NILE BASIN INITIATIVE

Eastern Nile Subsidiary Action Program

EASTERN NILE TECHNICAL REGIONAL OFFICE (ENTRO)

EASTERN NILE MULTI-SECTORAL INVESTMENT OPPORTUNITY ANALYSIS

SITUATIONAL ANALYSIS

December 2014

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ACRONYMS AND ABBREVIATIONS

AfDB	African Development Bank
AHD	Aswan High Dam
BCM	Billion Cubic Meter
BSG	Benishangul Gumuz Region
CC	Country Consultation
COMESA	Common Market for Eastern and Southern Africa
CRA	Cooperative Regional Assessment
CRGE	Climate Resilient Green Economy
EAC	East African Community
ECCAS	Economic Community of Central African States
ECGLC	Economic Community of the Great Lakes Countries
EEPCO	Ethiopian Electric Power Corporation
EIA	Environmental Impact Assessment
ENID	Eastern Nile Irrigation and Drainage
ENCOM	Eastern Nile Committee Of Ministers
ENIMIS	Establishment of Eastern Nile Irrigation Management Information System
ENPT	Eastern Nile Power Trade
ENSAP	Eastern Nile Subsidiary Action Plan
ENSAPT	Eastern Nile Subsidiary Action Plan Team
ENTRO	Eastern Nile Technical Regional Office (NBI)
EWUAP	Efficient Water Use for Agricultural Production
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GEF	Global Environment Facility
GERD	Grand Ethiopian Renaissance Dam
GIS	Geographic Information System
GWh/y	GigaWatt hour/year
HCENR	Higher Council for Environmental and Natural Resources
HDI	Human Development Indices
HSU	Hydrological Similar Units
IDEN	Integrated Development of Eastern Nile
IGAD	Inter-Governmental Authority on Development
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature and Natural Resources
IWMI	International Water Management Institute
IWRM	Integrated Water Resource Management
JICA	Japan International Cooperation Agency
JMP	Joint Multipurpose Project
MCA	Multi Criteria Analysis
MEDIWR	Ministry of Electricity, Dams, Irrigation and Water Resources
MoE	Ministry of Environment
MoWI	Ministry of Water and Irrigation
MSIOA	Multi Sector Investment Opportunity Analysis
MW	Mega Watt
NBI	Nile Basin Initiative
NCORE	Nile Cooperation for result project
NELCOM	Nile Equatorial Lakes Council of Ministers

NELSAP	Nile Equatorial Lakes Subsidiary Action Program
NELSAP-CU	NELSAP Coordination Unit
NELTAC Nile	Nile Equatorial Lakes Technical Advisory Committee
NGO	Non-Governmental Organization
NIB	National Irrigation Board
Nile-COM	Nile Council of Ministers
NWRMS	National Water Resources Management Strategy
OMM	Operation, Maintenance and Management
PMU	Project Management Unit
PRSP	Poverty Reduction Strategy Program
RATP	Regional Agricultural Trade and Productivity Project
RPSC	Regional Project Steering Committee
RSS	Republic of South Sudan
SAP	Subsidiary Action Program
SVP	Shared Vision Program
UNDP	United Nations Development Program
WB	World Bank
WRMA	Water Resources Management Authority
WRMD	Water Resources Management and Development
WSTF	Water Services Trust Fund
WUA	Water Users Association

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1. Introduction and Background

1.1 The NBI

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

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

1.2 NCORE and Earlier Initiatives

The Integrated Development of the Eastern Nile (IDEN), the first ENSAP project, was agreed in 2002 with a first set of seven sub-projects aimed at tangible win-win gains in the areas of watershed management, flood preparedness, early warning and response, irrigation and drainage, power supply interconnection and regional power trade and later the Joint Multipurpose Program [JMP]. Some of these projects have successfully completed their preparations, and are advancing to implementation.

As part of implementing the projects identified for the 5 year Strategic Plan period, NBI has applied for funding from the Nile Basin Trust Fund/Cooperation in International Waters in Africa entitled Nile Cooperation for Results Project (NCORE) supporting the three NBI centres – the Nile-SEC, NELSAP-CU and ENTRO.

The Nile Cooperation for Results (NCORE) Project is the first phase of the Nile Basin Climate Resilient Growth Program and is part of the overall NBI Strategic Plan. The development objective of the NCORE is "to facilitate cooperative water resource management and development in the Nile Basin."

The Project comprises the following three components:

- Component 1: Advancing Nile Basin-Wide Cooperation and Analysis: This Component will support activities at the NBI Secretariat related to its core functions of Facilitating Cooperation and Water Resource Management
- Component 2: Promotion of Sustainable Development and Planning in the Nile Equatorial Lakes Region: This will support the NBI in its efforts to advance investment opportunities in the Nile Equatorial Lakes region

- Component 3: Promotion of Sustainable Development and Planning in the Eastern Nile Region: This Component will support NBI in promoting cooperative activities, water resource management and sustainable development in the Eastern Nile.

Component 3, for ENTRO, will support results related to its core function under two sub-programs:

- The first provides a foundation for improved understanding of issues specific to the Eastern Nile sub-basin and aims to improve public domain access to the Eastern Nile knowledge base while
- The second promotes holistic approaches to preparing and operating water investments, to better take into consideration and communicate environmental and social issues.

1.3 THE EASTERN NILE MSOIA

1.3.1 Overview and Rationale

The EN-MSIOA study is one of several specific studies that is being undertaken to achieve the general objective of the NCORE from the Eastern Nile perspective.

Rapid Population growth, severe land degradation, and lack of adequate storage infrastructure are among the key challenges that hindered development in the Eastern Nile (EN).

The findings of the Cooperative Regional Assessment studies conducted by ENTRO for the ENSAP Projects reveals the followings:

- Unilateral, uncoordinated planning of expansions and Lack of "no-borders" analysis /basin-wide perspective for irrigation development in the EN could lead to Water Conflict in the EN Region. The projected water requirement per EN country master plans is estimated to be 108 BCM/Year.
- The EN region has huge untapped Hydropower potential. There is a need for a coordinated investment plan in power trade
- Through the Cooperative Regional Assessment (CRA), Power generation and interconnection, irrigation and drainage, watershed management as well as the Joint Multi-purpose Project have provided valuable information. However, the assessments have not been carried out from the wider basin resource optimization and efficiency considerations.

A multi sector investment opportunity assessment (MSIOA) is thus needed to identify a coordinated water infrastructure investment strategy for the EN, comprised of prioritized water-related investments (regional or national with regional significance), that promotes shared, sustainable economic growth and development in the EN region.

1.3.2 Objective of the Study

The overall objective is to develop a regional water investment strategy for the EN region that broadly supports socio-economic development, poverty reduction, and the reversal of environmental degradation.

1.3.3 Approach and Methodology

The EN-MSIOA study is being carried out over a 12 months and in addition the already Inception Phase (Task 0) has been divided into four (4) main tasks:

- Task 1: Inventory and Situation Analysis;
- Task 2: Strategic Scoping of EN Multi-Sectoral Investments;
- Task 3: Multi-Sectoral Analysis of Investment Opportunities;
- Task 4: MSIOA Final Products.

The methodology, as already presented in the Inception report is shown in Figure 1-1.

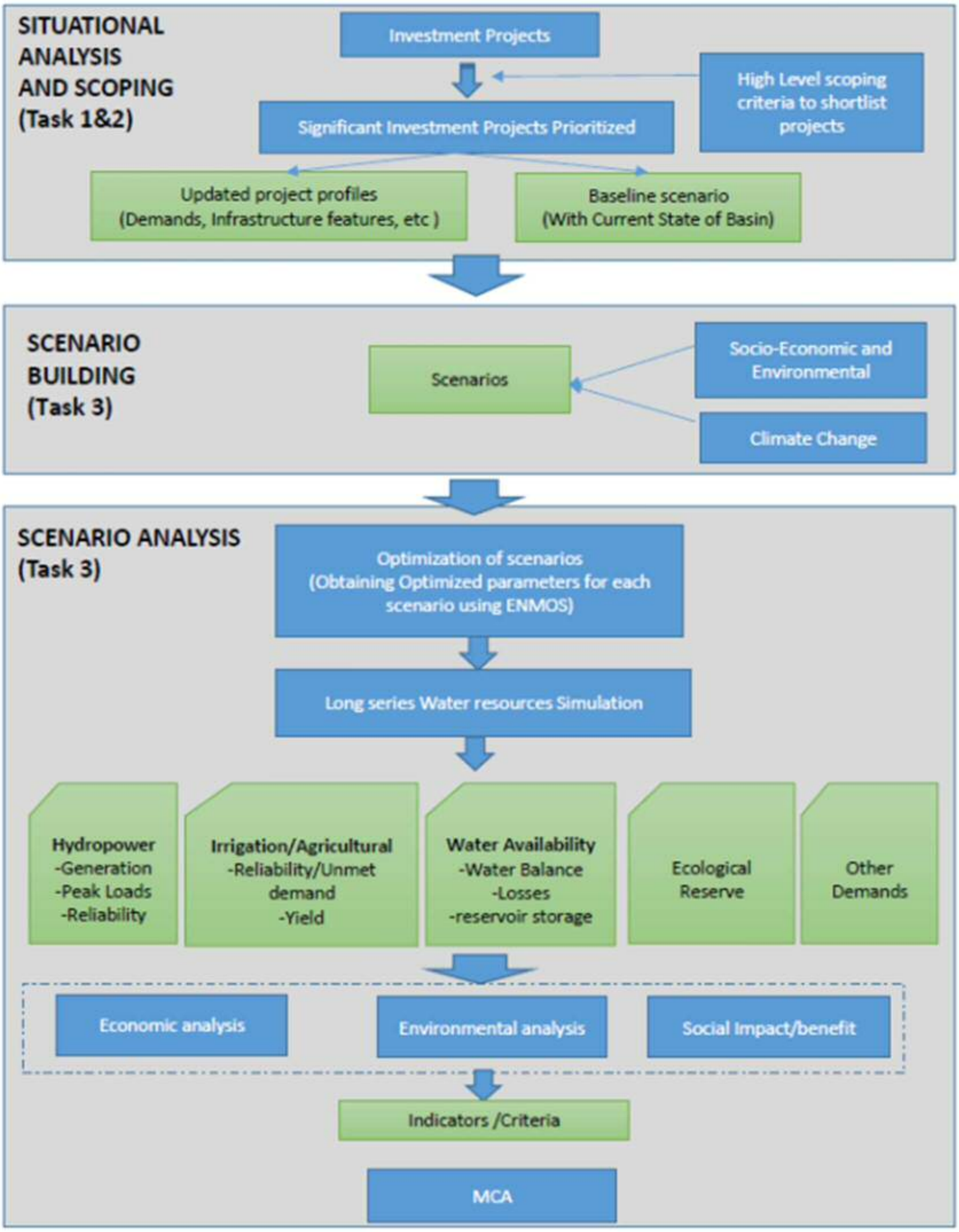


Figure 1-1: Methodology as set out in the Inception Report

1.3.4 Assumptions and Limitations

The main assumptions and limitations associated with the Situational Analysis and hence with much of the remainder of the study are related to the following:

- It was not possible to carry out the planned consultations in Egypt. As a result, while impacts on flows and activities downstream have been taken into account in the various analyses, the identification of projects for the future is/will be largely limited to the 3 upstream riparians
- Many of the water and development related institutions in South Sudan are either relatively new or not yet in place, as is also the case for the related planning tools including policies, development strategies and plans etc. As a result, some assumptions have been made and updating of some parts of the MSOIA will probably be required when more detailed information on development plans for South Sudan becomes available.

1.3.5 Situational Analysis

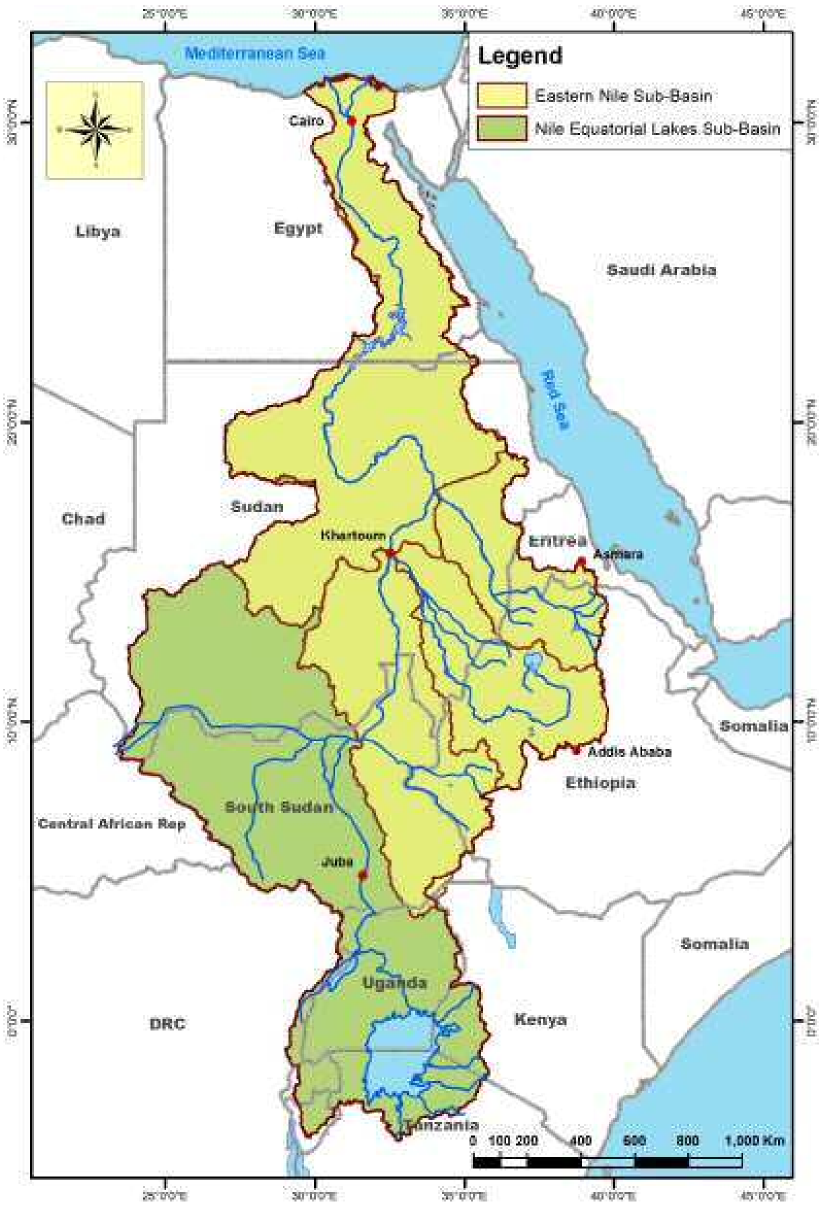
This situation al Analysis Report is structured as follows :

- Chapters 1 and 2 provides context on:
  - the EN and member states;
  - water resources development and management and related drivers, issues and challenges
  - this situational analysis including the approach, methodology, assumptions and limitations

  This is aimed at providing the reader with an understanding of the need for well-planned and sustainable water resources development and management projects as well as the need to plan within a transboundary context respecting the principles of IWRM
- Chapter 3 provides an overview of the water resources of the Eastern Nile basin and of the catchment characteristics of the four sub-basins
- Chapter 4 provides the necessary social and environmental context and aims at reinforcing the need for a sustainable approach that can result in both socio-economic benefits and improved natural resource management.
- Chapter 5 is effectively a sectoral review aimed at providing the necessary background and identifying the various development and management projects, both existing and planned, especially those of regional significance
- Chapter 6 provides a short introduction to the GIS and the proposed atlas to accompany this report.
- Chapter 7 presents an analysis of the water resources of the basis, providing the point of departure for the more detailed work that will be done in the next steps of the study when different development and management scenarios will be investigated.

2. Context

2.1 General Context



The Eastern Nile (EN) Basin is shown within the context of the entire Nile Basin in Figure 2-1. constitutes over 60% of the area of the Nile River Basin and contributes over 86% of the average annual flow of the main Nile River, which is about 84 Bm^3 at the Aswan High Dam in southern Egypt (NBI,2012)[1]. The Eastern Nile supports an extraordinary range of ecosystems from high mountain moorlands, afromontane forests, savanna woodlands, extensive wetlands, intensively cultivated catchments, groundwater, systems, and arid deserts. As shown in Figure 2-2, the Eastern Nile comprises four sub-basins: the Baro-Sobat-White Nile in the west, the Abbay-Blue Nile, the Tekeze-Atbara on the east and the Main Nile from Khartoum to the Nile delta.

Figure 2-1: Eastern Nile basin within the overall Nile Basin

The Eastern Nile Basin covers approximately 1.7 million km^2 It is home to about 154million people (ENTRO, 2008a). The riparian countries of the Eastern Nile basin are:

- ***Ethiopia***, the most upstream country in the Eastern Nile Basin and the poorest with a population of 84.7 million and a GDP per capita of 374 current US$ (World Bank, 2012a). The highlands of Ethiopia are the source of over 80% of the main Nile flow. Ethiopia is seeking to develop its water resources for both hydropower and irrigation in order to sustain high economic growth.

[1] Based on the period 1905-2005)

- **Sudan,** formerly the continent's largest country by land area with a population of 34.3 million and a GDP per capita of 1234current US$ (World Bank, 2012a), has traditionally used the Nile mostly for flood recession agriculture and pastoralism, but has constructed one of the world's largest irrigation schemes from a single water source at Gezira just upstream of the confluence of the White Nile and the Blue Nile Rivers.
- ***South Sudan***, which became independent from The Sudan in July 2011 encompasses portions of the White Nile and the Nile above the confluence of the Sabat and White Nile Rivers. The population of South Sudan is 10.3 million (World Bank, 2012a). The extraordinary and extensive Sudd wetland and Machar Marshes are found within South Sudan in the NEL and EN sub-basins respectively. Because of evaporation, the Sudd Wetlands play a major part in controlling the volume of flow from the Equatorial Lakes region into the White Nile. Following the long period of civil strife and war in South Sudan, development of water for agriculture, drinking and livestock is expected to be a very high priority. This report also includes South Sudan data when available. However, there is a general lack of information recommendations will be provided in subsequent stages of this study for institutional strengthening for data capture to support future updates.
- ***Egypt***, the most downstream country[2] 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 82.5 million and a GDP per capita of 2781 current US$ (World Bank, 2012a). The Nile waters, which flow into Lake Nasser created by the Aswan High Dam, generate hydropower at the power plant associated with the dam and the electricity generated is transmitted to the national grid.
- ***Eritrea***. Only a small portion if the basin (3,500km or 0.2%) lies within Eritrea.

Figure 2-2: Sub-basins and countries of the Eastern Nile Basin

2 It was not possible to carry out the planned consultations in Egypt. As a result, while impacts on flows and activities downstream have been taken into account in the various analyses, the identification of projects for the future is largely limited to the 3 upstream riparians

2.2 Sustainable Development – the Nile Basin Sustainability Framework (2012)

The Nile Basin Sustainability Framework (NBSF) notes that the despite the remarkable natural endowments and rich cultural history of the Nile Basin, its people face considerable challenges with regard to poverty, degradation of water and environmental resources, low economic development and insecurity. **Cooperation amongst the basin countries on the management of the common Nile water resources offers an important opportunity for addressing these challenges**. **Cooperation on water management can further serve as a catalyst for greater regional integration, both economic and political, with potential advantages far exceeding those derived from the river itself** (NBSF, 2012).

The desire of the Nile riparian states to jointly develop and manage the common Nile water resources to fight poverty, catalyse economic development and regional integration, build a solid foundation of trust and confidence, and promote stability in the region is proclaimed in their Shared Vision:

"To achieve sustainable socio-economic development through equitable utilization of, and benefit from, the common Nile Basin water resources."

The Nile Basin Sustainability Framework (NBSF) has been developed from this Shared Vision to provide a conceptual structure and organisational mechanism for achieving sustainability. The NBSF comprises of an overall goal, broad objectives, Key Strategic Directions (KSDs) and desired outcomes.

- **Goal of the NBSF**: To enable Nile Basin countries to consolidate the achievements of the past years of cooperation and move systematically towards realisation of shared vision through strategic actions derived from mutually agreed policies, strategies and guidelines that focus on identified development priorities for the Nile Basin

- **Broad Objectives are presented in an abbreviated form as:**
  - To facilitate and contribute to socio-economic development, poverty reduction and improvement of livelihoods of riparian communities through equitable utilisation and sustainable development of the common Nile basin water resources;
  - To facilitate and contribute to efficient management of the Nile water resources drawing on principles of integrated water resources management (IWRM), and good practices in trans-boundary water resources management;
  - To facilitate and contribute to wise use of sustainable management of the environment and water-related natural resources of the Nile Basin;
  - To facilitate the main streaming of climatic change adaption and mitigation measures in the development and management of Nile water resources, and support Nile Basin countries in dealing with issues of climate variability and change.
  - To augment the efforts at achieving basin sustainability through facilitating selected cross-cutting activities that support the sustainable management and development of water and environmental resources of the Nile Basin.

- **Desired Outcomes are presented in an abbreviated form as:**
  - Enhance social-economic development, reduced poverty and improved livelihoods for riparian communities from equitable utilisation and sustainable development of the common Nile Basin water resources.
  - Improved efficiency in the management and utilisation of the water resources achieved through the application of principles of integrated water resources management (IWRM) and good practices in trans-boundary water management.
  - Sustainable and well-managed watersheds, aquatic ecosystem and water-related natural resources of the Nile Basin.
  - Reduced impact of climate change and variability on water resources, aquatic ecosystems, water-related infrastructure, livelihoods of riparian communities, and the general social economic development of the basin.
  - Increased sustainability of NBI activities achieved through more effective communication, greater stakeholder participation, gender mainstreaming, capacity building and improved resource mobilisation.
- Key Strategic Directions. Four Key Strategic Directions (KSDs), namely:
  - Key Strategic Direction 1: Water-related socio-economic development;
  - Key Strategic Direction 2: Water resources planning and management;
  - Key Strategic Direction 3: Environmental and water-related natural resources management;
  - Key Strategic Direction 4: Climate change adaptation and mitigation.

Examination of the objectives and desired outcomes as outlined above provides a very clear context for the MSOIA. All of the five broad objectives are clearly central to the aims of the MSOIA as well. Drawing up and implementing the MSOIA can therefore play a significant role in contributing to the desired outcomes of the Nile Basin Sustainability Framework. Optimised sustainable development can best be achieved using an integrated transboundary and cross-sectoral approach and this requirement is a key driver for projects such as the MSOIA.

2.3 The Study Area

Comprises the four sub-basins:

- The Abbay-Blue Nile sub-basin with a population of 39 million accounts for ~ 26 % of the total population of the EN Basin and is the second most populous of the four sub-basins after the Main Nile sub-basin. Of this total 25 million live in the Abbay sub-basin, which is located in Ethiopia and is largely located within the Benishangul-Gumuz and Amhara Regional States, with a small area located within the Oromia Regional State. The remaining 14 million live in the Blue Nile sub-basin, starts where the Abbay enters Sudan from Ethiopia and is divided into the southern and northern zone (see Table 2-1). The southern zone stretches from the Sudan-Ethiopian border to Khartoum State, and includes the states of Blue Nile, Sinnar, Geziera, and Khartoum. The northern zone extends from north of Khartoum State to the Northern State, which borders with Egypt.

- The Baro-Akobo-Sobat-White Nile sub-basin is located in southwestern Ethiopia and eastern South Sudan and is home to four regional states in Ethiopia (Gambella, Benishangul Gumuz, Oromiya and SNNPRS) and three states in South Sudan (Jongeli, Unity and Upper Nile).). The total population of the sub-basin was 10 million in 2006 of which 7.6 million (76%) were rural (Table 2-1). Of this total 5.5, 3.3 and 1.7 million lived in Ethiopia, South Sudan and Sudan respectively (see Table 2-1).
- The Tekeze-Atbara sub basin comprises two major catchments covering the Ethiopia north western highlands (Tekeze river basin) and the Sudanese south-eastern lowlands (Atbara river basin). The population of the sub-basin in 2007-08 (see Table 2-1) was 13.5 million of which 9.3 million lived in Ethiopia and 4.2 million lived in Sudan (see Table 2-1). The sub basin, like the other sub basins of the Eastern Nile, originates from the Ethiopian highlands north of Lake Tana and flows westward into The Sudan joining the Nile as its last tributary at the town of Atbara. The Tekeze River basin includes the Tekeze River, Angereb River and the Goang River. The sub basin crosses two national boundaries, namely Ethiopia and Sudan and it population is made up of two groups. The first group lives in upper portion of the sub-basin located in Ethiopia and fall with the regional states of Amhara and Tigray. The second group lives in the Sudan comprising the three states of Nahr Elnil, Kassala and Elgadarif.
- The Main Nile sub-basin covers the entire region from the point that the Nile River crosses the Egyptian-Sudanese boarder and flows north towards Cairo before ending in the Mediterranean Sea. The entire Main Nile sub-basin is located within Egypt. With an estimated population of 79 million in 2006, the Main Nile sub-basin is the most populated of the four sub-basins.

Table 2-1: Summary of population data for Eastern Nile Region

SUMMARY EASTERN NILE BASIN	Egypt (2006 Census)	Ethiopia (2008 Census)	South Sudan (Sudan 2007 Census)	Sudan (Sudan 2007 Census)
EN Sub-Basin Total: 136.9 million Rural: 94.3 million (70%)	72.6 million (53%)	39.3 million (29%)	3.3 million (2%)	21.7 million (16%)
Main Nile Sub-Basin Total: 74.4 million Rural: 42.3 million (57%)	72.6 million (98%) 41 million rural			1.8 million (2%) 1.3 million rural
Tekeze-Atbara Sub-Basin Total: 13.5 million Rural: 11 million (81%)		9.3 million (69%) 8 million rural		4.2 million (31%) 3 million rural
Abbay-Blue Nile Sub Basin Total:39 million Rural: 32.4 million (83%)		25 million (64%) 22.5 million rural		14 million (36%) 9.8 million rural
Baro-Akobo-Sobat Sub Basin Total: 10 million Rural: 7.6 million (76%)		5 million (50%) 4 million rural	3.3 million (33%) 2.7 million rural	1.7million (17%) 0.92 million rural

3. Catchment Characteristics and Water resources

3.1 Overview/Introduction

A summary of the main characteristics of the Eastern Nile sub-basins is outlined in Table 2.1.

Table 3-1: Catchment Characteristics of the main Eastern Nile Sub-basins

Sub-basin	Area (km^2)	Flow (BCM)	Annual rainfall (mm)	Salient hydrological features
Baro-Akobo-Sobat	205,775	13	500 – 1750	• Important wetland areas
White Nile	262,441	15	<300 – 500	• Little water infrastructure
Blue Nile	311,548	54	500 – 1800	• Contributes majority of the water to Eastern Nile system; • Sediment flows are high; • Hydrological variability is high; • Significant potential for economic development • Gezira Irrigation • Blue Nile Main stem dam potential (GERD recently initiated)
Tekeze-Setit-Atbara	227,128	12	200 – 1500	• Water availability is highly variable • Little water infrastructure (except for new Tekeze hydropower dam and largely silted Kashm-el-Girba dam) • Sediment flows are high • Potential for small and medium-scale projects
Main Nile	656,398	84	0 – 200	• Very low rainfall • Aswan High Dam and Lake Nasser • Extensive irrigation systems • Nile delta

Source: ENTRO, 2008a

3.2 Physical Landscape and Topography

The Geologic history has largely determined the land and water resources context of the basin. The uplift of the Ethiopian plateau formed the highlands or rim of the Basin where the streamflow of the Eastern Nile Basin originates. As a result, all of the Eastern Nile tributaries flow generally northward from these highlands with the exception of the White Nile which originates in the vast flat Sudd wetland. The intense volcanism on the plateaux has resulted in the formation of rich and fertile soils. However there are few thick deposits of fluvial sediments that support large groundwater reservoirs. The exceptions are the alluvial sediments along the main Nile in the Sudan and the Nile delta in Egypt.

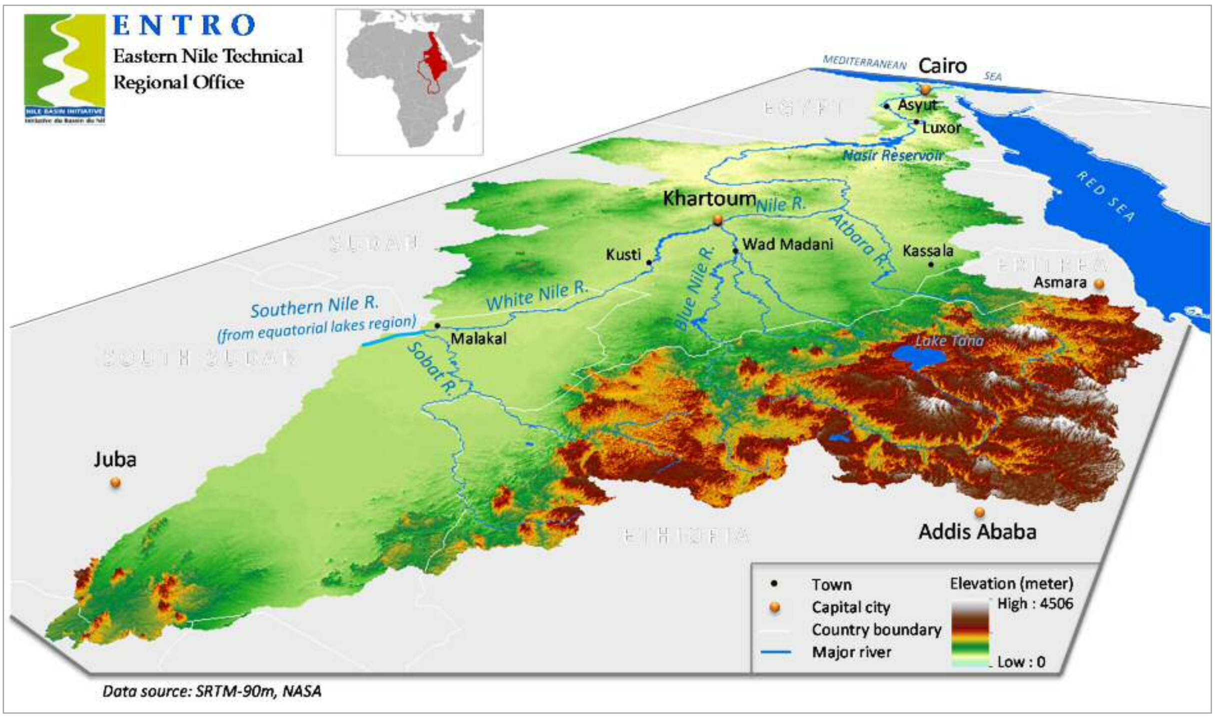
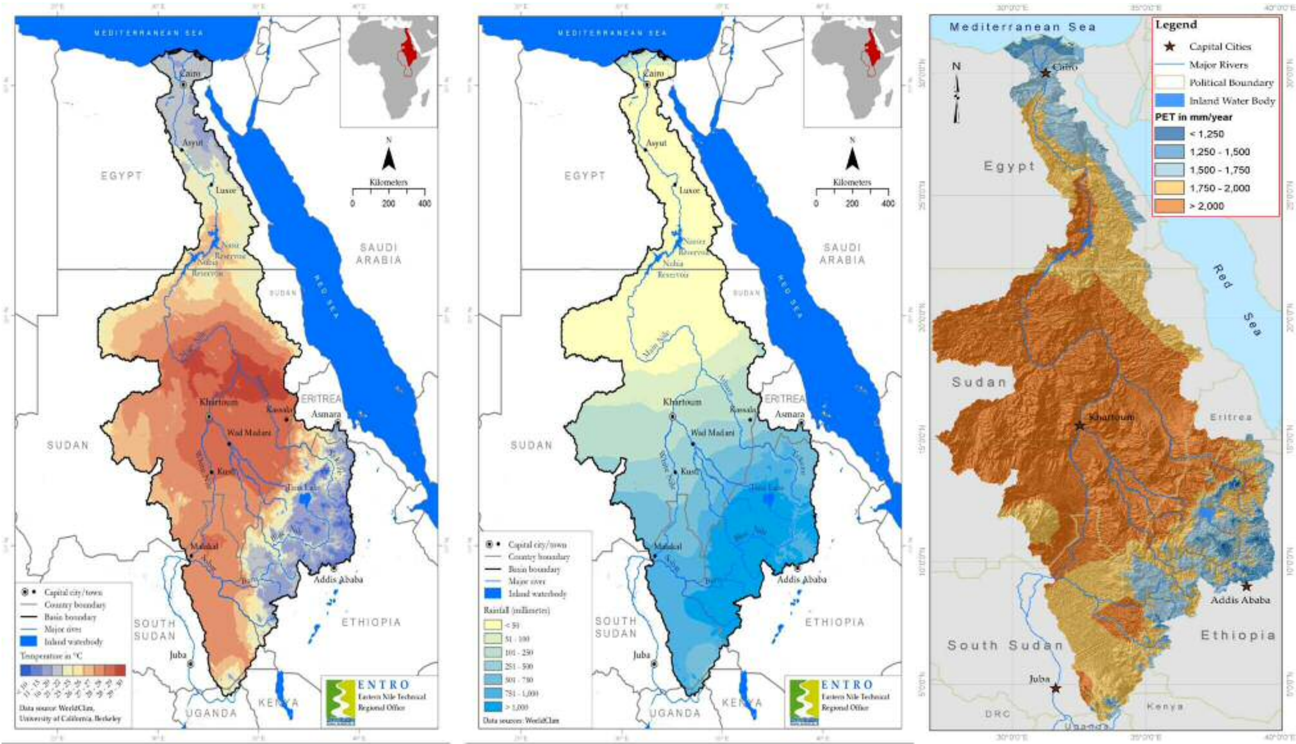


Figure 3-1: A 3-D Perspectives of the Eastern Nile Topography

Figure 3-1 shows the elevations of the different parts of the basin. The elevation of the basin drops quickly from the highlands (with elevations of more than 4000 metres above sea level), through the midlands to the lowland areas at approximately 400 metres above sea level (masl). The topography then becomes less steep as the elevation decreases from 400 masl to the lowest point in the basin where the Nile River meets the sea. The highlands in Ethiopia account for most of high elevations where the key eastern Nile tributaries emerge. For example, the Blue Nile now cuts through the landscape (formed during the Mezozoic era during the breakup of Gondwana and later filled with fluvial sediments) to form a spectacular landscape of gorges with elevations upstream over 3000m above sea level (masl) till it meets the White Nile at about 380masl. The great bend after the Atbara confluence is due to relatively more recent (in the past hundreds of thousands of years) tectonic uplift of the Nubian Swell that also led to the rocky cataracts that have posed historical challenges for navigation and later offered opportunities for storage and hydropower investments such as at Aswan and Merowe.

