history of conflicts in the Benishangul-Gumuz region between local ethnic groups that practice extensive, shifting cultivation and previous migrants, which practice a more sedentary agricultural system.

To minimize the potential for social conflict, mitigation measures for any loss of recession agriculture, pastoralism, as well as supplementary activities such as brick-making, should be implemented well in advance of any changes in flow regime.

7.1.8 Dam Safety

All the dams that will be built on the Abbay or its tributaries are by all means considered as large, although the ones on the Abbay are much larger than the ones on the tributaries. As such, failure of the dam structure or its systems has the potential for devastating effects on the communities downstream. Failure of a cascade would even be worst with the potential to produce flood events larger than a 1:100 year return period.

A dam safety program will be required by Ethiopia and the financing organizations for all dams constructed on the Abbay or its tributaries, and it will need to particularly comprehensive for the large dams on the Abbay which may not have any precedent in term of similar scale and/or construction type. The program would include the review of all features by an international panel of experts, and several studies on geology, seismicity to ensure that there are no undue risks.

7.1.9 Climate Change

Over the next two decades some 74,000 MW of additional capacity will be needed in the region to satisfy the growing demand with three quarters of the capacity being from thermal sources under unilateral development by each country. As a consequence greenhouse gases would increase. The generation of hydroelectricity under a cooperative JMP would lessen the need to use fossil fuels to generate the required energy.

Climate change will affect all of the three Eastern Nile countries. The development of large-scale infrastructure on the Abbay represents an important adaptation strategy, which may alleviate the vulnerabilities identified with respect to climate change in agriculture by supporting irrigation as well as a more stable water supply and the ability to manage extreme floods and sustain critical flood plains. It could also provide additional protection against extreme flood and drought events.

7.2 RED FLAGS

The main risk of the development in the Abbay is associated with the preservation of seasonal flooding to sustain a critical area of flood plain necessary to support natural and ecological services: recession agriculture, brick-making activities, spawning habitats for fish, sensitive ecosystems, and groundwater recharge.

In theory, environmental flows can be generated to maintain a critical level of seasonal flooding that would limit the impact of flow regulation on the groundwater recharge and ensure sufficient flood plain so that its functions can be maintained in a sustainable manner. It is nevertheless felt that not enough is known on the regional groundwater recharge characteristics along the Eastern Nile and the utilization of the flood plain by the biota to be reasonably certain of the robustness of the conclusions. A special study is underway to better assess regional groundwater characteristics and recharge, and it is recommended that the flood plain and its importance as critical habitat for several species be investigated as soon as possible.

Some impacts cannot be avoided. The most significant are the loss of land due the establishment of reservoirs and the impediment of fish migration towards their spawning grounds in tributaries. Loss of land and related livelihoods can be compensated by adequate resettlement plans and appropriate compensation measures to ensure that people are at least as well off as they were before, preferably better. Impact on fish can also in theory be compensated by the possibilities offered by the reservoir in fish rearing; but caution must be exercised as periodic drawdown larger than 3.5m, as planned in the large reservoirs, may very well prevent the materialization of this opportunity.

There are a number of socio-political issues associated with the existing social, economic and cultural conditions in the Abbay, Blue Nile, and Main Nile basins and the JMP development. These issues if not properly managed could lead to discontentment. They include land tenure systems and people's rights to the land that sustains their livelihoods; the potential for economic and physical displacement; current pressures on land and water resources, and the consequences for traditional livelihoods such as rain-fed agriculture in Ethiopian highlands and pastoralists in the Blue Nile basin; and women as a vulnerable groups.

It is expected that existing institutions will need to be strengthened for improved communications, data sharing and public participation and that national policies will be updated to bring them in line with international best practices.

7.3 THRESHOLDS AND TIPPING POINTS

Based on the assessment carried out in Chapter 6, the tipping point where most of the impacts, positive or negative, start to be felt in the entire Eastern Nile basin is estimated at about 10 BCM of live storage capacity. This corresponds roughly to one large dam on the Abbay or the five smaller dams on the tributaries. Anything smaller would have only a much localized impact in the tributaries. Even the Lower Didessa project, at 5 BCM live storage, as large as the four other small dams on the tributaries, would not have an impact felt regionally. This 10 BCM threshold of live storage will however have a different impact magnitude if it were to be built on the Abbay than on the tributaries for the simple reason of the difference in flows and catchment area involved. The total tributaries concerned would account only for about 25% of the total catchment area of the entire Abbay and only for about 20% of the total flow coming out of Ethiopia. Furthermore, these five smaller dams on the tributaries would generate only a fraction of the energy generated by a single large dam on the Abbay of equivalent live storage, for almost the same cost.

With 10 BCM of live storage on the Abbay, it is possible to regulate the flow with 1:10 year return period while maintaining environmental flows; to have enough storage to trap most of the sediment load carried by the Abbay; and to offer some flexibility to alleviate to a certain extent extreme events related to flooding and drought.

It is also suggested that about 20 BCM of live storage is the threshold where full flow regulation is achieved for events of a 1:100 year return period. This threshold, in addition to allowing sufficient flexibility to operate the dams in a multipurpose context under normal conditions, would also provide additional flexibility to face most of the extreme events occurrence, particularly floods and droughts.

Live storage capacity above 20 BCM does not increase the ability to regulate the flow, but the magnitude of several impacts, negative and positive, would increase. There would be more potential for water savings, for controlling flows during extreme precipitation, for drought alleviation, electricity sales, and reduction of GHG due to replacement of thermal generated energy with hydroelectricity. On the other hand, negative impacts intensity would also increase with additional footprint such as potential downstream water level decrease in Lake Nasser filling of reservoirs and operation, depending on operating rules; larger number of people potentially affected or relocated; water quality deterioration from biomass decomposition during reservoir filling; and loss of land and pasture with increased footprint and expansion of irrigated agriculture schemes.

7.4 TRADE OFFS

In a context of this complexity, there are several tradeoffs that are not avoidable and that must be carefully considered. The most significant, and by far, are the tradeoffs related to water management.

The first is the tradeoff between maintaining a flood plain at a critical level to preserve human livelihoods and habitats that it currently supports versus electricity generation, sediment trapping, slower refilling of reservoirs, and less stored water available for irrigation schemes expansion and for relief during droughts. Maintenance of the flood plain would benefit recession agriculture, brick-making, fish spawning areas, seasonal wetlands with their associated ecosystem and biodiversity, and groundwater recharge.

The second tradeoff is related to the storage of water. Upstream water storage in the Ethiopian highlands versus storage in Lake Nasser has the potential of reducing water loss from evaporation, while providing the upstream storage needed to mitigate the increasingly severe droughts anticipated under a changing climate. How much water is still open for debate and is a delicate balance between the various demands along the Eastern Nile and the increasingly irregular and unpredictable precipitation and temperature.

There are also other tradeoffs that will need to be considered despite their complexity:

- Maintain higher flows during dry periods to facilitate navigation versus lower water levels to allow people and herds to cross the River,
- Lower water levels in Lake Nasser to save water from evaporation versus navigation and fish spawning areas,
- Trapping as much sediment as possible in the new reservoirs on the Abbay to save on maintenance of infrastructure (irrigation, hydroelectricity and preserve storage capacity) in Sennar, Roseires and Merowe versus providing nutrients and silt for recession agriculture and brick-making.
- Development of fisheries in the new reservoirs versus drawdown amplitude during reservoir operation.

7.5 RECOMMENDATIONS ON THE WAY FORWARD

7.5.1 Filling the Critical Gaps

This Stage 1 SSEA report has been prepared based on secondary data available from ENTRO and from national and regional organizations, local experts, scientific literature, and some limited fieldwork. There are several issues that would greatly benefit from additional, more detailed, or more recent data in order to better quantify the scale of potential adverse environmental impacts and propose more detailed mitigating measures.

These issues, determined to be Key Strategic Issues at the onset of this study, are important and should not be left for future site-specific EIAs once the funds are committed for construction. It is recommended that environmental studies designed to address these shortfalls be commissioned as soon as soon as possible.

The Special Studies underway will address some of these baseline gaps, particularly the studies on groundwater resources and recession agriculture, particularly the aspects related to the quantity of water necessary to transform recession agriculture into irrigated agriculture (Appendix F). Other studies are needed for the following:

- Critical habitats and cyclic/seasonal utilization of the flood plain and seasonal wetlands by aquatic and semi-aquatic flora and fauna, and their role in sustaining these critical habitats.
- Data on the aquatic and semi-aquatic fauna is generally poor throughout the study area. Specific studies on the fish populations are particularly needed to properly assess the impacts of dam and reservoirs construction on the migratory routes and spawning grounds. The role of the flood plain in providing spawning areas must be better understood, and the potential to develop fisheries in the reservoirs must be realistically evaluated.

- Adequate inventories for important biodiversity areas are needed, including Important Bird Areas, permanent and seasonal wetlands, and for Protected Areas such as the Dabus Valley Controlled Hunting Area and the Dinder and Alatish National Parks. It will be necessary to identify species at risk and vulnerable species and to develop appropriate protection measures.
- Studies are required to determine the number of Pastoralists who depend directly on the flood plain and the extent of their potential losses following decrease of flood plain area, grazing areas and expanded irrigated agriculture. The additional data required include socio-economic baseline and livelihood profiles for different "migratory" groups such as resident and permanent migrants, cyclical or seasonal migrants, migrants related to civil strife (IDPs and returning migrants) and migrants due to government programs. This needs to be based on field work.
- A more detailed review and assessment of the capacity of national and regional level institutions is required in subsequent phases of planning for JMP 1. As such ENTRO is currently developing an institutional assessment and guideline for support of social and environmental safeguards for JMP. The assessment needs to include the capacity to manage the social and environmental impacts and the adequacy of policies to act as safeguards to protect the people and the environment.

7.5.2 Needs for Cumulative Impact Assessment

Cumulative Impact Assessment requires data with a level of detail usually associated with full Environmental Impact Assessments of the projects considered. At the time of preparing this report only preliminary Pre-feasibility level EIAs were available for Karadobi, Beko-Abo, Mandaya, and Border. Full EIAs for Beko-Abo and Mandaya were underway as were the Special Studies. In general, with the exception of occasional and limited specific field sampling, the data available is not site-specific, comes from older studies and usually only allows for qualitative assessment of the impacts of these project, particularly on the biological component.

No EIA was conducted for any of the dams on the tributaries, with the exception of a reconnaissance study for Lower Didessa carried out in 2001, and in general very limited information was available on the social and environmental impacts for the dams on the Abbay tributaries.

No cumulative impact study has been undertaken for any of the projects on the Abbay or its tributaries.

It is anticipated that some of the gaps will be filled by the Special Studies and full EIAs, particularly for topics such as groundwater characteristics and details on the flood plain utilization by the biota and its uses other than recession agriculture.

7.5.3 Moving Towards Stage 2 SSEA

The Stage 1 SSEA provides the foundation for the Stage 2 SSEA. This draft Stage 1 SSEA Report develops the initial baseline and provides a scoping of the main environmental and social issues associated with the development outlined by the JMP 1 Identification Studies.

The Stage 1 SSEA report is an important milestone. The next step is to disclose the report to the stakeholders for information and to collect public views and comments. The disclosure process for the Stage 1 SSEA report will follow ENTRO's JMP consultation and communication strategy. Comments and guidance provided by the stakeholders will be integrated into a Final Stage 1 SSEA.

The Stage 2 SSEA will focus on the selection and the assessment of the preferred cascade development and will examine in greater detail the various components of the most feasible JMP 1 investment package in relation to the nine Key Strategic Issues discussed in the present report.

As for Stage 1 SSEA, Stage 2 is also part of this extensive consultation process, which is seen as a *dialogue* with and among key stakeholders of the Eastern Nile basin. Broad and technical consultations will be set up to ensure full disclosure, transparency, and meaningfulness to the entire process.

8 REFERENCES

Abiy, S., 2008. Ethiopian Country report presented at 6th Regional Water Quality Working Group Workshop conducted from 28 th to 30 th July 2008 In Kigali, Rwanda.

Abu-Gideiri, Y.B. and Ali, M.T. 1975. A preliminary Survey of Lake Nubia. *Hydrobiologia*, vol. 46: 535-541.

Adams, W., 2000. The Downstream Impacts of Large Dams. World Commission on Dams (WCD) Thematic Review 1.1 (a) Social Issues, Cape Town, South Africa.

Ahmed, A.A., and H.H.A.E. Ismail, 2008. Sediment in the Nile River System. UNESCO International Hydrological Programme, International Sediment Initiative. Khartoum, Sudan.

Alam, S.A., 2006. Use of biomass fuels in the brick-making industries of Sudan: Implications for deforestation and greenhouse gas emission. Thesis submitted for an M. Sc. Degree in Forest Ecology /Tropical Silviculture Department of Forest Ecology Viikki Tropical Resources Institute (VITRI), University of Helsinki, Finland, Helsinki, April 2006

Ali, A.M., and Dr. M.B. Nimir, 2006. Putting People First: Sustainable Use Of Natural Resources In The Dinder National Park (Biosphere Reserve). The Engineers Society & the Sudanese Environment Conservation Society, Khartoum 2006.

Ali, M.M. and M.A. Soltan, 2006. Expansion of Myriophyllum spicatum (Eurasian water milfoil) into lake Nasser, Egypt: Invasive capacity and habitat stability. Aquatic Botany, Vol.84 (3) 239-244.J. aquatbot

Anteneh, W. Getahun A. and Dejen, E. 2007. Reproductive Biology of the fish *Labeobarbus intermedius* in the Dirma and Megech tributary rivers of Lake Tana (Ethiopia). *Eth. J. Sci. & Technol*. 4(2):13-26.

Anteneh, W., Getahun, A. and Dejen, E. 2008. The Lacustrine species of *Labeobarbus* of Lake Tana (Ethiopia) spawning at Megech and Dirma tributary rivers. *SINET: Ethiopian Journal of Science*, 31 (1): 21-28.

Arsano, Y., 2007. Ethiopia and the Nile – Dilemmas of National and Regional Hydropolitics. Center for Security Studies, Swiss Federal Institute of Technology, Zurich ETH Zentrum SEI, Seilergraben 49

Asheber, S.A., 2010. Mitigating Drought; Policy Impact Evaluation, A case of Tigray Region, Ethiopia. Theses submitted to the Geo-Information Science and Earth Observation, The Netherlands.

Ashraful, Alam, S. 2006. Use of biomass fuels in the brick-making industries of Sudan: Implications for deforestation and greenhouse gas emission. Thesis submitted for an M.Sc. Degree in Forest Ecology/Tropical Silviculture, Department of Forest Ecology, Viikki Tropical Resources Institute, University of Helsinki, Finland, April 2006.

Awoke, Tessema Chekun, Vetiver in the Rehabilitation of the Degraded Zegzeg Watershed in Ethiopia, Coffee and Tea Authority, Addis Ababa (Year uncited)

Aynalem, S. 2007. Species Composition, Distribution, Relative Abundance & Habitat Association of the Bird Fauna of Bahir Dar, Zegie Peninsula and the Nearby Island of Lake Tana, Bahir Dar. M.Sc. Thesis. Addis Ababa University, Addis Ababa, Ethiopia.

Badawy, H.A., 2009. Effect of Expected Climate Changes on Evaporation lossess from Aswan High Dam reservoir (AHDR). Thirteenth International Water Technology Conference, IWTC 13 2009, Hurghada, Egypt

Bartolome, L.J. et al., 2000. Displacement, Resettlement, Rehabilitation, Reparation, and Development. World Commission on Dams (WCD) Thematic Review 1.3 Social Issues, Cape Town, South Africa.

Béné, C.; Bandi, B. and Durville, F. 2008. Liberalization reform, 'neo-centralism' and black market: The political diseconomy of Lake Nasser fishery development. Water Alternatives 1(2): 219-235

Bernacsek, G.M., 1984. Guidelines for dam design and operation to optimize fish production in impoundment river basin. CIFA Technical paper (11): 98 p.

Berrebi, P. and Tsigenopoulos CS. 2003. Phylogenetic organization of the genus *Barbus* sensu stricto. In: The freshwater fishes of Europe, Cyprinidae 2, Banarescu PM, Boguytskaya NG (eds), Part II, AULA-Verlag, Wielsheim, Germany, pp. 11-22.

Birllife, 2010. http://www.birdlife.org/

Bishai, H.M, Abdel-Melak, S.A. and Khalil, M.T. 2000. *Lake Nasser*. Publication of National Biodiversity Unit. No. 11-2000.

Blackmore D., and D. Whittington, 2008. Opportunities for Cooperative Water resources Development on the Eastern Nile: Riaks and Rewards. Final report - An Independent Report of the Scoping Study Team to the Eastern Nile Council of Ministers.

Block, P., and K. Strzepek, 2010: Economic Analysis of Large-scale Upstream River Basin Development on the Blue Nile in Ethiopia Considering Transient Conditions, Climate Variability, and Climate Change, *Journal of Water Resources Planning and Management* 136(2): 156-166.