3.3 Climate

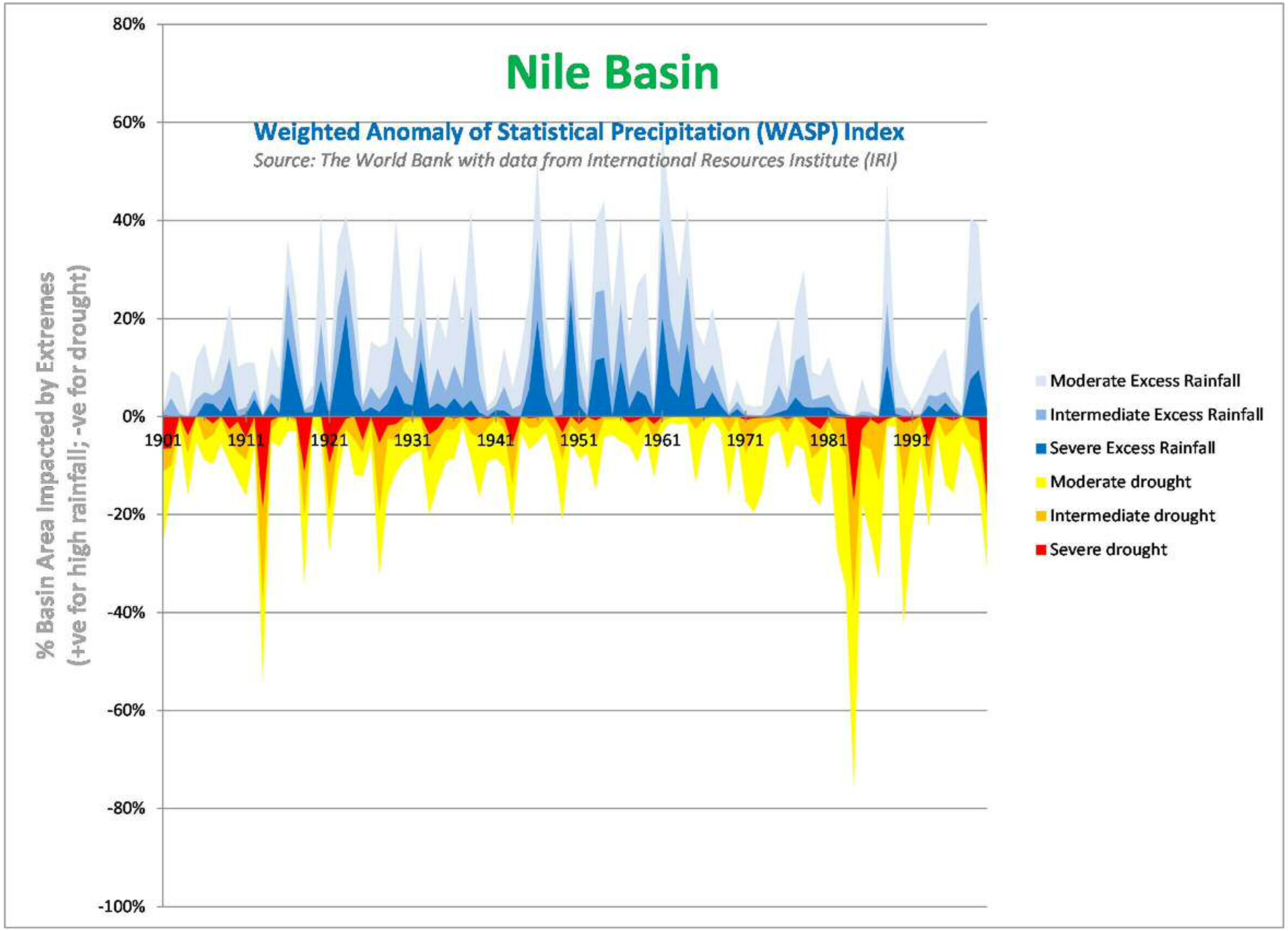
The Eastern Nile Basin is strongly influenced by the general circulation patterns in the Indian Ocean and by El Nino in the Pacific Ocean. Moist air flowing from the Indian Ocean rises up over the Ethiopian plateau and as this air is cooled, rain falls on the plateau. This part of the basin receives almost all of the rainfall in the Eastern Nile Basin. In the middle and lower basin, dry hot westerly winds cause extremely hot, desert conditions (**Figure 3-2**). Evaporation dominates the water balance (**Figure 3-2**) everywhere in the basin with the exception of the montane highlands. Due to the high rates of evaporation, large areas in the Eastern Nile Basin especially in the Sahara do not normally generate runoff. Also, as a consequence of the high evaporation, the water yields (the surface and groundwater flows) from the major sub-basins are relatively small, ranging between 10 and 20 percent of total rainfall. The climate of the lower basin and delta is also significantly influenced by the moderating influence of the Mediterranean Sea and the Red Sea. patterns.

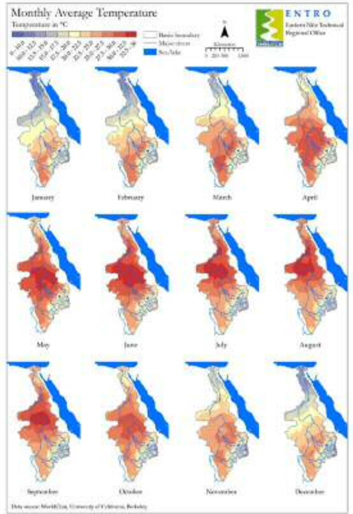


a) Temperature *b) Rainfall* *c) Potential evapotranspiration*

Figure 3-2: Average Annual Variation of Climate Variables

The high inter-year and intra-year climate variability in the Nile Basin is shown in **Figure 3-3**. This figure shows the annual difference from the long term average (1901-2000) in terms of the percent of the basin area affected by the extreme events (droughts and high rainfall). It also shows the high degree of seasonality in precipitation and temperature that largely determine the high seasonality of river flows and the agriculture.





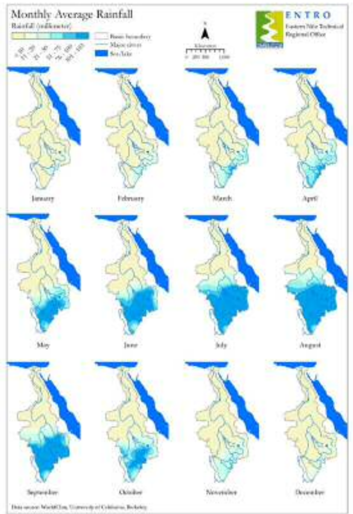


Figure 3-3: Weighted anomaly of statistical precipitation (WASP) index (wrt 1901-2000 mean)

3.4 HYDROLOGY OF THE EASTERN NILE SUB-BASINS

3.4.1 Surface Water & Catchment Characteristics

The Eastern Nile accounts for almost half of the 3.4 million square kilometre catchment area of the Nile River Basin. It contributes much more than half of the runoff to the Main Nile however. The White Nile which flows from Lake Victoria makes a much smaller contribution due largely to the fact that most of the 100 billion m^3 of rainfall that falls annually on Lake Victoria evaporates. Similarly, the other large lakes in Equatorial Lakes region also contribute relatively little additional runoff with the result that only just over 30 billion m^3 makes it into the Sudd from this upstream system. Despite being augmented by substantial flows (>11 billion m^3) from tributaries such as the Bahr-el-Ghazal, only about 15 billion m^3 emerging from the Sudd, Africa's second-largest wetland, to join the Blue Nile in Khartoum.

The Eastern Nile comprises four major Sub-basins these are :

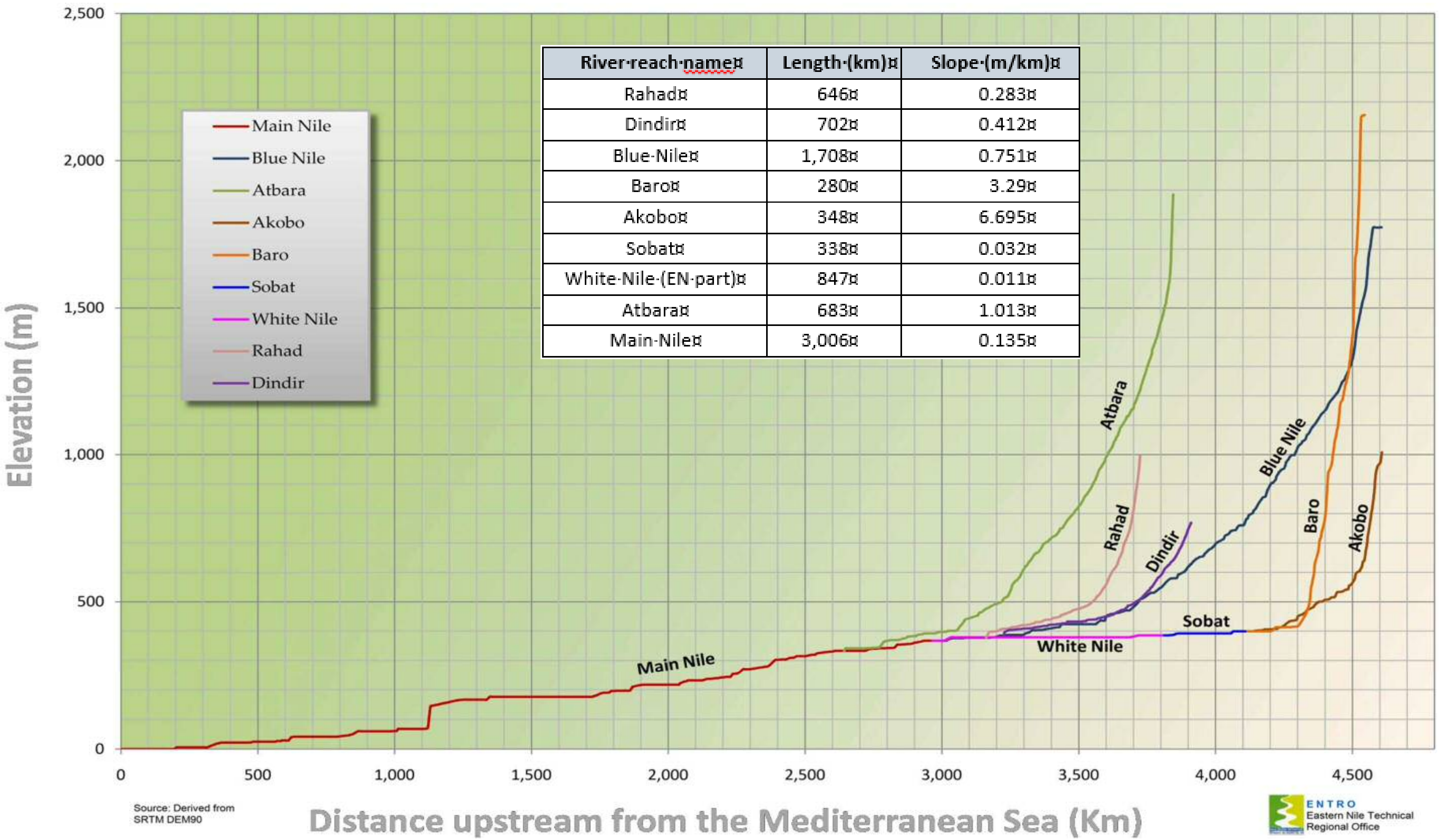
- the **Baro-Akobo-Sobat and downstream White Nile** (after joining with the Southen Nile at Malakal after its journey through the Sudd),
- the **Blue Nile** that rises from the Lake Tana outflow as the **Abbay River** and joins the White Nile in Khartoum,
- **Tekeze-Setit-Atbara** that joins the White Nile downstream of Khartoum, and
- the **Main Nile** basin which is the entire basin downstream of Khartoum (except for Atbara) till it empties into the Mediterranean. Each of these sub-basins (examined individually later in this chapter) has its unique combination of topography, climate and water infrastructure, and land use that dictate their resulting hydrology.

Maps of each of the sub-basins, showing the topography, main rivers and tributaries are provided in Section 3.8.

The Baro, the Akobo and the Pibor rivers are all ribuatries of the Sobat River which makes its confluence with the White Nile near Malakal. The Baro Originates at an elevation of 2,200 m and the Akobo at an elevation of 1,000 m.

The Blue Nile (Abbay River) originates at Lake Tana at an elevation of 1,800 m and flows through Ethiopia and then into Sudan before making its confluence with the White Nile in Khartoum at an elevation of about 350 m. The combined flow, now the Main Nile flows northwards through Sudan towards Egypt. Below the confluence, the only major tributary of the Main Nile is the Atbara River. Before reaching the Sudan-Egypt border the Main Nile reaches the reservoir of the High Aswan Dam before flowing on through Egypt and making its outfall into the Mediterranean sea.

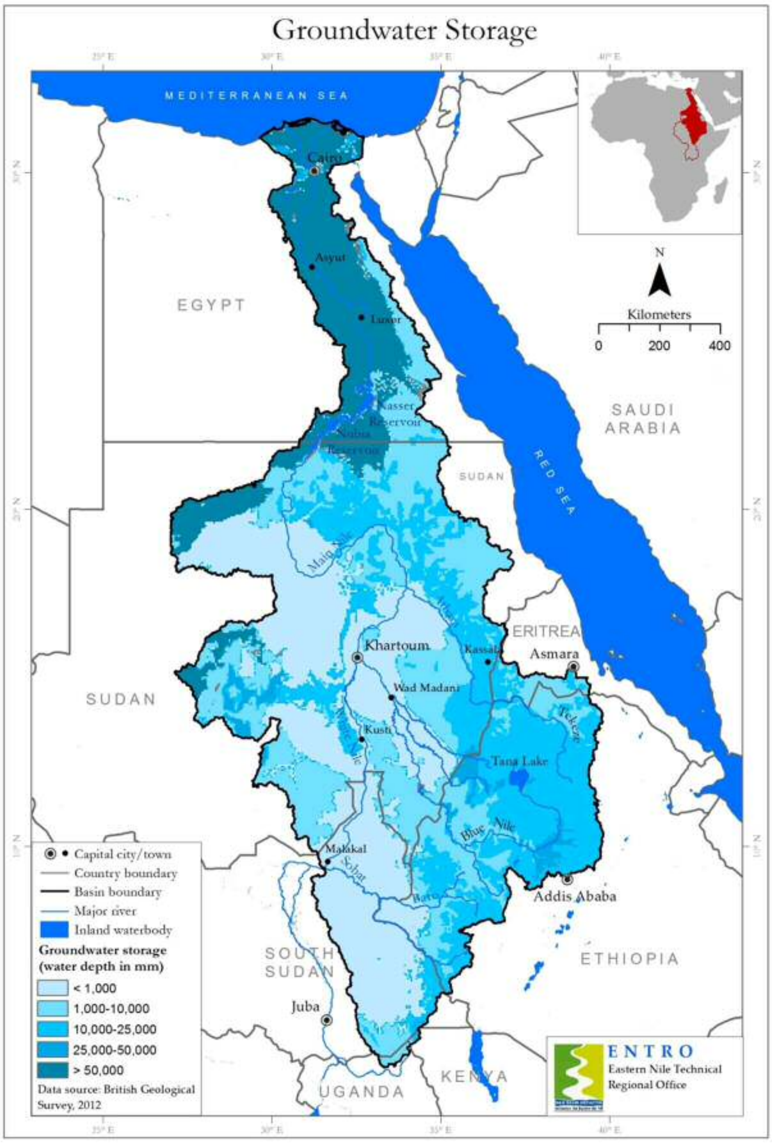
The stream lengths and the slopes of all major rivers in the Eastern Nile basin have been calculated according to their change in elevation and horizontal chainage. The stream lengths and slope are detailed in . The longitudinal profile of major rivers in the EN is shown in **Figure 3-4**. The table and figure indicate that the longest river is the Main Nile (3,006 km) and the Akobo River has the highest slope (6.695 m/km). Among the major rivers, the shortest is the Baro River (280 km) and the White Nile River has the flattest slope (0.011 m/km).



River reach name	Length (km)	Slope (m/km)
Rahad	646	0.283
Dindir	702	0.412
Blue Nile	1,708	0.751
Baro	280	3.29
Akobo	348	6.695
Sobat	338	0.032
White Nile (EN part)	847	0.011
Atbara	683	1.013
Main Nile	3,006	0.135

Figure 3-4: Elevation Profile of Major River Mainstems in the Eastern Nile

3.4.2 Groundwater & Aquifer Characteristics



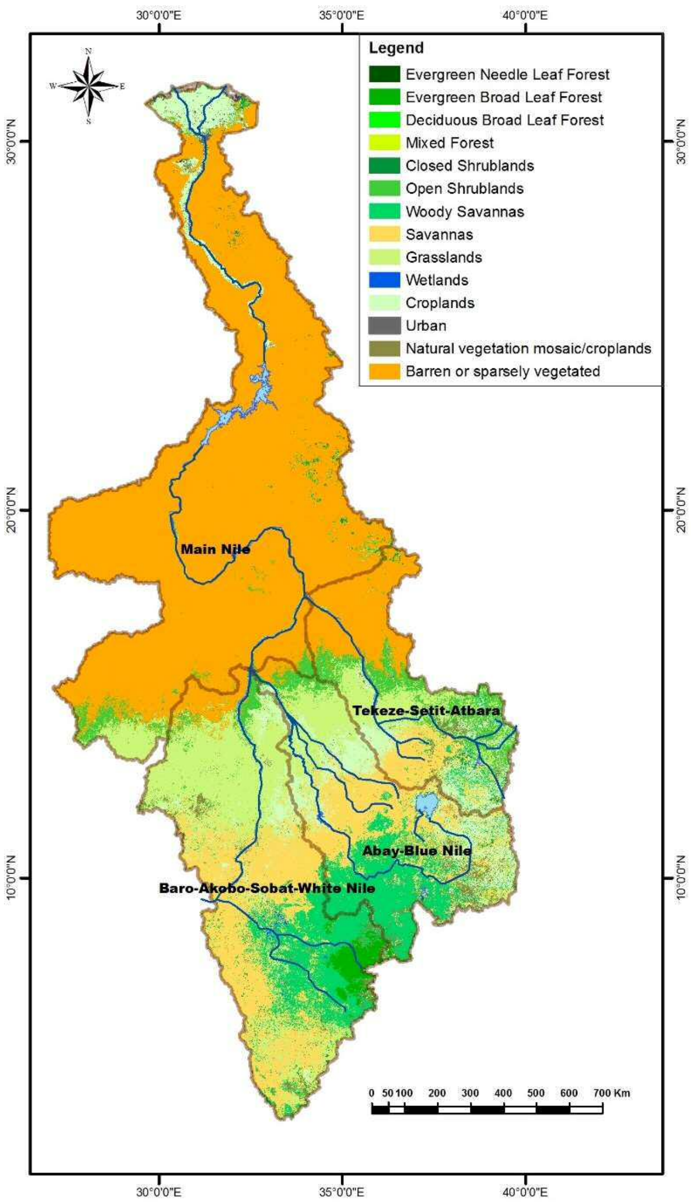
The Eastern Nile basin's groundwater resources are less well studied. There is likely to be some groundwater storage in the upstream areas - in basement rocks, multi-layered consolidated sedimentary rocks, volcanic rocks, and loose alluvial-lacustrine sediments, each of which represent aquifers of different size, thickness, and water bearing properties, yielding from less than 1 litre/second to over 100 litres/second (World Bank, 2013). Many of these smaller aquifers could be developed from a distributed socio-economic perspective, such as through watershed and rural water supply projects. The deep Nubian sandstone aquifer is the world's largest fossil water aquifer system (with about 150 trillion cubic meters of water), and that lies near the Nile delta; exploitation would be expensive due to the great depths but as demonstrated by Libya's "man-made river" (> 2.3 BCM annually from this aquifer from depths exceeding 500m), is possible

Figure 3-5: Groundwater Storage in the Eastern Nile Basin

3.5 Vegetation Cover and Land Uses

The EN basin has nine predominant land cover types. Almost fifty percent of the basin comprises barren/desert areas with sparse vegetation, making up the bulk of the northern and central parts of the whole basin. As can be seen from **Error! Reference source not found.**, the majority of croplands are to be found in the Ethiopian highlands where rainfed agriculture predominates, along the Nile river and in the delta.

Changes in land cover in the EN from 1961 to 2009 have been assessed using classified remotely sensed images as shown in Annex 1. The analysis revealed that natural vegetation had decreased by 1.6 Mha (1.8%) between this period. This is as a result of conversion of land to agriculture and urban area. In the same period, agriculture area had increased by 1.3 Mha (5.3%) and urban area by 67,000 ha (18%).



Source: Extracted from Global MODIS Landcover Database

Figure 3-6: Vegetation and Land cover in the Eastern Nile basin

Table 3-2 shows the aggregated land cover types and percentage land cover changes between 2001 and 2010. Changes over one decade have been very significant. Most notably there is an increase of almost 29% in the total cropland areas from 2001 to 2010. This increase is generally spread around the basin and is likely to be the result of population expansion and governments policies of land reclamation for agricultural production particularly in Egypt. Grasslands have also increased by 17% over this period. The forest and savannas cover have undergone large decline of approximately 27% and 13%, respectively. Both natural and human factors can be attributed to this land cover change. Clearing of forests for agricultural production coupled by decreased rainfall and wild fires have likely seriously affected the forest canopies within the EN sub-basins. The decline of the forest areas, shrub lands, and savannahs along with the natural vegetation mosaic is a sign of persistent decrease in the overall greenness and ecological diversity of the basin.

While it is difficult to detect or quantify, these changes are likely to have had some impact on the hydrology of many parts of the basin, generally adversely reducing base flows and increasing the frequency and magnitude of floods.

Table 3-2: Aggregated Land Cover Types and Percentile Land Cover Change

Aggregated Land Cover Types	% covered in 2010	% Change of Land Cover (2001-2010)
Forest Areas	01.01%	-26.58
Shrub Lands	03.61%	-02.06
Savannas	20.22%	-13.08
Grasslands	10.73%	17.34
Wetlands	00.15%	56.71
Croplands	12.27%	28.88
Urban	00.29%	00.02
Crop/Natural Vegetation Moasic	04.61%	-16.72
Barren and Sparsely Vegetated	47.10%	00.06

Figure 3-7 below shows the mean monthly NDVI for the year 2005 for the whole EN basin. The vegetation pattern displayed by the NDVI is as expected. The vegetation biomass and quantity in the southern parts of the EN are predominantly governed by the rainfall pattern in the region. The NDVI starts rising in early June with the start of the rainy season, and peaks by August/September which is the peak rainfall for the region. The vegetation activity in the northern part of the EN is, governed by the cropping pattern within the Nile delta. Two cropping cycle pattern can be noticed. The winter and summer growing seasons.

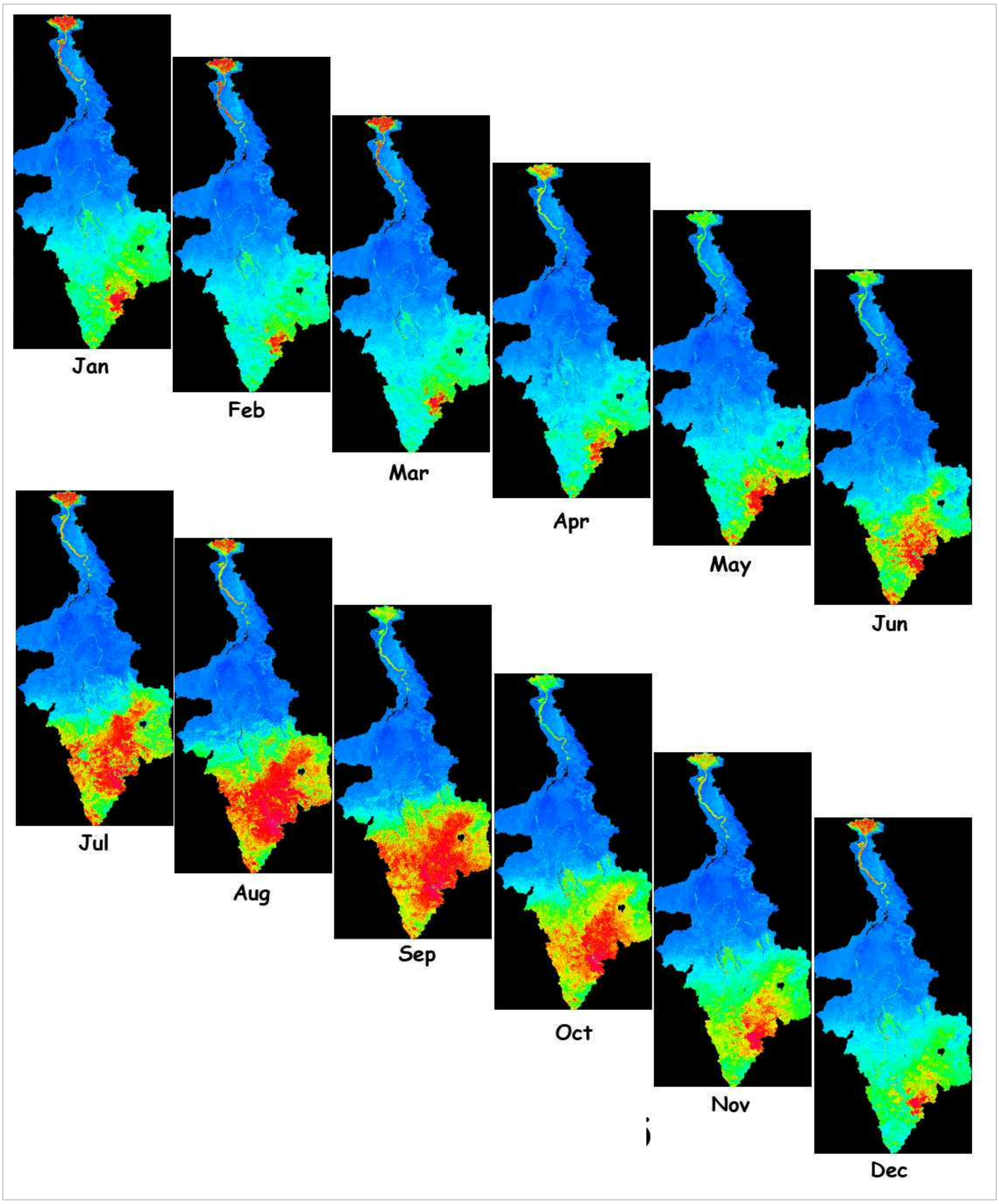


Figure 3-7 : Monthly NDVI in the Eastern Nile Basin (2005)

3.6 WATER USES IN THE BASIN

Increasing population, urbanization and agricultural practices are creating pressure on land and water resources all over the world. In urban areas, water withdrawal (both from surface and ground water sources) is increasing to fulfil domestic and industrial water demand, while in rural areas water is withdrawn for agriculture. Furthermore, agriculture land is being converted to urban settlements and wetlands and forests are being converted to agriculture land. Consequently, the land and water resources are under considerable, and increasing stress, which may lead to unsustainable development of water resources and the environment.

Egypt, Ethiopia, the Sudan and South Sudan are facing these problems, with both land and water resources under stress. World's Water (2010) estimates of freshwater withdrawal for domestic, agriculture and industrial use in the four countries are shown in Table 3-3. The table shows that agriculture is by far the principal water user accounting for almost 90% of the total water use in all three countries. In comparison to agricultural use, domestic and industrial uses are very insignificant. However, their consideration, is important because they depend upon water of good quality being available with a very high assurance. A brief overview of urban water use and requirements is provided in Section 5.6.

Table 3-3: Freshwater withdrawal by country

Country	Domestic (%)	Industrial (%)	Agricultural (%)	Domestic (m^3/p/yr)	Industrial (m^3/p/yr)	Agricultural (m^3/p/yr)
Egypt	8	6	86	62	49	695
Ethiopia	6	<1	94	4	<1	61
South Sudan and Sudan	3	1	97	23	6	835

Source: FAO AQUASTAT estimates from http://www.fao.org (January 2011).

Current and future water requirements for the two biggest users, irrigated agriculture (consumptive) and hydropwer (non-consumptive except where impoundments are required for regulation and which therefore incur evaporative losses) are presented as part of the sections covering these sectors (see Section 5.2 and 5.3). Domestic water requirements are also briefly reviewed in section 5 of this report.

3.7 MAJOR WATER MANAGEMENT ISSUES

3.7.1 Flood

The EN has a long recorded history of flooding. The region is characterized by highly variable river flows and a significant proportion of the annual runoff volume of the Eastern Nile, contributing over 86% of the total River Nile flows, which occur in only three months, July to September. During high rainfall periods, major rivers in the region often give rise to large scale riverine flooding, particularly in the floodplains of the Sudan and Ethiopia, with devastating effects on lives, livelihoods, and properties. The estimated average annual damage is USD 25.77 million and USD 5.54 million in rural settlements riparian to the Blue Nile and the Main Nile in the Sudan and in the Fogera and Dembiya floodplains adjoining Lake Tana respectively. The 2006 flood in Ethiopia, for example, resulted in 700 deaths and 242,000 people became displaced. Furthermore, in the Fogera and Dembiya floodplains, flooding is still considered as a necessary annual occurrence and most of the communities have adequate knowledge of how to live with, and benefit from floods. In the Gambella plain severe flooding, estimated to be of annual exceedance probability 2%, occurred in 1988, during which most of the city of Gambella and other towns along the Baro River were inundated.

Over the last ten years, heavy flooding was experienced in the Sudan in 1998, 1999, 2001, 2002, 2003 and again in 2006. The 1998 flood in the Sudan had caused a direct flood damage of US$ 24.3 million. Prior to this period, the country experienced very severe floods in 1878, 1946, and 1988. The socio-economic impacts of these floods included the displacement of large numbers of people, loss of agricultural crops, damage to agricultural inputs such as seeds and pumps, deterioration of health conditions due to the increased incidence of malaria and water-borne diseases, and disruption of social services such as education and health.

3.7.2 Drought

Egypt has been drought prone since time immemorial. Egypt is a very arid country where rainfall is virtually non-existent. Two of the worst hydrological droughts are known to have occurred in 1067-1072 and 1199-1202. The droughts that occurred in 1199-1202, referred to as "the years of starvation" were due to very low levels of the Nile. Around 2/3 of the population died in that famine. Of course if levels in the Nile were very low, it can only have been the result of devastating drought in the upland countries as well. There was also very low rainfall at the beginning of the 20th century and prolonged drought following the years 1913-1914 and around the years 1939-1942. The years 1972 -1973 were dry and the period 1979-1984 coincided with the drought in the Sahel that extended to Ethiopia and the Sudan. In 1913-1914, Egypt suffered one of its worst droughts in recorded history (since 1695). The natural yield of the river at Aswan was 42 Bm^3 (Fahmy, 2006). The available storage water plus the natural summer flow were too little to fulfil the irrigation requirements at that time which badly affected agriculture.

3.7.3 Salt water intrusion

In the EN salinity intrusion might be a problem in the Nile delta which is located in Egypt. Egypt has a relatively long coast line, including more than 950 km along the Mediterranean Sea in the north and 1200 km along the Red Sea in the east (Fahmay, 2006). The coastal region is one of the most densely populated areas in Egypt and faces challenges due to the rise of sea level. The most important coastal lowland in the Nile basin lies along the Mediterranean Sea and there is possibility of hydraulic contact between the Nile Delta aquifer system and underlying the formations directly by embedded faults.

Studies have predicted that relative rise in sea level in the Mediterranean Coast could lead to increased flooding and saltwater intrusion. In summary there are three main reasons for salt water intrusion:

- reduced fresh water flow in the dry season,
- increasing water withdrawal for irrigation and
- sea level rise due to climate change.

In the Sudan, the Ministry of Water Resources and Irrigation (MWRI) of the Sudan has started looking into the use of low salinity brackish groundwater in irrigating certain seasonal crops as an adaptation strategy to climate change.

3.7.4 Sedimentation

The sedimentation problems in the Eastern Nile originate from the Ethiopia Highlands. Rainfall in the Ethiopia Highlands falls on bare lands at the beginning of the rainy season in July and resulting in a high sediment load. The highest sediment concentrations occur in the rising flood waters in late July to the first ten days of August. The average specific sediment yield rate of the basin is 9000 tonne/sq. km/yr (Shenkut, 2006). The Hydraulics Research Station (HRS) under the MWRI, the Sudan measures sediment concentration and discharge in several locations of the Gezira Scheme canalization system. It has concluded that 5% of the sediment settles in the main canals, 23 % in the major canals, 33% in the minor canals and 39% passes into the farm fields. The huge reduction of the original capacity of the Sudan reservoir due to sedimentation is easily noticeable. The Sennar lost 66%, the Girba 60% and the Roseires 30% (Ahmed, 2006). However, this will change with the construction of the GERD in Ethiopia near the border with Sudan. The majority of sediment will now be trapped in this reservoir.

3.7.5 Surface water quality

Several areas and cities in the Eastern Nile depend on the Nile system for their drinking water. Watershed erosion and heavy sediment movement during flood season especially the flood season cause high turbidity and suspended solids in the Nile River water making the water unsuitable for domestic use and drinking purposes. For example at Khartoum, the turbidity has increased tremendously during the last decade. It was increased from 5000 NTU to above 20,000 NTU during the floods of 1999 to 2003 (Ahmed, 2006). Many water treatment plants have been affected by such a heavy sediment load. For example, the Khartoum water treatment plant, which was designed initially to treat raw water up to a maximum turbidity of 8000 NTU (Ahmed, 2006), now produces water of poor quality when the sediment dose is greater than the maximum allowable quantity. Besides sedimentation, discharge of untreated or partially treated industrial and domestic wastewater, leaching of pesticides and residue of fertilizer as well as navigation and mining (oil) are often factors that affect the quality of water of the Nile River.

3.8 SUB-BASINS OF EASTERN NILE BASIN

3.8.1 Introduction

The four sub-basins of the Eastern Nile are briefly reviewed rom the hydrological and water resources perspective in the following sections (3.8.2 to 3.8.5)

3.8.2 Abbay-Blue Nile

The Blue Nile (or Abbay as it is known in Ethiopia) originates in the highlands of the Ethiopian plateau and this sub-basin has an area of over 310,000 km2. It begins its long journey to the Main Nile from Laka Tana that is fed by the Gilgil Abbay (the "little" Abbay, considered to be the start of the Blue Nile system). Water resources developments in the Gigel Abbay basin currently include the Koga irrigation system, with a gross command area of 7,000 ha (net 5,100 ha).

The topography, sub-basin limits and rivers of the sub-basin are shown in Figure 3-8..

In 1995-1996 the Chara Chara weir at the outlet of Lake Tana at Bahir Dar was put into operation in order to control the level of Lake Tana and regulate outflows for hydropower production at Tis-Abbay HPP I & II not far downstream (77 MW installed capacity). The weir controls a volume of 9.1 billion m^3 in the lake (equivelant to 2.4 x average annual outflow) between the levels 1784 and 1788 masl. Currently, the weir is also used to control levels for the diversion of water from the lake to the Tana-Beles system.

Downstream of Lake Tana a number of major tributaries discharge to the Blue Nile upstream of the border with Sudan, including the Beshile, Welaka, Jemma, Muger, Guder, Birr, Finchaa, Diddessa (including Wama, Dabana River and Angar), Dabus and Beles rivers. From the Sudanese-Etiopian border to the river mouth at Khartoum the river is joined by the Dinder and Rahad Rivers.

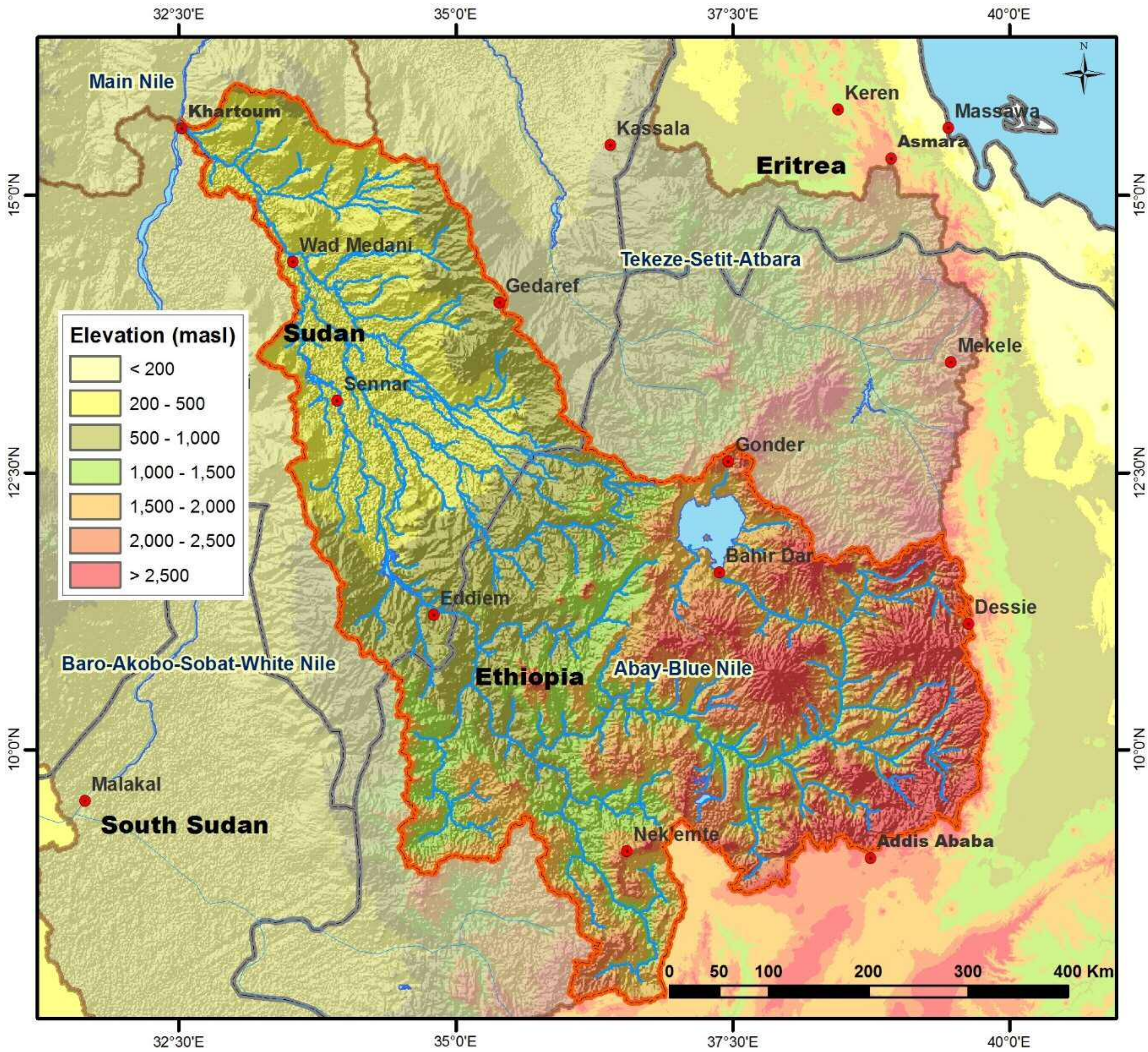


Figure 3-8: Abbay – Blue Nile Sub-basin

In the Abbay River basin downstream of Lake Tana the following significant water resources developments are currently to be found in Ethiopia:

- Beles basin with Tana-Beles hydropower dam having an installed capacity of 460 MW and 2,000 ha irrigatio n project under development (not yet in operation),
- In Finchaa basin the Finchaa-Amerti dams with 134 MW installed capacity producing hydropower and supplying irrigation water to 6,205 ha under the Finchaa Sugar

In addition the following developments are under construction:

- Grand Ethiopian Rennaissance Dam (GERD) close to the border with Sudan, which will have a large reservoir (and generate up to 6,000MW of electricity

On the Blue Nile in Sudan the Roseires (1966) and Sennar (1924) dams and associated reservoirs supply water for irrigation and generate hydropower. Their storage capacity at present is less than 3 billion m^3 . The second and main filling of the reservoirs takes place in September and October as soon as the river flow at Deim has dropped to 350 Mm ^{3}/day. Their emptying starts in November and lasts till April-May. To increase the capacity of Roseires reservoir to allow development of new irrigation schemes the dam has recently been. At present, the total irrigated area along the Blue Nile in Sudan, including Dinder and Rahad, amounts 1,304,940 ha. This comprises the schemes Gezira and Managil, Rahad, El Suki, Guneid Sugar, Sugar NW Sennar, Abu Naama, Seleit, Waha and public and private pump schemes.

Rainfall is highly variable. Rainfall in Abbay-Blue Nile Sub-Basin ranges from nearly 2,000 mm/yr in the Ethiopian Highlands to less than 200 mm/yr at the junction with the White Nile (NBI, 2012). The hydrological variability is high. As can be seen from Historical flow variability is very high on the Blue Nile (see **Figure 3-10**), with sharp changes from periods of intense floods to severe hydrological droughts.

The flood impacts in the sub-basin are felt mostly around Lake Tana and downstream in Sudan.

The Blue Nile derives its name from the relatively dark colour of the sediment-laden water when it meets the clear White Nile at Khartoum. It is estimated that the Blue Nile transports about 100 million tonnes of sediment downstream. This results in siltation of the downstream reservoirs (such as Roseires and Sennar), increased maintenance costs, and reduced hydropower production.

An indicative water balance for the Blue Nile system is presented in **Figure 3-11**. The mean annual flow at the Ethio-Sudan Border and the Roseries Dam is 51.03 billion m^3 and 49.30 billion m^3 respectively, indicating a loss of 1.73 billion m^3 between the border and the Roseries station. Annually 6.3 billion m^3 is abstracted from the Sennar reservoir for irrigation purposes while the Rahad-Dindar contributes 4 Bm^3 and finally the annual mean flow of the Blue Nile at Khartoum becomes 48.7 billion m^3 . The Blue Nile contributes 65% of the inflow to the Main Nile (ENTRO, 2006a).

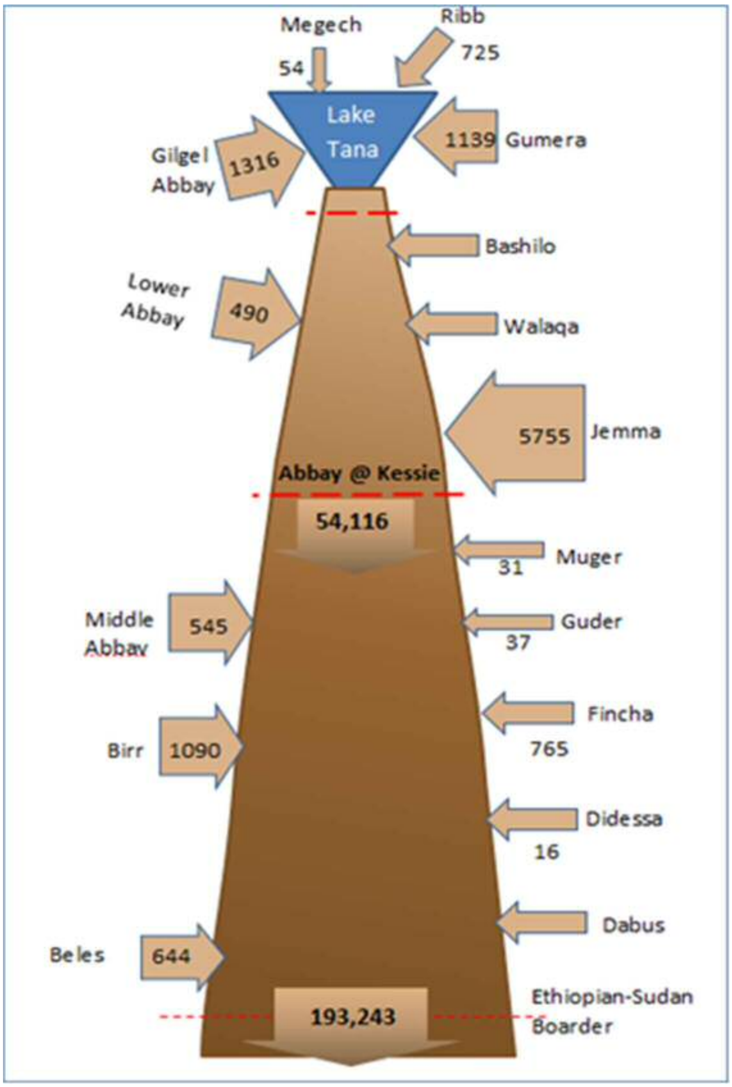


Figure 3-9: Illustrative Sediment Budget of the Abbay-Blue Nile (Avg '000 tonnes/yr estimated for 1994-2000)

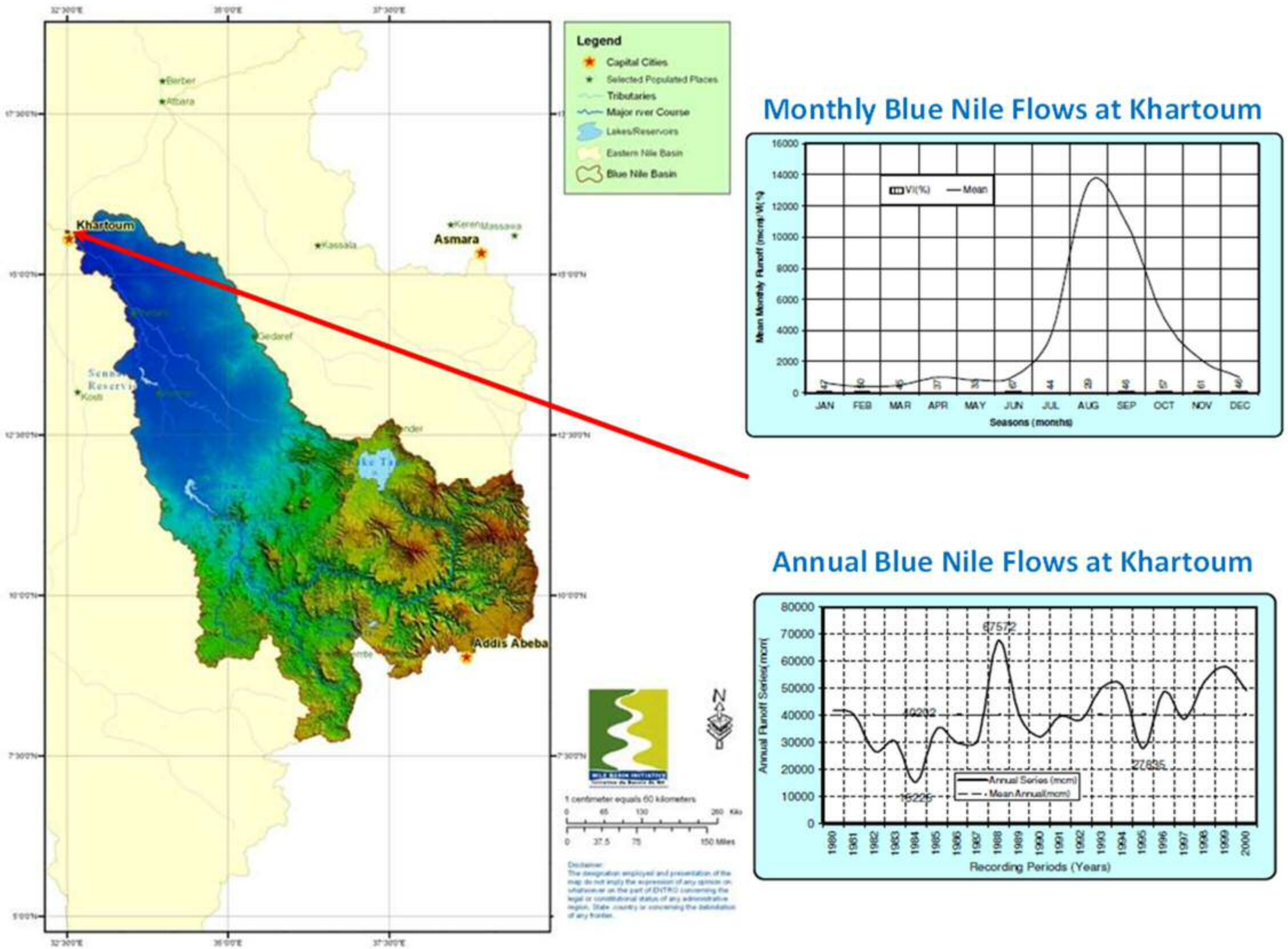


Figure 3-10: Flows in the Abbay-Blue Nile

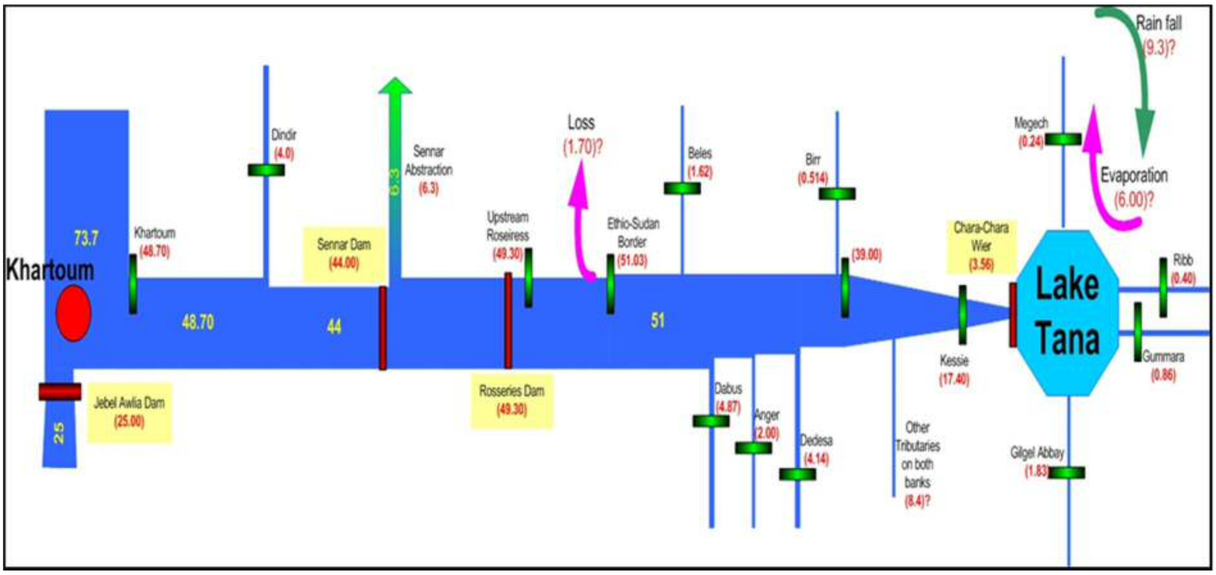


Figure 3-11: Indicative water balance schematic for the Abbay-Blue Nile sub-basin (Source: ENTRO, 2006a)

3.8.3 The Baro-Akobo-Sobat and White Nile sub-basin

The Baro-Akabo-Sobat sub-basin (covering about 206,000 km^2) consists of the Baro River (and its tributaries such as the Birbir) and the Akobo river (with its main tributary, the Pibor). After the confluence of the Baro and Akobo, the river is called Sobat in South Sudan. The river makes its way from an altitude of over 3000 masl in the Ethiopian hills to about 400 masl when the Sobat crosses into South Sudan on the way to its junction with the outflow from the Sudd wetlands.

The resulting White Nile (with its basin covering about 262,000 km^2) flows north to Khartoum where it joins the Blue Nile. Population densities range from a sparse 5 people/km^2 in upstream Jongli to almost 1000 people/km^2 near Khartoum. The rugged upstream areas offer hydropower potential although they are quite far from load centers.

The topography, sub-basin limits and rivers of the sub-basin are shown in Figure 3-12. The flows in the Baro-Akobo-Sobat Sub-Basin are summarised in Figure 3-13.


A view of the Sobat River

There are important wetland areas in this sub-basin. The seasonal rainfall pattern and large flat areas have resulted in the formation of many wetlands (e.g. the Gambella, Machar Marshes, etc.) that have been a defining influence on the activities of the people (including tribal groups) of the sub-basin. The Machar wetland is located north of the Baro River upstream of its confluence with the Pibor River. The Machar swamp has been studied by different research teams since 1950.

These different research activities have revealed some important features of the Machar wetland system and its inflows. The wetland system in a depression has a hydrology primarily driven by evaporation and local rainfall.

Most of the flow that goes from the Baro river system to the wetland during high flows comes back into the Baro and White Nile rivers downstream (through an extended grass field channel called Khor Adar) although flow estimates vary. The high rainfall, fertile lands, and nearby rivers in this sub-basin could offer significant potential for sustainable agricultural growth. Sutcliffe and Parks (1999) estimate the loss between Gambela and the mouth of the Baro at 2.8 billion m^3/year.

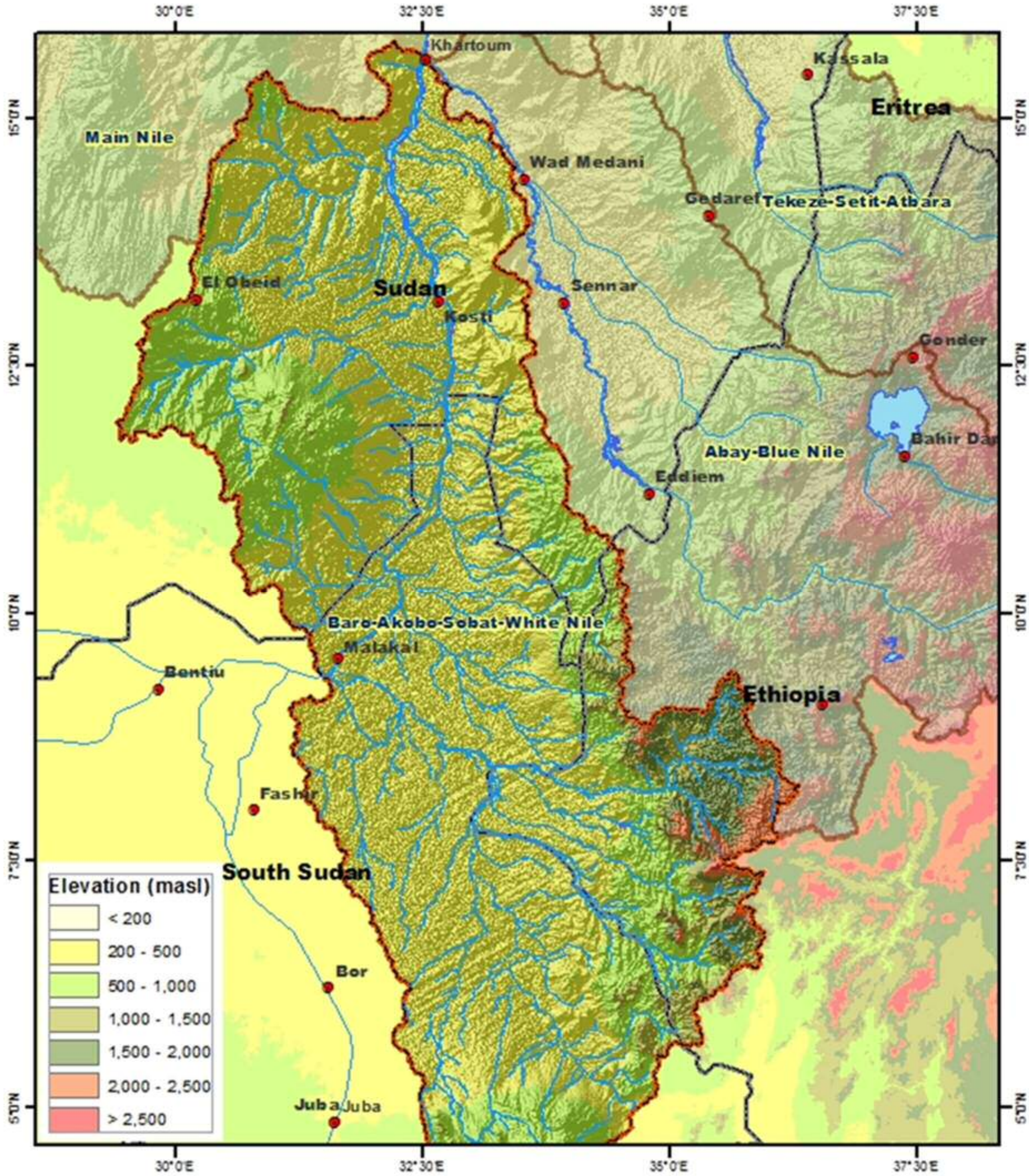


Figure 3-12: Baro – Akobo – Sobat Sub-basin

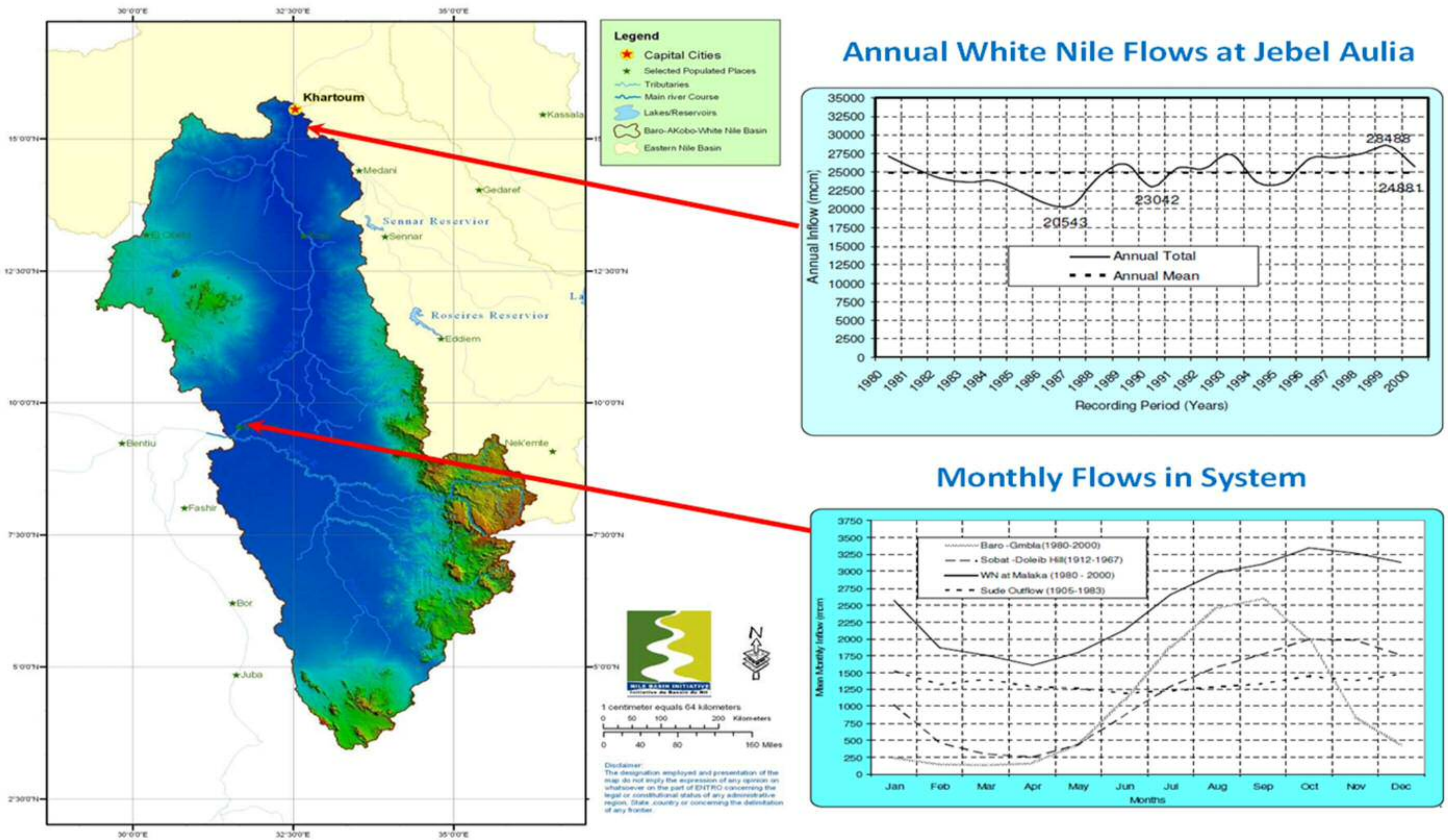


Figure 3-13: Flows in the Baro-Akobo-Sobat Sub-Basin

On the Alwero River the Abobo dam has been constructed and is is planned to supply irrigation water to a command area of 10,400 ha, most of which is currently being developed. Downstream of Malakal the slope of the White Nile is very small: 1.5 cm/km. In the 730 km reach from the mouth of the Sobat to Khartoum inflows from tributaries are negligible; only the Khor Adar River debouching at Melut contributes. There is a net water loss due to evaporation from the river, further increased by the operation of Jebel Aulia dam and reservoir since 1937 which heads up the water table for irrigation and navigation purposes. At present irrigation water is supplied from the White Nile in the Sudan to a total command area of 348,600 ha, including public and private pump schemes, Kenana Sugar, Kenana, Hagar Asalaya Sugar, Sondos and White Nile schemes.

The mean annual flow of the Baro River at Gambella is 12.4 billion m^3 (1980-2000). In its lower course, the flow spills and a large amount of spillage enters the Machar swamp. Annual spillage is estimated to be above 3.03 billion m^3 (1980-2000). This spillage is estimated to be 3.6 billion m^3 (1905-1955). At the mouth of the Baro River, the mean annual flow is recorded to be 9.53 billion m^3 (1905-1955). Due to the combined flow from the Baro (9.53 billion m^3), the Gilo (3.2/1.12 billion m^3), the Pibor (0.224/1.04 billio m^3) and the Akobo (3.9/0.37 billion m^3), the average annual inflow of the Sobat River at the Doleib hill located upstream of the Malakal station becomes 13.687 billion m^3 (1905-1955). The mean annual inflow from the Sude to the White Nile at Malakal has been estimated as 16.82 billion m^3 and together with the Sobat system it is estimated to produce a mean annual inflow of 30.50 billion m^3 to the WN system. At the Jubel Aulia station, the average annual flow of the White Nile has reduced to 25 billion m^3. The flow loss is mainly due to evaporation from the Jubel Aulia reservoir as well as evapotranspiration from agricuktural activities. The White Nile system contributes about 30% of the Nile flow at Aswan. (ENTRO 2009b).

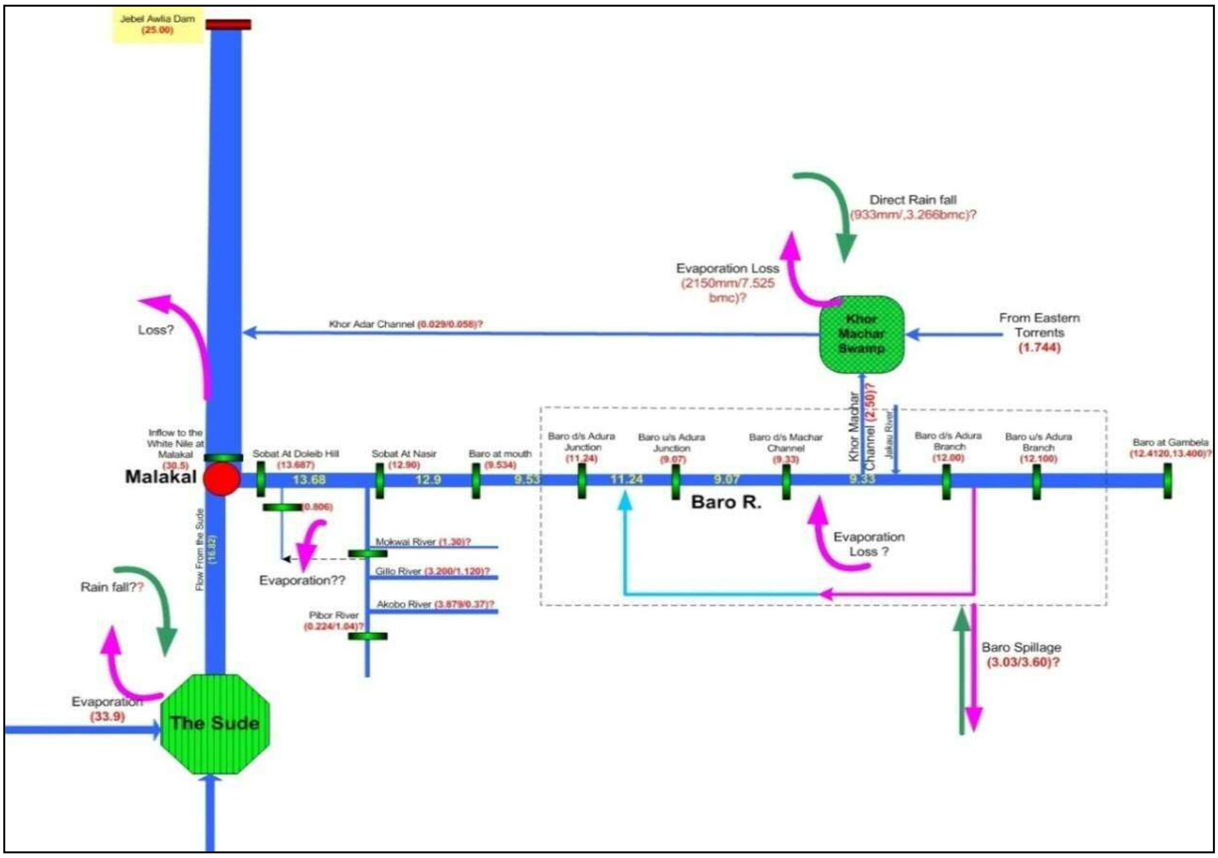


Figure 3-14: Flow Schematics of Baro-Akobo-Sobat-White Nile Basin (Source : ENTRO, 2006b)

3.8.4 **Tekeze-Setit-Atbara**

The Tekeze-Setit-Atbara sub-basin (covering about 230,000 km^2) consists of the Tekeze river (known as the Setit in Sudan), and its tributaries, the Goang (Atbara in Sudan) and Angereb, all of which originate in the north central highland plateau of Ethiopia. As the river makes its 1325 km journey, it falls from a height of about 3000 masl near its origin to about 500 masl when it joins the main Nile in Sudan, about 285 km downstream of Khartoum. The population in the basin is primarily rural. About 75% of the basin area is grassland, shrub land or bare land and 15% of the basin area is covered by rainfed crops. Rainfall in the Tekeze-Setit-Atbara is highly variable. The rainfall varies from 1000 mm near the source of the river to about 40 mm near its junction with the Main Nile. The Sub-basin limits, topography and rivers are shown in **Figure**

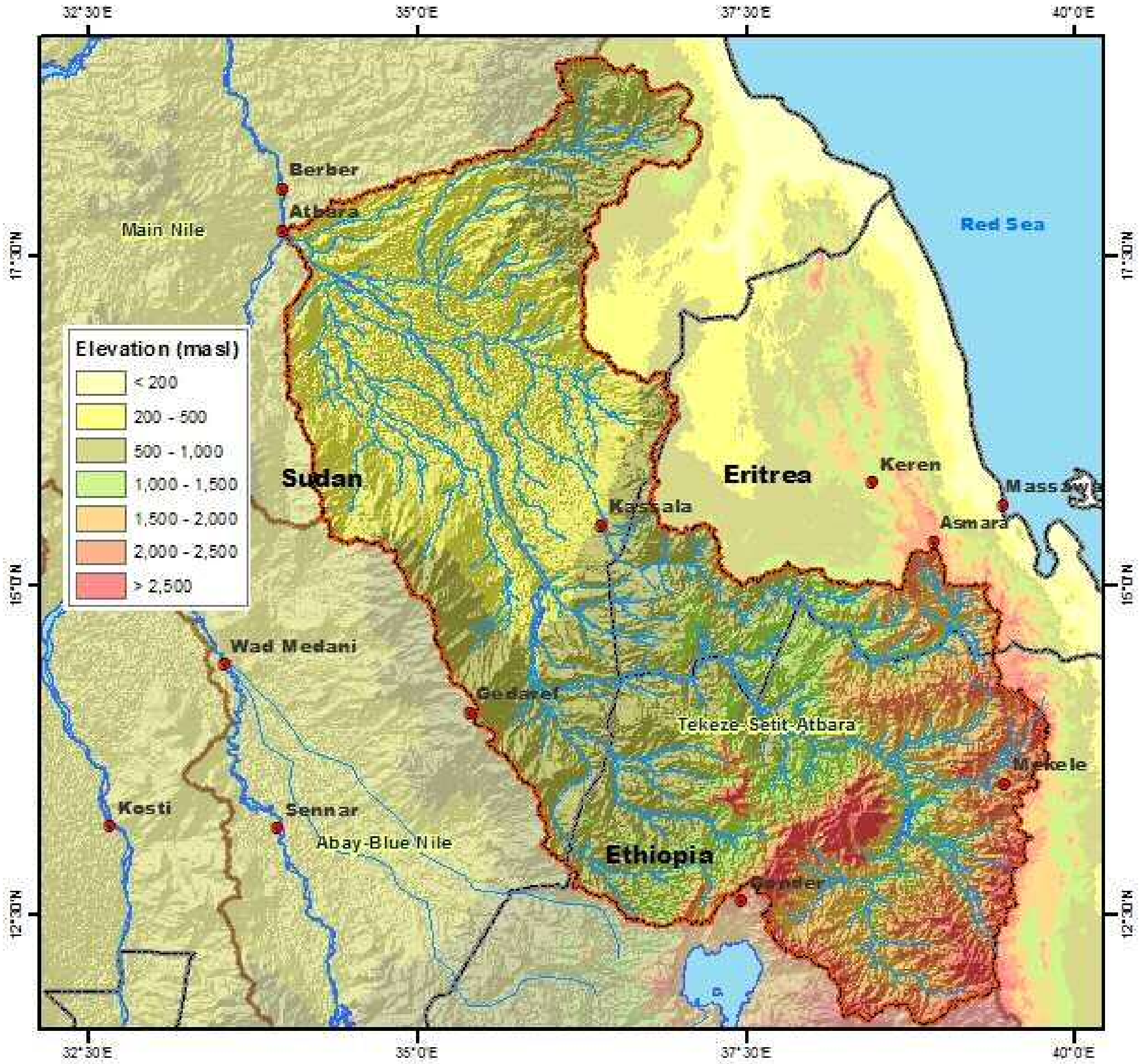


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Figure 3-15: Tekeze - Setit - Atbara Sub-basin

The flows are highly variable (compared to the Blue Nile and Baro-Akobo-Sobat sub-basins) especially in the crucial low flow months. The main stem of the sub basin at El-Girba station has an annual average inflow of 11.45 Bm^3 (1980-2000). Groundwater in upstream areas is limited to isolated rock faults and fractures due to the absence of large tracts of permeable sediments in the system. Downstream, the upper Nubian aquifer (8.4 Mm^3/yr) and recent Neogene deposit sediments (11.2 Mm^3/yr) offer additional groundwater opportunities subject to the costs of tapping these resources.

In Ethiopia at present no large-scale irrigation schemes exists in the Tekeze Basin, though a number of small scale irrigation farms exist. Recently, the Tekeze hydropower dam (TK5) in the upper Tekeze basin was put in operation. In Sudan the Khasm El Girba Multipurpose Dam supplies water to the New Halfa schemes with a total irrigated area of 206,640 ha.

An indicative water balance showing the magnitude of the mean annual flow at important nodes in the system is given in **Figure 3-16**.

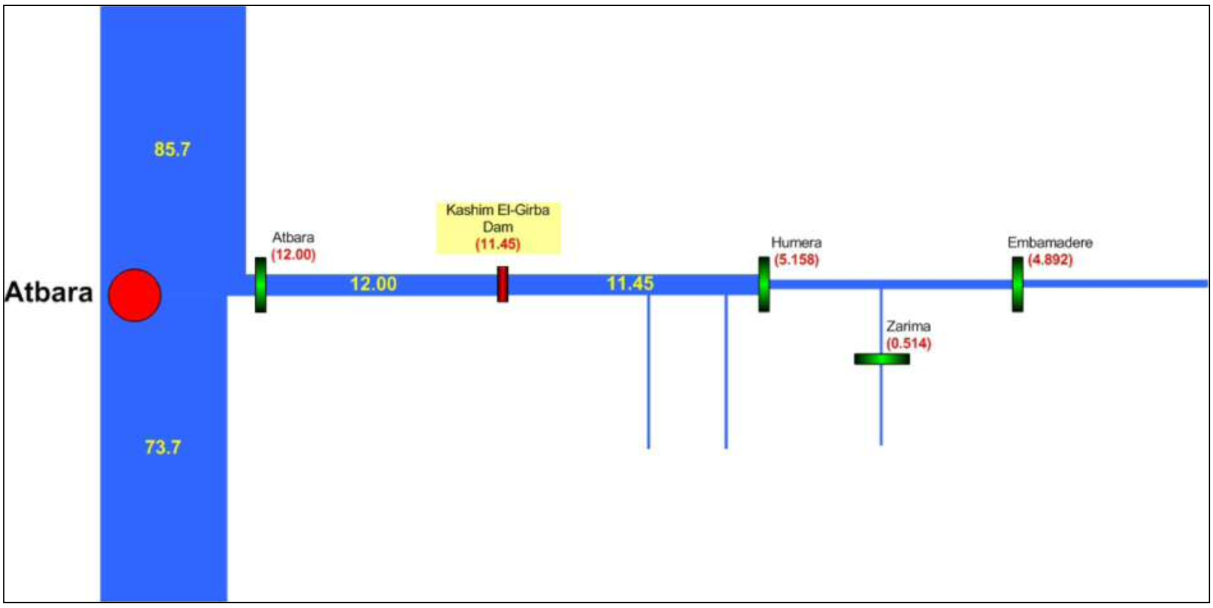


Figure 3-16: Flow Schematics of Tekeze-Atbara-Setit Sub-basin (Source : ENTRO, 2006b)

Sediment flows are high There is high erosion from the grazing/settlement areas (over 70 Mt/yr) and from cultivated land (almost 30 Mt/yr). Approximately 40% of the sediment is re-deposited in the landscape. It has been estimated that about 80 million tonnes of sediment flow annually into Khasham-el-Girba reservoir, and its capacity is now half what it was when it was built. Sediment load at the Humera is estimated at 68.61Mt/yr. The contribution of the upper Atbara (Goang and Angereb) at the border is estimated at 7.37Mt/yr, which yields mean annual sediment inflow of 76Mt/yr to the system at the border. The Kerib land in the Sudan contributes mean annual sediment inflow of 3.22Mt/yr. Mean annual sediment load reaching the mouth of the sub-basin (Atbara) is estimated at 58.43Mt/yr. The Atbara River contributes 12.7 % of the total discharge of the Main Nile. The average discharge at the Kashm el Girba station (1986-2000) has been found to be 11.45 km^3 . The total runoff is 52,834 m^3 water per km^2 per annum, compared with 169,612 $m^3/km^2/yr$ for the Blue Nile and 28 833 $m^3/km^2/yr$ for the Baro-Akobo-Sobat (ENTRO, 2006d).