Boelee, Eline and Henry Madsen, 2006. Irrigation and Schistosomiasis in Africa: Ecological aspects. Colombo, Sri Lanka: International Water Management Institute, 2006.

BRL, June 2008. Eastern Nile Irrigation and Drainage Study (ENIDS). Phase 2: Analysis. Eastern Nile Technical Regional Office (ENTRO)

Brown, L. and Thérivel, R. 2000. Principles to Guide the Development of Strategic Environmental Assessment Methodology. Impact Assessment & Project Appraisal 18(3): 183-189.

CAPMAS, 2009. Population and Housing Census, 2006. Central Agency for Public Mobilization and Statistics, Arab Republic of Egypt. (www.capmas.gov.eg)

CAPRI, 2008. Land Tenure in Ethiopia: Continuity and Change, Shifting Rulers and the Quest for State Control. CAPRI Working Paper No. 91, September 2008. CGIAR systemwide program on Collective Action and Property Rights (CAPRI) (http://www.capri.cgiar.org/pdf/capriwp91.pdf)

Cave, F.O. and McDonald J.D 1958, Birds of Sudan. Oliver and Boyd, UK.

Cawood, 2005. *"Rapid appraisal of flood damages along the Blue Nile & Main Nile Rivers in Sudan".*

Chapin Metz, H., 1991. *Sudan: A Country Study*. Washington: GPO for the Library of Congress, 1991.

Christensen, J.H., B. Hewitson, A. Busuioc, A. Chen, X. Gao, I. Held, R. Jones, R.K. Koli,W.-T. Kwon, R. Laprise, V.M. Rueda, L.Mearns, .G.Menéndez, J. Räisänen,A. Rinke,A. Sarr and P.Whetton, 2007: Regional climate projections. *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller, Eds., Cambridge University Press, Cambridge, 847-940.

CIA Factbook for Sudan and Egypt, 2009;

CIDA, 2005. Improving Productivity and Market Success of Ethiopian Farmers –Project Implementation Plan, March 2005, CIDA, ILRI, MARD Ethiopia

Comments on the Scoping Study of the Joint Multipurpose Program (JMP), 2008. Main Report prepared by a Panel of Experts – Cairo, Egypt.

Conradie and Hoag, 2003. *"The Cost of Meeting Equity: Opportunity Cost of Irrigation at the Fish-Sundays Scheme, South Africa".*

CSA, 1999. National Labor Force Survey

CSA, 2006. Atlas of the Ethiopian Rural Economy

Dawod M.A.A. and M.A El-Rafy, 2006. Effect of the Climatic Change on Nasser Lake Evaporation in Egypt. Egyptian Meteorological Authority- Meteorological Research Bulletin - ISSN 1687 – 1014, VOL.- 21 - 2006.

de Graaf, M., Eshete Dejen, Sibbing, F.A. and Osse, J.W.M. 2000. The piscivorous barbs of Lake Tana (Ethiopia): Major questions on their evolution and exploitation. *Netherland Journal of Zoology*, 50 (2): 215-223.

de Graff, M. , Marcel, AM, Machiels, M., Tesfaye Wudneh and Sibbing, FA. 2004. Declining stocks of Lake Tana's endemic *Barbus* species flock (Pisces: Cyprinidae): natural variation or human impact? *Biol. Cons.* 116: 277-287.

de Graff, M. Nentwich, D, Osse JWM and Sibbing, FA. 2005. Lacustrine spawning: is this a new reproductive strategy among "large" African Cyprinid fishes? *J. Fish Biol.* 66: 1214-1236.

Dejen, E. 2007. Endowments, Potentials and Constraints on Fisheries and Aquaculture in the Tana abd Beles subbasins. Amhara Region Agricultural Research Institute, Bahir Dar.

Dellelegn, Y., and M. Wondafrash, 2001. Guidelines for Monitoring Ethiopian's Important Bird Areas (IBAs). Ethiopian Wildlife and Natural History Society.

Demissie, S. 2003. Socio-economic study on Lake Tana fishery: its role in the livelihood of the fishing community and local people in the region. MSc thesis, The Norwegian Fisheries Collage of Science, University of Tromso, Norway, 81 pp.

Dena, Rashed. 2005. Fishing for investments. Al-Ahram Weekly on line. Issue No. 736(31 March – 6 April, 2005).

Dessalegn, R., 2003. Resettlement in Ethiopia: The Tragedy of Population Relocation in the 1980s. FSS Discussion Paper No 11.

Dinar, S. "Negotiations and International Relations in Hydropolitics." *International Negotiations* (Martinus Nijhoff Publishers) 5, no. 2 (2000): 375-4-7.

Dixon A., and A. Wood, 2001. Sustainable Wetlands Management for Food Security and Rural Livelihoods in South-West Ethiopia. The Interaction of Local Knowledge and Institutions Government, Policies and Globalisation. Paper presented at the "Séminaire sur l'aménagement des zones marécageuses du Rwanda", 5-8th June 2001 at the National University of Rwanda.

Earth Trends, 2003. http://earthtrends.wri.org/

EDF, Scott Wilson, EPS, Tropics, Yam, 2007. Eastern Nile Power Trade Program Study, Institutional Settlements and Modeling, Different Modules. Eastern Nile Technical Regional Office (ENTRO)

EDF, Scott Wilson, EPS, Tropics, Yam, 2007. Eastern Nile Power Trade Program Study: Prefeasibility Study of Border Hydropower Project, Ethiopia. Eastern Nile Technical Regional Office (ENTRO)

EDF, Scott Wilson, EPS, Tropics, Yam, 2007. Eastern Nile Power Trade Power Study, Strategic Environmental and Social Assessment

EDF, Scott Wilson, EPS, Tropics, Yam, 2007. Eastern Nile Power Trade Power Study, Pre-Feasibility Study of Dal Hydropower Project, Ethiopia. Final Initial Environmental Impact Assessment.

EDF, Scott Wilson, EPS, Tropics, Yam, 2007. Eastern Nile Power Trade Power Study, Pre-Feasibility Study of Mandaya Hydropower Project, Ethiopia. Prefeasibility Study of Mandaya Hydropower Project, Ethiopia.

EDF, Scott Wilson, EPS, Tropics, Yam, 2007. Eastern Nile Power Trade Power Study, Pre-Feasibility Study of Border Hydropower Project, Ethiopia. Final Initial Environmental Impact Assessment.

Egypt National Human Development Report, 2008

El Moghraby, A.I., M. Tag el Seed, F. Sinada and O. M. Ali, 1986. Recent Ecological Change in the Nule System in the Sudan. Geojournal 13.4, 1986.

El Moghraby, A.I.,1982, The Jonglei Canal – A Needed Development or Potential ecodisaster? Env.Cons.9 (2) 141-148.

Eltahir, E.A.B, 2009. Approach paper on Climate Change in Eastern Nile Countries. Consultancy Service for Eastern Nile Technical Regional Office (ENTRO), June 7th, 2009.

El-Shinnawy, I.A., M. Abdel-Meguid, M.M. Nour Eldin, and M.F. Bakry, 2000. Impact Of Aswan High Dam On The Aquatic Weed Ecosystem. Icehm2000, Cairo University, Egypt, September, 2000, page 534-541.

Eldaw, A.K., 2003. Sudan Water Resources: Challenges and Perspectives. Water Harvesting and Future Development in Sudan, conference, August 2003, Friendship Hall, Khartoum, Sudan.

Elasha, B. O., 2010. Arab Human Development report – Mapping of Climate Changes Threats and Human Development Impacts in the Arab Region. UNDP Research Paper Series, Regional Bureau for Arab States.

Elderdery, Abozer YA, Mohamed Ahmed Mohamed Eltoum, Babiker Ahmed Mohamed Ahmed and Hani Bahaeldien Abdelgalil, 2008. Schistosomiasis in Sudan and Beyond. In Urological Cancer, Volume 3, Issue 4, December 2008.

El-Din Amer, S., Y. Arsano, A. El-Battahani, O. El-Tom Hamad, M. Abd El-Moenim Hefny, and I. Tamrat, 2005. Sustainable development and international cooperation in the Eastern Nile Basin. Aquat. Sci. 67 (2005) 3–14

Elshamy, M.E., I. A. Seierstad and A. Soterberg, 2008. Impacts of climate change on Blue Nile flows using bias-corrected GCM scenarios. Hydrology and Earth System Sciences Discussion, 5:1407-1439.

ENTRO, 2008. *"Watershed Management in the Eastern Nile Basin".* 2008.

ENTRO, 2010. SICAS Implementation Plan. Prepared by SNC-Lavalin International and Hydrosult Inc., May 2010.

Ethiopian Institute for Agricultural Research, 2004. Background document for the UNEP/GEF-Funded Project: entitled "Removing Barriers to Invasive Plant Management in Africa"

Ethiopia National Action Plan for Gender Equality, 2006-2010.

FAO, 1984. Assistance to Land use Planning Ethiopia, Geomorphology and Soils

FAO, 1986 Irrigation in Africa south of the Sahara. FAO Investment Centre Technical Paper 5 FAO, Rome, Italy, 1986.

FAO, 1989. *"The Economics of Water Allocation"*. As an FAO paper entitled *The Economics of Water Allocation* notes: "*A review of World Bank policy and practices recommends that for efficient use, irrigation water is priced volumetrically, based on opportunity costs* (Julius and Alicbusan, 1989). http://www.fao.org/docrep/007/y5582e/y5582e06.htm

FAO, 2000. Source Book for the Fishery Resources of Africa: Volume 3, FAO, Rome.

FAO, 2000. *Acacia nilotica* (L.) Willd. ex Del, by Le Houérou. http://www.fao.org/ag/AGP/agpc/doc/Gbase/DATA/pf000124.htm

FAO. 2000. Forestry outlook study for Africa (FOSA): Sudan. Ministry of Agriculture & Forests and Forests National Corporation, Government of Sudan. ftp://ftp.fao.org/docrep/fao/003/AB574E/AB574E00.pdf

FAO. 2001. Fishery Country Profile-The Republic of the Sudan. Food and Agricultural Organization, Rome, Italy

FAO, 2003. Training series. Simple methods for aquaculture. Management for fresh water fish culture. 21/1: ponds and water practice. In The Ethiopian Fisheries and Aquatic Sciences Association

(EFASA) Proceedings of the First Annual Conference of EFASA Held at Zwai Fisheries Resources Research Center Zwai, Ethiopia

FAO, 2005. Aquastat, Africa: is the source for Egypt & Ethiopia.

FAO, 2005. Fertilizer Use by Crop in Egypt.

FAO, 2007. Population Pressure and Agricultural Production in the Nile Basin (2005-2030), FAO, UNPD, Landscan, Integrated Development for East Africa conference in Addis Ababa, Ethiopia. November 2007)

FAO, 2010. AQUASTAT online database, Total renewable water resources, The Food and Agriculture Organization of the United Nations. Rome, Italy, http://www.fao.org/nr/water/aquastat/main/index.stm, Accessed 2 Feb 2011.

FAO, 2010. Fisheries and Aquaculture Information and Statistics Service - 25/06/2010

FAO, 2011 – Population Prospects. www.fao.org/nr/water/faonile/PopulationProspects.pdf

Famine Early Warning System (FEWS) Net, 2010., USAID Sudan Food Security Outlook Update. http://www.fews.net/docs/Publications/Sudan_FSOU_September_2010_final.pdf. Accessed February 28th, 2011.

Fessehaie R., *"Water Hyacinth (Eichhornia crassipes): A Review of its Weed Status in Ethiopia"*, *Arem.*, 6 (2005): 105-111.

FEWS, 2010. Famine Early Warning System, www.fews.net.,

FPME, 2007. Fish Production and Marketing Enterprise, Bahir Dar Branch. Unpublished. Jackson, D. The influence of Dams on River Fisheries. www.dams.org

Gay, P.A., 1960. Ecological Studies of *Eichhornia crassipes* Solms, in the Sudan. I. Analysis of Spread in the Nile. *Journal of Ecology*, Vol. 48, No. 1 (Feb., 1960), pp. 183-191.

Getahun, A. 2003. The Nile: Riverine fish and fisheries. Presented at the Food and water challenge international workshop that took place in Addis Ababa, Ethiopia on Dec. 10-11, 2003.

Getahun, A. 2009. Enhancing Conservation of the Labeobarbus Species Flock of Lake Tana, Ethiopia, through Better Understanding of their Ecology and Active Participation of the Community. http://www.ruffordsmallgrants.org/rsg/projects/abede_getahun

Getahun, A., Dejen, E. And Anteneh, W. 2008. Fishery studies of Ribb River, Lake Tana basin, Ethiopia. A report submitted to the World Bank financed Ethiopian Nile Irrigation and Drainage Project Coordination Office, Ministry of Water Resources.

Gomes, N., 2006. Access to water, pastoral resource management and pastoralists' livelihoods: Lessons learned from water development in selected areas of Eastern Africa (Kenya, Ethiopia, Somalia). FAP Livelihood Support Programme Working Paper Number 26.

Green, J. 2009. Birds of the Nile. IN: *The Nile: Origin, Environments, limnology and human use*, Springer Science + Business Media, B.V

Guariso G., and D. Whittington, 1987. Implications of Ethiopian Water Development for Egypt and Sudan. Water resources development, Vol. 3 (2):105-114.

Haisman, Brian. "Institutional and Broad Legal Considerations Associated with Achieving a Joint Multi-Purpose Program, Discussion Note No. 1." Eastern Nile Technical Regional Office, 2008.

Hassoup, A., 2002. Seismicity and water level variations inLake Aswan area in Egypt. Journal of Seismology 6: 459-467.

Haug, R., 2000. Livelihood Security among Pastoralists in Northern Sudan. NORAGRIC Working Paper 19.

Head, Chris. "Briefing Note: Financing Options for the Anchor Project." Eastern Nile Joint Multipurpose Program, 2008.

Holmes, J.C. 1972. *An Ordinal Method of Evaluation*. Urban Studies 9 (1): 179-191.

Hoogeveen, J. et al. (2004): A Guide to the Analysis of Risk, Vulnerability and Vulnerable Groups. Washington.

Hughes, J Donald (2004) Encyclopaedia of World Environmental History, Volume 1 A-E, p.423. Routledge.

Hughes, R.M., and J.S. Hughes, 1992. A Directory of African Wetlands. IUCN, Gland, Switzerland/WCMC, Cambridge, UK, UNDP.

Hydrosult Inc., Tecsult, DHV and Associates, Nile Consult, Comatex Nilotica and T and A Consulting. 2006a. Cooperative Regional Assessment for Watershed Management. Transboundary Analysis. Country Report. Ethiopia.

Hydrosult Inc., Tecsult, DHV and Associates, Nile Consult, Comatex Nilotica and T and A Consulting, 2006b. Cooperative Regional Assessment for Watershed Management. Transboundary Analysis. Country Report. Sudan.

Hydrosult Inc., Tecsult, DHV and Associates, Nile Consult, Comatex Nilotica and T and A Consulting, 2007a. Cooperative Regional Assessment for Watershed Management. Transboundary Analysis. Country Report. Egypt.

Hydrosult Inc., Tecsult, DHV and Associates, Nile Consult, Comatex Nilotica and T and A Consulting, 2007b. Cooperative Regional Assessment for Watershed Management. Transboundary Analysis. Abbay- Blue Nile Sub-basin.

Hydrosult Inc., Tecsult, DHV and Associates, Nile Consult, Comatex Nilotica and T and A Consulting, 2007c. Cooperative Regional Assessment for Watershed Management. Transboundary Analysis. Main Nile Sub-basin. Final.

Hydrosult Inc., Tecsult, DHV and Associates, Nile Consult, Comatex Nilotica and T and A Consulting, 2007d. Cooperative Regional Assessment for Watershed Management. Transboundary Analysis. Distributive Analysis (Draft)

IFC, 2009. Projects and People, A Handbook Addressing Project-Induced In-Migration. Washington, D.C.: International Finance Corporation, September 2009.

ILO, 2007. HIV/AIDS + Work, Using the ILO Code of Practice on HIV/AIDS and the world of work, Guidelines for the construction sector. Geneva: International Labor Organization, December 2007.

Institute of Biodiversity Conservation, 2005. National Biodiversity Strategy and Action Plan. Government of the Federal Democratic Republic of Ethiopia.

Institute of Biodiversity Conservation, 2010. http://www.ibc.gov.et/biodiversity/ecosystems-of-ethiopia/wetland-ecosystem

International Lake Environment Committee, 2011. Promoting Sustainable management of the World's Lakes and Reservoirs. http://www.ilec.or.jp/database/afr/afr-19.html. Consulted March 7, 2011.

International Water Management Institute. 2009. *"Importance of Irrigated Agriculture to the Ethiopian Economy: Capturing the Direct Net Benefits of Irrigation*". IWMI Research Report #128.