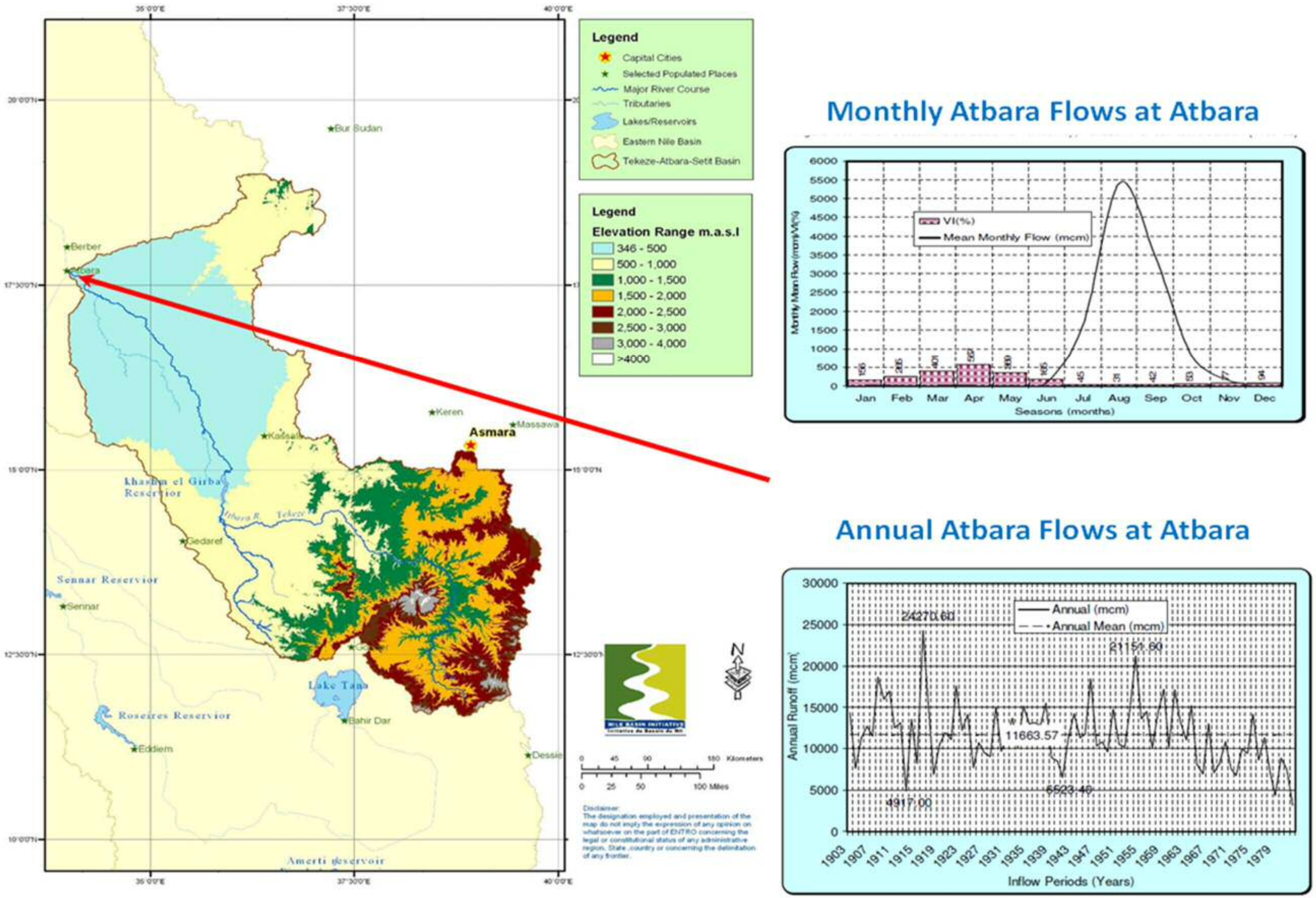


Figure 3-17: Flows in the Tekeze-Setit-Atbara Sub-Basin

3.8.5 **Main Nile**

At Khartoum the Blue Nile joins the White Nile and the combined waters, increased with the runoff from Atbara, flow for 1430 km to Aswan. The river's course consists of a series of mildly sloped placid reaches, separated by steep sloped turbulent rocky sections, called cataracts. From Khartoum onward the following cataracts are discerned: 6th cataract or Sabaluka cateract between Khartoum and Shendi, 5th cataract between Atbara and Abu Hamed, 4th cataract near Merowe, 3rd cataract at Kajbar, Dal cataract, 2nd cataract at Wadi Halfa and 1st cataract at Aswan. The Sub-basin limits, topography and rivers are shown in **Figure 3-18**.

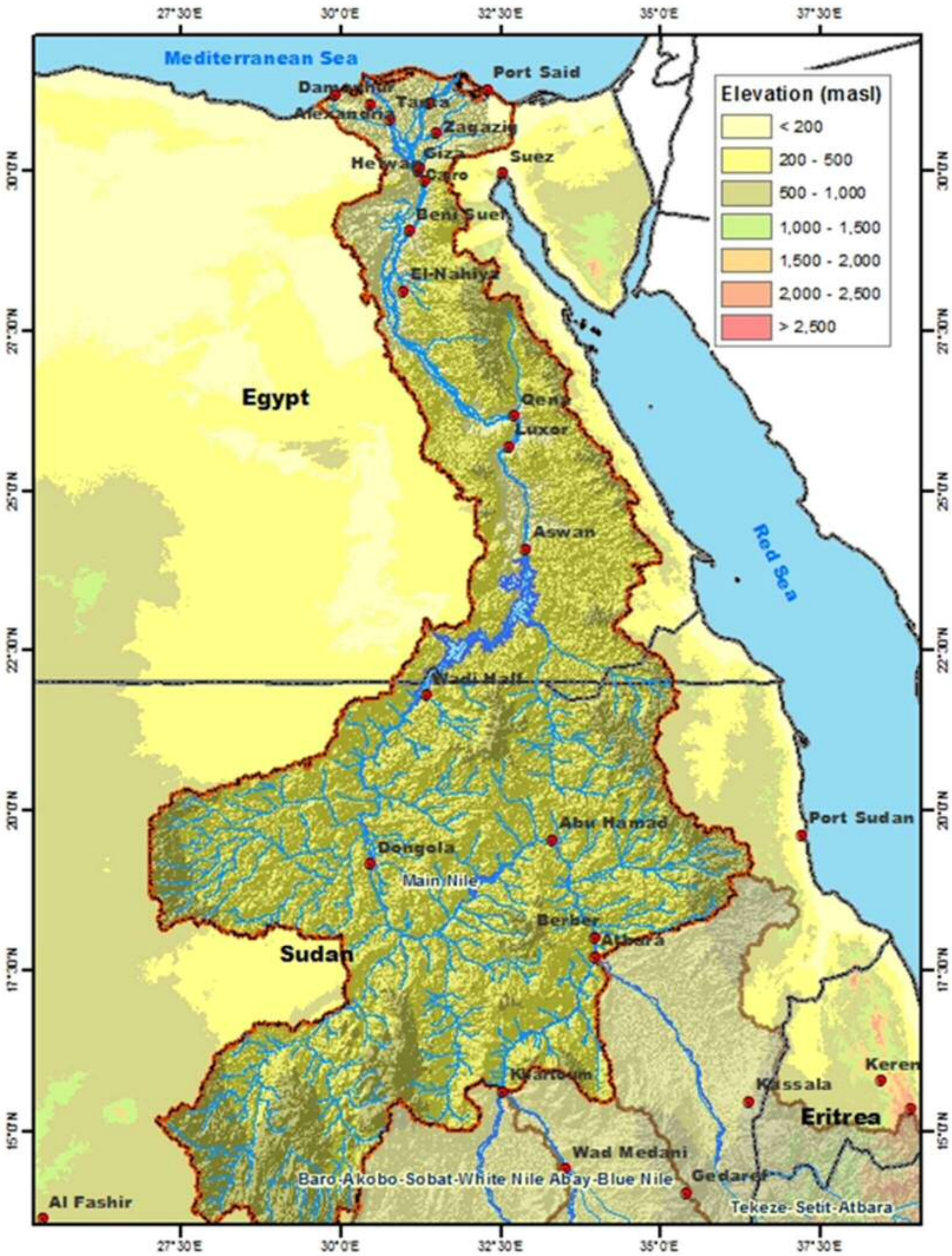


Figure 3-18: The Main Nile Sub-basin

The Main Nile sub basin is characterized by a mild land slope. The total sub basin area is estimated at 656,000 km2. Evaporation is considerably high. Lake evaporation at the Aswan High Dam is estimated at 2.6 m/year (OSI, 2006b) – which translates to about 10-14 BCM/yr. The recently constructed Merowe dam has also increased the system evaporation losses in the Main Nile. The potential evapo-transpiration in the sub basin is estimated at 6.8 m/year (Khartoum station), 7.8 m (Dongola station), 5.8 m (High Aswan Dam station) and 1.8 m (Alexandria) on the Mediterranean coast (ENTRO, 2008a).

A number of dams and barrages have been built in the Main Nile to generate hydropower and/or to head up/store water mainly for irrigation. In 1903 at Aswan the first dam (now called Old Aswan Dam) in the Main Nile was constructed, followed in 1968 by the High Aswan Dam with Lake Nasser fully controlling the Nile regime in Egypt, whereas in 2009 the Merowe multipurpose dam for hydropower

production and irrigation water supply in Sudan was inaugurated. At Lake Nasser, Nile water is diverted to the Toshka New Valley scheme. Further downstream the Esna, Nag Hammadi, Asyut and Delta (Damietta and Rosetta) barrages head up the water to divert virtually all Nile water released at Aswan mainly to irrigations areas along the river. Before entering the Mediterranean Sea the Damietta branch diverts water at Zifta barrage and ends up at Farascour dam and the Rosetta branch is controlled by Idfina barrage. The following sections in this reach are distinguished:

- Old Aswan dam to Esna barrage
- Esna barrage to Nag Hammadi barrage
- Nag Hammadi barrage to Asyut barrage
- Asyut barrage to Delta barrages
- Damietta branch, from Damietta, via Zifta barrage to Farascour dam
- Rosetta branch, from Rosetta to Idfina barrage.

The latter two branches ultimately discharge into the Mediterranean Sea. At present, in Sudan along the Main Nile the total irrigation area amounts 150,620 ha, including 20,000 ha at Merowe. In Egypt the irrigated area along the Main Nile amounts currently 3.9 million ha.

The inflow to the main Nile system at the Khartoum junction is estimated to be 74bcm. The total BN inflow including that of the Rahad and the Dindar is 56bcm. Accounting for mean annual abstraction of about 6.50bcm and 0.786bcm evaporation from the Roseires reservoir and the Sennar reservoir respectively in the Sudan BN system, 48bcm of inflow reaches Khartoum. The 30.5bcm inflow of the Sobat-White Nile system at Malakal is reduced to 26bcm d/s of the Jubel Aulia reservoir, the balance being for the abstractions in the Assalaya & Kenan sugar farms (all together 1.3bcm), evaporation losses (estimated at 2.12bcm) from the Gebel Aulia reservoir and losses through seepage and spillage along its route from Malakal to the Jubel Aulia reservoir. At Atbara, some 300km d/s of the Khartoum junction, the Atbara-Setite-Tekeze sub-basin contributes mean annual inflow of 12bcm, which increases the inflow of the main Nile d/s of the Atbara confluence to be more than 84bcm. The Sudan's abstraction d/s of the Khartoum confluence is insignificant (0.534bcm). The mean annual inflow reaching the Aswan reservoir is estimated to be 84 bcm (OSI Water Synthesis Report p. 174). The Blue Nile with mean annual inflow of 50 bcm contributes 60% of the inflow entering the Aswan reservoir. The White Nile and the Tekeze-Setit-Atbara contributes 25% and 15% of the inflow entering the Aswan reservoir respectively.

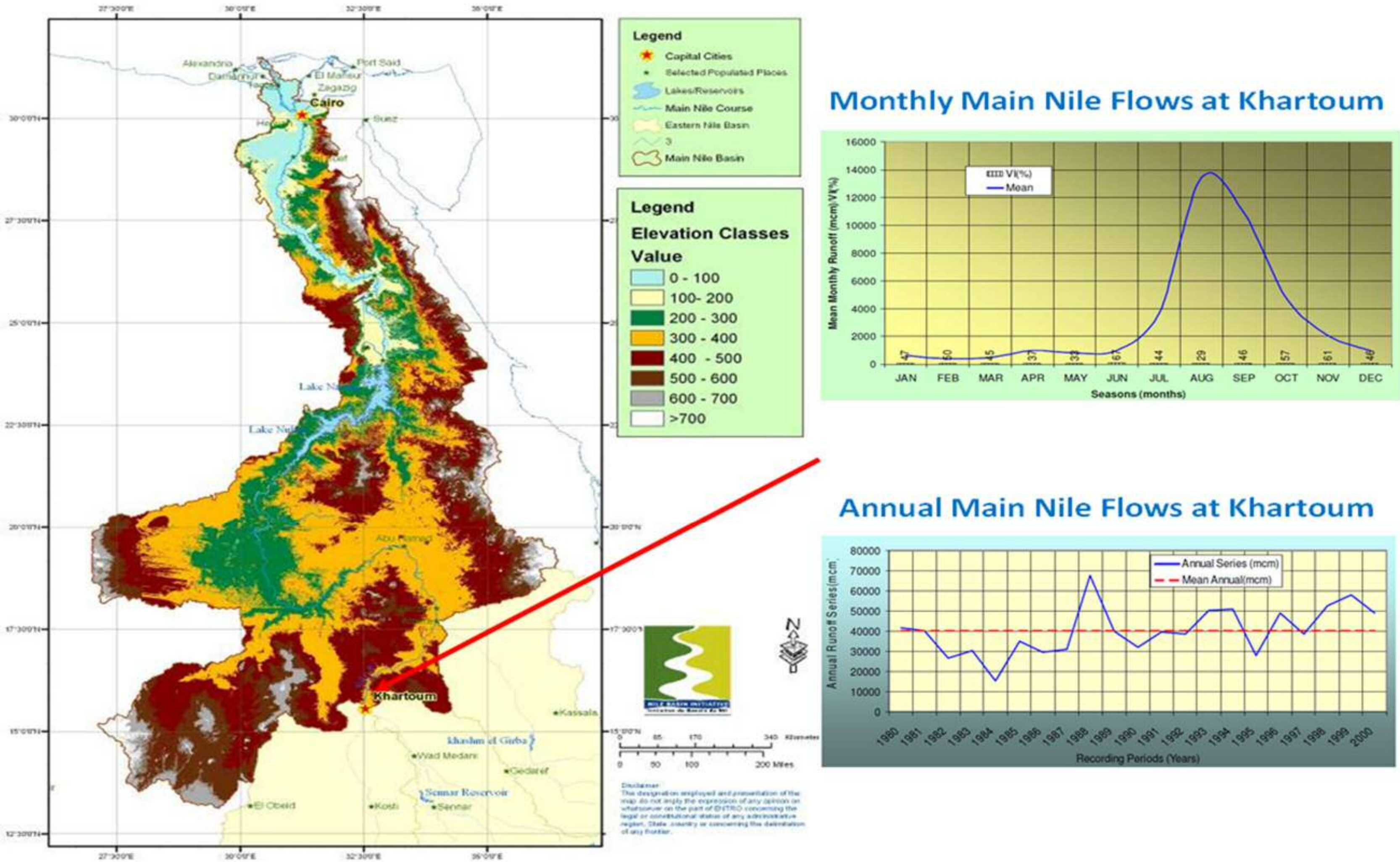
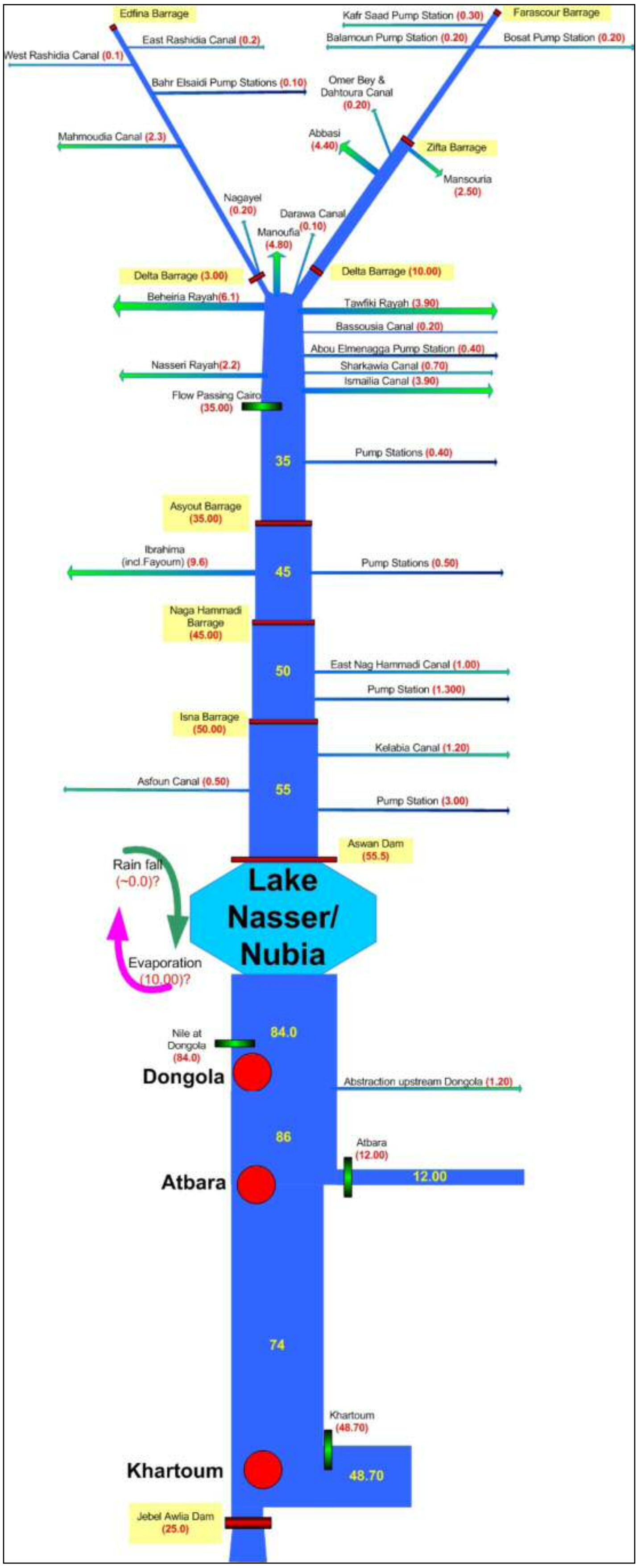


Figure 3-19: Flows in the Main Nile Sub-Basin

However, there are inconsistencies in the data on the water balance at Aswan. This is a significant information gap with implications for the MSOIA since it is important to be able to accurately assess impacts of different development and management actions on the system downstream.

A schematic diagram of the Main Nile sub-basin and the Eastern Basin are presented in **Figure 3-21**.

Figure 3-21: Flow Schematics of the Main Nile Sub-basin (Source : ENTRO, 2006b)



3.9 AN OVERALL PERSPECTIVE ON THE WATER BALANCE OF THE EASTERN NILE BASIN

Figure 3-22 provides an overall perspective on the hydrological cycle in each sub-basin and the water balance of the entire Eastern Nile basin in terms of the "green water" used productively, infiltrated and evaporated and "blue water" that ends up in rivers. As shown, the three upper sub-basins all have much more rainfall and surface water outflows than are experienced downstream in Sudan and Egypt. Very little of the water supply in Egypt comes from rainfall; the vast majority originates from surface water flows from Sudan. Evapo-transpiration outflows in Egypt (includes crop water use, evaporation losses from reservoirs, and other system evaporation losses) amount to about 57 Bm3 annually; another 13 Bm3 flows into the sea.

Southward and upstream, rainfall in sub-basins within Sudan plays a greater role but is still only about 30% of total inflows; evapo-transpiration there is about equal to surface water (outflows). In all three of the Ethiopian sub-basins the hydrology is dominated by rainfall. However, evapo-transpiration losses still far exceed surface water outflows.

Of about 580 billion m^3 of rainfall in Ethiopia annually, only 14% (about 80 billion m^3) makes it to a surface watercourse that flows to South Sudan or Sudan. Specifically, net amounts that reach the rivers are 12, 54, and 13 billion m^3 for the Atbara, Blue Nile, and Sobat rivers respectively. It is estimated that the Sudd Swamps contribute approximately 15 billion m^3 to the White Nile.

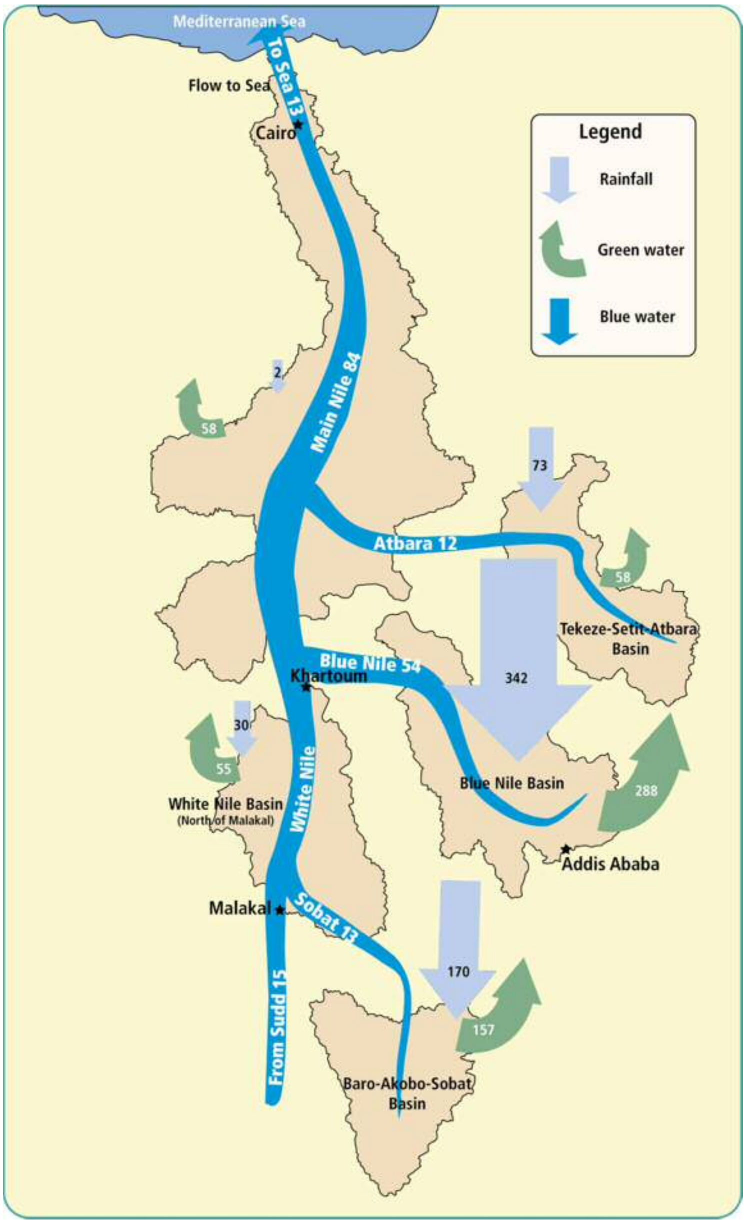


Figure 3-22: Green and Blue Waters of the Eastern Nile

It is estimated that in the Eastern Nile system abstractions (approximately 60 billion m^3 for irrigation) from the system occur in the form of net consumptive use, net groundwater loss, and further losses (e.g. reservoir losses, conveyance losses in rivers, canals, irrigation systems, and through crops). Evaporation losses from man-made reservoirs in the system are high and estimated to be almost 20 Bm3 annually. Annual conveyance losses directly from the river channel, floodplains and associated wetlands are estimated at 20 – 23 billion m^3. 0bviously, actions that can reduce evaporation for regional benefits can be investigated as part of the MSOIA. One key area will be the optimised management of the system and this will be part of the scenario design.

This rapid overview of the hydrology and water resources of the basin has highlighted a number of aspects which merit bearing in mind when looking at management and development options. They include the facts that:

- There is high variability in flow in most part of most tributaries coupled with low per capita storage
- Erosion is very high in many parts of the up and areas and this results in high rates of sedimentation of reservoirs, reducing yield and lifetime
- The understanding of the hydrology in many parts of the sub-basin is limited and there is a need to improve knowledge in these areas through further studies and improved data collection.
- There are high levels of evaporation, both as a result of man-lade reservoirs and naturally from lakes, wetlands and river channels.

4. Environmental and Socio-economic Baseline

4.1 Introduction

The aim of this section of the report is to provide the social and environmental context to the situational analysis. A clear picture and understanding of this context is critical to the **sustainable** development and management of the water resources of the Eastern Nile.

Socio-economic and environmental contexts are always very much intertwined and this is especially true when the livelihoods of a large proportion of the population are directly dependant on natural resources, as is the case in the Eastern Nile. For this reason, Sections 4.2 and 4.3 look at policy and institutional aspects as they relate to both socio-economic and environmental aspects together. Section 4.3 then provides the socio-economic baseline but includes frequent references to dependency on and anthropogenic impacts on the environment and natural resources. The environment is then covered in Section 4.4.

The contents of this section have been drawn from two comprehensive thematic reports. It has not been possible to included much of the detailed background – the focus has been more on providing the minimum of context necessary to understand the socio-economic and environmental issues, challenges, opportunities and constraints, and then to highlight the implications going forward for the MSOIA.

4.2 Guiding Environmental and Social Policies

4.2.1 Introduction

There are numerous environmental and social policies. The main ones are briefly introduced in the following paragraohs.

4.2.2 The Nile Basin Sustainability Framework (2012)

Elements of this framework, already introduced in Chapter 2, are particularly important with respect to the socio-economic and environmental context. The NBSF notes that sustainable development requires a dynamic balance between social equity, economic efficiency and environmental sustainability. The planned interventions under the first two key strategic directions, which seek to address the fundamental social and economic needs of the communities of the Nile Basin, will not have lasting positive impacts **without balancing actions to prevent irreversible damage to the natural systems**. The third key strategic direction, "*Environmental and water-related natural resources management*", therefore reflects NBI's overriding desire to reconcile water development projects with the carrying and regenerative capacity of the natural ecosystems of the Nile Basin.

The NBI also recognises the need and urgency for mounting and coordinating basin-wide efforts to adapt to, and mitigate the impacts of, climate change. This is addressed in the fourth KSD. Major watershed management and infrastructure measures to mitigate the impacts of flooding and droughts will have trans-boundary impacts and require the establishment of mechanisms for basin-wide planning and joint action.

In addition to the key strategic directions, there are a number of key cross-cutting complementary actions concerning communication, participation, gender mainstreaming, capacity building and resource mobilisation. These actions are critical to achieving IWRM, which is at the heart of the NBSF and of the MSOIA.

Stakeholder participation is identified as a key cross-cutting theme. Effective and meaningful stakeholder participation in the planning, development and management of water projects improves effectiveness, equity, and social inclusion. Communication is also a critical requirement for increasing participation and a sense of ownership of basin management interventions under the NBSF. Gender mainstreaming and pursuing a gender-balanced approach is also essential to achieving IWRM. In the Nile Basin there are significant gender differences in terms of use, access and management of water.

4.2.3 NBI Environmental and Social Policy (2013)

The NBI Environmental and Social Policy (ESP) was devised with four key objectives in mind, based on the NBI's recognized mandate:

- Objective 1: To provide a set of principles and fields of action for the integration of environmental and social concerns in NBI programs;
- Objective 2: To provide guidance for managing trans-boundary environmental and social impacts of national activities;
- Objective 3: To provide support to Nile Basin countries for the protection and conservation of critical Nile Basin environmental resources;
- Objective 4: To demonstrate commitment of the NBI and Nile countries to international best practices regrding environmental and social management of development.

The Key Principles of the Policy are:

- Sustainable socio-economic development;
- Basin-wide cooperation;
- Subsidiarity principle;
- Compatibility and complementarity;
- Precautionary principle;
- Public participation and consultation;
- Accountability and transparency;
- Social equality;
- Gender equity.

The 5 Key policies areas are aimed at achieving social and environmental sustainability of the NBI's programs and provide orientation for national WRM and WRD interventions:

- Policy area 1: Information and knowledge
- Policy area 2: Advocacy and awareness raising
- Policy area 3: Assessment and management of environmental and social risks and impacts. Within this policy area the focus is on:
  - Human health
  - Water quality
  - Climate change
  - Biodiversity

  - Wetland degradation
  - Involuntary resettlement
  - Public consultation, disclosure and awareness
- Policy area 4: Institutional strengthening
- Policy area 5: Partnerships, networking and linkages

4.2.4 Relevance to MSIOA study

The objective of the MSIOA project is to identify potential investment opportunities that create the opportunity for regional benefits and cooperation between the EN Basin countries. The identification of potential investment opportunities should therefore be consistent with the broad objectives and outcomes outlined in the NBSF and the key principles that underpin the Environmental and Social Policy (ESP). It is therefore **critical that each of the projects be tested against their ability to contribute towards achieving the broad objectives and outcomes outlined in the NBSF and the policies of the ESP**. The broad objectives, desired outcomes and principles set out in the NBSF and ESP therefore provide the MSIOA study with a **high level, strategic checklist** for identifying and evaluating potential investment options in the EN Basin.

4.3 INSTITUTIONAL FRAMEWORK /OVERVIEW

4.3.1 Introduction

This review briefly provides; (i) an overview of the key national policies and institutions involved in ensuring socially and environmentally sustainable management of the Eastern Nile; (ii) discussion on how transboundary issues are addressed at national level, identification of gaps and (iii) recommended measures for strengthening national capacities especially related to management of trans-boundary investments.

4.3.2 National Policies and Institutions

4.3.2.1 Introduction

The detailed description of the roles and functions of the main institutions in the areas of environment, water, and energy are provided in Annex 1. The following sections very briefly describe relevant policies in each country and identify critical policy gaps for the implementation of a joint development projects in the EN Basin.

4.3.2.2 Ethiopia

The Environmental Protection Authority and the Ministry of Water and Energy in Ethiopia are the two institutions who represent the country in discussions about shared water resources. Their roles are consistent with their mandates and reflect the priority given to hydropower.

The Environmental Policy of Ethiopia is the principal source of environmental and social management legislation. It sets the objectives for sustainable use of the environment including mandatory EIAs for development projects. The Ethiopian Water Resources Management Policy is the primary water related policy.

Recently, Ethiopia has undergone a decentralization of its environmental management function by delegating line agencies to conduct necessary studies and meet all requirements before issuing a project clearance. Hence, the role of the EPA is supervisory.

4.3.2.3 South Sudan

Not available.

4.3.2.4 Sudan

In Sudan, there are three major sectors represented in trans-boundary water management in the Blue Nile/Main Nile. These are environment and natural resources, through the Higher Council for Environment and Natural Resources (under the Ministry of Environment and Physical Development); water resources under the Ministry of Water Resources, the Ministry of Agriculture and Irrigation; and energy under the Dams Implementation Unit of the Ministry of Electricity and Water Resources.

While there are many pieces of environmental legislation in Sudan, it is the Environmental Protection Act of 2001 which provides the “umbrella law” for environmental matters. The National Plan for Environmental Management further details priorities for the environment. Legislation regarding water resources management is quite fragmented, while the Electricity Act of 2001 governs generation, transmission, supply, and use of electricity.

4.3.2.5 Egypt

The three main institutions in Egypt which are engaged in trans-boundary cooperation over the shared water resources in the Blue Nile and Mail Nile are the Egyptian Environmental Affairs Agency, (executive branch of the Minister of State for Environmental Affairs), the Ministry of Water Resources and Irrigation, and the Ministry of Electricity and Energy.

Specifically for the environment, Law 4 of 1994 and its Executive Regulations (amended by Law 9 of 2009) is the framework environmental legislation in Egypt. It provides the legal requirement for Environmental Impact Assessment. The national EIA Guidelines were issued and revised in 2009, and various sectoral guidelines have since been developed. The National Environmental Action Plan and the National Water Resources Plan are the major policy documents affecting Environment and Social Management (ESM) related to ENSAP activities.

4.3.2.6 Summary of Gaps

The policy gaps across the three countries that have been reviewed for achieving environmentally and socially sustainable management of shared water resources along the Blue Nile/Main Nile are summarized in Table 1 (below).

As can be clearly seen, several important gaps exist across all three countries. There is a gap in the ability of the existing EA systems to address both trans-boundary and cumulative impacts, or impacts of plans and policies.

A noticeable gap also exists in each country concerning provisions, guidelines, and procedures for various forms of social management, as well as the capacities to perform such social management. A central organization for management and monitoring of social issues is needed. The most important need is full and consistent inclusion of relevant stakeholders in the assessment and decision making processes. Provisions should be made for public review of assessment reports, documentation of consultation meetings, and stakeholder approval as an additional requirement for project (or policy) approval.

Enforcement is weak in all four countries, specifically South Sudan, and measures to monitor impacts and mitigation implementation need to be strengthened. Baseline data and information is also frequently non-existent or out-dated, creating general deficiencies in impact assessment capabilities. Monitoring networks and indicators need to be developed on a consistent basis from country to country. These gaps will have to be addressed in order to sustain water resources development projects. The impact of these gaps in relation to MSOIA projects is discussed in the next section.

Table 4-1: Summary of policy gaps for Ethiopia, Sudan and Egypt

Summary of Country Policy Gaps			
Egypt			
Constitution	**Environmental Policy**	**Water Resources Policy**	**Social/Resettlement Policy**
• no reference to sustainable development • no right to participation • no statement supporting regional cooperation and economic integration • no mention of efficient use of resources • promises equality before the law, equality of opportunity, and fair distribution, but not equitable use or benefit	• no overarching policy, only umbrella law • no requirement for SSEA • no mention of sustainable development (except in NEAP) • lack of emphasis on equitable utilization and benefit from resources • no focus on environmental management as a means of poverty eradication • no mechanism for trans-boundary management • no details regarding social impacts, particularly resettlement	• fragmented water resource legislation • policy development have yet to deal with future mismatch of supply and demand • drastic policy decisions may be required at national level after 2017 • projected agricultural expansion has varied from one policy to another based on available excess water	• lack of legal provision to compensate temporarily occupied land for public interest • inadequate legal provision to determine the market value and compensation for temporarily occupied structure • the right of squatters has not been addressed • no provision on how vulnerable groups should be treated • no allowance for business disturbance losses • monitoring or evaluation measures are not stipulated
Ethiopia			
• no mention of efficient resource use • no specific mention of poverty eradication, but addresses basic needs and improving conditions • weak provisions relating to trans-boundary issues	• no specific requirement for SSEA • vague guidelines for EIA, no guidelines for SSEA • no requirement for screening/scoping of project activities • weak requirements for reporting • no requirement for public review and incorporation of comments in EIA • no mechanism for trans-boundary management	• policy mainly deals with surface and ground water, leaves out rain water management • does not address the implications of water rights such as right of access to water, transfer of water rights, etc • does not address capacity building of stakeholders and beneficiaries at the lowest institutional level • rarely specifies responsible bodies or timeline for actions • lacks linkages between actors • not cover trans-boundary issues well	• no guidelines for calculation of compensation • civil code uses asset-oriented approach to valuation and compensation which differs from livelihood approach in the constitution and WB policies • provisions for indirect expropriation may exclude possibility of prior compensation

		•	
Sudan			
• no mention of efficient resource use • weak provisions relating to trans-boundary issues	• no specific procedures for ESIA • no requirement for SSEA • weak standards & requirements for reporting • no mechanism for trans-boundary management • insufficient provisions for enforcement and compliance	• policy is not based on a comprehensive approach to planning and management that takes physical, economic, social, and environmental factors into account • role of women in user organizations was not defined in 1992 Water Policy	• unresolved issues related to grazing lands

4.3.2.7 Implications for MSIOA

OVERVIEW

The gap analysis highlights some key areas which are relevant to the MSIOA study. The overall gap assessment in the four EN countries highlights the following overarching issue areas:

- **Strategic issues** which are more related to institutional mandates and policy alignment with NBI shared vision and addressing issues of trans-boundary cooperative water resources development.
- **Institutional gaps** such as the existence of necessary cooperative capacity within some institutions as well alignment of mandates with adequate response to issues that may arise upon trans-boundary cooperative water resources development. Linkages and networking between institutions also need enhancement.
- **Capacity gaps** related to technical capacity within institutions to address trans-boundary environmental and social issues.
- **Procedural gaps** as relates to enforcement, monitoring and audit functions and ability to discharge these functionalities to support JMP projects.