IPCC (2007a). Climate Change 2007: The Physical Basis of Climate Change: Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom and New York, NY, USA, Cambridge University Press.

IPCC (2007b). Climate Change 2007: Impacts, Adaptations and Vulnerability: Scientific-Technical Analyses: Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom and New York, NY, USA, Cambridge University Press.

Jagannathan, N. Vijay. "Water Diplomacy in the 21st Century." In *Water in the Arab World: Management Perspectives and Innovations*, by N. Vijay, Ahmed Shawky Mohamed, and Alexanger Kremer, Eds. Jagannathan, 269 - 282. Middle East and North Africa Region, The World Bank, 2009.

Jeuland, M., 2008. *The Implications of Climate Change on Proposed Multipurpose Storage on the Blue Nile.* Literature review, University of North Carolina – Chapel Hill

Jeffrey, P., 2000. Why Another Drought in Ethiopia? UMCOR News Archives, April 26, 2000.

Kandagor, D. K.2005. Rethinking pastoralism and African development: A case study of the Horn of Africa. Egerton University, Njoro, Kenya

Karyabwhite, D., 2000. Water Sharing in the Nile RiverValley. UNEP/DEWA/GRID – Geneva, UNEP.

Maison, S., 2003. From Conflict to Co-operation in the Nile Basin. PhD dissertation, Swiss Federal Institute of Technology

McCully, Patrick. 1996. Silenced Rivers: the Ecology and Politics of Large Dams, London, Zed Books.

MCE, BRL, Shoraconsult Co. Ltd. September 2008. Eastern Nile Irrigation and Drainage Study (ENIDS). Cooperative Regional Assessment Analysis, Several Volumes. Eastern Nile Technical Regional Office (ENTRO)

MCE, BRL, Shoraconsult Co. Ltd. September 2008. Eastern Nile Irrigation and Drainage Study (ENIDS). Phase 1: Diagnostic and Planning Phase, Several Volumes. Eastern Nile Technical Regional Office (ENTRO).

McKee, J., 2007. Ethiopia – Country Environmental Profile. EC Delegation, Addis Ababa.

Medany, M., 2008. Impact of Climate Change on Arab Countries. Arab Environment – Future Challenges. Edited by Mostafa K. Tolba and Najib W. Saab.

Mengistu, A.A., 2001. Fishery Resources in Lake Tana. Part 1. Proceedings of the Wetlands Awareness Creation and Activity Identification Workshop in Amhara National Regional State. Ethio Wetlands and Natural Resources Association (EWNRA), January 23rd 2001, Bahar Dar, Ethiopia.

Metha L., and B. Srinivasan, 1999. Balancing pains and gains: A perspective paper on gender and large dams. Report for the Dam Commission of Dams thematic review: Social impacts. http://www.dams.,org

Ministry of State for Environmental Affairs, 2006. Protected Areas of Egypt – Towards the Future.

Ministry of State for Environmental Affairs, 2008. Egypt State of the Environment Report 2007. Arab Republic of Egypt, Ministry of State for Environmental Affairs, Egyptian Environmental Affair Agency.

Ministry of Water Resources in association with BCEOM, BRGM and ISL Consulting Engineers (September 1998). Abbay River Basin Integrated Development Master Plan Project, Several Volumes.

Ministry of Water Resources, 2001. Lower Didessa Medium Hydropower Project - Reconnaissance Study. Ministry of Water Resources, Federal Democratic Republic of Ethiopia, August 2001.

Ministry of Water Resources in association with BRL, DHV and T&A (May 2005). Institutional Set Up Studies of the Ethiopian Nile (Abbay) Basin Project: Putting IWRM principles in practice for collaborative planning and management of the Abbay river basin.

Mishrigi, S.Y. 1970. Fishes of Lake Roseires, on the Blue Nile. *Rev. Zool. Bot. Afr.*, LXXXII, 1-2: 193-199.

Moges, Semu, Yirga Alemu, Stuart McFeeters and Worku Legesse, 2010. Flooding in Ethiopia, Recent History and the 2006 Flood, Chapter 10 of Water Resources Management in Ethiopia, Implications for the Nile Basin, ed. Helmut Kloos and Worku Legesse, Cambria Press, 2010.

MoWR, 2007. Climate change National Adaptation Program of Action (NAPA) of Ethiopia, June 2007. The Federal Democratic Republic of Ethiopia, Ministry of Water Resources, National Meteorological Agency, Addis Ababa, Ethiopia.

MoWRI, 2005. Integrated Water Resources Management Plan. Arab Republic of Egypt, Ministry of Water Resources and Irrigation.

MoWRI, 2005. Water for the Future – national Water Resources Plan 2017. Arab Republic of Egypt.

MoWRI, 2010. Water Challenges in Egypt. Ministry of Water Resources and Irrigation, Water Conservation Unit. www.mwri.gov.eg/En/pdf_files%20english/Brochure%20%20Eng.pdf

Mutiku, T., 2001. Floristic Analysis and Ethiobotanical Investigation of the Awash Riverine Vegetation. M.Sc. Thesis, Addis Ababa University.

National Adaptation Program of Action, July 2007. Republic of the Sudan Ministry of Environment and Physical Development Higher Council for Environment and Natural Resources.

National Meteorological Agency, 2007. Climate Change National Adaptation Programme of Action (NAPA) of Ethiopia. The Federal Democratic Republic of Ethiopia, Ministry of Water Resources, Editor: Abebe Tadege, Addis Ababa, June 2007.

National Nile Basin Water Quality Monitoring Baseline Report, 2005. Nile Basin Organization.

National Water Research Center, Ministry of water resources and Irrigation. Sustainable Development for the Southern Valley Area. This project is due for completion in July 2010.

NBI, 2005. Nile Basin Regional Water Quality Monitoring Baseline Study Report for Burundi, DRC, Egypt, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, and Uganda. Nile Transboundary Environmental Action Project.

NBI, 2005a. Nile Basin Regional Water Quality Monitoring for Sudan. Nile Transboundary Environmental Action Project.

NBI, 2005b. Nile Basin Regional Water Quality Monitoring for Egypt. Nile Transboundary Environmental Action Project

NBI, 2005c. Nile Basin Regional Water Quality Monitoring for Ethiopia. Nile Transboundary Environmental Action Project

Nichols, David, David Von Hippel, and Theo Stewart, 2000. Thematic Review. VI Planning Approaches. Chapter 4: Multi-Criteria Analysis Methods. Report Prepared for the World Commission on Dams.

Nile Basin Capacity Building Network, 2005. Watershed Erosion and sediment Transport. Survey of Literature and Data Inventory In Watershed Erosion and Sediments Transport. Nile Basin Capacity Building Network for River Engineering.

Nile Basin Initiative Nile Transboundary Environmental Action Project (NBINTEAP), 2007. Regional Summary of Key Messages From the National Water Quality Monitoring Baseline Report

Nile Basin Initiative Nile Transboundary Environmental Action Project (NBINTEAP), 2008. Requirements for sustaining the transboundary water quality monitoring stations and functions after NTEAP close Proposal for Phase out and sustainability (draft proposal)

Nile Basin Initiative Nile Transboundary Environmental Action Project, 2006. Simple Procedures for Water & Waste Water Sampling for Nile Basin Countries for Transboundary Water Quality Monitoring

Nile Basin Initiative Nile Transboundary Environmental Action Project, 2003. Sudan, a report presented on Water quality monitoring component, Kigali, Rwanda, 28-30th July, 2008.

Norplan, NorConsult and Lahmeyer JV, 2006. Karadobi Multipurpose Project Pre-feasibility Study, Draft Final Report, Volume 1, Main Report, May 2006. Volume 5: Initial Environmental Assessment, May 2006. Ministry of Water Resources, Addis Ababa.

Norplan, Norconsult in association with Shebelle Consulting Engineers, 2007. Beko-Abo Multipurpose Project – Reconnaissance Study Report. Report for the Federal Democratic Republic of Ethiopia 0 Ministry of Water Resources.

Norplan, Norconsult, Scott-Wilson, EDF, in association with Shebelle Consult Plc and Tropics Consulting Engineers PLC, 2010. Beko-Abo Multipurpose Project Pre-Feasibility Study. Draft Report for Federal Democratic Republic of Ethiopia – Ministry of Water and Energy.

North, Douglass C. *Institutions, Institutional Change and Economic Perfromance.* Cambridge: Cambridge University Press, 1990.

One-System Inventory, 2007. A Synthesis Report on Socio-Economic Profile of Abbay-Blue Nile, Baro-Akobo-Sobat-White Nile, Tekeze-Setit-Atbara and Main Nile Basins. Eastern Nile technical Regional Office.

One-System Inventory, 2007. Multi-purpose development of the Eastern Nile. Eastern Nile Technical Regional Office

One-System Inventory, 2007. Synthesis of Environmental Assessment of Eastern Nile Sub-basins. Eastern Nile Technical Regional Office

One-System Inventory, June 2009, One-System Inventory of Information on the Eastern Nile Basin – Sub-basin, Summary and Appendixes. Eastern Nile Technical Regional Office

Omwenga, J.M., 2006. Summary of the Recommendations of the Cairo, Bujumbura & Entebbe Workshops, A report presented on NBI-NTEAP highlights of the activities of the regional water quality working group 4th Regional Water Quality Working Group Workshop conducted from 8 to 11 NOV.2006.

Omwenga, J.M., 2006.Concept Paper on Establishing and Making Operational the Nile Transboundary Water Quality Monitoring Network, June 2006.

Perveen, S., L.A. James, 2010. Scale invariance of water stress and scarcity indicators: Facilitating cross-scale comparisons of water resources vulnerability. Applies geography, 2010.04.003

Phiri, G., L. Navarro, M. Bashir, C. Cilliers, Y. Fayad, and A. Khattab, 2000. Water Hyacinth In Africa And The Middle East A Survey of Problems and Solutions. *Edited by Luis A. Navarro and George Phiri.* IDRC

Population and Housing Census, 2007. Ethiopia

Rahman, M. M. 2005. How hazardous are the brickfields? The Daily Star (online), May13, 5 (340), Dhaka, Bangladesh. http://www.thedailystar.net/2005/05/13/d505131802105.htm

Riverside and Unesco, 2009. Flood Risk Mapping Consultancy for Pilot Areas in Sudan. Draft Final Report submitted to ENTRO.

Riverside, 2010. Flood Risk Mapping Consultancy for Pilot Areas in Sudan. Final report submitted to ENTRO.

Seckler, David, David Molden, and R. Barker, 1999. Water Scarcity in the Twenty-First Century – IWMI Water Brief, International Water Management Institute.

Shakak, N.B.I, and M. Khalafalla, 2008. Nile Water Quality Report.

Sharing - The Newsletter of Practical Action-Sudan, 2008. Sam Turuk Water Pond a Successful Response to Pastoralists Rights. Issue No. 14.

Skelton, PH. 2001. *A complete guide to the freshwater fishes of southern Africa*, 2nd edition, Southern Book Publishers, South Africa, pp. 388.

SMEC, 2006a. Ethiopia-Sudan Power System Interconnection ESIA, Environmental and Social Impact Assessment, Final Report. Prepared by SMEC for ENTRO, October 2006.

SMEC, 2006. Ethiopia-Sudan Power System Interconnection Project; Sudan Gender Profile, WFP, 2004

SMEC, 2006. Flood Preparedness Early Warning Project Preparation, Vol. 2 Appendices, July 2006

SMEC, 2006. International, 2006. Resettlement Action Plan, Ethio-Sudan Power System Interconnection.

SMEC, 2010. Pilot Study on Improving Water Use Efficiency and Productivity on the Rahad Irrigation Scheme – Sudan, for ENTRO. FINAL REPORT September 2010

Snoeks, J. 2004. The non-cichlid fishes of the Lake Malawi system In: *the cichlid diversity of the Lake Malawi: identification, distribution, and taxonomy*, Snoeks, J. (Ed), Cichlid Press, El Paso, Texas, pp. 20-26.

SOS-Arsenic.net.2005. Toxic fumes from brick kilns a threat to health. http://www.sos-arsenic.net/english/environment/toxic-fumes.html

Steinmann, Peter, Jennifer Keiser, Robert Bos, Marcel Tanner and Jurg Utzinger, 2006. Schistosomiasis and water resources development: systematic review, meta-analysis and estimates of people at risk. http://infection.thelancet.com, Vol. 6, July 2006.

Stiassny, M. L. J and Getahun, A. 2007 An overview of labeonin relationships and the phylogenetic placement of the Afro-Asian genus *Garra* Hamilton, 1922 (Teleostei: Cyprinidae), with the description of five new species of *Garra* from Ethiopia, and a key to all African species. *Zoological Journal of Linnaean Society*, 150, 41-83.

Sudan Higher Council for Environment and the Natural Resources, 2009. Sudan's Fourth National Report to the Convention of Biological Biodiversity, Khartoum.

Sudan, 2008. 5th Population and Housing Census

Sudan Country Report, 2006. Presented at the 4th Regional Water Quality Working Group Workshop, Kenya/ Nairobi 6-11 November 2006

Svensson, B., 2005. Greenhouse gas emissions from hydroelectric reservoirs: A global perspective. pp. 25-37, In: dos Santos, M.A. & Rosa, L.P. (Eds.) Global warming and hydroelectric reservoirs. Proceedings of International Seminar on Greenhouse Fluxes from Hydro Reservoirs & Workshop on Modeling Greenhouse Gas Emissions from Reservoir at Watershed Level. Rio de Janeiro, Brazil, 8-12 August 2005. COPPE/UFRJ, Eletrobrás 2005. 197 pp.

Swain, A., 2008. Mission Not Yet Accomplished: Managing Water Resources In The Nile River Basin. Journal of International Affairs, 2008

Tadesse, w., G. Desalegn and R. Alia, 2007. Natural gum and resin bearing species of Ethiopia and their potencial applications. In Investigacion Agraria: Sistemas y Recursos Forestales 2007 16(3), 211-221.

Teodoru, C., A. Wüest, and B. Wehrli, 2006. Independent Review of the Environmental Impact Assessment for the Merowe Dam project (Nile River, Sudan). EAWAG Aquatic Research, Switzerland.

The Higher Council For Environment And Natural Resources. Sudan's Fourth National Report To The Convention On Biological Diversity, Khartoum, Sudan, 2009.

Tremblay, A., L. Varfalvy, C. Roehm and M. Garneau, 2005. Greenhouse Gas Emissions - Fluxes and Processes: Hydroelectric Reservoirs and Natural Environments"Publisher: Springer, ISBN: 3540234551, edition 2005, 742 pages.

UN Population Fund & Sudan Central Bureau of Statistics, 2002.

UNAIDS, AIDS in Ethiopia, 6th Report; www.unaids.org

UNEP, 2007. Sudan Post-conflict Environmental Assessment. United Nations Environment Program, Nairobi, KENYA

Unesco, 2007. 'Water security': what does it mean, what may it imply? Discussion Draft Paper for the session on Water Security. 13 June 2007 Delft, The Netherlands.

United Nations Educational, Scientific, and Cultural Organization, World Water Assessment Program, 2006. National Water Development Report for Ethiopia, Addis Ababa December 2004

United Nations, 2008. World Population Prospects – The 2008 Revision.

USAID, 2003. Sudan Gender Assessment.

Van Noordwijk, M, 1984. Ecology Textbook for Sudan. Khartoum University Press, Khartoum.

Viva News, 2010. http://en.vivanews.com/news/read/121294-indonesia_to_build_water_hyacinth_factory

Wahaab, R.A., and M.I. Badawy, 2004. Water Quality Assessment of the River Nile System: An Overview. Biomedical And Environmental Sciences 17, 87-100 (2004).

Warrag, E.I., A.A. Elfeel, and E.A. ElSheiksh, 2002. Forest Genetic Resources (FAO) 30:48-51.

Water Works Design and Supervision Enterprise, 2001. Lower Didessa Medium Hydropower Project Reconnaissance Study, Main Report, Volume. Addis Ababa: Ministry of Water Resources, August 2001.

WFP, 2004. Sudan Gender Profile.

Williams, D., *2005 "Economic Aspects of Water Management in the Cau Sub-basin, Vietnam*". Prepared as part of the Regional Technical Assistance (RETA) "2nd Red River Basin Sector Loan" for the Asian Development Bank.

Witte, F., M. de Graaf, O.C. Mkumbo, A.I. El-Moghraby, and F.A. Sibbing, 2009. Fisheries in the Nile System. In The Nile – Origin, Environments, Limnology and Human Use, Henri H. Dumont, Editor, Monographiae Bioligicae 89, Springer.

Witte, F., van Oijen, and Sibbing, F. 2009. Fish fauna of the Nile. IN: *The Nile: Origin, Environments, limnology and human use*, Springer Science + Business Media, B.V.

Wood, A., 2001. The role and importance of wetlands in Ethiopia. Proceedings of the Wetlands Awareness Creation and Activity Identification Workshop in Amhara National Regional State. Ethio Wetlands and Natural Resources Association (EWNRA), January 23rd 2001, Bahar Dar, Ethiopia.

Woods, A.P., A. Hailo, P.G. Abbot, and A.B. Dixon, 1998. Sustainable Management of Wetlands: Local Knowledge versus Government Policy. In Proceedings of the 2nd International Conference on Wetlands Development, 8-14th November 1998, Dakar, Senegal.

World Bank, 1998. Greenhouse gas assessment handbook: A practical guidance document for the assessment of project-level greenhouse gas emissions. Global Environment Division, the World Bank, USA. 168p.

World Bank ,2000. Options for the Sustainable Development of the Gezira Scheme, Report No. 20398-SU. Prepared jointly by Government of Sudan and World Bank, October 2000.

World Bank, 2004. Country Assistance Strategy Ethiopia.

World Bank, 2006. Ethiopia: Towards a Strategy for Pro-Poor Tourism Development Prepared for the Government of Ethiopia by the World Bank, Report 38420 – ET.

World Bank, 2007. Export Marketing of Gum Arabic from Sudan, Policy Note. Washington, D.C.: World Bank, March 2007.

World Bank, 2010. *Wind Power Development Project in Egypt: Project Appraisal Document.* Sustainable Development Department, Middle East and North Africa Region. Report No: 54267-EG

World Bank, 2011. Africa Development Indicators 2011. ISBN: 978-0-8213-8731-3

World Economic Forum Water Initiative, 2009. Managing our future water needs for agriculture, industry, human health and the environment. (http://www.weforum.org/pdf/water/WaterInitiativeFutureWaterNeeds.pdf)

World Health Organization, 1987. Atlas of the global distribution of Schistosomiasis, Ethiopia. Geneva: World Health Organization, 1987.

Yewhalaw, Delenasaw, Worku Legesse, Wim Van Bortel, Solomon Gebre-Selassie, Helmut Kloos, Luc Duchateau and Niko Speybroeck, 2009. Malaria and water resource development: the case of Gilgel-Gibe hydroelectric dam in Ethiopia. In Malaria Journal 2009, 8:21.

Yirgalem, A., A. Chebud and A.M. Melesse, 2008. Groundwater Flow Simulation Of The Lake Tana Basin, Ethiopia. Proceedings of the workshop on hydrology and ecology of the Nile River Basin under Extreme Conditions.

9 SSEA TEAM MEMBERS

The SSEA Team includes:

Mr. Timothy Hannan	Team Leader and Water Resources Planning and Management Expert
Mr. René Fontaine	Task Leader and Senior Environmental Specialist
Ms. Susan Novak	Senior Social Development Specialist
Ms. Sohinee Mazumdar	Environmental Expert
Dr. Mary Matthews	Institutional Expert
Mr. Marc-André Bélanger	GIS and Mapping
Mr. Claude Desjarlais	Climate Change Expert
Ms. Penda Diagne	Modelling Expert
Mr. Raymond Noël	Economic and Financial Analyst
Mr. Michel Tremblay	Water Resource Planning Modeler

Mr. Melaku Mukugeta	Ethiopia Local Partner – Tropics Consulting Engineers Plc
Dr. Mohammed Ali Dingle	Sudan Local Partner – Comatex Nilotica Ltd.
Dr. Tareq Genena	Egypt Local Partner - EcoConServ Environmental Solutions
Mr.Lemma Eschetu	Local Social Expert
Dr. Abebe Getahun	Local Natural System Expert
Mr. Solomon Kebede	Local Water Quality Expert
Dr. Babekar Ibrahem	Local Flood expert
Dr. Atef Saad	Local Irrigation Expert

APPENDICES

Appendix A

Plates

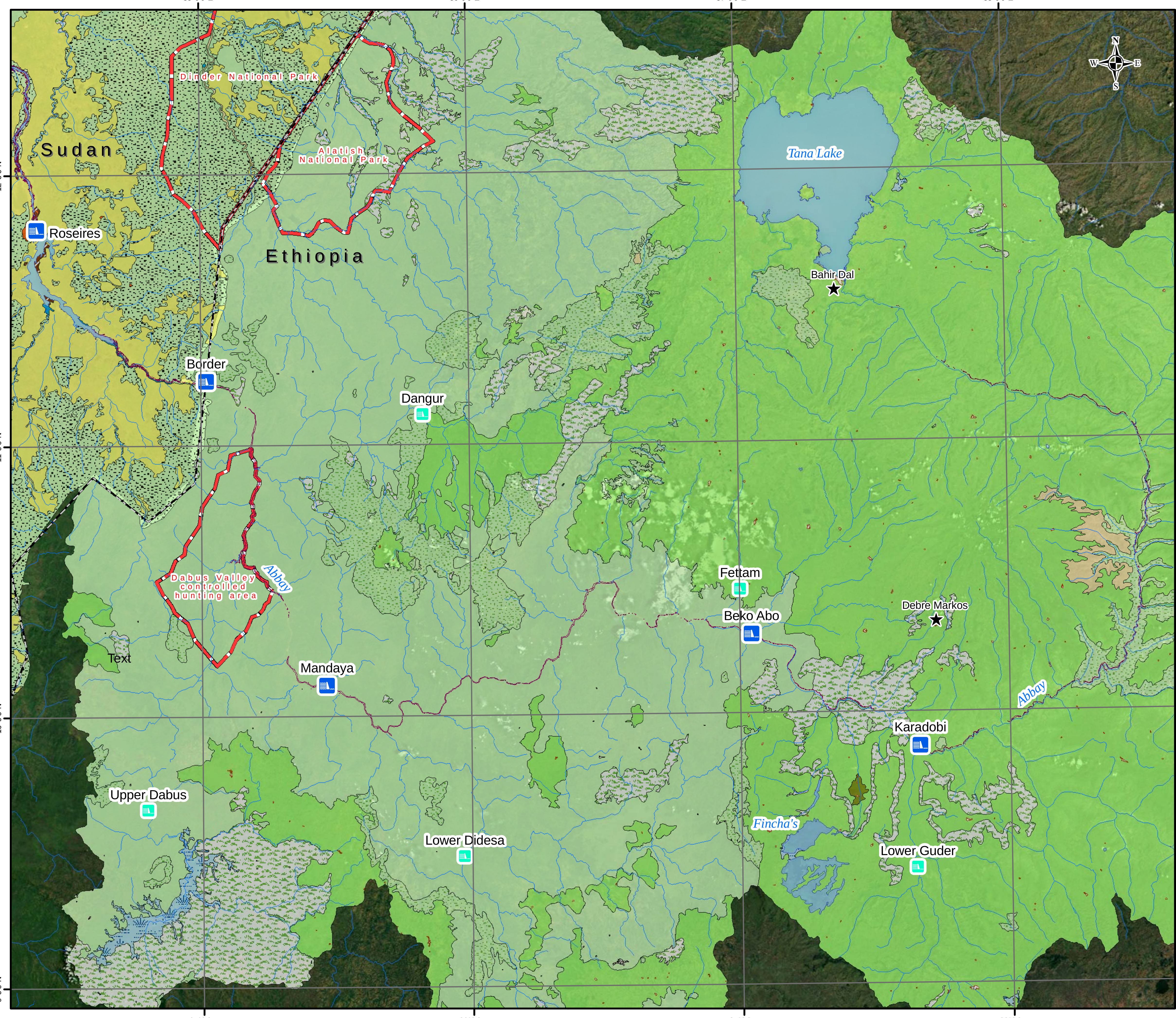


PLATE
1

- Capital Cities
- Selected Populated Places
- Country Boundary
- Lake/Reservoirs and River
- Flood Limits (100 years)
- Dam on Abbay
- Dam on Abbay Tributaries

Landcover

- Rocks and Sand
- Bushland / Shrubland
- Grassland
- Forest and Woodland
- Urban
- Rainfed agriculture
- Irrigated and postflooding herbaceous crops
- Irrigated and postflooding shrub crops, irrigated tree crops, irrigated forest plantations
- Aquatic agriculture
- Aquatic closed to open grass incl. Sparse trees and shrubs (fresh water, permanently and temporarily flooded)
- Aquatic closed to open trees, shrubs and woody vegetation (fresh water, permanently or temporarily flooded)
- Aquatic floating forbs (fresh water, permanently and temporarily flooded) and closed to open herbaceous (brackish water)
- Agriculture / Highlands
- Swamp
- Water body

Source: Copyright:© 2009 ESRI, i-cubed, GeoEye
Land Cover Classification System : Africover
Food and Agriculture Organization of The United Nations for Egypt and Sudan

Project

Consulting Services for Studies on Identification of Projects Constituting the First Joint Multipurpose Program (JMP-1) on Abbay/BLue - Main Nile

Title

Flood Plain and Land Use Tana Lake - Roseires Stretch

Client
Eastern Nile Technical Regional Office

Consultants
SNC·LAVALIN International
HYDROSULT Inc.

Scale
0 5 10 20 km

Project #	Fichier / File
606529	Plate 1_Lands uses_01_LacTana_Roseires.mxd

00	2011/02/18	Preliminary	M.-A. B.	R. Fontaine
No.	yyyy/mm/dd	Description	Drawn	Verified

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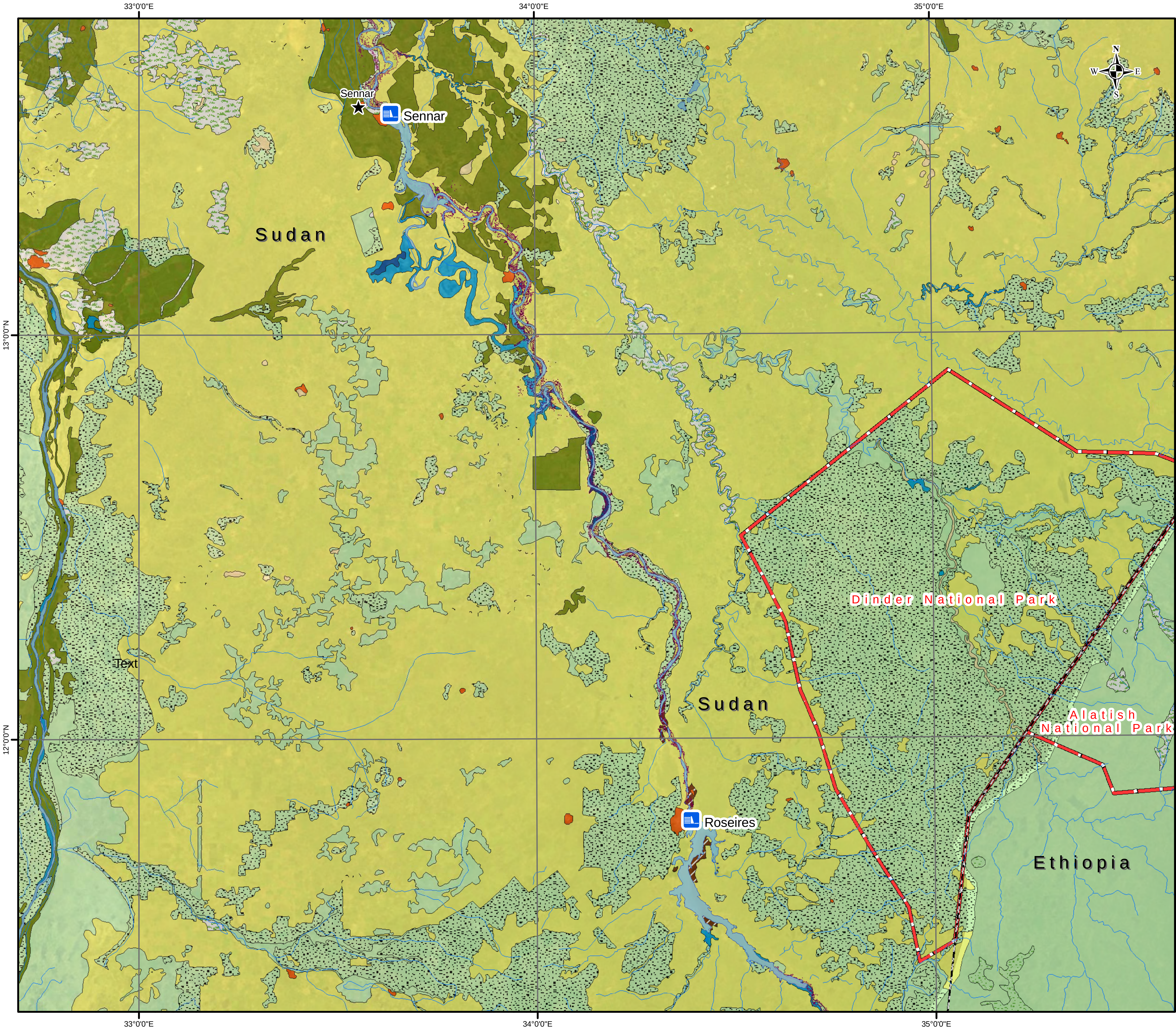

PLATE 2

- Capital Cities
- Selected Populated Places
- Country Boundary
- Lake/Reservoirs and River
- Flood Limits (100 years)
- Dam on Abbay
- Dam on Abbay Tributaries

Landcover

- Rocks and Sand
- Bushland / Shrubland
- Grassland
- Forest and Woodland
- Urban
- Rainfed agriculture
- Irrigated and postflooding herbaceous crops
- Irrigated and postflooding shrub crops, irrigated tree crops, irrigated forest plantations
- Aquatic agriculture
- Aquatic closed to open grass incl. Sparse trees and shrubs (fresh water, permanently and temporarily flooded)
- Aquatic closed to open trees, shrubs and woody vegetation (fresh water, permanently or temporarily flooded)
- Aquatic floating forbs (fresh water, permanently and temporarily flooded) and closed to open herbaceous (brackish water)
- Agriculture / Highlands
- Swamp
- Water body

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Land Cover Classification System : Africover
Food and Agriculture Organization of The United Nations for Egypt and Sudan

Project

Consulting Services for Studies on Identification of Projects Constituting the First Joint Multipurpose Program (JMP-1) on Abbay/BLue - Main Nile

Title

Flood Plain and Land Use Roseires - Sennar Stretch

Client
Eastern Nile Technical Regional Office

Consultants
SNC·LAVALIN International
HYDROSULT Inc.

Scale
0 5 10 20 km

Project #	Fichier / File
606529	Plate 2_Lands uses_02_Roseires_Sennar.mxd

No.	yyyy/mm/dd	Description	Drawn	Verified
00	2011/02/18	Preliminary	M.-A. B.	R. Fontaine

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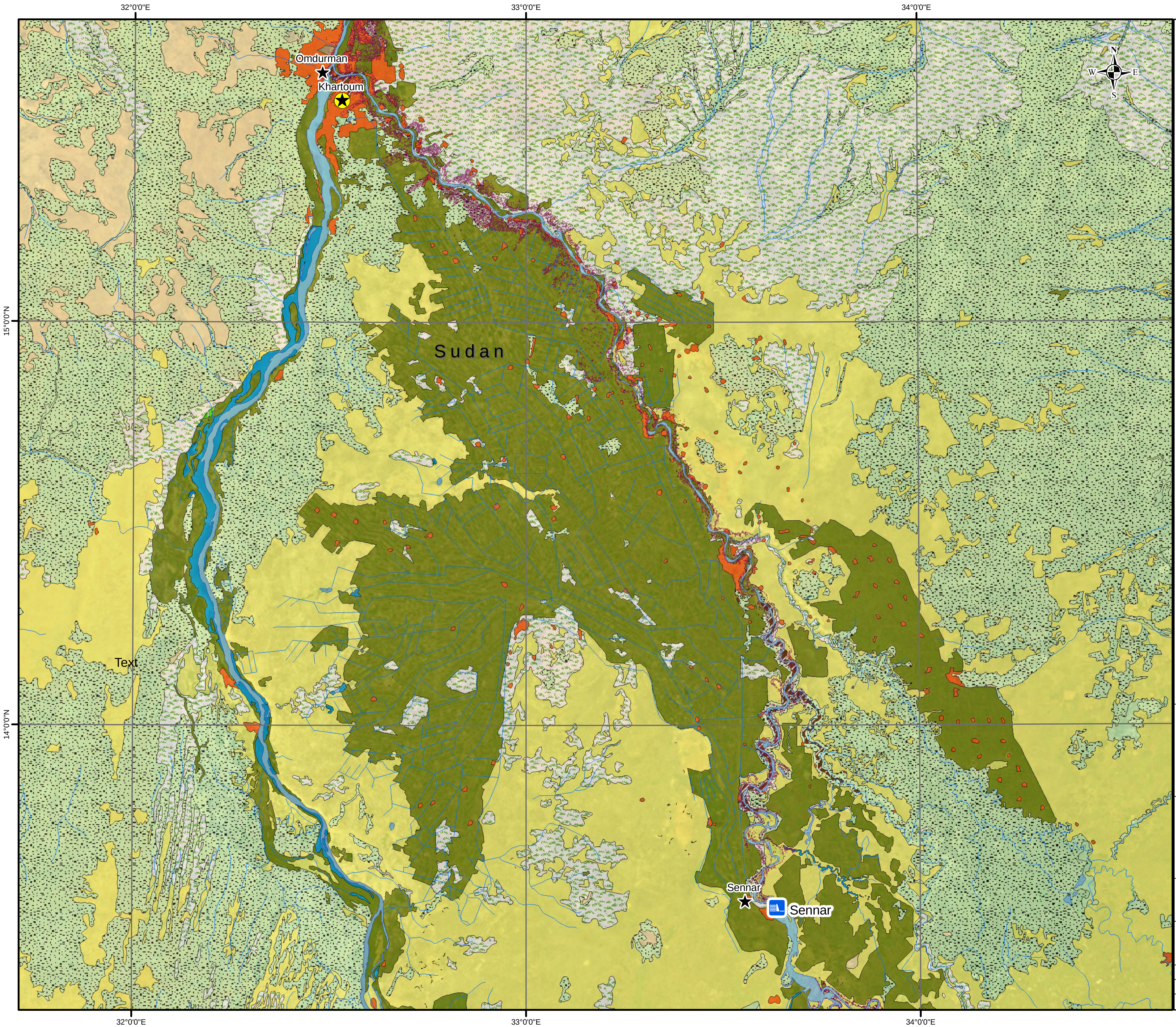
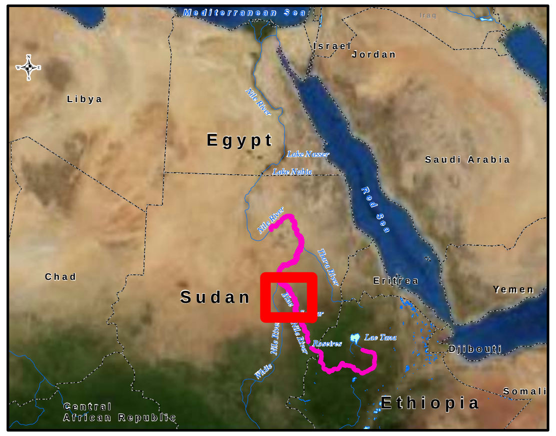
PLATE
3