As discussed previously there are still major socio-economic and environmental issues such as wetlands, forests and river crossings where substantial numbers of people are dependent for agricultural, pastoral, fishing and other income sources. In addition, there may be requirement for some displacement of land and resources for which adequate compensatory mechanisms will be required.

There are good environmental policies, capacities, and some experience in the region to implement mitigation measures to prevent, reduce, or offset negative impacts on the environment in case impacts are significant. This capacity is further strengthened by MEAs and a wide NGOs and CBOs base supporting and acting as focal points for these MEA. However, it is to be noted MEA ratification and implementation varies considerably between the three EN countries.

A number of gaps which would be relevant to the planning, design and implementation of an investment programme include the following. A specific gap area relating which can provide a bottleneck for smooth preparation and implementation of many investment projects is that of **Resettlement Policy Gaps.**

RESETTLEMENT POLICY

- **Ethiopia**: the Constitution of Ethiopia provides for either compensation or resettlement. The eligibility for compensation/resettlement is broad as it encompasses "one whose livelihood has been affected". Ethiopia is one of very few countries in the world to have a livelihood-oriented legal approach to compensation/resettlement, rather than the usual asset-oriented approach. It is, in this respect, fully consistent with World Bank policies on involuntary resettlement that consider both impacts on livelihoods and impacts on assets as the basis for eligibility to assistance for resettlement.

  While the Civil Code of Ethiopia uses an "asset-oriented" approach to valuation and compensation, neither the Constitution nor the Civil Code provides guidelines for the calculation of compensation.

  The Civil Code also includes provisions for indirect expropriation which, if applied, would contravene Constitutional requirement that compensation be "prior", as well as World Bank safeguards. However, subject to compensation being paid in advance to abide with more recent Ethiopian law and WB policies, this process as described in the Civil Code may provide an adequate framework for small works where a declaration of public interest is not required.

- **Egypt**: In general, the Egyptian regulation provides for resettlement and compensation noting the following points:
  - The law provides for committees to address grievances driven by misunderstandings of the project policy, or resulting from conflict(s) with neighbours, but the processes embrace long procedural steps.
  - Egyptian regulation has no provision on how vulnerable groups should be treated in case of involuntary resettlement.
  - While Egyptian law requires the provision of information to those the project affects, the experience in Egypt suggests that PAPs have not been part of the resettlement consultation, planning and implementation process.
  - Monitoring or evaluation measures are not stipulated in Egyptian regulation. Programs and plans may not be able to benefit from corrective action in cases of mistakes or receive rewards in cases of good performance.

- **Sudan**: The most important recent change in Sudanese resettlement policy is reflected in the Interim Constitution, 2005 I which the right of customary tenure and traditional customary regulations and right of use in common land are recognised. Furthermore, the constitution establishes National Land Commission and State Land Commissions to regulate land ownership and acquisition through arbitration and consultation of local users. Specifically, Article 43 (2) of the Interim Constitution gives the right for land acquisition for public use and compensation of the claimants either land for land or cash compensation and through committees to decide on replacement costs for lost assets. Still the issues on grazing land are to be solved by the Land Commission but as land is available for such uses, the traditional authorities assign grazing areas for nomads.

  There are many similarities between the World Bank policies and the Sudanese policies despite the unresolved issues related to grazing lands.

4.3.3 Transboundary Institutions and Policies

NBI institutions and particularly ENTRO have developed a set of Environmental and Social Management Guidance (ESMG) to ensure good practice in addressing social and environmental issues as per the instructions of ENCOM. These set of guidance are available to build capacity of the EN countries with regard to environmental and social management and to act as a regional umbrella for addressing transboundary environmental and social impacts.

ENTRO ensured good practice in addressing social and environmental issues in its previous project activities (Annex 3) which has laid the foundation for the environment and social management guidance. The main tools adopted by these guidance to be used for all development policies, plans, and projects (as relevant) with significant impact on the environmental and social concerns identified are SSEA and ESIA (both of which include detailed social assessment, thorough public consultation, and long term monitoring and feedback), as well as other specific forms of social management such as resettlement planning and compensation for affected livelihoods.

Procedures need to be developed for the consideration and resolution of trans-boundary project impacts, in order to effectively manage the environment of the entire region. An important development is the linkage and coordination of the separate national authorities that respects national sovereignty and at the same time allows for each state to protect the rights it guarantees to its citizens. It is important to note that significant institutional and capacity building is needed at the national level and ENTRO has developed reference material and conducted necessary training programmes.

4.3.4 Recommendations

Priority capacity building areas and other aspects in environment and social management of future transboundary projects are identified as follows:

- Procedures need to be developed for the consideration and resolution of trans-boundary project impacts, in order to effectively manage the environment of the entire region. An important development is the linkage and coordination of the separate national authorities that respects national sovereignty and at the same time allows for each state to protect the rights it guarantees to its citizens;
- A central organization for management and monitoring of social issues is needed. The most important need is full and consistent inclusion of relevant stakeholders in the assessment and decision making processes.
- Low levels of environmental education, public awareness, dissemination and training need to be addressed by establishing clear mechanisms to coordinate human resource capacity raising efforts..
- Provision should be made to bring policies and laws regarding land expropriation, resettlement, and compensation into line with international standards. Important areas include calculation of compensation, provisions for resettled peoples, transitional assistance, vulnerable groups, handling of grievances etc
- Social capacities must be developed to ensure a reliable process of managing social issues and a mechanism to ensure beneficial outcomes are achieved.
- Increased training and capacity building is required in specific environmental fields for environmental and social management. Institutionally,
- The involvement of NGOs and CBOs should be supported in determining the scope of assessments, identifying impacts, and assigning management roles can greatly increase the effectiveness of public consultation, and lead to better assessments.

4.4 Socio-economic Baseline / Context

4.4.1 Introduction

In this section of the report the following is provided:

- a broad overview of the socio-economic conditions in the Eastern Nile (EN) Basin
- an overview of the socio-economic conditions in each of each of the concerned countries
- an overview of the socio-economic conditions within each of the four sub-basins:

The focus of the report is on the key socio-economic conditions that will have a potential bearing on the identification and selection of Multi Sectoral Investment Opportunities in the EN Basin and the four associated sub-basins.

The report also identifies potential Multi Sectoral Invesment Opportunities that have the potential to address the socio-economic challenges facing the EN Basin and the four sub-basins. The identification of the challenges is informed by the review of relevant socio-economic baseline data and information collected during the Country Consultations. The report also identifies social hotspots and social indicators to be used to scope and identify potential investment options etc.

4.4.2 Socio-Economic Profile[3]

4.4.2.1 *Regional Overview - the Eastern Nile Basin*

The population of the ten Nile countries was estimated at 424 million in 2010[4]. 54% – 232 million – live in the four countries of the Eastern Nile basin. Ethiopia has the largest total population, closely followed by Egypt. But while most Egyptians live within the basin, the proportion is lower in Ethiopia. A large percentage of the populations of South Sudan and Sudan also lives within the basin.

Settlement patterns in the lower riparians clearly follow the river. Population density is therefore very high in the Nile Delta and Nile valley in Egypt, which represent 5 per cent of the country's total land, while vast stretches of the desert are unoccupied. This pattern continues in the north of The Sudan, with most people living along the River Nile, in the Khartoum area, and in the irrigated areas south of Khartoum.

- Egypt: 84.5 million, of which 82.9 million live in Main Nile Basin;
- Ethiopia: 85 million, of which 34.1 million live in EN sub basins
- Sudan: 34 million, of which 32 million live in EN sub basins
- South Sudan: 11 million, of which 3.5 million live in the EN sub basins.

The medium population growth projections for the EN Basin indicate that the population of Ethiopia will grow to 132 million by 2030, Egypt is projected to increase to 111 million, Sudan to 46 million and South Sudan to 17 million. Significantly, the population of Ethiopia is projected to increase to 186 million by 2050, while the population of Egypt projected to increase marginally from 111 to 114 million. This is due to the continued existence of a large, rural population in Ethiopia (see below).

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[3] Information is taken from the State of the River Nile Basin Report published in 2012. The report does not provide separate data for South Sudan

[4] United Nations Population Division

Of the total population the majority of the population in Ethiopia (82%), Egypt (57%), South Sudan (83%) and Sudan (55%) were rural in 2010. However, there is a move towards urbanisation, with the rural population in Ethiopia, Egypt and Sudan projected to decrease to 73%, 50% and 39% respectively by 2030. No information was available for South Sudan. However, given the limited level of infrastructure development the majority of the population are likely to remain rural.

With a large proportion of the population living below the poverty line, the Nile countries are facing serious socioeconomic challenges. This condition is reflected by their ranking in the Human Development Index (HDI). Six Nile countries rank among the bottom 25.

The agricultural sector makes a substantial contribution to national economies, but introduces an element of insecurity. Economic growth in wet years tends to alternate with contraction in drought periods. Agriculture also provides food for rural people, mostly through small-holder, rain-fed subsistence farming. In the upper Nile riparians, it provides employment for almost all the workforce, but is increasingly unable to meet the needs of the expanding population.

- Ethiopia: Agriculture contributed 43% to the total GDP and accounted for 85% of the total labour force in the country;
- Egypt: Agriculture contributed 14% to the total GDP and accounted for 32% of the total labour force in the country;
- Sudan: Agriculture contributed 32% to the total GDP and accounted for 80% of the total labour force in the country.

The State of the River Nile Basin Report (2012) notes that the rapidly rising population in the Nile Basin presents enormous challenges for the region and the riparian governments, placing increasing pressure on regional natural resources, infrastructure, and services.

Most people in the rural areas are intimately dependant on the agricultural economy and as such, the natural resource base, for their livelihood and food security. The agricultural sector therefore plays a key role in the economy the EN region. Sustainable development therefore requires the implementation of effective and appropriate rural development policies coupled with the sustainable use of the regions natural resources.

The State of the River Nile Basin Report (2012) notes that the increasing population pressure and demand for land will result in encroachment into natural areas and nature reserves, which will in turn impact on the functioning of natural ecosystems. Population growth will also result in the fragmentation of agricultural holdings, settlement on marginal lands, and rising landlessness. As a result tension over access to and use of natural resources, such as water, arable land and grazing, is likely to intensify and create the potential for local conflicts. In the EN Basin resource related conflicts are already widespread. Local authorities will also be placed under growing pressure to provide clean water and improved services, such as sanitation, to scattered rural settlements. Failure to improve rural livelihoods will perpetuate poor living conditions and accelerate rural to urban migration, with marginalized and landless people moving to the larger towns and cities in search of work, better services, and better education opportunities. This will in turn place growing pressure on the services in these cities.

In this regard rapid urban growth poses specific challenges to city administrators with regard to high unemployment and provision of key services, such as housing, water, sanitation, health care, schooling and waste management. Urban growth in the EN Basin is typically not well planned, with many urban poor living in informal settlements.

Despite the challenges, there have been improvements in the access to water for urban populations in the EN Basin. With Egypt and Ethiopia having 100% and 98% of their urban population respectively having access to improved drinking water in 2008. However, in Sudan the figure decreased from 85% in 1990 to 64% in 2008.

The **growing population in the EN Basin will in turn increase the demand on water resources. The impact of population growth on food security is amplified in the EN Basin given that the majority of the large rural population cannot afford food imports. Their food security depends on local produce for food security, mostly grown in close vicinity to the actual consumers**.

CHALLENGES

Following on from the above the challenges and opportunities (State of the River Nile Basin Report, 2012) can be briefly summarised as follows. The challenges include:

- Rising populations put increasing pressure on natural resources, underlining the critical importance of managing natural resources in a sustainable way;
- Most basin countries will continue to have predominantly rural populations until at least 2030, leading to land fragmentation and serious environmental degradation;
- Lack of opportunities in rural areas is causing people to migrate to cities;
- Governments need to intensify efforts aimed at rural development and at making rural areas more productive;
- Unplanned urbanization is posing major challenges for city governments in terms of the management of pollution and traffic congestion, and the provision of social services, housing, and essential infrastructure;

The State of the River Nile Basin Report concludes, "**given the economic conditions and natural resource limitations in the Nile Basin, the challenges posed by the rising population currently outweigh the likely benefits".**

In order to address these challenges the Report suggests two distinct policy focus areas, namely:

- Foster rural development and efficient resource management for the large rural populations;
- Accommodate and manage rapid urbanization.

OPPORTUNITIES

The EN Basins growing population Basin also creates opportunities for economic development and growth including opportunities for local and foreign investment in large-scale production of goods and services. An expanding population increases the availability of labour, and creates growing demand for food produce, manufactured goods, and services. However, a number of conditions will be required to achieve sustained economic development. These include provision and maintenance of effective services and infrastructure, such as water, sanitation, housing, education, health care, roads and transportation (State of the River Nile Basin Report, 2012).

RELEVANCE TO MSIOA STUDY

The rapid increase in population in the EN Basin may therefore be beyond the ability of the four countries to deal with individually, highlighting the importance of regional co-operation in the area in order to create the conditions for sustainable economic development. Agricultural trade has been identified as a key opportunity for promoting regional cooperation and this would support regional food security while simultaneously fostering much-needed rural development. Other possible areas for co-operation include trade in energy, inter-connection of the power grid, and infrastructure development.

As indicated already, the objective of the MSIOA project is to identify potential investment opportunities that create the opportunity for regional benefits and cooperation between the EN Basin countries. The **identification of potential investment opportunities should therefore seek to create opportunities to address the challenges facing the EN Basin**. Projects that do not address the challenges facing the EN Basin are unlikely to achieve the shared vision of the NBI**. It is therefore critical that each of the projects be tested against their ability to address these challenges, specifically the challenges facing the rural population in the EN Basin and loss of natural resources**.

4.4.2.2 Country Overview

INTRODUCTION

A review of socio-economic conditions in each country is provided in Annex 4. The following is limited to a summary of key challenges and opportunities.

ETHIOPIA

The challenges and opportunities are summarised in **Table 4-2**.

Table 4-2: Summary of socio-economic Challenges and Opportunities in Ethiopia

Summary of Challenges and Opportunities	
Challenges	**Opportunities**
• Population growth and pressure on natural systems and services; • High poverty levels, combined with low education and skills levels; • Food security and high dependency on rain-fed agriculture; • Climate change and vulnerability of rural communities, specifically farmers that rely on rain fall to irrigate their crops; • Fragmentation of land due to population pressure; • Urbanization and pressure on services in large cities, such as sanitation and water supply; • Land degradation and soil erosion; • Limited infrastructure and impact on access to markets for farmers; • Poor storage facilities for agricultural produce; • Impact on agriculture on natural ecosystems and environmental goods and services; • Rapid, poorly planned urbanization; • Poverty and food security issues • Limited access to funding and technical support for small-scale farmers; • Poor access to safe drinking water and sanitation services; • Limited employment opportunities outside of the agricultural sector	• High hydro-power potential, specifically in the Blue Nile; • Tourism development linked to cultural and natural environment (diverse ecosystems, rich biodiversity and wildlife); • Good rainfall and high potential agricultural land in the highlands; • Available and sufficient water resources to meet current and future needs (if well managed); • Growing and diversifying economy

SOUTH SUDAN

The challenges and opportunities are summarised in **Table 4-3**

Table 4-3: Summary of socio-economic Challenges and Opportunities in Ethiopia

Summary of Challenges and Opportunities	
Challenges	**Opportunities**
• Internal conflict and political instability; • Low education and skills levels; • Lack of resources and skills; • Poor infrastructure; • Lack of reliable baseline socio-economic data; • Sanitation and access to potable water, especially in large cities;	• Oil in northern South Sudan; • Large, un-tapped agricultural potential; • Relatively undisturbed natural ecosystems;

• Urbanization and pressure on services in large cities, such as sanitation and water supply; • Limited infrastructure and impact on access to markets for farmers; • Loss of biodiversity and pressure on natural systems and services; • Poverty and food security; • Conflicts between pastoralists and farmers, specifically farmers involved in rain-fed mechanized irrigation; • Climate change and vulnerability of rural communities, specifically pastoralists and farmers that rely on rain fall to irrigate their crops; • Poor storage facilities for agricultural produce	• Tourism potential linked to diverse ecosystems, rich biodiversity and wildlife • Potential funding opportunities from international funding agencies (WB, IMF and AFDB etc.) • Hydropower potential along the Nile and other rivers in South Sudan

SUDAN

The challenges and opportunities are summarised in**Table 4-4**

Table 4-4: Summary of socio-economic Challenges and Opportunities in Ethiopia

Summary of Challenges and Opportunities	
Challenges	**Opportunities**
• On-going economic sanctions against Sudan and impact on access to funding and development; • Population growth and pressure on natural systems and services; • High poverty levels, combined with low education and skills levels; • Food security and large area under rain-fed agriculture; • Climate change and vulnerability of rural communities, specifically farmers that rely on rain fall to irrigate their crops, and pastoralists; • Fragmentation of land due to population pressure; • Rapid urbanization and pressure on services in large cities, such as sanitation and water supply; • Access to funding and loans for small-scale farmers; • Limited infrastructure and impact on access to markets for farmers; • Poor storage facilities for agricultural produce; • Land degradation and soil erosion; • Impact on agriculture on natural ecosystems and environmental goods and services; • Rapid, poorly planned urbanization; • Poverty and food security issues; • Limited access to funding and technical support for small-scale farmers; • Poor access to safe drinking water and sanitation services; • Limited employment opportunities outside of the agricultural sector; •	• Improve efficiency and productivity of existing irrigation schemes; • Large potential to expand irrigated and rain-fed mechanised irrigated land; • Hydropower potential linked to existing and future schemes; • Catchment management and water harvesting programs involving other EN countries; • Potential funding opportunities within the regional and international funding agencies (World Bank, IMF, AFDB etc.)

4.4.3 Socio-economic Overview of the sub-basins

4.4.3.1 Introduction

This socio-economic review of the sub-basins has been divided into two parts. Firstly, a demographic synopsis of the four sub-basins is provided and then each of the sub-basins is reviewed under the following themes:

- Demographic profile
- Ethnic groups
- Livelihoods
- Sources of conflict
- Gender disparities

- Infrastructure and services
- Vulnerability and food security

The reviews are brief, with further detail provided in the thematic report compiled for the Situational Analysis. Given that a brief overview of the demographic profile and ethnic groups is provided as part of synopsis (Section 4.4.3.2) the focus has been focussed on the other thematics, especially sources of conflict, livelihoods, infrastructure and services and food security. These are areas where the MSOIA can play a significant role in addressing problems and challenges. At the end of the review of all four basins a section has been included to review and summarise the implications for project identification going forward.

4.4.3.2 Demographic synopsis of the four sub-basins

The socio-economic overview of the four EN sub-basins is based largely on the information contained in *A Synthesis Report on Socio-Economic Profile of Abbay-Blue Nile, Baro-Akobo-Sobat-White Nile, Tekeze-Setit-Atbara and Main Nile Basins (April 2007),* updated where possible using the latest census data available.

Based on population projections using previous population census an estimated 152 million people inhabit the four sub-basins; The details are summarised in

Table 4-5: Key Demographic and population characteristics of the four basins (will be up-dated with information from interns

<table>
<tr><th colspan="5">Estimated population of the basin</th></tr>
<tr><th>Demographic variables</th><th>Main Nile</th><th>Abbay-Blue Nile</th><th>Tekeze-Atbara</th><th>Baro-Akobo-White Nile</th></tr>
<tr><td>Total population (million)</td><td>76.1</td><td>44.3</td><td>16.5</td><td>15.1</td></tr>
<tr><td>Sex ration</td><td>102:100</td><td>100:100</td><td>103:100</td><td>98:100</td></tr>
<tr><td>Child dependency ratio</td><td>NA</td><td>85:100</td><td>NA</td><td>NA</td></tr>
<tr><td>Old age dependency (per 100)</td><td>3</td><td>7</td><td>NA</td><td>NA</td></tr>
<tr><td>Population density</td><td>1500</td><td>7.3 – 127.4</td><td>59</td><td>3 - 127</td></tr>
<tr><td>Urban population (%)</td><td>60</td><td>10</td><td>NA</td><td>9.4</td></tr>
<tr><td>Infant mortality rate (per 1000)</td><td>40</td><td>100</td><td>NA</td><td>NA</td></tr>
<tr><td>Life expectancy, male</td><td rowspan="2">71</td><td>47.5 – 52.4</td><td>NA</td><td rowspan="2">46 - 55</td></tr>
<tr><td>Life expectancy, female</td><td>48.5 – 53.4</td><td>NA</td></tr>
<tr><td>Annual growth rate</td><td>2.4</td><td>2.7 – 3.5</td><td>2.5 – 2.9</td><td>3.0</td></tr>
</table>

Together the Abbay-Blue Nile and Main Nile sub-basins account for 79 % of the total population of the Eastern Nile countries..

In terms of population density, the density is modest in the Abbay section of the sub-basin, with higher population densities in the highlands compared to the lowlands, which tend to be malaria infested. The population density in the Main Nile sub basin is 1,500 persons per square kilometre and the Nile Valley has one of the highest population densities in the world.

Average life expectancy, an indicator of quality of life, varies from country to country and also by gender, with females enjoying relatively slightly higher survival rate. Regardless of slight variations between sub-basins and regions within a sub-basin, infant and under 5 mortality rates per 1,000 live births are slightly over 100 and 150 respectively. An exceptional case is Main Nile with infant mortality rate of 40 per 1,000 live births in 2000.

Rural-urban distribution of the population in the four basins generally follows a similar pattern. Thus, a large percentage of the population (excepting the Main Nile) lives in rural areas where access to basic infrastructure and social services is limited. Massive rural-urban migration, attributable to economic push factors and political instability in the region, may explain the increase in the size of urban population in the Blue Nile area. The trends are similar in the other sub-basins, with ten and twelve percent of the population in Tekeze and Baro-Akobo section of the sub-basins being urban residents, the figure rising to 34 percent in Tekeze-Setit-Atbara.

The greatest portions of the river basins are characterized by high ethno-linguistic and cultural diversity, except for the Main Nile, which stands out as a markedly homogeneous region in these respects. The Abbay area of the sub-basin is the home of five major ethno-linguistic groups and the northern and southern zones of Blue Nile are even more highly diversified, in fact, the most heterogeneous of all the regions in the three sub-basins, being inhabited by as many as eighteen ethnic and linguistic groups. The Tekeze-Setit-Atbara sub-basin is the second most diversified, comprising fourteen groups both on the Ethiopian and Sudanese sides. Details are provided in

Table 4-6: : Ethno-linguistic diversity in the four basins

Abbay-Blue Nile	Baro-Akobo-Sobat-While Nile	Tekeze-Atbara	Main Nile
Amhara, Oromo, Jebalawi, Gumuz, Agew. Ingassana, Berta, Watawit, Jaalyin, Danagala, Gumuz, Hamaj, Funj, Dwalla, Rufaa El Hoi, Om Bararo, Danagla, Jalfawien, Bidirya, Manasir, Mahas, Shaiygia, and nomadic Arabs	Oromo, Jebalawi Gumuz, Anuwak Nuer, Keffa and Bench	Tigre, Amhara, Al Gaalyin, Al Rubatab, Al Merafab, Al Omerab, Al Fdiniyaand, Al Manasir, Beja, Hadandwa, Bani Amir, Nubian, Shukrya, Habanya	Predominantly Arabs and some minorities such as Armenians, Geeks, Berbers, Nubians, and the Arabic speaking Bedouins

4.4.3.3 Abbay-Blue Nile Sub-basin

DEMOGRAPHICS AND ETHNIC GROUPS

The table below contains a summary of key demographic data based on the latest census data for Ethiopia (2007) and Sudan (2006). It should be noted however that this information is dated. Details on the demographic profile and ethnic groups residing within the sub-basin are provided in the socio-econmic thematic report.

Table 4-7: Demographic data for Abbay-Blue Nile Sub-Basin

ABBAY BLUE NILE SUB-BASIN	Ethiopia (2007 Census)	Sudan (2008 Census)
Population Total: 39 million	25 million Amhara: 15 million	14 million Khartoum: 5 million
Rural population	~90%	Average ~70%, except for Khartoum, 19%
Age breakdown	0-14: 43-50% 15-64: 52-53% 65-older:4-8%	Rural States: 0-14: 36-47% 15-64: 49-55%, 65-older: 3-4% Khartoum: 0-14: 34 %, 15-64:62 %, 65-older: 4%
Child dependency ratio	Amhara: 79.8	Blue Nile: 95.4

	Benshagul-Gumuz:87.3	Khartoum: 55.0
Infant Mortality (under 5) per 1 000 births	Amhara: 108 Benshagul-Gumuz: 169	Blue Nile: 205 Khartoum: 105
Maternal Mortality (per 100 000 births)	Amhara: 676 Benshagul-Gumuz: 676	Blue Nile: 578 Khartoum: 389
Life expectancy	No data	Blue Nile: 50.1 Khartoum: 61.4
Literacy rate (15 yrs and older)	No information	Blue Nile: 43% Khartoum: 80%
Access to safe water	Amhara: 50 % Benshagul-Gumuz: 42%	Blue Nile: 43% Khartoum: 82%
Access to sanitation	Amhara: 60 % Benshagul-Gumuz: 70 %	Blue Nile: 5.3% Khartoum: 51%

LIVELIHOODS

Abbay River

The majority of the population living in the Amhara, Oromiya and Benishangul Gumuz Regional States are rural. Their livelihood strategies are therefore linked to and dependent upon agriculture, specifically rain-fed, subsistence agriculture. Livelihoods are also supplemented by gold mining (panning along the Abbay River and its main tributaries), hunting and fishing. Small numbers of people are also engaged in trade or employed by government organizations. Incomes from these activities, however, tend to be low. As a result even those that are formally employed tend to live in poverty.

Traditional rain-fed agriculture, is the key economic activity in all of the three regions located adjacent to the Abbay River. Despite the availability of potentially suitable land and water resources outside the gorge, specifically in the Benishangul Gumuz Region, no irrigation is practised in the areas potentially affected by the various proposed dams on the Abbay River.

A survey conducted by Benishangul Gumuz Rehabilitation and Development Association (BRDA) indicated that the majority of households in the Benishangul Gumuz region are not able to produce sufficient food to meet their requirements. The situation in Amhara is only marginally better. In the Highland areas located adjacent to the eastern sections of the Abbay Gorge livestock form an important component of cereal based single cropping mixed farming system. The livestock in these areas provide manure and products that can be sold for cash.

Despite favourable conditions, the number of livestock in the Benishangul Gumuz Region is low.

The agriculture sector is typically characterised by the following challenges: *

- Low productivity;
- Scattered population of indigenous communities;
- Low level of community participation;
- High prevalence of human and animal diseases;
- Poorly developed agricultural cultivation systems; and
- Inadequate supply of agricultural inputs.

Traditional, small scale gold mining (by panning) is carried out along the Abbay, Beles and Dabus Rivers during the low flow periods by both men and women.

The Abbay gorge provides local communities living in the adjacent areas with a number of natural resources and the collection of timber and non-timber-forest-products is common. The resources harvested include firewood, building material, hunting, fishing and honey collection. The ESIA undertaken for the proposed Beko-Abo dam indicated that crop cultivation was the most common activity in the gorge, followed by charcoal burning and the collection of firewood, grazing and the extraction of timber for construction (Norplan et al. Beko-Abo Dam ESIA, November 2010). .

Based on the information contained in the pre-feasibility studies undertaken for the Border, Mandaya and Beko-Abo dams, hunting and fishing do not appear to play a key role in the livelihood strategies of the local inhabitants that live in areas located adjacent to the Abbay River. Hunting does, however, play and important cultural role amongst the Gumuz, where hunters occupy high status in the community.

Blue Nile

The majority of the Sudanese population are rural communities engaged in primary activities based on crop farming, agro-pastoralism and pastoralism. In this regard the agricultural sector plays a key role in the national economy and employs the bulk of the labour force.

Agriculture in the study area can be divided into four main cropping (Farming) systems:

- **Large scale irrigated schemes**; These irrigation schemes are owned and managed by the central government and are significant in three respects:
  - They are highly capital-intensive, requiring regular maintenance;
  - They produce a considerable volume of commodities for domestic consumption and export;
  - All schemes have been subsidized by the federal government because of low productivity and excessive costs.

  Approximately 90% of the irrigation schemes are located on the Central Clay Plain (CCP) of the eastern side of the central Sudan. Principal crops grown are cotton, wheat, groundnuts and sorghum. Although, the irrigated area only represents 20% of the cultivated area, it contributes more than 50% of the total value of the agricultural production of the whole country. The irrigated sub-sector, directly or indirectly, provides employment for more than 80% of the population. These large, Nile based irrigation schemes are therefore a key component of Sudan's agricultural development strategy and play a key role the country's economy. This role is set to increase with the secession of South Sudan and the loss of oil revenues for North Sudan.

  The Gezira Scheme, one of the oldest is a model for all public large-scale schemes in Sudan. It is farmed by tenant farmers with each farmer entitled to one tenancy, although other members of the immediate family (e.g., sons, wife) can also own tenancies in their own rights. Each tenancy consists of four plots that are farmed according to a prescribed rotation of cotton, sorghum, groundnuts, wheat and fallow land. The focus of irrigation schemes is on cash crops but the majority of tenants also grown their own crops for household consumption. Raising livestock also forms an integral part of the livelihood strategies of 90% of the tenant farmers and migrant workers.

There is the perception is that food insecurity and poverty levels are rising among tenant farmers as well as the migrant workers employed on large irrigation schemes (SNC Lavalin et al. SSEA Volume 2, 2011)

- **large scale semi-mechanized** rain-fed farms; In addition to the irrigation schemes, large scale, rain-fed semi-mechanised agriculture was established on the Butana Plains to the north of the Blue Nile and the clay plains to the south of the Gezira scheme in the 1940's. The total area under this system is extensive as can be seen from the adjacent map.

  These areas were and continue to be used by transhumant pastoralists.

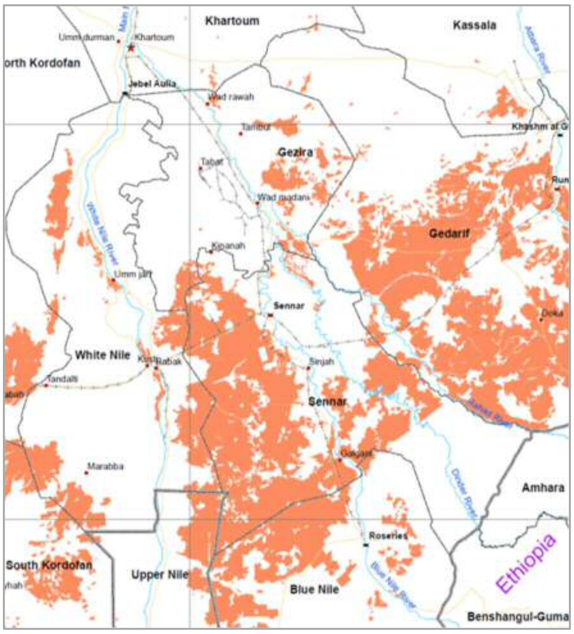


Figure 4-1: Location of rain-fed, semi-mechanised-Roseires to Merowe Dam

Mechanized rain-fed farms have had a negative impact on the natural resource base, environment and livelihoods with impacts including:

- Overgrazing and soil erosion.
- Deforestation and resulting gully erosion, degradation of soil structure, texture and fertility and associated decrease in crop and natural resource yields.
- Pressure on the grazing areas of pastoralists and exclusion of agro-pastoralists and traditional farmers from some of their traditional land.

- **Small scale, traditional irrigation** also play a key role in terms of livelihoods. The small-scale farmers living along the Blue Nile irrigate their land using a variety of methods including pumps and more traditional methods based on hand-operated water levers (*shaduf*) and animal-driven water wheels (*saqia*) (UNEP, 2007). The basic food crops grown in the Blue Nile sub-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 strategies of these farmers. The animals are an additional source of income as well as a "safety net" against shocks such as droughts (SNC Lavalin et al. SSEA Volume 2, 2011).

- ***Irrigation and recession agriculture.*** The prevailing agricultural system practised along the Blue Nile combines commercial crop production with small-scale subsistence farming. The agricultural cycle involves the *gerouf* season, plus two irrigation seasons (EDF Scott Wilson et al. Dal EIA, 2007). 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 fodder. Throughout this region, date palms are the main cash crop.

In Sudan **pastoral and agro-pastoral systems** are mainly confined to the Butana Plains located to the north of the Blue Nile and similar rangeland areas to the south. 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. Due to loss of range land to semi-mechanised rain fed agriculture, many of the pastoralists have been forced to enter the Dinder Park in search of forage and water. Included in this group is 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. Their presence along the river causes numerous problems as they compete with the communities that live in the same area for the meagre water resources available, especially when the summer season advances and the river forms only small scattered ponds (Sharing, 2008).

The Butana Plains provide excellent rangeland for camels and sheep due to the occurrence of good grazing fodder. However, these areas have been heavily grazed in recent times. Specific productions systems have developed over the years in specific areas as results of natural agro-ecological conditions including droughts, socio-cultural and economic factors and changing accessibility to grazing and water resources.

Cattle and cattle products serve a variety of important social and economic purposes. For poor herders, cattle function as a bank, allowing households to sell them when they need money and buy more cattle as an investment when they have extra money. For household consumption, they produce milk, meat and hides that can also be sold.

The loss of land to semi-mechanised farming, the drought of the 1980's and the civil war in Sudan have all combined to impact on the livelihoods of pastoralists. .

Subsistence and artisanal fisheries and capture fisheries help to sustain communities throughout the Nile Basin by providing a source of animal protein for household consumption and as a source of additional cash income. In Sudan, 95% of the annual catch comes from the Nile River and its tributaries and swamplands. The Roseires Reservoir has a reported potential of 1,700 tons/year and fish landings of 1,500 tons/year, while the Sennar Reservoir has an estimated fish capacity of 1,100 tons/year and actual yields of 1,000 tons/year (SNC Lavalin et al. SSEA Volume 2, 2011).

In Sudan, 83% of **brick production** occurs along the Blue Nile River, 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. The loss of the annual flood and associated sediment load due to the construction of large dams on the Abbay River would impact negatively on the brick making operations over time.

SOURCES OF CONFLICT

Abbay River

Inter-ethnic, inter-community, and sub-group conflicts have been identified as the most common types of conflict taking place in the Abbay River Basin of Ethiopia, which are triggered and aggravated by a multiplicity of contributory factors, mainly over shared natural resources.

The most common inter-community conflicts involve farming communities (farmer-farmer), farming and pastoral/agro-pastoral societies (farmer-herders/shifting cultivators), and pastoral communities (herder-herder) (Tesfaye, 2003). Inter-ethnic conflicts between migrant settler communities and the indigenous host populations have become more frequent following the large-scale settlement programs triggered by the severe drought and famine that hit the northern and north-central highlands in 1984/85, among other parts of the country.