- Capital Cities
- Selected Populated Places
- Country Boundary
- Lake/Reservoirs and River
- Flood Limits (100 years)
- Dam on Abbay
- Dam on Abbay Tributaries

Landcover

- Rocks and Sand
- Bushland / Shrubland
- Grassland
- Forest and Woodland
- Urban
- Rainfed agriculture
- Irrigated and postflooding herbaceous crops
- Irrigated and postflooding shrub crops, irrigated tree crops, irrigated forest plantations
- Aquatic agriculture
- Aquatic closed to open grass incl. Sparse trees and shrubs (fresh water, permanently and temporarily flooded)
- Aquatic closed to open trees, shrubs and woody vegetation (fresh water, permanently or temporarily flooded)
- Aquatic floating forbs (fresh water, permanently and temporarily flooded) and closed to open herbaceous (brackish water)
- Agriculture / Highlands
- Swamp
- Water body



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Land Cover Classification System : Africover
Food and Agriculture Organization of The United Nations for Egypt and Sudan

Project

Consulting Services for Studies on Identification of Projects Constituting the First Joint Multipurpose Program (JMP-1) on Abbay/BLue - Main Nile

Title

Flood Plain and Land Use Sennar - Khartoum Stretch

Client

Eastern Nile Technical Regional Office

Consultants

SNC·LAVALIN International
HYDROSULT Inc.

Scale

0 5 10 20 km

Project #	Fichier / File
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00	2011/02/18	Preliminary	M.-A. B.	R. Fontaine
No.	yyyy/mm/dd	Description	Drawn	Verified

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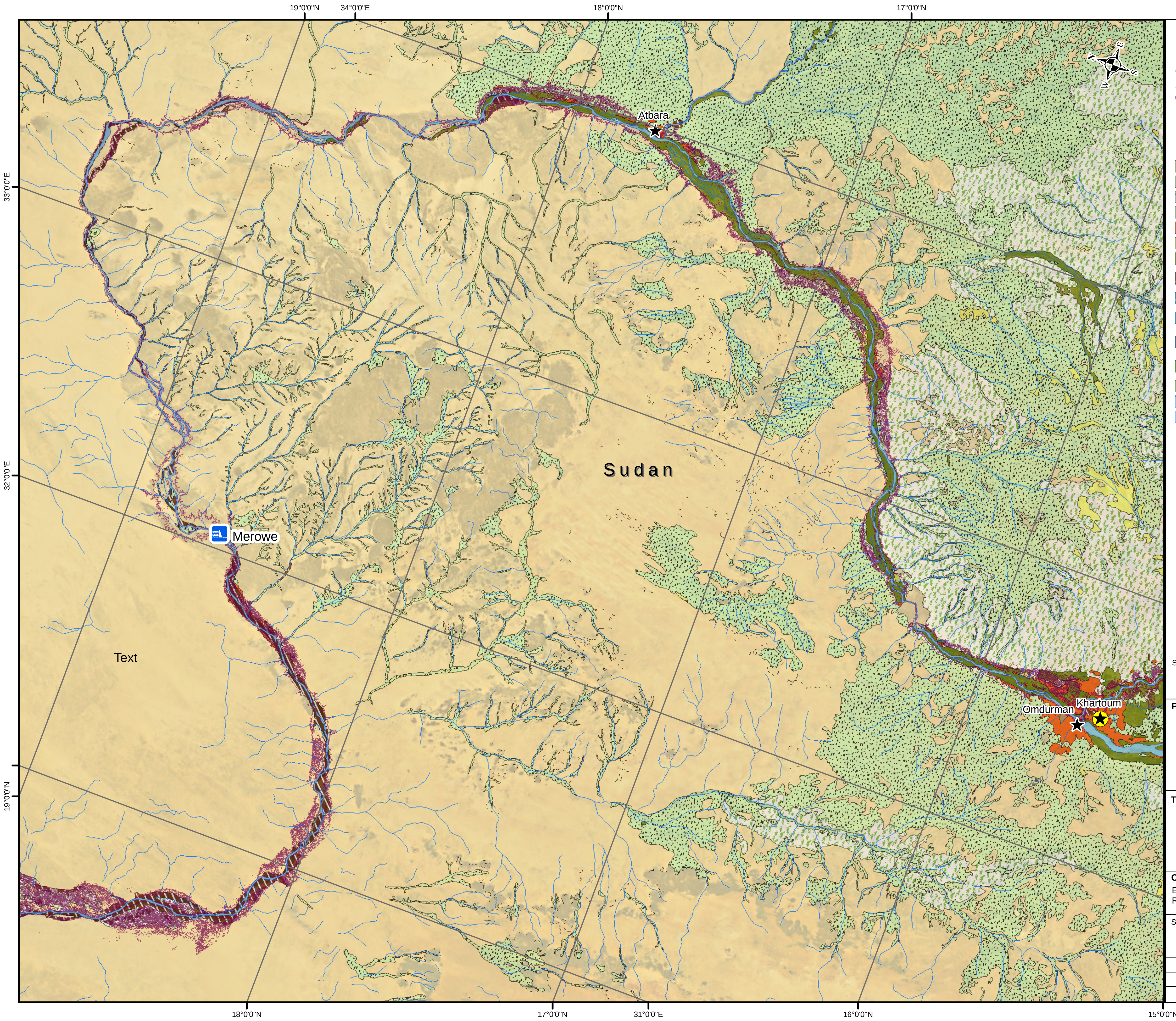

PLATE 4

- Capital Cities
- Selected Populated Places
- Country Boundary
- Lake/Reservoirs and River
- Flood Limits (100 years)
- Dam on Abbay
- Dam on Abbay Tributaries

Landcover

- Rocks and Sand
- Bushland / Shrubland
- Grassland
- Forest and Woodland
- Urban
- Rainfed agriculture
- Irrigated and postflooding herbaceous crops
- Irrigated and postflooding shrub crops, irrigated tree crops, irrigated forest plantations
- Aquatic agriculture
- Aquatic closed to open grass incl. Sparse trees and shrubs (fresh water, permanently and temporarily flooded)
- Aquatic closed to open trees, shrubs and woody vegetation (fresh water, permanently or temporarily flooded)
- Aquatic floating forbs (fresh water, permanently and temporarily flooded) and closed to open herbaceous (brackish water)
- Agriculture / Highlands
- Swamp
- Water body

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Land Cover Classification System : Africover
Food and Agriculture Organization of The United Nations for Egypt and Sudan

Project

Consulting Services for Studies on Identification of Projects Constituting the First Joint Multipurpose Program (JMP-1) on Abbay/BLue - Main Nile

Title

Flood Plain and Land Use Khartoum - Merowe Stretch

Client
Eastern Nile Technical Regional Office

Consultants
SNC·LAVALIN International
HYDROSULT Inc.

Scale
0 5 10 20 km

Project #	Fichier / File
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No.	yyyy/mm/dd	Description	Drawn	Verified

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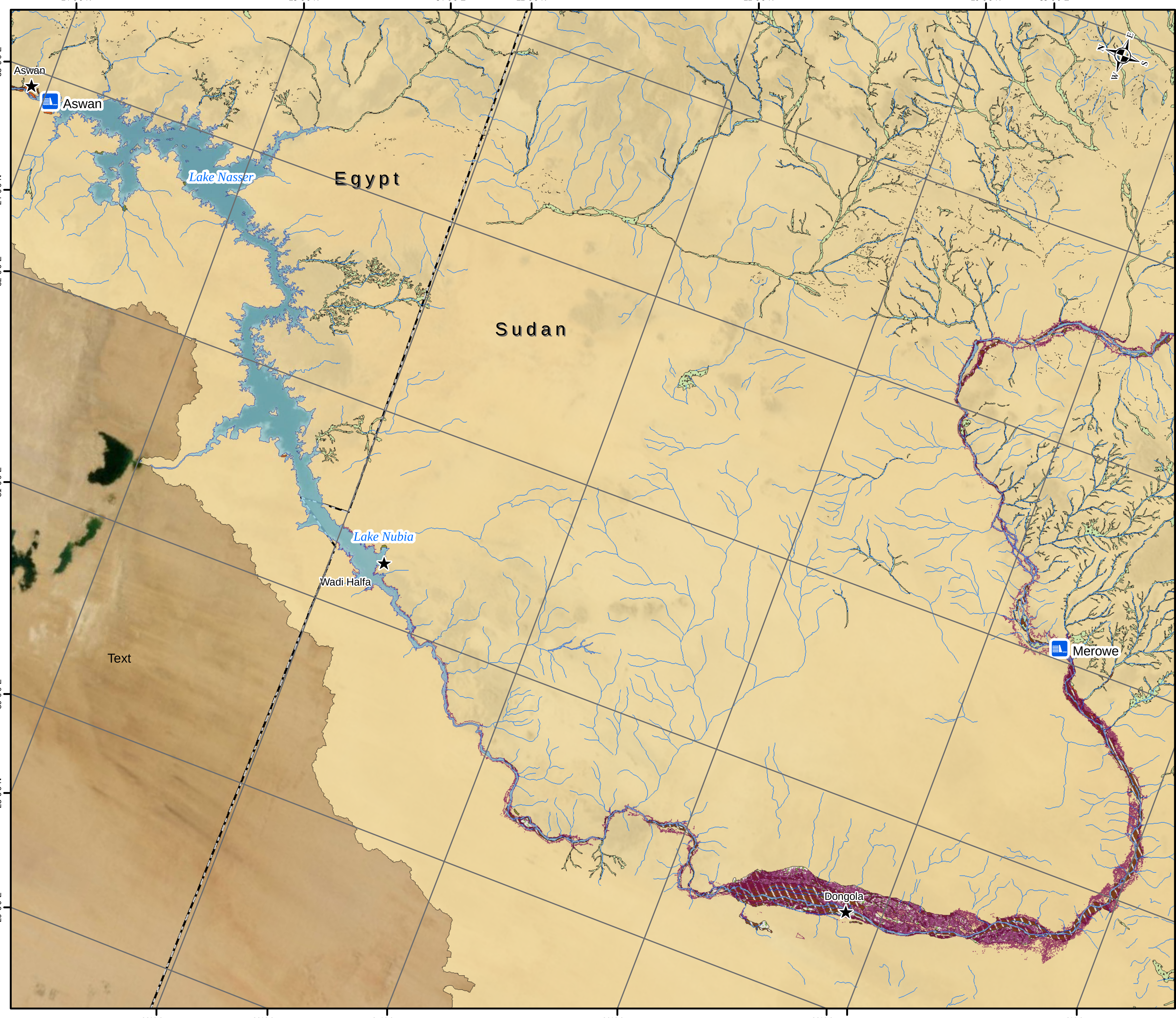
PLATE
5



Capital Cities
Selected Populated Places
Country Boundary
Lake/Reservoirs and River
Flood Limits (100 years)
Dam on Abbay
Dam on Abbay Tributaries

Landcover

Rocks and Sand
Bushland / Shrubland
Grassland
Forest and Woodland
Urban
Rainfed agriculture
Irrigated and postflooding herbaceous crops
Irrigated and postflooding shrub crops, irrigated tree crops, irrigated forest plantations
Aquatic agriculture
Aquatic closed to open grass incl. Sparse trees and shrubs (fresh water, permanently and temporarily flooded)
Aquatic closed to open trees, shrubs and woody vegetation (fresh water, permanently or temporarily flooded)
Aquatic floating forbs (fresh water, permanently and temporarily flooded) and closed to open herbaceous (brackish water)
Agriculture / Highlands
Swamp
Water body

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Land Cover Classification System : Africover
Food and Agriculture Organization of The United Nations for Egypt and Sudan

Project

Consulting Services for Studies on Identification of Projects Constituting the First Joint Multipurpose Program (JMP-1) on Abbay/BLue - Main Nile

Title

Flood Plain and Land Use Merowe - Aswan Stretch

Client

Eastern Nile Technical Regional Office

Consultants

SNC·LAVALIN International
HYDROSULT Inc.

Scale

0 5 10 20 km

Project #	Fichier / File
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00	2011/02/18	Preliminary	M.-A. B.	R. Fontaine
No.	yyyy/mm/dd	Description	Drawn	Verified

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Appendix B

List of Organizations and Experts Consulted

Appendix B - List of Organizations and Experts Consulted

Name	Position	Organization	Date of Contact	Information requested
Abate, Solomon	RPC Watershed Management	ENTRO	June 24	Conduct needs assessment: Prior watershed management information, especially the CRA
Abdal Abdelsalam, Ahmed	Director General Water Resources	UNESCO Chain in Water Resources, Khartoum, Sudan	June	Interview regarding Institutional Assessment, no follow on information requests were made
Abebe, Michael + ENTRO Social Team	JMP-1 Coordinator	ENTRO	June 15 June 29 July 01	Conduct needs assessment Debriefing on majors findings; Preliminary analysis
Abou Elseoud, Ahmed	First Deputy Minister, Head of Regional Sector	Egyptian Environmental Affair Agency, State Ministry of Environment, Egypt	July	Interview regarding Institutional Assessment, no follow on information requests were made
Ali, Hassen	Assistant FAO Representative in Ethiopia	FAO		Information on FAO programmes
Amasala, Ahmed	Professor of Water Resources, Civil Engineer	MIWR, Sudan	June	Interview regarding Institutional Assessment, no follow on information requests were made
Atinafe, Teshome	Irrigation & Drainage Directorate	Ministry of Water Resources (Ethiopia)	June 14	Conduct needs assessment
Bahm, Andrea	Programme Director	GTZ		General discussion GTZ programme in watershed management
Bebars, Reda	Assistant Minister of Foreign Affairs for Nile Basin Country Affairs	Ministry of Foreign Affairs Egypt	July 2010 July	Role within JMP Critical institutions to JMP Needs to improve the capacity of these institutions for support of JMP? Challenge to successful implementation of JMP? Financing, developing, and operating JMP Interview regarding Institutional Assessment,
Belete, Alehgne	Watershed Management Coordinator	BoARD, Amhara Region		Watershed management programmes in Amhara Region
Betru	MERET coordinator	MERET (MoARD)		Current status of MERET programme
Beyene, Teferra	Head Boundary & Transboundary River Affairs Dept.	Boundary & Transboundary River Affairs Dept. Ministry of Water Resources, Ethiopia	July	Interview regarding Institutional Assessment, no follow on information requests were made

Name	Position	Organization	Date of Contact	Information requested
Burke, Eileen		World Bank	June	Interview regarding Institutional Assessment, no follow on information requests were made
Danano, Daniel	SLM Coordinator	MoARD		Current status of SLM programme
Desta, Lakew	Capacity Building & Networking Advisor,	Tana Beles project (Finnish Aid)		Information on the Tana-Beles watershed management project
Dwumfour, Edward	Senior Environmental Specialist	World Bank		Status of SLM programme
El Den, Ekhlas Gamal	Head of Central Dept for Water Quality	EEAA	July 5, 2010	Role within JMP Critical institutions to JMP Needs to improve the capacity of these institutions for support of JMP? Challenge to successful implementation of JMP? Financing, developing, and operating JMP
El-Den, Eklas Gamal	Head of Central Dept. for Water Quality	EEAA, State Ministry of Environment, Egypt	July	Interview regarding Institutional Assessment, no follow on information requests were made
El Zawhry, Alaa	Partner and Manager, Hydraulics and Hydrology Projects	CEEG – Civil Engineering Group Consultants, Egypt	July	Interview regarding Institutional Assessment, no follow on information requests were made
Elmuntasir I. Ahmed, Mohamed	Environmental Management Specialist	ENTRO	June 24	Conduct needs assessment
El-Seoud, Ahmed		EEAA	July 4,2010	Role within JMP Critical institutions to JMP Needs to improve the capacity of these institutions for support of JMP? Challenge to successful implementation of JMP? Financing, developing, and operating JMP
Eshetu, Lemma	Sr Socio-Economist & Institutional Specialist	Tropics Consulting	June 15	Conduct needs assessment
Fahmy, Hussam	Director of Drainage Authority	MWRI	July 6, 2010	Role within JMP Critical institutions to JMP Needs to improve the capacity of these institutions for support of JMP? Challenge to successful implementation of JMP? Financing, developing, and

Name	Position	Organization	Date of Contact	Information requested
				operating JMP Interview regarding Institutional Assessment,
Faki	River Basins Management Coordinator	MoWR		Current status of Abbay River Basin Authority
Fattah Metawie, Abdel	Chairman Nile Water Sector	Nile Water Sector, Ministry of Water Resources and Irrigation, Egypt	July 6, 2010	Role within JMP Critical institutions to JMP Needs to improve the capacity of these institutions for support of JMP? Challenge to successful implementation of JMP? Financing, developing, and operating JMP Interview regarding Institutional Assessment,
Fekadu, Wubalem; Gebreyes, Million Abdelrahman, Hisham	Social Development & Communication Officer; SDCO; Communication Officer	ENTRO – Social Team	June 23	Knowledge Sharing Activities – Methodology Presentation and Scope of Works Agreement on scope of works and target groups
Fock, Achim	Senior Economist	World Bank		Information on Rural Capacity and Agricultural Growth programmes
Fulss, Richard	GIS specialist	GTZ		GIS information available
Hailu, Zerfu	Deputy Programme Manager	GTZ Bahir Dar		GTX watershed management programmes in Amhara Region
Honeli, Legatu	Community Facilitator, Tana-Beles Watershed Project	BoARD Amhara Region		Information on the Tana-Beles watershed management project
Kabede, Icho	Programme Director, SARDP	SIDA, Bahir Dar		Status of SIDA watershed management progammes
Kebede, Mikitu	Manager, Tana-Beles Watershed Project	BoARD Amhara Region		Information on the Tana-Beles watershed management project
Mashinkila, George	Agricultural Economist	FAO		Information on FAO programmes
Matu, Ala		EEPCO	June	Interview regarding Institutional Assessment, no follow on information requests were made
Mebrahtu, Tesfaye	Deputy Director	GTZ		Detailed information on GTZ watershed management programme

Name	Position	Organization	Date of Contact	Information requested
Megash, Fekahmed	Director – Basin Division and Implementation Supervision	Ministry of Water Resources, Ethiopia	June	Interview regarding Institutional Assessment, no follow on information requests were made
Mill, Ernst	Regional Programme Manager	GTZ Bahir Dar		GTX watershed management programmes in Amhara Region
Miller, Barbara		World Bank		Interview regarding Institutional Assessment, no follow on information requests were made
Mulugeta, Melaku	Managing Director	Tropics Consulting	June 15	Conduct needs assessment
Nigussie, Ayalew	RPC – Irrigation & Drainage	ENTRO	June 23	Conduct needs assessment
Pohjonen, Veli	Technical Advisor, M&E,	Tana Beles project (Finnish Aid)		Information on the Tana-Beles watershed management project
Sharma, Dev N.	Team Leader,	SWHISA project (CIDA)		Watershed management on SWHISA project
Siddig Eissa, Ahmed	General Manager	Gezira Scheme, Sudan	June	Interview regarding Institutional Assessment, no follow on information requests were made
Tadesse, Mulugeta	Floodplain Specialist	ENTRO	June 24	Conduct needs assessment
Taffesse, Alemeyehu	Watershed Management Coordinator	MoWR		MoWR programmes in watershed management
Taifour, Habib A.	Operations Analyst	World Bank		Status of Tana Beles watershed management project
Thiombiano, Lamourdia	Senior Soils Resources Officer	FAO		Information on FAO programmes
Yusseff, Sala	State Minister of Irrigation and Water Resources	Ministry of Irrigation and Water Resources, Sudan	June	Interview regarding Institutional Assessment, no follow on information requests were made

Appendix C

Individual Country Generation Expansion Plans

Appendix C - Individual Country Generation Expansion Plans

TABLE OF CONTENTS

LIST OF TABLES

1. GENERATION EXPANSION PLANS

Generation expansion plans have been assessed in order to compare the impact on overall power development between the three development alternatives. This is discussed in Chapter 5 of this report. The information on generation plans is derived from various sources, but primarily from the Final Report for the "Eastern Nile Power Trade Program Study" by EdF-Scott Wilson (2007). This report presents energy sector profiles and projections for Egypt, Ethiopia and Sudan. All information provided in the tables presented in the following section is developed by the consultant and may require revision as the work progresses.

1.1 EGYPT

Generation expansion plans for Egypt to 2030 were developed by the consultant adapted from the Power Trade study. Table 1.1 is the baseline plan for Egypt. Table 1.2 shows the generation expansion plan accounting for JMP with large dams on the Abbay. The values in red in the table are assumed by the consultant in an attempt to complete the table to 2030 for sake of comparison with other generation expansion plans. Such figures will need to be revised as the work progresses.

Table 1.1 Adapted Baseline Generation Expansion Plan for Egypt

Year			Peak Load MW	Capacity MW	Reserve Margin	Additions		
						Name	Type	MW
2006	-	07	18,435	20,563	12%			
2007	-	08	19,646	22,213	13%			
2008	-	09	20,921	24,552	17%	Sidi Krir	CCGT	500
						Kurimat 3	CCGT	500
						Nobaria	CCGT	500
						Atle	CCGT	500
						Kurimat	Solar	150
						New Naga Hamadi	Hydro	64
						Zafarana	Wind	125
2009	-	10	22,259	26,382	19%	Sidi Krir	CCGT	250
						Kurimat 3	CCGT	250
						Nobaria	CCGT	250
						Atle	CCGT	250
						Tebbin	Steam	700
						Zafarana	Wind	130
2010	-	11	23,658	27,905	18%	Abu Qir	Steam	650
						Cairo West Ext.	Steam	700
						Damietta	Hydro	13
						Zafarana	Wind	160
2011	-	12	*25,062*	29,861	-100%	Sharm El-Sheik	CCGT	750
						Abu Qir	Steam	650
						Ayoun Musa Ext.	Steam	350
						Zefta	Hydro	5.5
						Zafarana	Wind	200
2012	-	13	*26,550*	31,851	-100%	Suez	Steam	450
						Steam	Steam	1300
						Assiut	Hydro	40
						Zafarana	Wind	200
2013	-	14	*28,126*	34,401	-100%	Alexandria East	CCGT	500
						Combined Cycle	CCGT	500
						Steam	Steam	1350
						Zafarana	Wind	200

Year			Peak Load MW	Capacity MW	Reserve Margin	Additions		
						Name	Type	MW
2014	-	15	*29,795*	36,701	-100%	Alexandria East	CCGT	500
						Combined Cycle	CCGT	500
						Steam	Steam	450
						Steam	Steam	650
						Zafarana	Wind	200
2015	-	16	31,564	38,851	23%	Alexandria East	CCGT	500
						Steam	Steam	450
						Dabaa Nuclear	Nuclear	1000
						Zafarana	Wind	200
2016	-	17	*33,253*	41,151	*24%*	Combined Cycle	CCGT	500
						Steam	Steam	1300
						Borg El-Arab	Solar	300
						Zafarana	Wind	200
2017	-	18	*35,033*	43,601	*24%*	Combined Cycle	CCGT	500
						Steam	Steam	450
						Steam	Steam	1300
						Zafarana	Wind	200
2018	-	19	*36,907*	46,351	*26%*	Combined Cycle	CCGT	500
						Steam	Steam	450
						Steam	Steam	1300
						Borg El-Arab	Solar	300
						Zafarana	Wind	200
2019	-	20	*38,882*	48,851	*26%*	Combined Cycle	CCGT	1000
						Steam	Steam	1300
						Zafarana	Wind	200
2020	-	21	40,963	51,201	25%	Combined Cycle	CCGT	500
						Steam	Steam	650
						Dabaa Nuclear	Nuclear	1000
						Zafarana	Wind	200
2021	-	22	*42,959*	53,851	*25%*	Combined Cycle	CCGT	500
						Steam	Steam	1950
						Zafarana	Wind	200
2022	-	23	*45,052*	56,451	*25%*	Combined Cycle	CCGT	500
						Steam	Steam	450
						Steam	Steam	650
						Dabaa Nuclear	Nuclear	1000
2023	-	24	*47,248*	59,151	*25%*	Combined Cycle	CCGT	500
						Steam	Steam	900
						Steam	Steam	1300
2024	-	25	49,550	61,551	*24%*	Combined Cycle	CCGT	500
						Steam	Steam	900
						Dabaa Nuclear	Nuclear	1000
2025	-	26	51,823	64,201	*24%*	Steam	Steam	1350
						Steam	Steam	1300
2026	-	27	54,200	66,951	*24%*	Steam	Steam	450
						Steam	Steam	1300
						Dabaa Nuclear	Nuclear	1000

Year			Peak Load MW	Capacity MW	Reserve Margin	Additions		
						Name	Type	MW
2027	-	28	*56,686*	69,701	*23%*	*Steam*	*Steam*	*450*
						Steam	*Steam*	*1300*
						Dabaa Nuclear	*Nuclear*	*1000*
2028	-	29	*59,286*	72,451	*22%*	*Steam*	*Steam*	*450*
						Steam	*Steam*	*1300*
						Dabaa Nuclear	*Nuclear*	*1000*
2029	-	30	*62,006*	75,201	*21%*	*Steam*	*Steam*	*450*
						Steam	*Steam*	*1300*
						Dabaa Nuclear	*Nuclear*	*1000*
2030	-	31	*64,850*	77,951	*20%*	*Steam*	*Steam*	*450*
						Steam	*Steam*	*1300*
						Dabaa Nuclear	*Nuclear*	*1000*

Note: Figures in red are assumed by the consultant for the purpose of comparative analysis.

Table 1.2 Adapted Generation Expansion Plan for Egypt With Large Dams on the Abbay

Year			Peak Load MW	Capacity MW	Reserve Margin	Additions		
						Name	Type	MW
2022	-	23	*45,052*	56,451	*25%*	Combined Cycle	CCGT	500
						Steam	Steam	225
						Steam	Steam	650
						Additional imports from JMP		**225**
						Dabaa Nuclear	Nuclear	1000
2023	-	24	*47,248*	59,151	*25%*	Combined Cycle	CCGT	0
						Additional imports from JMP		**500**
						Steam	Steam	900
						Steam	Steam	1300
2024	-	25	49,550	61,551	*24%*	Combined Cycle	CCGT	500
						Steam	Steam	450
						Additional imports from JMP		**450**
						Dabaa Nuclear	Nuclear	1000
2025	-	26	49,550	64,201	*30%*	Steam	Steam	950
						Additional imports from JMP		**400**
						Steam	Steam	1300
2026	-	27	54,200	66,951	*24%*	Steam	Steam	225
						Additional imports from JMP		**225**
						Steam	Steam	1300
						Dabaa Nuclear	Nuclear	1000
2027	-	28	*54,200*	69,701	*29%*	Steam	Steam	450
						Steam	Steam	1300
						Dabaa Nuclear	Nuclear	1000
2028	-	29	*54,200*	72,451	*34%*	Steam	Steam	450
						Steam	Steam	1300
						Dabaa Nuclear	Nuclear	1000
2029	-	30	*54,200*	75,201	*39%*	Steam	Steam	450
						Steam	Steam	1300
						Dabaa Nuclear	Nuclear	1000
2030	-	31	*54,200*	77,951	*44%*	Steam	Steam	450
						Steam	Steam	1300
						Dabaa Nuclear	Nuclear	1000

Note: Figures in red are assumed by the consultant for the purpose of comparative analysis.
This analysis is from 2022 onward as that is when first power may be available.

1.2 SUDAN

The generation expansion plan for Sudan to 2030 was developed by the consultant adapted from the Power Trade study. The baseline is shown in Table 1.3. Table 1.4 shows the generation expansion plan accounting for large dams on the Abbay. Some values in the table are assumed by the consultant in an attempt to complete the table to 2030 for sake of comparison with other generation expansion plans. Such figures will need to be revised as the work progresses.

Table 1.3 Adapted Baseline Power Generation Expansion Plan for Sudan

Year	Peak Load (MW)	Capacity (MW)	Reserve Margin	Additions	
				Name/Type	MW
2006	1,223	871	-29%		
2007	1,927	1,187	-38%		
2008	2,577	1,627	-37%	Not stated	250
				Retirement/committed	190
2009	3,396	4,121	21%	Thermal	82
				Retirement/committed	2412
2010	4,179	5,274	26%	Thermal	0
				Hydro	0
				Retirement/committed	1153
2011	4,478	5,762	29%	Thermal	286
				Rumela	30
				Retirement/committed	172
2012	4,969	6,302	27%	Thermal	380
				Hydro	
				Retirement/committed	160
2013	5,322	6,617	24%	Thermal	0
				Shereiq	315
				Retirement/committed	
2014	5,843	6,855	17%	Thermal	208
				Hydro	
				Retirement/committed	30
2015	6,244	7,486	20%	Thermal	380
				Low Dal	340
				Retirement/committed	-89
2016	6,629	7,786	17%	Thermal	0
				Kajbar	300
				Retirement/committed	
2017	7,029	8,232	17%	Thermal	446
				Hydro	
				Retirement/committed	
2018	7,456	8,612	16%	Thermal	380
				Hydro	
				Retirement/committed	
2019	7,868	9,343	19%	Thermal	446
				Dagash	285
				Retirement/committed	
2020	8,995	11,114	24%	Thermal	950
				Fula I	720
				Retirement/committed	101
2021	9,449	11,684	24%	Thermal	570
				Hydro	
				Retirement/committed	
2022	9,898	11,894	20%	Thermal	0
				Shukoli	210
				Retirement/committed	
2023	10,337	12,134	17%	Thermal	342
				Hydro	0
				Retirement/committed	-102

Year	Peak Load (MW)	Capacity (MW)	Reserve Margin	Additions	
				Name/Type	MW
2024	10,786	12,404	15%	Thermal	60
				Lakki	210
				Retirement/committed	
2025	11,205	12,879	15%	Thermal	475
				Hydro	0
				Retirement/committed	
2026	11,704	13,621	16%	Thermal	342
				Bedden	400
				Retirement/committed	
2027	12,231	14,875	22%	Thermal	1254
				Hydro	
				Retirement/committed	
2028	12,756	15,623	22%	Thermal	912
				Hydro	
				Retirement/committed	-164
2029	13,315	16,535	24%	Thermal	912
				Hydro	0
				Retirement/committed	
2030	13,886	16,535	19%	Thermal	0
				Hydro	0
				Retirement/committed	

Table 1.4 Adapted Power Generation Expansion Plan for Sudan Accounting for Large Dams on the Abbay

Year	Peak Load MW	Capacity MW	Reserve Margin	Additions	
				Name/Type	MW
2022	9,898	11,894	20%	Thermal	0
				Shukoli	210
				Retirement/committed	0
2023	10,337	12,134	17%	Thermal	172
				Additional imports from JMP	170
				Retirement/committed	-102
2024	10,786	12,404	15%	Additional imports from JMP	60
				Lakki	210
				Retirement/committed	0
2025	11,205	12,879	15%	Thermal	475
				Hydro	0
				Retirement/committed	0
2026	11,704	13,621	16%	Additional imports from JMP	342
				Bedden	400
				Retirement/committed	0
2027	12,231	14,875	22%	Thermal	1154
				Additional imports from JMP	100
				Retirement/committed	0
2028	12,756	15,623	22%	Thermal	812
				Additional imports from JMP	100
				Retirement/committed	-164
2029	13,315	16,535	24%	Thermal	912
				Hydro	0
				Retirement/committed	0
2030	13,886	16,535	19%	Thermal	0
				Hydro	0
				Retirement/committed	0

1.3 ETHIOPIA

The generation expansion plan for Ethiopia to 2030 was developed by the consultant. It was adapted from various sources, including the Power Trade study, and is shown in Table 1.5. This is the generation capacity with no developments on the Abbay River. Without JMP1, Ethiopia would prioritize other rivers for their power generation. Table 1.6 shows the adapted expansion plan accounting for Large Dams JMP1 and Table 1.7 adapted for Dams on Abbay tributaries.