Blue Nile

Environmentally-induced conflict is common among groups in the Blue Nile Basin of the Sudan. High population density of both human and livestock and the resulting resource degradation have led to competition over land and water, resulting in conflicts between herders and cultivators. The expropriation of land for the development of mechanized rain-fed agriculture since the 1960's has been one of the principal causes for tension and conflict between local inhabitants, especially pastoralists and the owners of the mechanized farms. The situation has been aggravated by the failure to take into consideration the interest and rights of the groups who have been displaced by the mechanized rain-fed agriculture developments.

Gender Disparities

Abbay River

Like in many other countries, the status of women in Ethiopia is low relative to that of men, especially in the rural areas. This manifests itself in low representation in decision making power bodies and low participation in elections, low formal female employment rates and high illiteracy rates. In general women tend to have a higher work burden than men in terms of hours worked, and there is normally a gender differentiation in the tasks and chores within the household.

Female headed households are normally susceptible to loss of control over their agricultural land resources as single women often do not have the required social standing and access to influential figures to defend their rights. It is thus difficult for divorced or widowed women to hold on to their land rights in the long term. In rural parts of the country 15-20% of households are headed by women. These households tend to own fewer animals, cattle in particular, and fewer farm implements than households headed by men.

Blue Nile and Main Nile

In the Blue Nile and Main Nile sub-basin the participation of women in agriculture is largely 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 with herding goats and sheep, while the elderly women weed or glean open fields for livestock fodder. The economic, social and political position of women in the Nile Basin is defined by cultural and religious traditions, with the result that women often do not share equally with men in the opportunities and benefits of development. In the Muslim communities in Sudan and Egypt, women generally carry out their activities within the confines of the household compound. Under Sharia law, Muslim women cannot inherit camels, cattle or land (SNC Lavalin et al. SSEA Volume 2, 2011).

Land in many parts of Sudan is communal and is allocated by community leaders to male heads of households. Women have usufruct rights, and in areas where the Islamic practice of wife inheritance prevails it is to ensure that the land remains within the family line making women dependants of their male relatives. The 1927 Ordinance that established the Gezira Irrigation Scheme entitled women to own tenancies, however women owned only 13% of the tenancies in 2000 (World Bank, 2000). Moreover, the same Ordinance stipulates that because the Scheme is Government land, the Islamic Laws pertaining to wife inheritance would not apply in the event of the death of a scheme tenant. As a consequence, the tenancies tend to be transferred to an adult male rather than to the widows of deceased tenants (SNC Lavalin et al. SSEA Volume 2, 2011).

Infrastructure and Services

Abbay River

- Water and sanitation**:** Provision of and access to safe and adequate water supplies and sanitation are low and or absent in most parts of the Abbay Gorge and adjacent areas. The 2007 Census data for Ethiopia indicates that 42 % of the households in Benishangul-Gumuz Region of the Abbay River Basin in Ethiopia had access to safe drinking water. The sources of water supply include protected wells, springs, and shared public and private pipes. The figures for the Oromia and Amhara regions were 42% and 50% respectively. The majority of the population in the Abbay sub-basin do not have access to safe drinking water and are therefore exposed to water-borne diseases such as diarrhoea, cholera, dysentery, etc**.**

  Basic sanitation facilities for solid and liquid waste disposal are also virtually non-existent. Sanitation facilities in the woredas located adjacent the western sections of the Abbay River are among the poorest in Ethiopia. Most people do not have sanitation facilities of any kind. Approximately 80% of the population in the Benishangul Gumuz region does not have toilet facilities.

- **Health**: The main health issues and challenges are:
  - Limited health services, poor access to clean drinking water and sanitation facilities and widespread poverty. Access to the limited health facilities is also compromised by the large distances and physical barriers associated with the natural topography and rivers in the area.
  - Malaria is the single most important public health problem affecting communities located in the vicinity of the Abbay Gorge. Malaria remains the single largest cause of death for children under five in the Abbay-Blue Nile basin and other parts of the EN Basin. Malaria has a significant impact on potential earnings and household food security. Malaria also imposes direct financial costs on individuals in the form of expenditure on insecticide-treated mosquito nets, clinic fees, anti-malaria drugs, and funeral costs. Malaria has also a serious impact on children who tend to be more vulnerable. Repeated malaria infections amongst children can impact on schooling and result in children failing grades and dropping out of school altogether. Malaria therefore results in a considerable loss of income and places a heavy burden on families, health systems and society as a whole. In so doing malaria can be a major constraint to national economic development. Health economists argue that economic growth rates in countries with high malaria rates are lower than those without malaria.
  - The other dominant water-borne and water-related diseases include Schistosomiasis, Onchocerciasis and Trypanosomiasis (human sleeping sickness). Acute watery and bloody diarrhoeas, intestinal parasites and scabies, etc. are also common and are linked to the poor water supplies and absence of basic sanitation facilities.
  - HIV/AIDS is a new disease emerging in the study areas. Reports indicate that the disease is prevalent and on the rise (Norplan et al. Beko-Abo EIA, 2010). The adult HIV prevalence in Ethiopia in 2009 was estimated to be between 1.4% and 2.8% by the Ethiopian Health and Nutrition Research Institute. The HIV prevalence in the Abbay Valley area affected by the proposed dams is likely to be lower than the national HIV prevalence average due the isolated nature of large sections of the study area (Norplan et al. Beko-Abo EIA, 2010).

- **Roads and river crossings**: As a consequence of the dissection of the highlands by the Abbay River and its tributaries the road infrastructure in all three regions is poorly developed. All-weather roads tend to be confined to the ridges and plateaus between the deeply incised rivers. As a result the Abbay has only three road crossings. The main areas of inaccessibility are located in the western parts of North and South Wello in the Abbay Gorge; the middle and the Lower Abbay Gorges; and the western Lowlands of the Dinder and Beles Valley.

  The road infrastructure in Benishangul Gumuz region is one of the poorest in the country. As a result travelling within the region is difficult and expensive. Movement within the region is also negatively affected by the Abbay River, which divides Benishangul Gumuz region into two parts. While the road network in the Amhara Region is more developed than the network in Benishangul Gumuz, there is only one bridge crossing of the Abbay, namely at the Nekemte-Bure Bridge. In the absence of bridge crossings use is made of traditional boats. People use these boats to cross the Abbay River for trade, visiting relatives, health services and other personal reasons. The prefeasibility studies for the Border and Mandaya Dams indicate that there are in the region of four crossing points along the section of the Abbay River affected by the proposed dams.

- Education (Abbay River); Based on the information in the Socio-economic Synthesis Report (2007) education levels in the three regions located in the Abbay section of the sub-basin are low. More than half of the primary school age population (7 to 12 years) in each of the three regions did not attend school. The attendance levels for secondary school pupils were even lower, with over three-fourth of the population eligible for secondary education not attending school. Given that the majority of the population are rural it is likely that children of school going age are involved in agricultural activities and or do not have access to schools. The literacy levels in the three regions are also low. Based on the 2007 Census data only 26% of the rural population are regarded as literate

Blue Nile

- **Water and sanitation**; Based on the 2008 Census data for Sudan the access to safe water in the more isolated rural states, such as Blue Nile and White Nile, is 43% and 49% of the population respectively. The figures for Sinnar (78%), Gezira (81%) and Khartoum (80%) are significantly higher. The same trend is reflected for sanitation, with limited access to sanitation in the Blue Nile (5.3%) and While Nile States (34.4%) compared to Khartoum (51%). However, the majority of the population in the Blue Nile do not have access to sanitation.
- **Education**; The rural literacy rates in the Blue Nile Sub-Basin (Sudan) range from 43% in the Blue Nile to 67% in Khartoum. The urban literacy rates are on average 15-20% higher than the rural rates in each of the states that fall within the Blue Nile Sub-Basin.
- **Transport**; At present the Blue Nile and the Tekeze-Atbara basins in the Sudan are connected to railway network, which is not the case with the Akobo-Sobat Basin.

VULNERABILITY AND FOOD SECURITY

Food insecurity is a persistent and serious problem throughout parts of the Nile Basin in Ethiopia and Sudan. The problem of food security is linked to the lack of agricultural development and extreme vulnerability to drought. In the Blue and Main Nile sub-basins in Sudan, the month of August is the peak of the lean season. The current projections are that most of the areas in these sub-basins will remain generally food secure during this time, but people living in the states of North Kordofan, Red Sea and Blue Nile will be more vulnerable to food shortages (www.fews.net, accessed 28 June 2010). In parts of these sub-basins such as Gaderif, there were droughts and poor agricultural seasons with widespread failure of the sorghum harvests in 2008 and 2009. This resulted in high levels of food security within pastoralist communities (SOS Sahel, 2009).

Abbay River

Rural poverty in the region has been growing in both severity and magnitude for the last fifty years mainly due to population growth, lack of access to productive assets, crop failures and the like. A study undertaken by Dessalegn (2003) found that that the vulnerability of rural households was the outcome of a relentless ecological stress and large-scale degradation of environmental resources. Ecological stress and large scale degradation remains a key challenge in 2014.

Data on poverty and vulnerability also indicates that there is a strong link between poverty, gender and age, as well as other socio-demographic characteristics of the population in the Abbay River Basin of Ethiopia. A study conducted by the Institute of Development Studies (2002) revealed that 13.8% of the households of the study areas in Wollo are destitute, while a greater proportion of them were female-headed households and households headed by old men. These households are identified as victims of poverty mainly due to shortage of labour to engage in productive activities. Research undertaken by Yared (2002) found that female-headed households made up a large proportion of the poorest and most vulnerable households in the rural areas of North Shewa and South Wollo, both in the Abbay River Basin. The same conditions exist in 2014, with female headed households making up the poorest and most vulnerable households in the Abbay sub-basin..

Some of the main drivers and cause reinforcing both vulnerability and lack of food security in the Abbay basin are true for parts of the other basins in Ethiopia. They can be summarised as follows:

- **Deterioration of the natural resource base due to increased population pressure over time**: When population and livestock pressures exceed a cetain threshold rapid degradation of land takes place. Families and communities are locked into a downward spiral of increasing poverty and increasing degradation of the natural resources they depend on. This leads to an increased vulnerability to natural (drought) and social (sickness) shocks.
- **Dependency ratio** is also an important factor contributing to poverty in rural areas. Studies indicate that if the dependency ratio increases by one unit, the probability of a household falling below the poverty line increases by 31 %.
- **Female headed rural households** are also more vulnerable to poverty, and are 9 % more likely to be poor than male-headed households..

Poverty is prevalent in each of the three regions bordering on the Abbay River, especially the Benishangul Gumuz Region. Poor farming practices, droughts and pests contribute to the high poverty levels. The factors that contribute to food insecurity and poverty in the three regions are the same as those that affect the rest of the country, namely:[5]

- Vulnerability to droughts;
- Population pressure;
- Low investment in human capital;
- Low level of infrastructure;
- Low risk and low return trap (farmers cannot risk changing their system of cultivation from subsistence agriculture to higher return crops such as growing cash crops);

5 Sustainable Development to End Poverty, MoFED, Oct., 2005

- Early childhood trap (malnutrition during childhood affects long term mental and physical development affecting human productivity).

The months of July and August are the primary hunger season throughout most of the sub-basin, although this season begins as early as May in Benishangul-Gumuz.

4.4.3.4 Baro-Akobo-Sobat and White Nile Sub-basin

DEMOGRAPHICS AND ETHNIC GROUPS

The table below contains a summary of key demographic data based on the latest census data for Ethiopia (2007) and Sudan (2006)[6]. It should be noted however that this information is dated. Details on the demographic profile and ethnic groups residing within the sub-basin are provided in the socio-economic thematic report.

Table 4-8: Demographic data for Baro-Akobo-Sobat and White Nile Sub-Basin

BARO-AKOBO SOBAT WHITE NILE SUB-BASIN	Ethiopia (2007 Census)	South Sudan (2008 Sudan Census)	Sudan (2008 Sudan Census)
Population Total: 10 million	5 million Oromia 3 million	3.3 million Jongoli: 1.4 million	1.7 million White Nile: 1.7 million
Rural population	Oromia /SNNP: ~90% Gambella: 75%	Eastern Equatoria/Jongoli: ~90% Upper Nile: 75%	66%
Age breakdown	0-14: 42-48% 15-64: 50-56% 65-older:2-4%	0-14: 44% 15-64: 53% 65-older:3 %	0-14: 43% 15-64: 53% 65-older:4%
Child dependency ratio	SNNP: 97 Gambella: 74	~83	80.6
Infant Mortality (under 5) per 1000 births	Oromia: 127 Gambella: 123	Jongoli: 127 Upper Nile: 169	111
Maternal Mortality (per 100 000 births)	679	Jongoli: 1979 Eastern Equatoria: 989	503
Life expectancy	~60	~ 52	~ 60
Literacy rate (15 yrs and older)	No data	No data	56%
Access to safe water	Gambella: 70% Oromia: 42%	Jongoli: 62% Upper Nile: 31%	49%
Access to sanitation	SNNP: 83% Oromia: 60%	No data	20%

LIVELIHOODS

Rain fed crop cultivation is the principal livelihood activity in most of the basin where adequate rainfall is available. The economy, which is largely based on traditional methods of plough cultivation and supplemented by the hoe in the lowlands, is subsistence oriented. Production is dominated by cultivating crops (e.g. maize & sorghum) for local consumption.

The lowland population practise shifting cultivation, mainly for growing sorghum. In South Sudan more than 95 % of households are categorized as subsistence-level rain-fed farmers cultivating small areas using simple manual agriculture implements. The common cultivation practice (Huen et al. 2012) is to clear an area and grow the crops for a number of years (can be up to 15) with limited crop rotation. After this period the land is

6 The 2006 Census for Sudan included the states that now fall within South Sudan, namely Jongoli, Eastern Equatoria and Upper Nile.

abandoned and a new area is cleared, with the individual family moving to the new area. No fertilizer is applied, but in the plots close to the house and close to the cattle camps, manure and household waste is added to the soil. Irrigated farming is presently practiced on a small scale at Renk irrigation scheme (about 2,000 ha) and by individual farmers in isolated locations with simple water-lifting techniques from rivers and with river flooding. Irrigation is scattered and limited to small plots in the floodplain area.

In the semi-arid to arid areas of the sub-basin pastoral livestock becomes predominant. Livestock as a source of livelihood is more important for the South Sudan side of the basin where there is a high concentration of cattle, sheep, and goats. The main livelihood strategies in the sub-basin are therefore a combination of crop and livestock production followed by 'crop only' farming and 'livestock only' production. There is very little use of the basin and its tributaries for irrigation activities (except some traditional methods of water diversion). Fishing is also an important component of the livelihood strategies of communities that live along the rivers and wetlands in the sub-basin.

The contribution of the rivers in the areas to livelihoods and the economy of the Gambela Regional State were considerable. During wet season rivers flood large areas of land and create perennial and temporary water bodies and swamps. **Intensive fishing** activities take place in these perennial and seasonal swamp areas. Subsistence fishing takes place both in the main river channels and floodplain areas and there is a high degree of settlement alongside river courses.

The Baro-Akobo sub-basin has a high potential for flood plain **aquaculture**, but lacks efficient aquaculture technologies.

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

Sources of Conflict

There is inter-ethnic conflict between migrant settler communities and indigenous peoples and that these conflicts have become more frequent in recent years. These conflicts are linked to competition for land and resources.

Infrastructure and services

Overall, there is a dearth of infrastructure in the sub-basin, specifically in terms of road networks, water supply and sanitation facilities, health and education services, provision of credit and extension services. Within the Ethiopian section of the Baro-Akobo sub-basin the 2006 Census data indicates that 70% of the population in Gambella had access to safe drinking water. Based on other data this figure appears to be high. The figure for Oromia was 42%. In South Sudan 62% of the population in Jongoli, followed by 52.2 % in Eastern Equatoria and 31.3% in Upper Nile had access to safe drinking water (Sudan Census 2007). A study undertaken the *Government of the Republic of South Sudan in 2011 (GOSS, 2011b*. "Environmental Impacts, Risks and Opportunities Assessment: Natural Resources Management and Climate Change." Ministry of Environment, South Sudan) found that only ~ 27 % of the people have access to improved water supply, and only 15 % have access to improved sanitation. The figures from the 2007 Census therefore appear to be optimistic and potentially misleading.

The majority of the population in the Ethiopian section of the sub-basin has limited access to education. The rural literacy rates in the Oromia and Gembella were 26% and 36% respectively (2006 Census). In South Sudan the literacy rates in the three states was in the region of 20% (2007 Census). The situation in the South Sudan section of the sub-basin has likely deteriorated with the civil unrest in the area.

VULNERABILITY AND FOOD SECURITY

Research undertaken in the western part of the basin indicates that there is a wide spread poverty and high levels of vulnerability. According to the 2004 Welfare Monitoring survey, 22.8%, 36.3% and 26.9% of households respectively in the Benishangul-Gumuz, Oromiya and SNNP regions suffered from food shortages over the last 12 months prior to the survey date. Unpublished data from DPPC (2000) also showed that 12.6% of rural population from Oromia, 29.9% from Gamblella, 14.0% from SNNP and 2.1% from Benishangul-Gumuz regions required food aid.

A study undertaken by the Joint Assessment Mission (JAM) in 2005 estimated that 90% of the population in South Sudan was living below US$ 1.00 a day. The high rates of poverty in South Sudan are clearly related to the negative impact that the civil war has had on the reduction and in many cases total loss of household and community livelihood assets (capital, family labour, and secure access to land). Given these high rates of poverty, there will need to be substantial government support in providing rural infrastructure, establishing a climate for efficient markets and providing support to agriculture in terms of credit, extension and research. Communities themselves will need to respond to the expect influx of returning Internally Displaced Populations (IDP's) and refugees returning to their homeland. This will require very strong community level institutions that can equitably allocate access rights to the community's natural resources.

Overall, the area is one of the poorest sub-basins in the EN Basin. The poverty situation is likely to be worse amongst agro-pastoral communities whose livelihoods depend on raising cattle and small-scale farming. However, there is a critical lack of reliable and up-to-date socio-economic data on the welfare and poverty situation of the different communities living in the Baro-Akobo-Sobat sub-basin.

4.4.3.5 Tekeze-Setit-Atbara Sub-basin

DEMOGRAPHICS AND ETHNIC GROUPS

The table below contains a summary of key demographic data based on the latest census data for Ethiopia (2007) and Sudan (2006)[7]. It should be noted however that this information is dated. Details on the demographic profile and ethnic groups residing within the sub-basin are provided in the socio-econmic thematic report.

Table 4-9: Demographic data for Tekeze-Setit-Atbara Nile Sub-Basin

TEKEZE-ATBARA NILE SUB-BASIN	Ethiopia (2007 Census)	Sudan (2008 Sudan Census)
Population Total: 13.5 million	9.3 million Amhara 5 million	4.2 million Kassala 1.8 million
Rural population	~87 %	~72 %
Age breakdown	0-14: ~43% 15-64: ~53% 65-older:~4%	Nahr Elnil: 0-14: 36.2% 15-64: 58.8%, 65-older:5% Gedarif: 0-14: 46.5%, 15-64, 49.8% 65-older:3.7%
Child dependency ratio	~83	Gedarif: 93 Nahr Elnil: 62
Infant Mortality (under 5) per 1 000 births	Amhara: 108	Gedarif: 147

7 The 2006 Census for Sudan included the states that now fall within South Sudan, namely Jongoli, Eastern Equatoria and Upper Nile.

	Tigray: 85	Nahr Elnil: 96
Maternal Mortality (per 100 000 births)	679	Gedarif: 564 Nahr Elnil: 443
Life expectancy	~60	~ 60
Literacy rate (15 yrs and older)	No data	Nahr Elnil: 70% Kassala: 42%
Access to safe water	Tigray: 70% Amhara: 50%	Nahr Elnil: 62% Kassala: 34%
Access to sanitation	Amhara: 60% Tigray: 50%	Nahr Elnil: 42% Kassala: 34%

LIVELIHOODS

The majority of the population (87%) in the Ethiopian section of the sub-basin are rural and their livelihoods are linked to agriculture, with crop production and livestock herding the two most dominant economic activities within the sub-basin. Combined crop and livestock farming, followed by crop only and livestock only farming only are the primary livelihood strategies in the Ethiopian section of the sub-basin. In Sudan there is intensive crop cultivation associated with the Atbara River.

The dominance of sedentary agriculture in the basin area implies that crop farming is more important as a source of livelihood than pastoral production. However, there is also a substantial pastoral population, specifically in Sudan, who are engaged primarily in animal husbandry (~10%). In Ethiopia the number of people engaged in pastoralism as a way of life is higher in the Tigray region compared to the Amhara region.

There are at least two types of employment in agriculture, namely those engaged in subsistence agriculture (which makes up substantial proportion of the labour force), and those employed on mechanized/semi-mechanized commercial farms.

The contribution of mechanized agriculture to employment creation in the area is very limited, mainly concentrated around Humera in Ethiopia and near Atbara River in Sudan, but it does provide an important source of supplementary cash income for the basin through seasonal employment. With the exception of the Sudanese portion of the Tekeze-Atbara sub-basin there are limited opportunities for employment in sectors other than the agricultural sector.

In the Sudan section of the sub-basin opportunities are associated with the Portland Cement factory in Atbara town and the Shendi and Norab Textile Factories. In Ethiopia, the unemployment rate in the two basin states of Amhara and Tigray (defined as the proportion of the unemployed population to the economically active population) were 7.7% and 6.1% respectively. The unemployment rates in Nahr Elnil and Kasala state in Sudan were 10.5 and 23.9 % respectively (Socio-economic Synthesis Report, 2007).

SOURCES OF CONFLICT

Diversity in terms of ethnicity, socio cultural value system, livelihood strategies, and the natural environment is one of the key characteristics of the Atabara-Tekeze sub-basin. The conflicts in the area are linked to this diversity. The most common inter-community conflicts were between farming communities (farmer-farmer), farming and pastoral/agro-pastoral societies (farmer-herders/ shifting cultivators), and pastoral communities (herder-herder) (Tesfaye, 2003). These conflicts remain prelevant in 2014.

The causes of conflict in the Sudan, according to the study, are to be found in the conflict between the pastoral communities, and the agricultural settled communities. The majority of the pastoral communities occupy arid and semi-arid lands, characterized by frequent and prolonged droughts. The conflicts in Sudan have resulted in a significant increase in the level of poverty and displacement, violations of human rights and environmental degradation/depletion of natural resources. Poverty, unequal distribution of land, and the degradation of ecosystems are among the most pressing issues undermining community security. The basin population is vulnerable to problems of differential access to farmland, grazing land, water, forests, and mounting population pressure believed to cause conflict among different community groups in the region.

INFRASTRUCTURE AND SERVICES

The Tekeze-Atbara basin population, both on the Ethiopian and Sudanese sides, is characterized by differential access to social (education and health) and physical (water supply and roads) infrastructures. Due to the allocation of limited productive and investment resources favouring urban areas which was characteristics of government policies during and before the 1980s most of the rural population along the basin lacked basic social and physical services. Added to this were the protracted civil wars that consumed northern Ethiopia (in the 1970s and 1980s) and Southern Sudan (in the 1980s and 1990s), both of which fall within the Tekeze-Atbara basin. There have been some improvements in the 1990s and afterwards in terms of increasing school and health coverage in the rural parts of the basin and also building road networks connecting the basin population with each other and with other regions. However, much has to be done to make the basin accessible to social and infrastructure and improve quality of life of the basin population.

- **Drinking Water and Sanitation**: The 2007 Census Ethiopian Census data indicates that 50% of the population in Amhara and 71% in Tigray had access to safe drinking water. The sanitation data for Ethiopia indicated that 60% and 50 % of the population had access to sanitation. The figures in Sudan were 34% in Kassala and 62% in Nahr Elnil. In terms of access to sanitation the figures were 22% and 42% respectively (Sudan Census 2008).
- **Education**: Based on the enrolment data, more than 50% of the school going population in the Ethiopian section of the sub-basin do not attend primary school. The figures for secondary school are even higher, with 75% of the population eligible for secondary education engaged in other activities. The enrolment levels in Sudan are higher, and range from 60.5 % in Elgadarif state to 74.9 % in Kasala and 97.9 % in Nahr Elnil states. The lower enrolment rates in Ethiopia are reflected in the rural literacy rates. In Ethiopia the rural literacy rates were in the region of 30%. In Sudan the rates were higher, namely 42% in Kassala and 70% in Nahr Elnil. The figures indicate that the levels of education on the Ethiopian section of the sub-basin are low
- **Access to roads**: The Ethiopian side of the sub-basin is connected with the rest of the country by one asphalted road, which crosses the north eastern section of the upper basin and links the area with Addis Ababa to the south. All weather gravel roads provide a link between Tigray region in the north and the Amhara region to the south. An all-weather gravel road also provides a connection between the north western parts of Ethiopia and the eastern parts of Sudan. This road facilitates the movement of goods (fuel and agricultural products) and people between the two countries..

  The Sudanese side of the basin is better served in terms of road infrastructure. There is one all season road connecting the basin (Nahr Elnil state) with Khartoum. The town of Atbara is also linked by rail to other regions of Sudan, including the capital, Khartoum. Sudan has the oldest and most extensive rail system in Africa, extending for more than 4 570 kms.

VULNERABILITY AND FOOD SECURITY

Where livestock are the main livelihood capital assets, these livelihoods are also dependant on rainfall and are therefore prone to risk. In addition they are faced with dwindling rangeland resources due to the expansion of large semi-mechanized farms.

Research undertaken by Dessalegn (2003) and Yared (2003) indicate that rural poverty in the sub-basin has increased in severity and magnitude over the last fifty years. This increase is due mainly to population growth, coupled with a lack of access to productive assets, crop failures and climatic variations. The factors contributing to rural poverty identified by Dessalegn (2003) and Yared (2003) continue to persist in the region. The pressure has been exacerbated by population growth in recent years. Although the population on the Ethiopian side of the Tekeze-Atbara sub basin has been exposed to vulnerability conditions (e.g. poverty, ecological stress) similar to those experienced by other population groups residing in the Abbay-Blue Nile and Baro-Akobo-White Nile sub basins, the situation in the Tekeze-Atbara sub basin more intense and h_ence deserve special attention. The reasons are linked to the combined effects of protracted civil strife (1970s and 1980s), drought, famine, and population pressure, which made the basin population more vulnerable. This needs to be taken into account when identifying potential investment opportunities in the area.

Food aid can be used as a proxy indicator for poverty and according to the 2004 Welfare Monitoring survey, 31.9% and 30.5% of households in the Tigray and Amhara regions respectively suffered from food shortages over the 12 month period prior to the survey date. The level of child malnutrition can also be used as an indirect measure of the socio-economic status of the population and based on the results of the Welfare Monitoring Survey both the Tigray and Amhara regions had higher percentages of stunted and underweight children than the average for Ethiopia indicating that vulnerability among children is high in both of these regions. **Based on the information contained in the 2007 Census indicates that food security remains a challenge in the Tigray and Amhara regions.** The Socio-economic Synthesis Report (2007) identified a number of key socio-ecoomic data gaps, these include:

- Magnitude and dimension of poverty along the basin
- Socio-cultural and structural factors of poverty
- Indicators of vulnerability
- Socio-economic status of different groups in the basin
- Household and local level coping mechanisms
- Existing basin-level transboundary resources (e.g. pastures)

4.4.3.6 Main Nile Sub-basin

DEMOGRAPHICS AND ETHNIC GROUPS

The table below contains a summary of key demographic data based on the latest census data for Sudan (2006)[8] and Egypt (2006). It should be noted however that this information is dated. As indicated in the table, the majority of the population live in Egypt. The focus of the section is therefore on Egypt. Details on the demographic profile and ethnic groups residing within the sub-basin are provided in the socio-econmic thematic report.

[8] The 2006 Census for Sudan included the states that now fall within South Sudan, namely Jongoli, Eastern Equatoria and Upper Nile.

Table 4-10: Demographic data for Main Nile Sub-Basin

MAIN NILE SUB-BASIN	Egypt (2006 Census)	Sudan (2008 Census)
Population Total: 74.4 million	72.6 million	1.8 million Nile River 1.1 million
Rural population	~57 %	~70 %
Age breakdown	0-14: ~32% 15-64: ~66% 65-older:~2%	0-14: ~ 35% 15-64: 60% 65-older:5%
Child dependency ratio	~60	~ 49
Infant Mortality (under 5)	33	~ 93
Maternal Mortality (per 100 000 births)	55	~ 440
Life expectancy	~ 72	~ 62
Literacy rate (15 yrs and older)	No data	~ 71 %
Access to safe water	98 %	Northern State: 87 % Nile River: 62 %
Access to sanitation	85 %	Northern State: 74 % Nile River: 42 %

LIVELIHOODS

For the majority of Egypt's long history the economy was based almost entirely on farming. This is despite the fact that more than 95 % of the country's land is desert. Long an exporter of cereals, in the 19th century, Egypt began to specialize in growing cotton, which is still an important cash crop (Mohieddin, 2006). In the late 20th century other key sources of revenue included tourism, oil production and remittances from Egyptians working mainly in the Persian Gulf states.. **The largest proportion of the labour force work in the services sector which employs 47 % of all workers, followed by agriculture and fishing (29%), and industry (including manufacturing and construction)(24%) (2013**).

Despite growth in other sectors, the agricultural sector remains the most important source of new jobs for both men and women. In terms contribution to the economy, the agricultural sector, fishing included, made up 14.5% of the GDP in 2013. Egypt's area of cultivable land is small but highly fertile, located for the most part along the Nile and in the Nile Delta. Yields are high with and almost every piece of land growing at least two crops a year. The service sector, which contributed 48% towards GDP in 2013, and includes government social services, such as health and education, financial services, and personal services, was the single largest economic sector. The second most important was the industrial sector, including manufacturing, mining, and construction, which made up 37.5% of GDP in 2013. The main manufactured goods are textiles, chemicals, metals, and petroleum products.

Tourism is the other important economic sector within the basin and made up 5.6% of Egypt's GDP in 2013. Tourism also employs 5.1 % of the labour force (World Travel and Tourism Council, 2014).

The construction of the High Aswan dam enabled an additional 324 000 hectares (745 200 feddan) of land to be irrigated along the Nile and converted 283 000 hectares (650 900 feddan) from flood to perennial irrigation. In the early 1980s a number of land reclamation projects were initiated in the desert around the lake

The National Strategy of Agriculture Development aims to add significantly to the quantity of land under irrigation. One major project is the Tushka project which involves the establishment of the 22km Tushka Canal, which was constructed in 1978-1982, linking the High Aswan Dam to the Tushka Depression. The aim of the Tushka Project is to use water pumped from the Aswan reservoir to irrigate hundreds of thousands of feddans and to resettle two million Egyptians from the Nile Valley.

The Aswan lake is divided into two fishing areas (zones), namely the shallow water khors, which represent about 20% of the lake surface (about 250 000 feddans), and the deep water, which represents 80% of the lake surface (around one million feddan). There are four major Fishermen Associations which comprise approximately 5 000 inhabitants. Recorded catches in Lake Nasser dropped from 34,000 tons in 1981 to 8,000 tons in 2000. As a result of conservation legislation, catches have now recovered to a lrage degree. A Japanese study found that the fish potential of HAD reservoir is approximately 80 000 tons per year. Information from the Governorate of Aswan also indicates that 60 000-70 000 tons of fish are smuggled out of the lake on a yearly basis.

Along the section of the Main Nile in Sudan traditional and small-scale irrigation schemes constitute the principal farming system downstream of Khartoum. Small-scale farmers living along Main Nile River irrigate their land using a variety of methods. Along the Main Nile downstream of Khartoum, the topographic conditions of the flood plain also permit spate irrigation, which involves the collection of seasonal run-off water in basins for irrigation. On upper terraces beyond the floodplain but within 15 km of the river, farmers are increasingly relying on irrigation wells (mataras) to abstract from the shallow groundwater. The basic food crops grown in the Main Nile sub-basin 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 strategies of these farmers. The animals are an additional source of income as well as a "safety net" against shocks such as droughts.

INFRASTRUCTURE AND SERVICES

- **Water and sanitation**: The Nile is the main source of drinking water for those Egyptians that live along the banks of the Main Nile.
- In Sudan, 87% and 62% of the households in the Northern State and Nile Regions have access to safe water (Sudan Census 2008). The majority of the population in the Northern and Nile Regions are concentrated along the Main Nile. The Main Nile is therefore the key source of water for the majority of the population living in the Northern and Nile Regions. In Egypt 98% of the population have access to safe water (Egypt Census 2006).
- In terms of access to sanitation, 74% and 43% of the households in the Northern State and Nile Regions have access to sanitation (Sudan Census 2008). In Egypt 85% of the population have access to sanitation (Egypt Census 2006).
- **Education**: The adult literacy rate in Egypt was 74% while the youth literacy rate was 89% (World Bank, 2012). The literacy rate for people over 15 years of age in Sudan was 71% (Sudan Census, 2008).

Health

The major endemic diseases include tuberculosis, trachoma, schistosomiasis, and malaria. With the construction of the Aswan High Dam there has been an increase in the incidence of schistosomiasis in Upper Egypt.

VULNERABILITY AND FOOD SECURITY

Although Egypt is a middle-income country that placed itself on a high growth track speared by economic reform during 2005-2010, nevertheless, income poverty, food insecurity and multi-dimensional poverty are widely prevalent, most severely in the rural areas of Upper Egypt (World Food Programme, 2011). Research by the World Food

Programme indicated that 16.3 million people in Egypt live in households that spend less than the minimum level needed to meet basic needs, representing 21.6 % of the population. The incidence of poverty is highest in rural Upper Egypt where 43.7 % of the population is classified as poor. Households facing very high levels of vulnerability to food insecurity make up 20 % of the population. The Governorates in Upper Egypt have the greatest risk to higher food insecurity, with Assiut recorded as the poorest governorate in Egypt with a poverty rate of 60%. Although urban governorates like Cairo and Alexandria show low prevalence of highly vulnerable categories, they are nevertheless include very poor neighbourhoods and slum areas that are vulnerable to poverty (World Food Programme, 2011). The research undertaken by the World Food Programme identified persistent inflation in domestic food prices as one of the most significant threats to household access to food

4.4.4 Implications for project identification / the MSOIA

Some of the implications for project identification an d planning for the four sub-basins are summarised in **Table 4-11**

Table 4-11: Summary of Implications for project Identification

Themes	Abbay - Blue Nile	Baro – Akobo - Sobat	Tekeze -	Main Nile
• **Reduce potential for conflict**	• The identification of potential investment projects should aim identify ways in which groups in contested resource areas can work together in a co-operative and peaceful environment.			
	• One of the prime causes of inter-group conflict in the Abbay-Blue Nile Basin is the competition for and access to scarce natural resources. This needs to be acknowledged when identifying potential investment projects. This applies to all sub-basins.	•	•	•
• **Malaria**	• Water related projects must take into account the potential for increasing the risk posed by malaria. Potential investments should therefore include measures to control and minimise the potential risk posed by malaria			
• **Address challenges and create opportunities**	• The identification of potential investment opportunities should seek to improve the current situation and create opportunities to reduce poverty, increase access to basic services and improve the infrastructure in the area.			
• **Address socio-economic challenges**	• In the light of the poor socio-economic conditions in the area coupled with the poor level of services and infrastructure in both the urban and rural areas in the Abbay-Blue Nile Basin the identification of potential investment opportunities should seek to improve the current situation and create opportunities to reduce poverty, increase access to basic service and improve the infrastructure in the area. This applies to all sub-basins; •	• need to undertake a basin-level study aimed at improving understanding of socio-economics of the basin, esp. Livelihood strategies, gender relationships, indigenous resource management, marginalized occupational groups, social security systems	.	•
• **Understand and acknowledge local traditions and livelihood strategies**	• The identification of potential development interventions must take into account the diverse socio-economic and cultural diversity in the sub basin and the links between the livelihood strategies of these local communities and the natural resources, specifically the rivers and wetlands			
	• .	• Very limited data on the local communities that live in the sub-basin and their interaction with the basin's ecosystem. Need to understand a wide range of traditions and livelihood strategies • Important for potential Baro-Akobo multi-purpose water resources project.	•	•
• **Learn from other projects**	• Eg: large-scale multi-sectoral Tana-Beles development project, which focussed on mechanized agriculture, forestation, livestock,	• Importance of stakeholder involvement and consultation	• Key lessons to be learnt are from the New Halfa scheme, formerly known as	• HAD: dam-induced displacement resulted in a combination of

	fisheries, agro-industry, water supplies, roads, bridges, airport, and education and health. The success of the project was undermined by a lack of proper planning, responsible management, and failure to consult the re-settlers and host communities. • These lessons apply to all sub-basins.		the Khashum El Girba scheme, which was established in in Sudan in 1964 include: • Siltation of the dam • Variability of rainfall; • Weed infestation: • Selection of inappropriate crops, • Damage to crops by livestock of pastoralists - tension and conflicts.	physiological (exposure to different communicable diseases), psychological (undergoing stressful experiences, anxieties and uncertainties) and socio-cultural (denial of access to ritual sites and practices) shocks to the indigenous populations • Loss of sediment driven fertility downstream etc

4.5 Environmental Baseline / Context

4.5.1 Introduction

In this chapter of the report the focus has been on describing the major environmental issues in each of the sub-basins. This has been based on a review and understanding of a wide range of biophysical areas including:

- Geology and Soils
- Land use
- Vegetation
- Wetlands
- Wildlife
- Fish and Fisheries
- Protected and Conservation Areas
- Biodiversity

4.5.2 Overview of the Environmental Situation in the Eastern Nile Basin

The area of the Eastern Nile basin reaches 1, 787,624 km^2, of which the main Nile alone covers about 45 %. For the rest of the basin, the share of area coverage goes in the order of Baro-Akobo-Sobat and White Nile (26.3 %), Blue Nile 17.2 %) and Tekeze-Atbara-Setit (12.9 %).

About 46 % of the Eastern Nile basin falls in the altitude range of 200-500 masl and can be considered as desert. The mid altitude (1500 – 2300 masl) covers 13 %% of the whole basin. The highlands in the upper part of the eastern basin constitute only 5 % of the total area.

Analysis of the physiography data shows that about 84 %% of the basin's land area has a slope gradient below 5 %, corresponding to very flat-to-flat relief. The largest part of the flat topography lies in the middle and lower part of the basin. This portion is characterized by floods and sediments originating in the uplands constituting only 10 % of the whole basin area.

According to data from the FAO and the Woody Biomass Inventory and Strategic Planning Project (Ethiopia), 35 % of the basin's area is covered by tree crops, followed by croplands, and deciduous woodlands, covering 14 % and 12 %, respectively. Grassland occupies close to 11 %, while forestland coverage is estimated below 2.5 % of the total area.

Approximately 63 % of the basin's area receives a mean annual rainfall below 600 mm. Areas belonging to the humid and peri-humid zone in the Upper part, covering 25 % of the eastern basin area, receive over 900 mm a year. Around 60 % of the basin (middle and lower regions of the basin) has a mean temperature of over 25 0C. .

Poor land cover, high rainfall and steep slopes in the upper part of the basin are believed to cause severe soil erosion hazard. This concerns more than 38 % of the basin.

Large areas of forest have been altered by some form of clearing or tree removal. Many of these areas have been given over to human settlement and agricultural use. Some disturbed forests remain in few areas as National Priority Forest. Nevertheless, the situation has become critical with exploitation and uncontrolled burning exceeding the rate of forest growth. Very few primary forests remain on the steepest slopes where agriculture is not feasible.

With the high rate of increase in both human and animal populations, remnant woodlands and bush lands continue to be under pressure. A number of factors have contributed to this, including:

- population growth which induces both an increased demand for agricultural land and pasture and results in increased fuel wood harvesting exceeding regenerative capacity,
- long droughts,
- flooding and high winds.

Seedlings, whether from natural regeneration or plantation, usually suffer abrasive dust, sand storms, drought, browsing and animal trampling. As a result, much of the vegetation in the sub basins has disappeared and very little of the original vegetation remains.

Populations of the wide variety of wildlife in part of the Abbay/Blue Nile sub-basin, including the Walia Ibex, "Key Kebero" (Ethiopian wolf), the Gelada Baboon and the Mountain Nyala, are on the decrease due to anthropogenic pressures.

In the vast plains of the lower altitudes, trees and shrubs are usually gathered for domestic animals. Most of these areas have been deforested for rain-fed mechanized agriculture, which led to the rapid disappearance of the natural vegetation. Over-grazing, especially during the rainy season, has become the main hazard to plant density. More than half of the areas in the plains are drought-prone as they lie in the semi-desert belt.

Another threat is the hazard of fire. Expansion in mechanized rain-fed agriculture for food production has been at the expense of the natural ranges; and the balance between the numbers of livestock and grazing has been disrupted. There has been illicit felling of trees for domestic and commercial purposes especially in the remote and inaccessible parts of the plains. Lack of clear land use policies has also been an additional constraint to forest conservation. Furthermore, war conditions have led to the destruction of plantations owing to unauthorized felling of trees for commercial logs. Official figures on government plantations in the lower altitudes, for instance, illustrate that 80 % of the teak plantation has been damaged.

In general, there has been severe reduction in wildlife habitats and due to the conversion of large areas of land for agricultural use. This has particularly affected the more densely populated higher and cooler altitudes where few large animal habitats remain intact.

In the upper part of Blue Nile, there are limited fish reserves in both lake and riverine systems. Lake Tana has the **largest** fish resource**s**. Fishing is carried out on a subsistence basis and **for** limited commercial purposes both in the main river channels and **the floodplains.** Virtually, every family that lives near water fishes to supplement **their** diet**s**. Nile perch (Lates niloticus) Nile tilapia (Oreochromis niloticus), Catsish (Clarias sp), Bargrus, Barbus and Labeo species are known to be important both in ecological and commercial terms. However, there is little information on fish species and no systematic fish identification has been done. **Similarly there is no information available on fishing an catches.**

With regard to water quality, apart from high sediment loads, the water quality of all rivers that are distant from urban centres appears to be adequate for most uses. Lake Tana with a surface area of 3,042 km^2 is the largest freshwater inland lake **in Ethiopia** and remains an important regulating feature in the upper part of Blue Nile. The lake's water quality seems to be satisfactory and is used as a minor source of supply for the town of Bahir Dar.

Water Hyacinth: The neotropical aquatic weed Eichhornia crassipes was recorded from Sudan since 1955. First noted as a serious weed in the white Nile System in 1958, it spread rapidly throughout the Sudd region from Juba , over a distance of 1700 km , to Jebel Awlia Dam 40 km south of Khartoum . The Jebe Awlia Dam serves as a barrier and with the continuous monitoring and control by the Sudanese authorities, water hyacinth have not been observed downstream of the dam. The serious effects caused by this weed on the White Nile system include, interference with river transportation causing high operation and maintenance cost for ships, blockage of irrigation canals and pumps, water loss by vape-transpiration, fishing losses, and the high cost of chemical control programs and its impacts on human health.

Dinder National Park with its area of about 890,000 hectares preserves natural wildlife migration corridor. The park is the last remaining wildlife sanctuary in the clay plains. It supports a population of Tiang, Reedbuck, waterbuck, bushbuck, Pribi, roan antelope, warthog, buffalo, greater kudu and red fromted gazelle. Many birds are found in the park such as ostrich, marabou stork, Clappertoni francolin, cattle egret, crowned crane, grey heron, sacred ibis, hooded vulture, pink backed pelican, bee-eaters, starling and guinea fowl. The annual reports on the park show continuous decline in the population size of nearly all species.

4.5.3 Policies, Legislations, Institutional Framework, International Agreements

Countries of the Eastern Nile Basin have formulated, adopted and implemented policies and legislation aimed at combatting the problems of environmental degradation and water quality. Details are summarised in Annex 2.

The constitutions of Sudan and Ethiopia recognize the importance of the environment, the need for its proper management and protection. These provisions have become the major springboards for the subsequent issuance of environmental management legislation.

The environmental policies generally aim at improving and enhancing the health and quality of life of the people to promote sustainable social and economic development through sound management and use of natural resources and the environment as a whole. However, while the policies consist of lists of sectoral and cross-sectoral policies, there has been only limited evaluation of the implementation.

In the Sudan, for instance, the following are examples of relevant national policies and strategies:

- The 25 Years Strategic Plan (2003-2027);
- The National Comprehensive Strategy (1992-2002);
- National Economic Salvation Program (1992-1993);
- The Joint Assessment Mission;
- Poverty Reduction Strategy; and
- National Water Policy

The Ministry of Water Resources and Irrigation in the Main Nile (Egypt) has prepared a National Water Policy that lasts till the year 2017 with the following three main themes.

- Optional use of available water resources;
- Development of water resources; and
- Protection of water quality and pollution abatement.

In the upper parts of the sub-basins, the environmental policy has been legally enforced through the approval of the policy by the Council of Ministers. The sectoral and cross-sectoral issues in the policy are concerned with

- Improved soil management and sustainable agriculture;
- Forest and tree resources management;

- Genetic, species and ecosystem biodiversity conservation and management;
- Water resources development;
- Improvement of urban environment and environmental health;
- Control and management of pollution from industrial waste and hazardous materials;
- Control of atmospheric pollution and climate change; and
- Conservation and protection of cultural and natural resources.

Three different proclamations have been drafted and enacted. They are:

- Proclamation for the Establishment of Environmental Protection Organs;
- Environmental Pollution Control Proclamation; and
- Environmental Impact Assessment Proclamation.

In addition to these proclamations, the Council has also approved other laws, environmental guidelines and standards.

In the lower part of the sub-basins, the Higher Council for Environment and Natural Resources (HCENR) has initiated the development of environmental regulations called the Environment Protection Act, which has been issued through a presidential decree. Guidelines and requirements have been established for environmental impact assessments and environmental conservation frameworks. The environmental protection policy requires that any new projects that are deemed to have an impact on the environment have to conduct an Environmental Impact Assessment.

There is a wide variety of legislation in Main Nile (Egypt) for the control of the impact of human activity on the environment. Such environmental legislation is concerned with surface water contamination, soil pollution and degradation, air contamination, noise, energy consumption and effects on human beings and other living organisms. These are summarised in Annex 2.

In the region, environmental laws have not been enforced adequately for a number of reasons, including:

- Lack of adequate authorities with necessary resources to carry out inspection and enforcement;
- Lack of public awareness regarding the magnitude of the environmental problems and their negative effects;
- Ineffectiveness of the regulatory approach to allow the flexibility necessary for the polluter and the regulatory agency to negotiate quick agreement on a compliance schedule;
- Concentration of regulators on informing the polluter of a violation, without provisions for phasing in compliance measures after the violation has been announced; and
- Insufficient coordination and cooperation among the ministries and governmental institutions regarding the issue of environmental protection.

4.5.3.1 Institutional Framework

In the upper part of the sub basins (Ethiopia), an institution to protect the environment called Environmental Protection Authority (EPA) was established in 1995. At the federal and regional states levels, there are several institutions engaged in natural resource protection, development and research. They include most notably:

- Ministry of Rural Development;

- Ministry/Bureau of Agriculture;
- Ethiopian Wildlife Development and Protection Organization;
- The Ethiopian Agricultural Research organization as well as agricultural research institutions in most of the regional states;
- Ministry of Water Resources and Regional water and Energy Bureaus;
- Institute of Biodiversity Conservation and Research;
- Disaster Prevention and Preparedness Agency and
- Regional Disaster Prevention and Preparedness Bureaus; and
- Rural Energy Development Promotion Centre.

In addition to the above institutions, there are quite a number of non-governmental organizations, civil society institutions and trade associations that are involved in environmental protection, conservation and related activities.

In the lower part of the sub basins (Sudan), there are environmental institutions such as:

- The Higher Council for Environment and Natural Resources (HCENR),
- Wildlife Conservation General Administration (WCGA),
- Institute of Environmental Studies (IES), University of Khartoum,
- Non-Governmental Organizations:
- Sudanese Environmental Conservation Society (SECS); and
- Sudanese Social Forestry Society (SSFS).

The institutions involved with water quality management in Egypt are generally line-ministries with responsibilities in areas that are related to, but not necessarily coincident with, environmental protection. The following are institutions with major roles in water quality management:

- Ministry of Water Resources and Irrigation (MWRI);
- Egyptian Environmental Affairs Agency (EEAA);
- Ministry of Health and Population (MoHP);
- Ministry of Housing, Utilities and New Communities MHUNC);
- Ministry of Agriculture and Land Reclamation (MALR);
- Ministry of Industry (MOI);
- Ministry of Higher Education and Scientific Research (MHESR);
- Ministry of Interior; and
- Non-governmental Organizations.

4.5.3.2 International Agreements

Regarding international agreements and their implementation, the country constituting the upper part of the sub basins (Ethiopia) has adopted and ratified several conventions and agreements related to the environment, namely:

- Convention on Biodiversity;
- The united Nations Convention to Combat Desertification;

- The Vienna Convention for the Protection Of The Ozone Layer;
- Framework Convention on Climate Change;
- The Basel Convention: A Convention to Control and Regulate the Trans Boundary Movement of Hazardous Waste;
- The Stockholm Convention: A Convention Designed to Ban the Use of Persistent Organic Pollutants (POPs);
- The Rotterdam Convention, relating to the prior informed consent in the context of international trade in specific hazardous chemicals and pesticides; and
- International Convention on Trade in Endangered Species, Fauna and Flora.

In response to multilateral agreements, the Government in the lower part of the sub basins (Sudan) has developed a number of national strategies that include the following:

- Agenda 21 project-Sudan: a response to the Rio Earth Summit 1992;
- National Biodiversity Strategy and Action Plan (NBSAP);
- Towards national Implementation Strategy for the UN Framework Convention on Climate Change;
- Assessment of Impacts and Adaptation to Climatic Change;
- National Action Plan to Combat Desertification; and
- Persistent Organic Pollutants.

4.5.3.3 Environmental Programmes and Projects

The following projects either have been already implemented or are in the process of implementation the upper part of the three sub basins (Ethiopia):

- Project for the Control and Disposal of Expired Pesticides;
- Project for the Preparation of a National Chemical Handling and Registration guideline;
- The Ecologically Sustainable Industrial Development Project;
- The National Cleaner Production Centre Project;
- The Amhara Region Sustainable Development Project;
- The Energy and Woody Biomass Survey Project;
- The Addis Ababa Industrial Zone Cost Benefit Analysis Project;
- The Tannery Pollution Control Project;
- The Project for the Generation of Employment for Women Fuel-wood Carriers;
- The Project for the Environmental Auditing of 10 Factories; and
- The Federal and Regional Conservation Strategies.

4.5.3.4 Environmental Information System, education and knowledge

An efficient and consistent environmental information system for the whole basin is lacking. This would be useful to ensure that data from diverse sources and different periods would be compatible and consistent in time and space. However, efforts are being made at the different environmental authorities to organize systematic environmental information.

Education and awareness as essential tools in highlighting the importance of environmental protection have been recent initiatives aimed at developing more environmentally literate citizens who share a concern for environmental protection issues in the region. It can be achieved through introducing both formal and informal environmental education and training programmes. The Egyptian Environmental Affairs Agency (EEAA), provides continuous support to environmental training and awareness activities and initiatives. This is reflected in the protocol between the Ministries of Education and Environment signed in 1999.

4.5.4 Environmental Status and Threats

The causes of environmental threats are interconnected. Land degradation is the result of deforestation and inappropriate agricultural practices. As mentioned earlier, the main cause of deforestation in those regions is the increasing need for forest products by the rapidly growing rural and urban populations. Soil loss, due to removal of the vegetation cover, is an ever-increasing problem. As a result, in the upper parts of the sub basins (largely in Ethiopia) up to 400 tonnes of fertile soil per hectare is lost annually from degraded lands due mainly to lack of adequate soil conservation practices. About 130 tonnes of soil per year is lost within the upper part of Blue Nile sub-basin alone.

In the lower parts of the sub basins (largely Sudan) environmental degradation and floods remain the major environmental problems. Sudan was ranked among the 10 bottom countries in the 2005 Environmental Sustainability Index (ESI). This reflects a low environmental performance taking the five standard measurement components (Environmental System, Reducing Environmental Stresses, Reducing Human Vulnerability, Social and Institutional Capacity, Global Stewardship levels that cause no serious harm.)

The key driving forces of environmental degradation in the lower parts of the sub-basins include climatic variability and change, which is revealed in the form of severe drought and occasional floods. Climate change is expected to increase the frequency and severity of climatic variability.

In general, the following conditions characterize the environments in three sub-basins:

- **Land degradation** happens as the result of many factors such as ad hoc government policies regarding the use of natural resources, horizontal expansion of rain fed mechanized and traditional farming, heavy reliance on forest biomass energy, overgrazing, bush fire, etc.;
- **Unsuitable agricultural practices** are manifested in the form of reliance on seasonal bush and grassfires for purposes of preparing land for cultivation, pastoralism, overgrazing in some regions and limited extension services;
- **Wetland loss and degradation** results through direct drainage for cultivation, grazing, etc., or indirectly through sedimentation and pollution;
- **Loss of soil nutrients** becomes a phenomenon due to mono-cropping farming systems, years of extensive cultivation practices by the mechanized and traditional rain feed sectors, with limited or no access to fertilizers and improved farming techniques compounded by wind and water erosion which has left most soils depleted of nutrients;
- **Deforestation** has continued as a result of encroachments, agricultural activities and urbanization. Forest resources have also depleted as a consequence of uncontrolled felling of trees;
- **Desertification** has become a growing challenge affecting significant parts of the regions' land area. In the lower part, the largest portion ranges from light to severe desert. 13 of the 26 states in Sudan could be classified as desert or semi- desert;

- **War and civil strife** has had a major impact on the natural resources and the entire environment; and
- **Increased population pressures and urbanization** resulting in more demand on resources and services.

In conclusion, soil erosion , land degradation, sedimentation, extreme floods, deforestation, desertification, the movement of sand dunes, water quality and pollution, agrochemicals, conservation of sensitive ecosystems (protected areas, wetlands, forests etc) are major environmental issues that need to be carefully considered at the different development stages.

4.5.5 Impacts of Major Development and Ps

Catering for environmental issues should not be seen as hindering development. It should be seen as necessary for saving considerable costs in the long-term and enhancing sustainability.

A multi-sectoral/integrated planning approach is the best way to cater for environmental issues and minimize adverse impacts. Early consideration for the environmental issues such as at the strategic regional planning level (MSIOA) will reduce the eventual mitigation costs.

In the particular case of the upper part of the sub basins, the major areas of development that are given considerable focus are irrigation and hydropower development. Both activities could have direct and indirect impacts on the upstream and the downstream areas of all of sub basins.

- While there will be the expected positive impacts and the regional development benefits of the major developments including environmental and social enhancement due to new reservoir fishing industries, agricultural activities, downstream community water supply, forestry and wildlife reserves and rural electrification, there can be a range of direct and indirect negative impacts are expected to take arise including the following:
- Disruption of settlement areas and loss of agricultural lands;
- Land allocation conflicts, habitat destruction, erosion and changes in water table;
- Excessive watershed erosion;
- Upstream deterioration in water quality;
- Downstream flow variation;
- Inundation and losses of primary forests;
- Infrastructure loss;
- Impediments to movement of wildlife, livestock and people;
- Changes in routes of transmission lines; and
- Prevalence of diseases like malaria, schistosomiasis and other geohelminthic due to the construction of micro-dams.

Hydropower production and transmission of electricity, while essential to meet the rapidly increasing demand, are expected to create diverse and substantial environmental and socio-economic impacts. Currently, the electrical industry in the lower part of the basin is under considerable public pressure to minimize its potential negative impacts and improve its social and environmental performance. On the other hand, hydropower is currently the major renewable source contributing to electricity supply, and its future contribution is anticipated to increase significantly.

4.5.6 Environmental Issues in the Abbay – Blue Nile Sub-basin

4.5.6.1 Overview

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

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

4.5.6.2 Water Quality

Apart from high sediment loads, the water quality of all rivers that are distant from urban centers appears to be adequate for most uses. Lake Tana with a surface area of 3,100 square kilometres is the largest freshwater inland lake and remains an important regulating feature for the Blue Nile River at its head. The lake's water quality seems to be satisfactory and is used as a minor source of supply for the town of Bihar Dar. The remainder of the town's water supply is being pumped from shallow groundwater bores.

Several areas and cities in Sudan depend on the Nile system for their drinking water. The watershed erosion and heavy sediment movement during floods seasons cause high turbidity and suspended solids in the Nile River water. For example at Khartoum, the turbidity has tremendously increased during the last decade. It was increased from 5000 NTU to above 20,000 NTU during flood in 1999 to 2003. Water treatment plants at Khartoum abstracting raw water from River Nile have been affected by such heavy sediment load. Treatment plants being designed initially to treat raw water of maximum turbidity of 8000 NTU utilizing Alum salt as coagulant are now producing poor quality of water when maximum allowable dose of Alum (150 mg/l) is being utilized. Khartoum Water Corporation (KWC) has been applying many alternatives to overcome the problem of turbid water in piped water network. The presence of sediment in the Blue Nile produces poor quality of water for domestic use with the following impacts:

- Accumulation of sediments at the dead ends of water network, which encourages after growth of micro-organisms, and hence affects the health of consumers.
- Clogging of pipe network and increasing the incidence of pipes burst and occurrence of cross connection pollutes drinking water.
- If chlorine is utilized for disinfections of such water of poor quality, chlorine oxidizes organic matter in water usually generating complex compounds leading to health hazards of consumers.
- Accumulation of polymer residual in water may cause serious health risk for the consumers, if it is utilized over a long period of time.

- Combination of inorganic salts are being utilized, (Alum + Poly Aluminium Chloride) producing better quality of water during flood season. However, the effects of both salts in combination over a long period of time have not being determined.

4.5.6.3 Water-related diseases

The major concern is malaria which is increasing, is difficult to control, has potential to infect a very large population in epidemic outbreaks. The other water related diseases are Schistosomiasis, Typhoid, Diarrhea, Helminthiasis, Leshimaniasis, Onch ocerchiasis.

4.5.6.4 Soil Erosion

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

- **Sheet erosion**

  Key areas: Most sheet erosion in the Sub-basin occurs in the Ethiopian Highlands. Some sheet erosion occurs within Sudan, mainly on and around the rock hills (Jebels), which have become devoid of vegetative cover. Most of this is deposited on the footslopes and does not enter the drainage system. Four main areas of high sheet erosion are found in the Abbay Basin. The steep slopes around Mount Choke in East and West Gojam stand out as a significant area with a high sheet erosion hazard. This is an area with high rainfall causing problems in developing physical soil conservation structures because of the problems of providing effective water disposal structures. The second widespread area of high erosion hazards occurs north and east of the Abbay River in the Lake Tana Basin. This area includes the steep cultivated slopes around Mounts Guna (South Gonder) and Molle (South Wello). A third more restricted area is found in the upper Jema sub-basin in South Wello on the high hills north and west of Debre Birhan. A fourth area is found south of the Abbay and encompasses the upper and middle steep and cultivated slopes of the Middle Abbay Gorge Sub-basin in East Wellega. Two subsidiary areas with a high erosion hazard can be seen in the Upper Didessa Valley and along the escarpment hills to the west of Lake Tana in the upper Dinder and Beles valleys.

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

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

- **Gully erosion**

  Ethiopia: Although some work has been undertaken on gully formation and extension (Billie & Dramis, 1993), (Shribrus Daba et al., 1993), there is no information on gully distribution, density, erosion rates and sediment delivery ratios. Very recent research by the Universities of Makelle, Ethiopia and KU Leuven, Belgium in Tigray (Nyssen, J et al., 2005) have provided information of gulley erosion rates, sediment yields and sediment delivery ratios in northern Ethiopia. They report that gullies were initiated by a variety of changes in environmental conditions: removal of vegetation between fields, Eucalyptus planting in valley bottoms and new road construction. Where soil conservation measures have been introduced and gullies are relatively stable they contribute approximately 5 percent to sediment load. Where there are no conservation measures the average rate is 32 percent.

Sudan: The main erosion problem in the Blue Nile Sub-basin is the gully erosion along the Blue Nile and Dinder Rivers producing kerib land. The plains are overlain with Vertisols (black cracking clays). The Vertisols develop very wide cracks during the dry season. At the onset of the rains water enters the cracks. Whilst the soils are covered with deep rooted vegetation there is no problem as roots take up any excess sub-soil water. However, once this vegetation is removed there is excess water in the subsoil and tunnels develop in the subsoil. These eventually collapse leaving an incipient gulley. These gradually extend back into the plain stripping the soil away from the underlying weathered rock of unconsolidated sediments, which are extremely soft and erodible. The weathered rock is quickly gullied. The Dinder is gullied for about 50 kilometres upstream from its confluence with the Blue Nile. The Rahad River does not appear to be affected except very locally near its confluence with the Blue Nile. However it is not as extensive nor has it gullied back to the same extent as it has along the Atbara. Most the kerib land along the Atbara has gullied upto 2.5 kilometres from the river, whilst along the Dinder it about 500 meters. It is possible that the Dinder is not as incised as the Atbara River. An interpretation of 2,000 Landsat TM imagery gave an estimate of 337,640 feddans (141,810 ha) of land that is affected. Some kerib land adjoins rainfed and some irrigated cropland. As no information is available on erosion rates it is difficult to estimate the impact on loss of cultivated land.

- **River bank erosion:** Possibly a bigger problem in terms of sediment delivery to the river is bank erosion, particularly along the Blue Nile. Much of it is a natural phenomenon caused by river meandering over flat flood plains and subject to a complex array of hydraulic factors. Along the Blue Nile bank material is mainly clay and silt. Human influences can alter the very delicate balance of hydraulic forces and set in chain accelerated bank erosion. Excavation of soil for brick making and building, the removal of tree vegetation along the banks, different cropping patterns and dumping of material into the river can all causes accelerated bank erosion. A change from deep rooting fruit trees to shallow rooting bananas is reported to have caused accelerated bank erosion along the Blue Nile (Mekki Abdel Latif, 2005).

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

Ethiopia Highlands: In the Ethiopian Highlands the immediate causes are the burning of dung, removal of grain and soil erosion. Within the Abbay Basin some 1,751,600 tons of dung collected from crop fields (about 40% of total dung produced) and some 3,207,046 tons of crop residues were burnt as household fuel. This resulted in a loss of some 44,060 tons of N and 9,250 tons of P. The rate of loss of nutrients is nearly 2.5 times the rate of loss occurring in the Tekeze Basin, confirming the work of other workers (e.g. Desta et al, 1999, World Bank, 2004) that soil nutrient breaches and decline in soil nutrient status is major problem in the higher rainfall areas. It is noticeable that in contrast to the Tekeze Sub-basin where the greatest losses are from burning dung and residues, losses from grain removal make the largest contribution to total losses in the Abbay Basin.

Sudan: Semi-mechanized Farms: Within the Abbay-Blue Nile Basin in Sudan, the Africover mapping of rainfed cropping with large to medium size fields suggest that there are approximately 7.454 million feddans (3.131 million ha) of large to medium semi-mechanized farms (SMF). However, a proportion of this land has gone out of production and in some cases has been abandoned. The FAO/WFP crop survey for 2005 estimated cereal production from the SMF Sector for Gederef State as 589,000 tons. Average yields are 0.36 tons per ha, which suggests that approximately 1.636 million hectares were under crops. The Africover estimate for land under SMF's in Gederef State (in 2000) was 3.1 million hectares. This suggests that in 2005 (a good rainfall year with high sorghum prices) only 50 percent of the SMF land was cropped. During the 1990's the area harvested on the SMF's contracted by 2.4 percent per annum whilst yields declined even further by 5.1 percent per annum (World Bank, 2005). This resulted in a decline of GDP from SMF sector of 7 percent. These reductions in yield are partly due to a decline in soil fertility in the absence of fallowing or fertilizer application. There has also been a decline in productivity partly due to the build-up of weeds (including striga) and partly to an expansion onto marginal land resulting in destruction of soil structure, soil erosion and soil fertility. The removal of natural predators (snakes and cats) has led to an increase in rats and other vermin. Insect eating birds have disappeared leading to a big increase in the use of insecticides and insect damage. With only approximately 50 percent of the land being cropped and yields declining at just over 5 percent per annum this represents a substantial waste of natural resources.

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

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

  The two main dams in the Blue Nile Basin are Roseires completed in 1966 with a storage capacity of 2.4 cubic kilometres and the Sennar completed in 1925 with a capacity of 0.7 cubic kilometres. The hydro-electric facilities at each of the dams have installed capacities of 250 MW and 15 MW at Roseires and Sennar respectively. Both dams are affected by siltation.

  The Sudan Ministry of Irrigation and Water Resources report that sedimentation in the Roseires Dam rose from 300 million m^3 in 1970 to 1,264 million m^3 in 2000 resulting in a loss of 38.3 percent of its designed capacity. Sedimentation is now reducing the live storage. As well as the loss of storage impact on crop area that can be irrigated there is also a reduction of hydro power generation. High sediment loads in the rivers used as sources for domestic and industrial water supplies cause problems and additional expenditures for water treatment plants.

DEFORESTATION AND DEGRADATION OF WOODY BIOMASS

Deforestation and degradation are two different processes that cannot be directly compared. Clearing woody biomass for agriculture is a sudden and complete process. The "degradation" of woody biomass stocks caused by wood removal for fuelwood and charcoal is gradual and partial. The conversion of forest land to crop land and then grazing land has implications for hydrology. Although there is much debate at present about the role of forest land in affecting the volume of flow, due to evapotranspiration by trees, there are clear implications of forest loss upon the moderation of stream flow, especially the storage of water from the rainy season into the dry season. Hence, linked to the loss of forest are trends towards higher floods and lower dry season flows.

- ***Ethiopian Highlands***: In the northern Highlands in the Abbay-Blue Nile Basin there is little or no potential for expansion of agriculture except in very local situations. However, south of the Abbay River in Oromiya Region there is some potential for agricultural expansion and this taking place into areas covered by shrubland, woodland and forest. In the western lowlands, mainly encompassing Beneshangul- Gumuz Region there remains considerable areas for agricultural expansion. Hitherto settlement and expansion of agriculture in these areas have been constrained by the presence of human diseases (particularly malaria) and cattle diseases (particularly trypanosomiasis). In the late 1970's a large-scale mechanized farm of 96,000 ha was cleared and developed in the lower Didessa and Anger Valleys. It experienced continued declining yields and following the fall of the Derg it was abandoned. Such was the efficiency of the clearing of the original woodland that even after 10 years it remains grassland with no woody vegetation. Since 1991 a new voluntary resettlement programme is being implemented in Oromiya region and to a much lesser extent in Amhara region. The main areas for resettlement are in the Didessa and Anger valleys. The Pawi scheme has also continued to receive settlers. In BSG Region some 128,000 ha have been allocated for medium-large scale agricultural investment. By 2015 some 56 percent of forests, 61 percent of woodlands and 43 percent of shrublands will have been cleared for agriculture and settlement as a result of natural population increase. No account is taken of resettlement and migration, or of expansion of large-medium scale commercial agriculture.

  In BSG given its low population densities the rates of clearing are much lower and only some 5 percent of Acacia-Commifera woodland and 27 percent of shrubland are estimated to be cleared for agricultural expansion due to natural population increase. Again no account is taken of expansion of agriculture for irrigation (e.g. the Beles scheme), resettlement for rainfed agriculture or large-medium scale commercial agriculture. The pattern of weredas consuming in excess of sustainable yield mirrors that of the weredas with high proportions of their area experiencing moderate to severe soil erosion.

  Most weredas that are consuming more wood than the sustainable yield are located in the highlands a clear reflection of the low population densities in the lowlands.

  Sudan: Semi-mechanized farms: Substantial areas in the Abbay-Blue Nile Sub- basin have been cleared to make way for the Semi-mechanized farms. These now cover some 1.32 million hectare. This was formerly woodland and shrubland. The clearing has been particularly severe in the west of the Blue Nile and towards the Ingessena Hills. Map 19 indicates the encroachment of these farms towards the Ingesenna Hills (near to Bau). An unknown area of Semi-mechanized Farms is abandoned each year because of falling crop yields. Because the land is totally cleared of all tree cover and combined with years of constant harrowing and disking the tree seed bank in the soil has been completely destroyed.

  The abandoned areas are a waste land with no tree cover. The quality of the grass cover is very poor because of the very low levels of soil fertility.

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

LOSS OF BIODIVERSITY

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

The proximity of the Park to the desert and semi-desert makes it an important buffer zone for the vegetation cover of central Africa in addition to its significance in providing genetic material for the rehabilitation in the semi-arid and arid areas. The Park is an important watershed area protecting the most important feeders of the Blue Nile, the Dinder and Rahad Rivers. The Park, together with the south-western corner of the Ethiopian Plateau make a complete Ecosystem for wild animals, for which the Park is the dry season habitat for migratory species.

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

There are three groups of people who have an interest in the park:

- The first is the original inhabitants of the areas - a small group of Maganu people who continue to live in the south-eastern part. They depend on subsistence farming in the rainy season and supplement their diet by collecting fruits and wild honey. In the dry season they move to the Dinder for fishing.
- The second group are pastoralists and agro-pastoralists who enter the Park in the Dry Season looking for forage and water because much their rangeland has been converted into semi-mechanized farms. They burn the tall grasses in the dry season to make green grass available, but in doing so eliminate susceptible herbs and shrubs.
- Around the Park are a considerable number of Internally Displaced Peoples taking refuge from the war in Dafur in the 1970's and are settled along the Dinder ands Rahad rivers and enter the Park for fishing, fuelwood and honey collection but also for illegal hunting and present the most serious threat to the wildlife. It is estimated that 100,000 people live around the park in 36 villages.

The Maya'a: The Dinder and the Rahad Rivers and their tributaries drain the Park. They rise in the Ethiopian Highlands and are highly seasonal almost drying out in the dry season. Due to the abrupt change in gradient the rivers meandering a large number of cut-off meanders have been formed locally called Maya'as. They are generally flat and cover an area some 0.16 to 4.5 sqaure kilometer. Rain and flood water fill them during the rainy season. The maya'as provides a valuable source of water and forage for domestic livestock and wildlife, as well as unique habits rich in biodiversity. Under natural conditions there is a constant evolutionary sequence of the formation of young maya'as that are deeper with clear water. Gradually they pass through stages of becoming gradually silted up. Over long periods of time with the meandering new maya'as are being formed. The spectrum runs from young productive maya'as to old non-productive dry ones. With the accelerated erosion in the Ethiopian Highlands this gradual and long term evolutionary process has been disturbed because increased flood peaks and high sediment loads. The area is now subject to annual flooding and many of the Maya'as are becoming silted up with a consequent loss of habitat biodiversity and forage productivity.

Alatish National Park: In Ethiopia the Amhara regional Government has proposed to develop the Alatish Regional Park in Quara wereda of North Gonder Zone, almost opposite the Dinder national Park in the Sudan. The area represents the Sudan- Guinea Biome. The park has been gazetted as a Regional Park and demarcated. However, the Park lacks national legislation and international recognition (Cherie Enawgaw et al., 2006). The Park covers an area of 2,666 sqaure kilometer to the north of the Dinder River, which forms its southern boundary, and to the south of the Gelegu River that forms its northern boundary. The Alatish and other ephemeral streams drain the central area. Its altitude ranges from 500 to 900 masl. The main vegetation is woodland, shrubland and lowland bamboo thicket. Studies so far have revealed that the Park contains 48 mammal species and 180 bird species.

It contains such endangered species as Loxodonta africana, Panthera pardus and Panthera leo. The area is intact with no permanent settlement, although Fellata pastoralists enter the Park in the dry season with over 10,000 head of livestock. The northern and eastern sides have a 2 kilometres buffer zone, but the southern boundary has no buffer zone as it border Beneshangul-Gumuz regional State. The Gumuz people have settled to the south of the Park and practice poaching and fishing along the Dinder River. Settlement is increasing and agriculture expanding along the northern boundary and numbers are being swelled by migrants from other parts of Amhara region. There is an urgent need to collaborate with the Beneshangul-Gumuz Regional government and with the Government of Sudan to secure the area. The Ethiopian Wildlife Conservation Organization has strongly recommended that the Alatish Park been proclaimed a National park and that in the future it should form part of a Transboundary Park with the Dinder National Park. There is also an urgent need to develop a park management plan in participation with local communities.