Table 1.5 Adapted Power Generation Expansion Plan for Ethiopia

Year	Peak Load – MW			Capacity MW	Reserve Margin	Additions	
	Internal	Exports	Total			Name/Type	MW
2007				733			
2008	826		826	808	-2%	Tekeze 1	75
2009	967	21	988	1913	98%	Gilgel Gibe II	420
						Tekeze (3 units)	225
						Beles	460
2010	1125	245	1370	2008	78%	Neshe	95
2011	1266	447	1713	2944	133%	Gibe III Phase 1	900
						Wind	36
2012	1418	*497*	1915	4154	193%	Gibe III Phase 2	900
						Chemoga Yeda I	118
						Chemoga Yeda II	162
						Aluto Langano Geothermal	30
2013	*1580*	*547*	2127	4790.5	203%	Halele	96
						Werabesa	326
						Geba I	214.5
2014	1765	*597*	2362	5205.5	195%	Genale Dawa III	258
						Geba II	157
2015	1967	653	2620	6677.5	239%	Gibe IV	1472
2016	*2130*	*693*	2823	6677.5	213%		
2017	*2300*	*733*	3033	6677.5	190%		
2018	*2490*	*773*	3263	6677.5	168%		
2019	*2690*	*813*	3503	7337.5	173%	*Gibe V*	*660*
2020	*2910*	853	3763	7337.5	152%		
2021	*3150*	*913*	4063	7337.5	133%		
2022	*3410*	*973*	4383	7337.5	115%		
2023	*3690*	*1033*	4723	7743.5	110%	*Genale Dawa VI*	*256*
						Gojeb	*150*
2024	*3990*	*1093*	5083	8453.5	112%	*Baro I*	*200*
						Baro II	*510*
2025	*4320*	*1153*	5473	8453.5	96%		
2026	*4670*	*1213*	5883	9107.5	95%	*Genji + Aleltu E*	*210*
						Aleltu West	*189*
						Tekeze II	*255*
2027	*5050*	*1273*	6323	10007.5	98%	*Unknown #1*	*900*
2028	*5460*	*1333*	6793	10507.5	92%	*Unknown #2*	*500*
2029	*5910*	*1393*	7303	11257.5	90%	*Unknown #3*	*750*
2030	6400	1453	7853	12257.5	92%	*Unknown #4*	*1000*

Notes: Figures in red italics are added by SNC-Lavalin/Hydrosult.
Unknown plants are assumed as new plants on rivers other than the Abbay River that have not yet been identified.
All power generation projects are hydro except where specified.

Table 1.6 Ethiopia Expansion Plan Accounting for Large Dams on the Abbay

Year	Peak Load - MW			Capacity	Reserve	Additions	
	Internal	Exports	Total	MW	Margin	Name/Type	MW
2006	-	-	-	-	0%	0	0
2007	-	-	-	733	0%	0	0
2008	826	-	826	808	-2%	Tekeze 1	75
2009	967	21	988	1,913	98%	Gilgel Gibe II	420
						Tekeze (3 units)	225
						Beles	460
2010	1,125	245	1,370	2,008	78%	Neshe	95
2011	1,266	447	1,713	2,944	133%	Gibe III Phase 1	900
						Wind	36
2012	1,418	497	1,915	4,154	193%	Gibe III Phase 2	900
						Chemoga Yeda I	118
						Chemoga Yeda II	162
						Aluto Langano	30
2013	1,580	547	2,127	4,791	203%	Halele	96
						Werabesa	326
						Geba I	214.5
2014	1,765	597	2,362	5,206	195%	Genale Dawa III	258
						Geba II	157
2015	1,967	653	2,620	6,678	239%	Gibe IV	1472
2016	2,130	693	2,823	6,678	213%		
2017	2,300	733	3,033	6,678	190%		
2018	2,490	773	3,263	6,678	168%		
2019	2,690	813	3,503	6,678	148%		
2020	2,910	853	3,763	6,678	129%		
2021	3,150	913	4,063	6,678	112%		
2022	3,410	973	4,383	7,353	116%	Advance Beko Abo	675
2023	3,690	1,033	4,723	7,683	108%	Part of Mandaya 1/2	330
2024	3,990	1,093	5,083	8,173	105%	Part of Mandaya 2/2	490
2025	4,320	1,153	5,473	8,573	98%	Part of Karadobi I/2	400
2026	4,670	1,213	5,883	9,466	103%	Part of Karadobi 2/2	233
						Gibe V	660
2027	5,050	1,273	6,323	10,222	102%	Part of Border 1/2	500
						Genala DawaVI	256
2028	5,460	1,333	6,793	11,582	112%	Part of Border 2/2	500
						Gojeb + Baro I + Baro II	860
2029	5,910	1,393	7,303	11,792	100%	Genji + Aleltu East	210
2030	6,400	1,453	7,853	12,236	91%	Aleltu West + Tekeze II	444

Table 1.7 Ethiopia Expansion Plan Accounting for Dams on Abbay Tributaries

Year	Peak Load - MW			Capacity	Reserve	Additions	
	Internal	Exports	Total	MW	Margin	Name/Type	MW
2006	0	0	0	0		0	0
2007	0	0	0	733		0	0
2008	826	0	826	808	-2%	Tekeze 1	75
2009	967	21	988	1913	98%	Gilgel Gibe II	420
						Tekeze (3 units)	225
						Beles	460
2010	1125	245	1370	2008	78%	Neshe	95
2011	1266	447	1713	2944	133%	Gibe III Phase 1	900
						Wind	36
2012	1418	497	1915	4154	193%	Gibe III Phase 2	900
						Chemoga Yeda I	118
						Chemoga Yeda II	162
						Aluto Langano	30
2013	1580	547	2127	4790.5	203%	Halele	96
						Werabesa	326
						Geba I	214.5
2014	1765	597	2362	5205.5	195%	Genale Dawa III	258
						Geba II	157
2015	1967	653	2620	6677.5	239%	Gibe IV	1472
2016	2130	693	2823	6677.5	213%		
2017	2300	733	3033	6677.5	190%		
2018	2490	773	3263	6677.5	168%		
2019	2690	813	3503	6677.5	148%		
2020	2910	853	3763	6677.5	129%		
2021	3150	913	4063	6677.5	112%		
2022	3410	973	4383	6677.5	96%		
2023	3690	1033	4723	7083.5	92%	Genale Dawa VI	256
						Gojeb	150
2024	3990	1093	5083	7565.5	90%	Baro I	200
						Beles Dangur	104
						Fettam	126
						Lower Guder	52
2025	4320	1153	5473	8522.5	97%	Baro II	510
						Lower Didessa	295
						Upper Dabus	152
2026	4670	1213	5883	9176.5	96%	Genji + Aleltu E	210
						Aleltu West	189
						Tekeze II	255
2027	5050	1273	6323	9836.5	95%	Gibe V	660
2028	5460	1333	6793	10736.5	97%	Beko Abo	900
2029	5910	1393	7303	11236.5	90%	Unknown #1	500
2030	6400	1453	7853	12236.5	91%	Unknown #3	1000

Note: data in red are derived by the consultant.

Appendix D

Bilateral Agreements

Appendix D - Bilateral Agreements

SAMPLE BILATERAL AGREEMENTS	
Egypt - Ethiopia	
Memorandum of Understanding creating Ethiopia-Egypt Council of Commerce **December 2009**	Bilateral commitment to enhance the trade and investment ties between the two countries, including agriculture, industrial development and trade (protecting and encouraging investments); new agreements were signed (double taxation avoidance; removing obstacles to trade). The agreement includes multiplying the amount of frozen meat and living cattle imported from Ethiopia. This memorandum of understanding was agreed under the terms that include the construction of three medium sized dams on the Eastern Nile Basin to generate electricity for industry as long as it does not affect Egypt's Nile water quota.
Memorandum of Understanding on 20 sectoral points, March 2010	Ethio-Egyptian Joint Ministerial Commission signed cooperation agreements in the areas of agriculture, trade, health, transit of live animals and beef meat, economic development, information science, technology, education, air service, media and communications among others. The agreement increased trade partnership projects with Egyptian investors significantly boosting the economic relations of the two nations and enhancing trade relations of the two countries by encouraging Egyptian investors to Ethiopia.
Ethiopia - Sudan	
Treaty between Britain and Ethiopia in 1902	This was signed on May 15, 1902, between Britain, representing the Sudan, and Ethiopia, to determine the boundary between Ethiopia and the Sudan. It also contained a provision relating to the water of the Nile. Ethiopia agreed, under Article III of the agreement, not to construct or permit construction on the Blue Nile and its tributaries, of any works that would arrest their flow, without the prior agreement of the government of Britain. (Interpretation of the treaty, and translation concerns not fully resolved).
Memorandum of Understanding on General Cooperation, Communications and Transportation, 2003	This agreement builds on prior un-specificed agreements and MoUs between Sudan and Ethiopia, including those on general cooperation, communications and transportation, and specific to power trade agreements.
Memorandum of Understanding on Free Trade Area between Ethiopia and Sudan, 2010	Relations between Ethiopia and Sudan continue to emerge as strong interrelated partnerships. There has been a recent series of Memoranda of Understanding pertaining to economic, social and infrastructure development, diplomatic ties, and measurement standards. The intention is to increase the work toward creation of a "free trade area" between Ethiopia and Sudan (Redi, 2010).
Egypt - Sudan	
Nile water agreement in 1929	This was concluded between Egypt's then Prime Minister Mohammad Mahmud and the British High Commissioner Lord George Lloyd. The agreement took the form of two letters dated May 7, 1929 and a report by the Water Committee, which had been prepared in 1929 and attached thereto. Britain signed the agreement on behalf of Sudan, Uganda and Tanganyika (present Tanzania), the three of which were countries under British occupation. The most prominent stipulations were that: • Without the prior agreement of the Egyptian government, no works, either for irrigation or power generation purposes, and no arrangements of any kind should be attempted affecting the Nile, its tributaries or the lakes

SAMPLE BILATERAL AGREEMENTS	
	where it originates in Sudan, or in the other countries under British occupation. • No works and/or arrangements were allowed that could reduce the amount of water reaching Egypt, change the date on which it was due or lower its levels in any way that would be harmful to Egypt. • Egypt's natural and historical rights to waters of the Nile were protected under the agreement.
Egypt and the Sudan Nile Agreement in 1959 (*Also referred to as the Nile Water Treaty of 1959, or the '59 Agreement*)	Signed by Egypt and Sudan in November 1959, it ensures Egypts right to 48 billion meters^3 of water a year as well as Sudan's right to 4 billion meters^3. The two countries also agreed to the establishment in Egypt of the High Dam and in Sudan of Roseires reservoir on the Blue Nile. The Agreement further provides for the sharing by both countries of the 22 billion cubic meters of water that could have been lost to spill and evaporation had it not been for the establishment of the High Dam (Egypt's share is put at 14.5 billion meters^3 (bringing the country's total quota to 55.5 billion meters^3), Sudan's at 7.5 billion meters^3 (its total quota is 18.5 billion meters^3). Egypt and Sudan moreover agreed to a number of projects which aim at reducing water wasted in Bahr al-Jabal, Bahr al-Zaraf, Bahr al-Ghazal, the Sobat and the White Nile. Any losses from upstream developments would be split 50/50, as would any net gains in water quantity. Under the Agreement, an organization (The Nile Water Authority) was established jointly by Egypt and Sudan to handle Nile water issues, both operate within each country Ministry of Water Resources and Irrigation (Egypt) and Ministry of Irrigation and Water Resources (Sudan). Established the Permanent Joint Technical Commission for Nile Waters (PJTC).
Agreement promoting political and economic integration, 1974	Signed by both Presidents to support integration between countries and enhance trade.
Egyptian Sudan Integration Scheme, 1982	Established: • The Supreme Council for Integration, • The Nile Valley Parliament, and • The Egypt-Sudan Integration Fund.
Multiple Trade Agreements (1993 - 2003	A trade exchange protocol (signed March 1993) An agreement (signed November 2003) whereby Egypt would import frozen meat from Sudan; Agreement on facilitating the purchase of Sudanese camels by Egypt; and, Agreement on the establishment of a free trade zone in Juba.
Joint Projects (ongoing)	A number of joint projects are being implemented in the fields of transport, roads and irrigation. The most important are: • The Coastal Egypt-Sudan Highway. • The Aswan-Wadi-Halfa-Dongola Highway. • Developing and restructuring railroads to facilitate the movement of individuals and commodities. • Extending the electricity grid to north Sudan. • Cooperating in the area of water resources and reviving the Jonglei Canal project. • Clearing the southern part of the River Nile. • Developing Sudan's irrigation and sewage network.

Appendix E

National Institutions and Policies

Issue	Ethiopia	Sudan	Egypt
Water Security	**The Ministry of Water Resources** Water Resource Management Policy. Ministry of Agriculture and Rural Development (MoARD) oversees the Food Security Strategy, but Policy objectives do not address the implications of water rights such as right of access to water, transfer of water rights, etc.	**The Ministry of Irrigation and Water Resources** Protection of Water Security is under Section 187 of the Interim National Constitution: Nile Water Commission, the management of the Nile Waters and transboundary waters and disputes arising from the management of interstate waters between Northern States and any dispute between Northern and Southern States (item no. 31). Also policies pertaining to water security include: Groundwater Act 1997; Water Resources Act 1995; National Water Corporation Act 1995; National Water Policy of 2001.	**The Ministry of Water Resources and Irrigation** The Water Master Plan is updated through the National Water Resources Plan (NWRP) project that protects both water quality and quantity. The high sensitivity and dependence on Nile water in Egypt leads to the Office of the Prime Minister, Cabinet of Ministers, Office of the President and the Ministry of Defence and Military Production to actively monitor developments pertaining to the Nile River.
Access to Water and Livelihoods	**The Ministry of Water Resources** Proclamation No. 197/2000 declares that "All water resources of the country are the common property of the Ethiopian people and the State." Article 43 (1) of the Constitution gives broad right to the peoples of Ethiopia to improved living standards and to sustainable development. This is tied to the Plan for Accelerated and Sustainable Development to End Poverty (PASDEP), and the Water Resource Management Policy in 1999, Water Sector Development Programme (WSDP) to meet Millennium Development Goals, and Guidelines on Irrigation, 2004.	**The Ministry of Irrigation and Water Resources** The 2005 Interim National Constitution (INC) of the Republic of the Sudan aims to address issues of environmental and social justice, wherein Chapter II: Guiding Principles and Directives, Section 11 on Environment and Natural Resources, National Water Policy (2001) Guarantees that the State shall promote, through legislation, sustainable utilisation of natural resources and best practices with respect to their management. Sudan is also in the process of formulating a national poverty reduction strategy under the coordination and leadership of the Ministry of Finance and National Economy, which will pertain to livelihoods.	**The Ministry of Water Resources and Irrigation** Under law No. 12 of 1984, MWRI retains the overall responsibility for the management of all water resources, including available surface water resources of the Nile system (Law 48 for the protection of the Nile and its waterways), irrigation water, drainage water and groundwater. The Water Master Plan is updated through the National Water Resources Plan (NWRP) project that protects both water quality and quantity. A current draft for the 2050 Water Strategy is under development.

Issue	Ethiopia	Sudan	Egypt
Water Quality	**Environmental Protection Authority** By Article 6 of Proclamation. No. 9/1995, for example, the EPA became responsible for protecting the water resources of the country. Environmental Pollution Control Proclamation *No. 300/2002* was issued in 2002 and Guidelines on Ambient Water Quality of Domestic, Agriculture and Industrial Wastes allows sanctions of violations of environmental standards.	**Ministry of Health, Environmental Health Act** (1975) prevents the discharge of harmful substances to human and animal's health into any drinking water source, and possible imprisonment. Criminal Act 1991. Article 70 (1&2) Sudan constitution 2005, provides the right to a safe and hygienic environment. Higher Council for Environment and Natural Resources (HCENR) for POPs.	**The Central Department for Water Quality** Monitoring within the EEAA in coordination with the MWRI as the central institution for water quality management. The main instrument for water quality management is Law 48. National Environmental Action Plan of Egypt 2002/17 (2002).
Hydropower	The **Ministry of Water and Energy of Ethiopia** is a federal organization established to undertake the management of water and energy resources of Ethiopia. This involves development, planning and management of water and energy resources, development of polices, strategies and programs, develop and implement water and energy sector laws and regulations, conduct study and research activities, provide technical support to regional water and energy bureaus and offices and sign international agreements. State Enterprise for power The **Ethiopian Energy and Power Company (EEPCO)** with Water Sector Development Program (2006-2016) Proclamation *No. 300/2002* was issued in 2002, and Guidelines for Hydropower Production, Transmission and Distribution, issued in 2004. EEPCO has its own Environmental Monitoring Unit.	**The Ministry of Energy and Mining (MEM)** is in charge of the energy sector. **The Ministry of Electricity and Dams** (ME) was established in 2009, and owns and operates hydro plants, isolated diesel systems, and thermal and steam plants. Decree 34, September, 2005 charges **MIWR** with Operation of dams for efficiency and effectiveness management and maintenance.	The Decree of 1974 established **the Ministry of Electricity and Energy** with the goal of providing electric energy for all consumers over the country. Hence, it coordinates with the MWRI regarding hydropower generation. The MoEE also operates thermal plants that draw water from the Nile for cooling purposes. **The Ministry of Water Resources and Irrigation** has the Public Authority for Aswan High Dam and Aswan Reservoir. The Mechanical and Electrical Authority of the Ministry of Water Resources and Irrigation co-manage dams and are charged with dam safety.

Issue	Ethiopia	Sudan	Egypt
Erosion/ Sedimentation	**Environmental Protection Authority** The Environmental Policy of Ethiopia issued in 1997 requires soil erosion control and promotes water conservation for physical soil conservation for more secure and increased biomass production, including crop production in drought-prone and low rainfall areas. ENCP (East Nile Cooperation Projects) to assist Ethiopia to address this.	**Ministry of Agriculture and Forests, Ministry of Irrigation and Water Resources, and Management of State Agricultural Schemes** to oversee siltation resulting from irrigation. **National Action Plan** (NAP) to Combat Desertification - National Drought and **Desertification Control Unit** (NDDCU) in.	**The Ministry of Water Resources and Irrigation** has the Public Authority for Aswan High Dam and Aswan Reservoir that faces significant challenges due to sedimentation.
Critical Habitats, Ecosystem Functions, and Biodiversity	Environmental Policy of Ethiopia under the **Environmental Protection Authority** oversees ecosystem function through (*inter alia*): the National Conservation Strategy for natural, cultural and human resources; The Ethiopian Biodiversity Strategy and Action Plan (EBSAP) issued in December 2005; The Fishery Development and Utilization Proclamation was enacted in February 2003.	**Higher Council for Environment and Natural Resources (HCENR) and the Ministry of Environment and Physical Development** is the main government organization responsible for the protection of environment and resource conservation, via the Wildlife Protection and National Parks Act 1986 and Forestry Act 1989, Forests and Renewable Natural Resources Act 2002, including forests in the Gezira. Scheme on the Blue Nile. The Interim Constitution guarantees the right of the Sudanese people to promote the country's biodiversity and through legislation, (encourages) sustainable utilization of natural resources and best practices with respect to their management in Section 11.	**Egyptian Environmental Affairs Agency, State Ministry of Environment** Agricultural Law 4/1994 Through Law 4 of 1994, the EEAA is the authority responsible for preparing legislation and decrees to protect the environment in Egypt. With regard to the Nile River protection, there is a separate law 12/1984 for Nile river protection That gives the Ministry of Water Resources and Irrigation the main responsibility for Nile water protection.

Issue	Ethiopia	Sudan	Egypt
Vulnerable Groups and Resettlement	**Ministry of Labor and Social Affairs** Land in Ethiopia is common property under Article 40(3) of the Constitution, however, Article 40(7) states that land may be used and if expropriation is required the government must pay those on the land for the property. Legislation on Expropriation of Land and Compensation – Proclamation No. 455/2005 on Expropriation of Land for Public Purposes & Compensation supports this and provides mechanisms for valuation of property at the Woreda level, and full reinstatement. Environmental laws include ESIA for all projects of significant scale, such as JMP. Proclamation No. 295/2002 empowers each Regional state to establish its own independent environmental agency with the responsibilities to coordinate and follow-up the Regional effort to ensure public participation in the decision making process.	**Ministry of Social Welfare, Women and Child Affairs (MSWWCA)** implements Constitutional Decree 34 issued in 2005, with the sector main objectives as "Accomplishing building of a unified, secured, civilized advanced Sudanese Nation". Ownership of private property is guaranteed under Section 43 subject to expropriation by law in the public interest and in consideration for prompt and fair compensation under the Interim National Constitution. The responsibility for resettlement and compensation policies is assigned to the Commission for Environmental and Social Affairs of the Dams Implementation Unit when applied to dam construction. These are based in the Land Acquisition Ordinance 1930 and Unregistered Land Act 1970.	**Office of Prime Minister, Ministry of Health and Population** Article 34 of the Constitution: "Private ownership shall be safeguarded and may not be placed under sequestration except in the cases defined by law and in accordance with a judicial decision. It may not be expropriated except for the general good and against a fair compensation as defined by law. The right of inheritance shall be guaranteed in it." A decree from the Prime Minister is required to assign private lands to national use. All resettlement for specific projects is covered under the existing EIA Laws. Non-land owner status is less clear as well as related compensation.
Dam Safety	State Enterprise for power The **Ethiopian Energy and Power Company (EEPCO)** with Water Sector Development Program (2006-2016) Proclamation *No. 300/2002* was issued in 2002, and Guidelines for Hydropower Production, Transmission and Distribution, issued in 2004. Also **MoWE** Manage dams and hydraulic structures constructed under federal budgets unless they are entrusted to the authority of other bodies.	**The Dams Implementation Unit** (DIU) is headed by the State Minister for Irrigation and Water Resources. DIU is an autonomous body directly under the Office of the President of the Republic with a status of full Federal Ministry. Decree 34, September, 2005 charges **MIWR** with Operation of dams for efficiency and effectiveness management and maintenance. Supervision.	**The Ministry of Water Resources and Irrigation** has the Public Authority for Aswan High Dam and Aswan Reservoir. The Mechanical and Electrical Authority of the Ministry of Water Resources and Irrigation co-manage dams and are charged with dam safety.

Issue	Ethiopia	Sudan	Egypt
Climate Change	**Environmental Protection Authority** Signatory to the 1992 UN Framework Convention on Climate Change. Ratification of the Kyoto Protocol. EPA has authority for compliance under Proclamation No. 295/2002.	**Higher Council for Environment and Natural Resources** (HCENR) is the main body. Signatory to the 1992 UN Framework Convention on Climate Change. Ratification of the Kyoto Protocol.	EEAA/ **State Ministry for Environmental Affairs, National Committee for Climate Change** with all concerned ministries including MOWI. Signatory to the 1992 UN Framework Convention on Climate Change. Ratification of the Kyoto Protocol.

Appendix F

Terms of Reference for Selected Studies

TABLE OF CONTENTS

1. SOCIO-ECONOMIC STUDIES ON RECESSION AGRICULTURE ON THE BLUE/MAIN NILE IN SUDAN

1.1 STUDY OBJECTIVES

The study objective is to provide information on the magnitude of the affected population and the extent to which the population depend on the flood recession to support agriculture.

1.2 EXTENT OF THE STUDY

The study shall include the Blue River Nile reach from the Ethiopian border to Khartoum

1.3 SCOPE OF THE STUDY

The development of a major regulating reservoir on the Abbay/Blue Nile in Ethiopia as part of the JMP1 Project will affect future water levels in the Blue Nile and Main Nile. River levels during flood seasons will generally be reduced from those currently experienced while river levels in the dry seasons will be raised.

A substantial number of people are thought to depend on the annual flooding of their land along the banks of the Blue Nile and Main Nile in Sudan to provide sufficient water for growth of crops. This occurs in two ways. Firstly, in areas remote from the river which are flooded at times of peak flows and provide both grazing as well as land for planting of crops. Secondly, agriculture is practised along the river banks as the floods gradually recede exposing slopes and low lying terraces on which crops are planted.

The JMP1 project is expected to result in the areas remote from the river being flooded much less frequently. The JMP1 project will also result in the area along the river banks that is currently used for recession agriculture being reduced in size owing to high water levels in the Blue Nile and Main Nile being reduced and low water levels raised.

The study is intended to provide information on the magnitude of the affected population and the extent to which the population depend on the flood recession to support agriculture.

Specific issues to be considered include:

a) To determine the areas affected by reduced flooding, both for higher areas less frequently flooded and those closer to the river and map them.
b) To assess the demographic characteristics of the population directly and indirectly dependent on the annual flood.
c) To assess the numbers and demographic characteristics of the population directly and indirectly dependent on groundwater resources that will be impacted by the JMP1 project.
d) To describe the socio-economy of the area in relation to agriculture and related activities, and surface and groundwater supplies, in relation to years when “normal”, “alert”, “critical” and “flooding” conditions have occurred according to the Ministry’s flood warning scheme.
e) To determine possible mitigation interventions (such as providing technical irrigation) that would be acceptable to the people.

1.4 IMPLEMENTATION

This Terms of Reference provide an outline of the scope of work envisaged. The Consultant shall discuss and agree with ENTRO a detailed work plan which will be reviewed and amended as necessary during the course of the assignment.

The Consultant shall liaise with the JMP Core Team of ENTRO and with the appointed consultants carrying out the JMP1 Identification Study, other ENSAP projects and the Site Specific Feasibility Studies (through ENTRO), particularly in the gathering of data to ensure that a consistent set of data is used by all parties.

In accordance with the work plan the Consultant shall travel to the region to meet with assigned officials at mutually agreed times and to visit key sites as considered necessary. In carrying out the assignment the Consultant shall inform and consult stakeholder and relevant organisations.. It is critical that the

Consultant be aware of the political sensitivities of trans-boundary water management and not advocate specific solutions but shall rather describe potential options with associated merits and demerits.

The Consultant shall report to ENTRO, but he will also liaise with the EN Countries and National Project Coordinators on gathering of information.

1.5 DELIVERABLES

The Consultant shall prepare a draft report describing the work undertaken and findings of the study. The draft report (in colour) shall be submitted in 10 hard (paper) copies together with an electronic copy on a CD. The anticipated deliverables as part of the report shall include and not limited to the following:

- Introductory section which outline purpose and scope of the study
- Description of previous and on-going studies/projects that that deal with the same topic within and outside NBI
- Details of study approach and methodology which includes office and field works, data collected tools and models utilized in the analysis.
- Maps of affected areas
- Possible mitigation measures which would be acceptable to those affected.
- Study finding and recommendation which can be integrated into the main consultancy tasks.

2. SPECIAL STUDY OF WATER SAVING MEASURES TO MINIMISE SYSTEM WATER LOSSES

2.1 STUDY OBJECTIVES

The study is intended to investigate and make recommendations for water savings possibilities throughout the Eastern Nile sub-basin through reducing system losses with the objective of sustaining increased population and higher levels of productivity. This shall include options of minimizing water losses through evaporation, seepage, conveyance and overbank flooding spillage.

2.2 EXTENT OF THE STUDY

The study shall include the entire Blue and Main Nile River reaches from source to outfall. In addition it shall include the White Nile reach from Malakal to Khartoum.

2.3 SCOPE OF THE STUDY

The water resources of the Nile basin are limited and under increasing pressure due to population increase and increasing per capita demand. Additionally climate change impacts may reduce future water availability while increasing demand due to higher temperatures causing increased levels of evapo-transpiration. The breakdown of the tasks to be conducted as part of this special study could be listed as follows:

Task 1: Secondary Literature Review

- Review all previous and on-going studies/projects that deal with the same topic within and outside NBI, with relevance to this project
- Collate information on all system potentiality and measures that could contribute to system water savings

Task 2: Evaluate System water losses due to evaporation

- Analyse the evaporation losses and operation rules at existing and planned reservoirs and make recommendations for revising operation rules with the objective of minimizing the evaporation losses and maximizing water availability for downstream water users
- For the existing and planned reservoirs quantify the benefits of regulatory storage. This shall include quantifying water saving for deep reservoirs in low evaporation areas, compared to shallow reservoirs/large surface area or areas with high evaporation.
- Investigate extent of losses associated with overbank flooding along the Blue Nile and Main Nile, and estimate the extent to which this will be reduced by flood alleviation associated with development of upstream dams

Task 3: Evaluate Water System Conveyance losses & Irrigation efficiency

- Conveyance losses in the canalization system due to seepage and evaporation
- Computation of actual crop water requirements and comparison of historical demand (indents) versus supply
- Water use efficiency for irrigation schemes in Sudan and Egypt
- Computations of crop yield and productivity per unit volume of water utilized

Task 4: Develop and recommend strategies for water saving through improved water management practices and improved infrastructure

The consultant shall explore different options for water management practices such as:

- Water harvesting schemes as supplementary irrigation systems
- Modern irrigation techniques such as drip and sprinkler irrigation

- Evaluate different scenarios of water saving through revising cropping patterns and cropping intensity (Packages such as AquaCrop or Cropwat could be used)
- Consider the potential benefits of minimising irrigation in high Et zones, with preference for irrigation in lower Et zones to maximise productivity per m^3 of water
- Develop a water saving strategy for the EN countries that includes all the above mentioned aspects with a proposed action plan for implementation.

Make recommendations on which water saving efforts or interventions would be most effective in the various parts of the basin.

2.4 IMPLEMENTATION

This Terms of Reference provide an outline of the scope of work envisaged. The Consultant shall discuss and agree with ENTRO a detailed work plan which will be reviewed and amended as necessary during the course of the assignment.

The Consultant shall liaise with the JMP Core Team of ENTRO and with the appointed consultants carrying out the JMP1 Identification Study, other ENSAP projects and the Site Specific Feasibility Studies (through ENTRO), particularly in the gathering of data to ensure that a consistent set of data is used by all parties.

In accordance with the work plan the Consultant shall travel to the region to meet with assigned officials at mutually agreed times and to visit key sites as considered necessary. In carrying out the assignment the Consultant shall inform and consult stakeholders and relevant organisations. It is critical that the Consultant be aware of the political sensitivities of transboundary water management and not advocate specific solutions but shall rather describe potential options with associated merits and demerits.

The Consultant shall report to ENTRO, but he will also liaise with the EN Countries and National Project Coordinators on gathering of information.

2.5 DELIVERABLES

The Consultant shall prepare a draft report describing the work undertaken and findings of the study. The draft report (in colour) shall be submitted in 10 hard (paper) copies together with an electronic copy on a CD. The anticipated deliverables as part of the report shall include, but not limited to, the following:

- Introductory section which outlines the purpose and scope of the study
- Description of relevant previous and on-going studies/projects that that deal with the same topic within and outside NBI
- Details of the study approach and methodology which include office and field work, data collected, tools and models utilized in the analysis.

Study finding and recommendation which include a list of recommendations for water saving options and how these recommendations can be integrated into the main consultancy tasks.

3. GROUNDWATER RESOURCES STUDY FOR AGRICULTURE ALONG THE BLUE/MAIN NILE IN SUDAN

3.1 STUDY OBJECTIVES

To conduct a groundwater resources study for agriculture and domestic water supply along the Blue/Main Nile in Sudan in relation to the JMP I implementation.

3.2 EXTENT OF THE STUDY

The study area encompasses the Blue Nile stretch from the Ethiopian Border to Khartoum.

3.3 SCOPE OF THE STUDY

The development of a major regulating reservoir on the Abbay/Blue Nile in Ethiopia as part of the JMP1 Project will affect future water levels in the Blue Nile and Main Nile. River levels during flood seasons will generally be reduced from those currently experienced while river levels in the dry seasons will be raised. These changes may affect groundwater levels along the Blue Nile and Main Nile valleys and levels in wells, boreholes and mataras on which the local population depend. This study is aimed at determining the extent and magnitude of such impacts to facilitate identification of the affected population and potential mitigation measures. The key tasks are:

- To conduct a groundwater resources study to map and determine the yield and recharge characteristics of existing representative wells, boreholes, etc. in relation to seasonal Nile river water levels.
- To estimate the impact of the potential future river flow regime within the Blue Nile following implementation of the JMP1 project (reduced levels in flood season, raised levels in dry season) on groundwater resources.

3.4 IMPLEMENTATION

These Terms of Reference provide an outline of the scope of work envisaged. The Consultant shall discuss and agree with ENTRO a detailed work plan which will be reviewed and amended as necessary during the course of the assignment.

The Consultant shall liaise with the JMP Core Team of ENTRO and with the appointed consultants carrying out the JMP1 Identification Study, other ENSAP projects and the Site Specific Feasibility Studies (through ENTRO), particularly in the gathering of data to ensure that a consistent set of data is used by all parties.

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- Introductory section which outline purpose and scope of the study
- Description of previous and on-going studies/projects that deal with the same topic within and outside NBI

- Details of study approach and methodology which includes office and field works, data collected tools and models utilized in the analysis.
- Study findings and recommendations which can be integrated into the main consultancy tasks.
- Groundwater maps showing well locations, potential yield, areas of flooding which contribute to groundwater recharge (this task may be shared with the Recession Agriculture SS)

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