4.5.7 Major environmental Issues in the Tekeze – Setit – Atbara Sub-basin

4.5.7.1 Introduction and overview

There are a number of environmental issues in this sub-basin.

4.5.7.2 Major environmental issues

Water Quality

Except for its high sediment load, water quality, especially away from urban centers is suitable for most uses.

Industrial and agricultural Pollution

These include air pollution in Mekelle from the cement factory, water pollution from the newly constructed Sheba Tannery and the dyeing factories of Tigray.

Water Related Diseases

In the upper course of the sub-basin (largely confined in Ethiopia) four major vector-borne diseases, notably malaria, intestinal schistosomiasis, visceral leishmaniasis (VL) and onchocerciasis are confirmed as being endemic and pose a major challenge to socio-economic development effort in the area. The incidence of malaria and schistosomiasis will increase in areas of ongoing micro-dam construction. Most major settlements in the basin have non-extent or inadequate drinking water supply systems. Sanitation is also inadequate, piped drinking water should be boiled for use.

Mekelle already has a water quality problem due to the chemical composition of the aquifer rocks. At present Lalibela has severe water shortage with daily water cuts. The existing residential areas have few latrines. People defecate on the hills surrounding the town. This has resulted in the pollution of the land underneath the rock-hewn churches in the valley. Sample taken from the churches foundations show evidence of erosion with urine concentrations.

Soil Erosion & Land Degradation

Land degradation refers to degradation of soils and natural vegetation, resulting in a disrupted hydrological equilibrium. Erosion and/or land degradation is generally recognized as the main environmental problem in the Tekeze Sub-basin in particular in the highlands. Land degradation is virtually caused and/or accelerated due to two important factors; human and natural factors and it is related not only to the geographic distribution of natural resources but also to the historical pattern of land use.

Of the natural conditions/factors, two general features have caused high erosion hazards since ages are (1) the erosive character of the rainfall pattern, and (2) the predominantly steep relief in most of the sub-basin areas.

The high erosion is related to the high intensity of rain storms, causing damage particularly at the onset of rainy season when soils are least protected against the impact of rain. Erosion hazard turns in to actual erosion if the protective vegetation cover is depleted.

Development of habitation and land use pattern and related depletion of vegetation resources and land degradation, historically, have different levels as seen from the national and sub-basin/regional perspectives. At the sub-basin/regional level, for longer period of time(it exists even at the present) habitation in the highlands was more preferable than in the lowlands, owing to the highlands having more favourable climate and less suffering from endemic diseases like malaria. Population increase, which has resulted in an increased demand for cultivation land, which in turn has caused massive destruction of forest land and biomass. This has accelerated land degradation in the sub- basin. Sever scarcity of woodlands in the highlands and being as one of the outstanding characteristics for the lowlands today is the reflection of the then mentioned historical habitation pattern in the sub-basin. On the other hand when seen at the national/basin level, largely in the upper course, land degradation, historically, has spread from north to south. The northern highlands of the upper course of EN Basin indeed shows a state of sever degradation as compare to the highlands in the southern portion of the upper course of the EN Basin, which could be the combined effect of longer lasting pressure on resources in a more fragile (drier) environment. In the northern portion originally, the highland plateau was covered by *Juniperus*, *Olea,* and *Cordia*, alternating with mixture of *Acacia-Andropogon savannas*, and by edaphic grasslands and swamps in flat valley bottoms. By centuries of continuous abuse, these lush conditions have been converted into the almost barren plateau which exists today, where forest and natural woodland is virtually confined to small areas around churches and holy places, and destructive high winds blow over the bare lands.

As seen at the local level in the sub-basins, settlement and cultivation have first concentrated in highland plains, on plateaus and on gentle foot-slopes, all sites with suitable fertile soils and low erosion hazards. Sustained usage of land resources was possible because of the relative abundance of fertile soils and the possibilities of shifting cultivation and fallow periods being sufficiently long to allow regeneration of soil productivity. Fuel and timber were available in abundance and could be collected from the direct surroundings. With gradually increasing population, both the possibility of shifting cultivation within areas of low erosion hazard and the length of fallow periods have decreased. At present, highland plateaus and plains are fully under cultivation (or grasslands and are completely deforested. Fuel and timber have to be collected from other areas with a much higher erosion hazard, notably, steep hill sides and valley sides bordering plateau.

Soil degradation in terms of fertility loss and erosion has come into the picture in the process and decrease in productivity could be compensated for by expansion of the cultivated land area and by increasing management inputs such as weeding and more frequent cultivation/ploughing. Consequently, initially low but gradually increasing land degradation rates, i e. in the form of erosion, probably remained unnoticed.

Factors underlying land degradation: In the Tekeze Basin, food production, livestock feed and fuel requirements put competing demands on scarce and vegetation resources. The Tekeze Basin has been a process of gradual degradation of land and vegetation under population pressure and inadequate management of natural resources. An analysis of scarcity and degradation of resources in the studied 42 PAs showed that pressure on resource is strong or critical in 31 PAs and low or moderate in 11 PAs. Most of the latter are situated in the western lowlands of the basin. (OSI Water Synthesis Report, Forest Land, p. 146)

Two important phenomena must have been the main causes for crossing critical thresholds of natural regeneration of resources: (1) the increasing demand for land that has forced the farmers to expand cultivation onto steeper land being much more susceptible to erosion; and (2) the increasing demand for fuel and timber, which has caused large scale deforestation at a rate increasing beyond natural regeneration and the indiscriminate cutting has long been coupled with very little replacement effort.

Shortage of land has also had its repercussion on livestock husbandries. Most of the suitable land is reserved for crop production. Grazing of cattle is limited to hydromorphic valley bottom lands to marginal deforested hill slopes and to a limited number of enclosures within the cropland reserved for grazing.

Land degradation in the Tekeze Watershed is distinguished between physical, chemical and biological soil degradations, water and wind erosion, and mass movement (Barber,1984). Chemical degradation refers to the leaching and removal of nutrients and the buildup of toxicity other than those due to excess salts. Physical degradation includes those processes which adversely affects soil physical properties such as infiltration rate, structural stability, root penetrability and permeability. Biological degradation refers to processes which accelerate humus mineralization rates, and reflect the moisture/temperature regimes of the environment and land use practices.

Water erosion in the form of sheet, rill and gully erosion is the most intensive and widespread form of land degradation and also recognized as the main environmental issues in the sub-basin. Rill and gully erosions are more spectacular because more evident features are formed during much shorter periods, generally during one season, and even as a result of one exceptional rain storm or a few storms at short intervals.

Stream bank erosion is one of the striking features of the land degradation in the sub-basin. By far the greatest majority of natural drainage routes in the areas are actively eroding. Highly variable rainfall (high hydrologic variability, due to sever environmental degradation) that produces seasonal high peak river flows exceeding the channel capacity of the drainage routes; destroy the protective role of vegetation. Intensive deforestation actions within the watershed, that causes the depletion of riverine forest or bushes also eliminates the protective capacity of vegetations, is the other factor enhancing stream bank erosion in the watershed.

Above all land topography plays important role for land degradation in the watershed. Nearly 30% of the upper course of the Sub-basin is identified to have land slope exceeding 30% and about 25% has land slope that ranges from 15% to 30%. Due to cultivable land shortage resulting from land degradation and population pressure, these steeply sloping areas are intensively cultivated, aggravating land degradation events in the Sub-basin. Research activities in soil loss are rare in the Sub-basin. Very few attempts indicate soil loss in the watershed ranges from 17 tones/ha per year to 33tone/ha per year. Landownstreamoil degradation in the watershed has caused an average loss of 3% in agricultural produces (Tekeze Master Plan Studies, May 1998).

PESTS AND WEEDS

Regular crop yield loss caused by various pests such as weeds, diseases, insects, rodents and birds are common. The existing weed control measures are limited to hand weeding, commonly performed quite late after crop emergence. Farmers do not use herbicides. Single weeding is the common practice in all cereals, except teff, which gets more attention. Diseases such as rust, smut, scald and blotch are reported to cause damage to various crops, virtually no measures are taken by peasant farmers to control these diseases. Insects are the major pests in the area. They cause a substantial damage on different crops. However, only a very limited number of farmers use Malathion in order to control insect pests like armyworm and grasshoppers. Due to inadequate and/or delayed supply and poor technical know-how of farmers, the present efficiency of pesticide use by peasant farmers is quite low.

4.5.8 Environmental issues in the Baro-Akobo-Sobat-White Nile Sub-Basin

4.5.8.1 Context

The sub-basin has an area of 468,216 km^2, accounting for about 28.3% of the total area of Eastern Nile Basin. The Ethiopian part of the sub-basin comprises high plateaux elevations ranging from 1500 to 2000 m and mountains with peaks exceeding 2,500 m. The elevation decreases towards the Sudan reaching as low as 250m.

In the Baro-Akobo area of the sub-basin, the temperature ranges from around 27 C in the lower lying areas down to 17.5 0C in the highlands. There are short periods where temperatures are in excess of 40 C, the critical value for anthesis of some crops, notably maize, but this does not coincide with the cropping season. Daytime temperature in lowlands is very stable over the year with mean maximum not falling below 30 C even during the rainy season. In contrast, land above 2000m is markedly cooler, with mean maximum temperaurure in the hottest period not exceeding 28 C and generally being in the range of 21-260C. The annual mean minimum ranges from 15 C at Atnago to 7C at 2320 m at Fincha.

The sub-basin is part of a particularly well-watered region of Ethiopia. Most of the upper sub-basin has an annual total rainfall over 1800 mm.

LIVESTOCK

The Baro-Akobo area contains about 1.2 million cattle and more than half a million sheep and goats. Cattle are of primary importance, used for draught, milk, capital reserve, and source of cash. Furthermore, they are used for cultural purposes such as status and serve as bride price during marriages.

In the lower sub-basin, the livestock are managed on a migratory system in response to the availability of grazing and water in the plain but the seasonal distribution of the feed is a constraint. In the upper part of Baro-Akobo, feed resources are the main constraints to livestock production.

DEGRADATION OF FORESTS AND WOODLANDS

The Baro-Akobo part of the sub-basin contains about 2.2 million ha of forests. Although isolated into small stands and seriously degraded, they constitute more than half of Ethiopian's remaining forests. Nonetheless, their situation is critical. Loss by exploitation and uncontrolled burning exceed the rate of forest growth. Few primary forests remain: those that remain occur on steep land that is unsuitable even for shifting agriculture.

There are 11 National Priority Forestry Areas: Gerjeda, Sigmo Gaba, Sele Mesengo, Gesha, Yeki, Sheko, Guraferda, Saylem Wangus, Godere, Abobo Gog and Gambela Park.

Based on reconnaissance observations rather than delineating of map units, the forest types delineated include Natural Forest (Afro-Alpine and Sub-Alpine, Coniferous, Aningeria, Olea, Baphia, Evergreen Clump-shade, Mixed Deciduous, Combretum and Acacia, Riparian) and Plantation Forest.

The Afro-Alpine and Sub-Alpine forests lie above 3,200 m where they comprise small trees, herbs, and suffrutecents. Little human activity occurs in the zone other than grazing and barley cultivation. Coniferous forest, lying between 1800 and 2500m occur principally on steep lands, where gravity dispersion of seeds assists their regeneration. Aningeria forestes lie between 1600 and 2000 m where the annual rainfall is about 1600-2400 mm. Olea forests lie between 1500 and 200m, their preference for gentle slopes exposes them to disturbance and exploitation. They comprise a wide range of commercially desirable species. Bahpia forests often merge with riparian forest and are open forest type. The evergreen clump-shade forests occur throughout the highlands plateau. Remnants of the forest, which once clothed Ethiopian's uplands, are now made-up of islands of trees with the spaces between often used for coffee cultivation. There is no forest regeneration. The Mixed Deciduous extends along the southwestern edges of the plateau at about 1200m altitudes. The Combretum and Acacia woodlands occupy the low and upper basin between 500 and 1500m altitude. Riparian forest extends throughout the plateaux drainage pattern, dropping down to the flood plain. Like the woodland of savannah and upland basin, riparian forests are under enormous pressure from local and refugee population.

Forests are key components of the Baro-Akobo environment. Improved forest provides suitable habitat for many types of wildlife. Dense forest intercepts rainfall and helps protect the soil surface against soil erosion. The resulting betterment of hydrological condition will provide benefits to much of the infrastructure such as roads, dams, bridges, and water supply that lead to improvement to human health. Advance in the forest economy will offer alternatives to subsistence agriculture, and off-farm income will improve.

BIODIVERSITY (FAUNA AND FLORA)

The following are the major environmental concerns and measures identified through the biodiversity assessment made in some of the states found in the Baro-Akobo-Sobat-White Nile sub-basin in the Sudan (NBSAP, 2002)

White Nile State

According to the 1958 classification, White Nile State is divided into two divisions. The first is semi- desert and woodland savannah on clay. It has four subdivisions: Acacia tortilis/ Mearua crassifolia desert scrub, semi-desert grassland on clay, and semi-desert grassland on sand and Acacia mellifera-Commiphora desert scrub. The second division is the woodland savannah. It has two subdivisions: Acacia mellifera thorn and Acacia Senegal savannah. From comparison of the historical Harrison and Jackson's classification with the more recent investigations, it can be concluded that annual grasses are still there in their old areas. There are indications of a southern shift in species occurrence. This however awaits further investigation. Available field evidence shows that trees and shrubs have been affected by browsing. Affected species are Maerua crassifolia, which has low density and only found scattered. Browsing, over-cutting and drought are the main causes affecting trees density. Commiphora africana is one of the most affected tree species in the semi-desert.

Clearance of natural stands for residence and agricultural production, particularly in the southern limits of the White Nile is the main threat. The cut stands are not normally replaced with planting. As a result, the species Dalbergia melanoxylon and Acacia tortilis are endangered. Over grazing especially during the rainy season is the main hazard to plant density. The northern limits of the state are drought-prone as they lie in the semi-desert belt. The second threat is the hazard of fires. Expansion in mechanized rain fed agriculture for food production has been at the expense of the natural ranges. The balance between the numbers of livestock and the grazing has been disrupted. Sand dune fixation in the western part of the state has proved successful.

Upper Nile State

The state is endowed with vast plains of relatively stable clay soils, covered by savannah woodland ecological zone. The low rainfall woodland savannah on clay, Acacia seyal-Balanites alternating with grassland type covers an area of 17,000 km² along the boundary with Blue Nile State, extending in a narrow belt to river Sobat in the south, extending towards Jelhak and the White Nile. It also occurs in an area of about 7,000 km² round Riangnom. The Upper Nile Swamps ecology surveys and the range ecology survey conducted between 1979-1983 are the latest and most detailed investigation of the Sudd of the Upper Nile. A total of 350 species of higher plants were identified. The northern Upper Nile area is now open for both legal and illegal charcoal producing activities. According to Khartoum State in 1999, 38 to 50% of the monthly fuelwood supplies to the capital city originate from northern Upper Nile State. Almost all the fuelwood supplies are in the form of charcoal. The bulk is produced in areas already marked for clearance for mechanized rain fed agriculture.

An adverse effect of the civil war conditions has been the cessation of forestry presence and supervision on forestry plantations and installations. The war conditions were also conducive to destructive elements and profiteers to destroy the forestry plantations by unauthorized felling for logs for sale in the north. Forests National Corporation 1999 figures on government plantations, illustrates the extent of damage caused to the plantations of teak, Tectona grandis, Sunt, Acacia nilotica and other exotic species. The damage caused to teak plantations amounts to 80% of the teak planted area.

WILDLIFE

Gambela National Park has apparently received legal protection since 1974 and the region was at one time considered as one of the most important wildlife areas. However, its present status hardly warrants designation as a protected area of any kind. Large areas of the original park have been cleared and is being used for cultivation and/or grazing.

A high density of wildlife in the south and south west of the sub-basin were reported fpr 30% of the area sampled from the air. Migration pattern of large mammals were inferred from air photographs; giving a general account of dry season dispersal to the wetter grassland of the west, with rainy season movement to the higher levels of the watershed.

The Baro-Akobo environment was once abundant with wildlife: At least 27 species of large mammals were recorded 25 years ago,(Aatwell (1996)), the basin has undergone severe hunting, civil unrest, and depletion of habitat in recent years that resulted in the reduction of its significant mammal population. Important changes to the habitat have occurred, most notably the occupation of large part of Gambela National Park by a state farm and Abobo Dam, part of whose upper reservoir also extends in to the Abobo Gog protected area.

FISHERIES

Studies on the fish and fisheries of the Baro-Akobo part of the sub-basin are limited. The Russian Academy of Sciences carried out a comprehensive study of the fish species of the lower basin in the late 1980s. This study examined the species composition, tropic status and parasitology of the fish populations but provided no information on the fisheries. No estimates of the number of fisheries operation in the region or an evaluation of their catch are available, and the fisheries department does not, as yet, collect such information. Similarly, in the upper sub-basin, ARDCO-GEOSERV study did not cover the fisheries sector in any detail, and with the exception of an ad hoc fish inventory survey around Ale District by the Russian delegation of the Science and Technology Commission, little information is available from other sources. No formal studies have been carried out in the upper sub-basin region and no assessment of the status of the fisheries has been made.

- **Fish Species**: The ad hoc Russian study in the upper catchment around the Ale District found Some 40 fish species out of the 75 identified in the lower Baro-Akobo plain. On the upper plateau, there are Species with a preference for slower flows. As the river descends from the plateau to the lowland plain, it cuts through steep gorges and is fast flowing. In this region, rheophilic (fast water) species such as barbus and Labeo are found.
- **Fishing**: In comparison to the Lower catchment, there is little fishing in the upper catchment of the Baro-Akobo. Fishing occurs on the Baro, Sor, Weber, Yobi, Dibo and Uka rivers, but is purely on a subsistence basis using traditional methods. The Dominant species caught are Oreochromis niloticus, oreochromis zillii and Barbus species. No data exist on the number of fishermen or intensity of fishing in different parts of the catchment or at different times of the year. The reason for the lack of fishing include: the absence of any suitable sized, slow-flowing water or lakes; inaccessibility of major rivers and tributaries for most of the course: and lack of a fishing tradition amongst the local ethnic groups.
- **Fisheries Development**: There is some evidence of attempts to increase fish production. The fisheries department of the Ministry of Agriculture in Ethiopia, for example, stocked Lake Bishan Waka Haye near Tepi with 11,000 tilapia fingerlings and Barta reservoir, west of Dembidolo, constructed by the world Lutheran Federation for irrigation purposes, with 58,000 fingerlings. Unfortunately, there has been no follow up of these activities.

Fish Species (Lower Baro Akobo): Studies carried out on Species by the Russian Academy of Science as part of the overall Russian study (Selkhozpromexport, 1980) found 72 fish species in the lower sub-basin of Baro-Akabo. Nile perch (Lates niloticus) Nile tilapia (Oreochromis niloticus), Catsish (Clarias sp), Bargrus, barbus and Labeo species were important both in ecological and commercial terms.

Fishing in the region is mainly on a subsistence basis, both in the main river channels and many of the floodplain lakes. Virtually, every family that lives near water fishes to supplement its diet. Active fishing is carried using spears, or modifications thereof, cones, various hook and line devices, traps made of reed, etc.

In addition to the subsistence fishermen, there are three fishing co-operatives at Pinudo (at Tata), Pinkew and Itang which were established by Lutheran World Federation.

Fishing is highly seasonal in the lower Baro-Akobo sub-basin. Flooding between June and October prevents most fishermen from operating and thus the main fishing season is restricted to the drier periods between October and April.

No direct estimates of present fishing efforts and production are available because catch and effort data are not collected.

Water Resources and Wetlands

The major rivers in the Baro-Akobo- sub-basin are Baro and its tributaries (Birbir, Geba, Sore), Gilo with its Tributaries (Gecheb, Bitum, Beg), and Akobo with its tributaries Kashu and Alwero. The general direction of the rivers is from east to west. The rivers rise in the high land (2000-3500m) situated in the east of the area and flow to the Gambela plain (500m) in the west

According to the report on the 43 surveyed wetlands of Ethiopia; Cheffie Gebo, Ginina, Abol, Alwero and Tata (Thata) are located in the Baro-Akobo River Basin.

National Parks

The lowland area of Baro-Akobo is the site of Gambela National Park. Three controlled hunting areas, Jikau, Alobo, and Tado, are also located in the sub-basin. Despite efforts made to set aside habitat for the preservation of wildlife, the result has not matched expectation and suitable habitat has become compressed. Important constraints are insufficient staff, insufficient awareness, insufficient finance, and absence of plans to manage priority areas, inadequate infrastructure, and no research capacity.

4.5.9 Major Environmental Issues in the Main Nile Sub-basin

4.5.9.1 Introduction and overview

The Egyptian coastline extends or 3,000 kilometres along the Mediterranean Sea and Red Sea beaches in addition to the Suez and Aqaba gulfs. Natural conditions on Egyptian Mediterranean coasts differ significantly from those on the Red Sea coasts in terms of salinity, sea currents and temperature. Such difference has led to different biodiversity and ecosystems in each. Nearly 40% of industrial development activities are practiced in Egyptian coastal zones, in addition to a number of urban and tourism development activities. Furthermore, coastal zones monopolize the seaports infrastructure, in addition to agricultural and land reclamation sectors, as well as a developed road network capable of accommodating all development aspects. Egyptian coastal zones production is estimated at 85% of Egypt's production of oil and natural gas; The Gulf of Suez production alone is estimated to be 36 million tons. In addition, the crude oil and natural gas production in the Mediterranean coastal zones is increasing every year.

Through many joint efforts on the regional and international levels under the Global Program of Action for the Prevention of Marine Pollution From land-based Activities (GPA/LBA & MEDPOL), it was possible to identify many polluted areas in need of urgent action. Most of the adverse impacts were identified and their volume estimated in order to enable their elimination. Data pointed out to the existence of hot spots that need special attention where pollution has exceeded permissible limits, such as Abu Qir and El Max. Environmental inspection program results indicated an increase in the number of land-based sources that have adjusted their status and complied with Egyptian Laws and regulations, or that have active environmental compliance programs in place.

Moreover, evidence provided by applied marine environment quality monitoring programs showed a noticeable improvement in the quality of marine environment since the launching of these programs in 1998, particularly at hot spots in the Mediterranean Sea.

The policy measures to tackle environmental degradation comprise both preventive measures and long-term policies. The preventive measures are carried out through the regular assessment of the water quality status and suitability for various uses. Moreover preventive measures include enforcement of laws to protect water resources from pollution. The Ministry of Water Resources and Irrigation formulated a National Program for Water Quality Monitoring in the Nile, canals and drains and Lake Nasser. The Central Laboratory carries out the substantial lab work for Environmental Quality Management affiliated to National Water Research Centre. The monitoring program includes 300 locations for surface water and 230 locations for groundwater. The long term policies to control pollution include covering open conveyance system passing through urban system to closed conduits; coordinating with other concerned ministries to set priorities for wastewater treatment plants due to budget limitation; introducing environmentally safe weed control methods either mechanical, biological or manual and banning the use of chemical herbicides. Subsidies on fertilizers and pesticides were removed and some long lasting agricultural chemicals were also banned. Public awareness programs are introduced to promote the issue of conserving Egypt's water resources in terms of quality and quantity. (OSI Environment Synthesis Report pp. 44-45)

4.5.9.2 Major environmental issues

WATER RELATED DISEASES

Throughout history, epidemics related to water- borne or water-related pathogens have plagued Egypt. Some of these events are briefly recounted (Helwa, 1995) here as follows:

The 1973 typhoid epidemics was localized in a small village in Damietta Province, where about 400 students and villagers fell ill.

In the summer of 1983, infective diarrhoea started in a small village in Giza Province and later spread to other areas. The causative organisms were isolated in drinking water network, which was contaminated by an overflow of sewage caused by broken pipe connection.

The 1986 typhoid epidemic affected the old section of Suez City. It was the result of heavy contamination of the old water treatment plant intake by untreated human wastes.

The Ministry of Health monitors routinely for pathogenic bacteria, viruses, and parasites in natural water around Egypt. Results of these surveys indicate that the following pathogens have been found in Egyptian waters:

- **Salmonella**: Have been detected in Alexandria sewage discharged into Mariut Lake, El- Mahmoudia canal and Alexandria beach.
- **Shigella**: The causative agents of bacillary dysentery were isolated from Mariut Lake.
- E.histlita and E.coli were detected also in tap water in Abbis II village even though water is treated and chlorinated.
- **Vibrio Cholera**: As a preventive measure, local health authorities in Egypt collect 110 water samples daily from the Nile and main canals, at the intake point of water treatment plants, and from drains and sewage discharges. The samples have been analyzed for Vibrio cholera, with results so far negative.
- **Parasites**: A clear decline in the presence of infective stage of human with Schistosomiasis (Cercaria). The results indicated a decreasing infected snails (intermediate host) population. Infected canals are by now treated with molluscicide.
- **Hepatitis A virus**: No figures are available in Egypt
- **Hepatitis E virus:** Have been detected among children, especially in the rural areas.
- **Viral gastroenteritis**: Gastroenteritis and diarrheal diseases are the most common diseases transmitted by water. These viruses are responsible for 40% among children's under five years of age in Egypt. These diseases are spread by faecal contamination and transmitted to humans via contaminated water supply and food.
- **Poliomyelitis virus**: These viruses have been detected in sewage in Egypt. It is the only water-borne disease, which has a potent vaccine giving testing immunity to vaccinated children. For this reason, the disease is now being eradicated in Egypt.

SOIL DEGRADATION AND CONTAMINATION

The use of traditional inefficient irrigation techniques and the inadequacy of drainage systems have led to the increase in water logging and salinization. Salinity is a potential limiting factor that stifles land productivity in Egypt. Over-exploitation of water for irrigation has led to the depletion of groundwater resources, which has resulted in excessive intrusion of salt water from sea into ground water aquifers.

According to published research, vehicle emissions affect the soil of the agricultural land around traffic roads. A strip of at least 40 meter parallel to the Cairo-Alexandria Agricultural

Road receives air pollutants, mainly lead, carbon monoxide, nitrogen oxides and sulphur dioxide. These pollutants fall on the plants as well as passing directly into the soil.

Pollutants carried by irrigation water are also a major source of soil pollution. An estimated 50 per cent loss of productivity of agricultural land was recorded at Helwan and Shoubrah El-Kheima. Severe damage to plants has been reported in areas close to the industry in Kafr El-Zayat, Edfu, Abu Za'abal and others. Toxic heavy metals accumulate in the tissues of vegetation grown adjacent to sources of air pollution, such as lead smelters, and near traffic roads.

Baseline Status of Lakes and Wet Lands

- **Lake Manzala:** Lake Manzala is the largest northern lake. It is situated in the northeast corner of the Nile Delta, and falling in the jurisdiction of five governorates. It is separated from the Mediterranean Sea by a sandy beach ridge, which has three open connections (bugaz) between the lake and the sea. The surface area of the lake is 280,000 feddans. Lake Manzala has the largest fishery production (78,261 tons in 1998) compared to the other northern lakes. The fish species of the lake have been changed, which previously were characterized as marine fish. After the construction of Aswan High Dam (AHD), the mullet –based brackish water fishery has been replaced by tilapia–based fisheries due to the constant inflow of freshwater with high nutrient concentration. Tilapia represented about 51% of the lake fishery, while mullet represented about 3.6% of the total harvest. (OSI Environment Synthesis Report p. 26)
- **Lake Burullus:** Burullus Lake is situated along the Mediterranean coast and occupies a more or less central position between the two branches of River Nile. The lake is oval in shape with estimated area of about 114,520 feddans. It is a shallow basin with variable depth ranging between 0.6 and 1.6 meters. The lake has about 70 islands, of which 55 are artificially created by filling reed-infested area with soil. Burullus Lake receives its water from different sources:
  - Sea water, through natural inlet at it's northeast border;
  - Brackish water dumping from agricultural reclaimed areas and drains; and
  - Brackish-salty water, through the bramble Manila on the wet coast.

  After the closure of AHD, margins of the lake were made to develop for land reclamation for agriculture expansion. Eight drains were constructed to leach the soil salinity into the southern shore of the lake. Burullus Lake is considered one of the highly productive lakes in the Mediterranean with about 31% of the delta lake's area. Burullus Lake produced 59,033 tons, representing about 42% of all delta lakes. It has the most productive mullet fishery of the delta lakes due to wide lake- sea connection, which allows high recruitment of mullet fry from the sea each year. (OSI Environment Synthesis Report p. 26)
- **Edku Lake:** It is the smallest northern delta lakes. It is located about 30 kilometres to the Northeast of Alexandria. The lake area reaches about 27,470 feddans. Edku lake is the third fishery productive among delta lakes (10,280 tons in 2001). The source of lake water is coming from two agricultural drains. Bersik drain enters the lake from the southern edge and Edku drain enters from eastern side of the lake. Exchange of water between the northern side of the lake and the sea is insured through a narrow slit 'Boughaz El-Maadia'. The area of the lake is divided into three basins due to emergence of a number of islets. The salinity of Edku lake varies locally and seasonally. It fluctuates from less than 0.09 % in the eastern basin to about 1.4 % at El-Maadia region inside the Boughaz. Edku lake contributes 7% of the overall production of northern lakes (10,300 tons), of which 90% Tilapia and only 5% mullet. (OSI Environment Synthesis Report p. 27)

- **Qarun Lake:** Qarun lake is an inland closed basin of 23,000 hectare, and an average depth of 8 meters. In the ancient times, Qarun Lake was connected with river Nile forming a natural reservoir of freshwater, which supplied Fayoum depression with floodwater of the Nile. Whenever the lake became disconnected from the river Nile, its water level lowered and its surface shrunk due to evaporation, until a new flood raised its level and size again. Consequently, salinity has been steadily increasing. The mean salinity had increased from about 11 ppt in 1906 to about 34 ppt in 1982, and at present, the average salinity reaches 39 ppt. It is estimated that 589,000 tons of salt enters the lake annually. If the level of salinity continues to increase, it may reach 50 ppt by the year 2020 transforming the lake into a dead sea. The only source of water supplying the lake is the agricultural drains (especially wadi and Bats drains). (OSI Environment Synthesis Report p. 27)

WATER QUALITY AND POLLUTION OF THE NILE

Water Quality

Water quality is one of the most important environmental issues in the Main Nile largely in Egypt. Due to intensive agricultural and industrial uses pollution is significantly higher and is important economic problem in the sub-basin.

The protection of water resources is one of the most critical environmental issues in Egypt. Egypt is facing an increasing demand for water due to the rapidly growing population, as well as the growth in urbanization, agriculture and industry. In the meantime, Egypt faces a rapidly increasing deterioration of its surface and groundwater due to increasing discharges of heavily polluted domestic and industrial effluents into its waterways. Excessive use of pesticides and fertilizers in agriculture also causes water pollution problems.

An assessment of water quality in Egypt indicated that the major water quality problems are pathogenic bacteria/parasites, heavy metals and pesticides. Major sources of these pollutants are the uncontrolled discharge of human, industrial and agricultural wastes.

- Industrial and Agricultural Pollution

  At present industrial use of water is estimated at 5.9 bcm per year out of which 550 mcm per year is discharged untreated into the River Nile. About 125 major industrial plants are located in the Nile valley, which represent about 18% of the existing industries and discharging 15% of the heavy metal loads. About 250 industrial plants are located in Greater Cairo, which represents 35% and contributing about 40% of the total metal discharges. The Delta excluding Alexandria has some 150 industries, which contribute about 25% of the heavy metals discharging to drains. Alexandria is a major heavy industrial centre with some 175 industries, about 25% of the total in Egypt

Sources of Pollution

- **Upper Egypt:** Sources of industrial pollution along the Nile in Upper Egypt area are mainly agro-industrial and small private industries. Sugar cane industries significantly influence Nile water quality at Upper Egypt-South zone. Hydrogenated oil and onion drying factories influence Nile water quality at Upper Egypt-North zone.

- **Greater Cairo:** The area has a population of approximately 18 million and encompasses many industrial and commercial activities. Heavy industry is located around, south and north of Cairo. Many small industries and some heavy industry are randomly located throughout the city. Although wastewater discharges of the small industries are generally low, concentrations of certain industries in specific areas, such as the tanning industry may cause local contamination problems. An overview of pollution sources include 23 chemical industries, 27 textile and spinning industries, 7 steel and galvanizing industries, 32 food processing industries (including a brewery), 29 engineering industries, 9 mining and refraction industries, and petrol and car service stations, bakeries (>350), marble and tile factories (>120) and tanneries in South Cairo.
- **Lake Nasser:** Generally speaking, water released from Lake Nasser mostly exhibits the same seasonal variation and the same overall characteristics from one year to another. Downstream changes in river water quality are primarily due to a combination of land and water use as well as water management interventions such as: different hydrodynamic regimes regulated by the Nile barrages, agricultural return flows, and domestic and industrial waste discharges, including oil and wastes from passenger and riverboats.
- **River Nile from Aswan to Delta Barrage: *Chemical Contamination***: From the available data, the following can be concluded that Dissolved Oxygen Concentration (DO) situation is not alarming. Specific "hot spots"could not be detected. In all monitored sites, DO concentrations were higher than 7.0 mg O2/l, indicating the high assimilation capacity of the Nile. Chemical Oxygen Demand (COD) values showed slight, but steady increase from south to north. 21 samples out of the 35 samples were not complying with the standard value given by law 48/1982 for ambient water quality (10 mg O2/l). Biochemical oxygen Demand (BOD5) which is a measure for biodegradable organic compounds showed a random distribution but did not exceed the standard value (6 mg O2/l) given by the law. The relationship between COD/BOD values indicates the presence of non-biodegradable organic compounds, from industrial sources. An increase in TDS from 171 mg/l at Aswan to 240 mg/l at the Delta Barrage has been recorded. But this is within the permissible limit given by the law.
- ***Biological Contamination***: Law 48/1982 did not specify a standard for faecal coliform (FC) counts for the ambient water quality of the Nile River. Therefore, the value given by the WHO (1989) as a guideline for use of water for unrestricted irrigation (103/MPN 100ml) has been taken as a guide for the evaluation of the water quality in this report. The results of the microbiological examination indicated a great variation in the spatial distribution of the faecal coliforms counts. Great excesses have been found around the catchments areas of Kom Ombo, El-Berba, Main Ekleet and Fatera drains. FC counts in the water samples taken from the specific bank side, where the drain water is pumped, are even higher. This proves the presence of untreated human wastes in these drains.
- **Damietta and Rosetta Branches:** The Rosetta receives water of a number of agricultural drains, which are heavily polluted by industrial and domestic sewage. The drains receive large parts of the wastewater of Cairo. The wastes in the drains contain high levels of suspended and dissolved solids, oil, grease, nutrients, pesticides and organic matter. It is suspected that toxic substances are present as well. The Damietta Branch also receives polluted water from a number of agricultural drains; The Fertilizer Company is considering the major point source of industrial pollution at Damietta branch.

- **Alexandria Area:** Alexandria is a major industrial centre with some 175 industries, about 25 per cent of the total in Egypt. These industries include paper, metal, chemical, textile, plastic, pharmaceutical, oil and soap and food processing. The plants are reported to contribute some 20 percent of the total wastewater of Alexandria. The industries discharge their effluents mainly to Lake Mariut and partially to the sewerage network. According to a survey made by Drainage Research Institute, different types of industrial wastes are disposed to Lake Mariut. At least 17 factories discharging directly to the lake through pipelines, 4 factories collect their wastewater in trenches. Moreover, nineteen factories are lying in the vicinity of the treatment plants, 22 factories discharging to nearby drains and then to the lake.

Factors responsible for contamination of Egyptian Waters

Eighty percent of the urban population is reported to have acceptable sanitation, including toilet facilities (55% in developing countries). Seventy–seven percent of the urban population is connected to public sewers.

In rural areas only 5% of the population is connected to sewers and only about 25% is considered as having some sanitary facilities (15% in developing countries) (Egypt Environment Action Plan).

About 20% percent of the total population (5% urban and 25% rural) lacks safe public drinking water supplies and rely instead on potentially contaminated, untreated surface water or hand pumps which tap often contaminated shallow groundwater.

Not all the existing sewage treatment facilities are providing complete secondary treatment of wastewater, and the effluents discharged are either only partially treated or left untreated, especially in the rural areas of Egypt. In addition, in most cases many industries combine their wastes with sewage, discharging them into fresh waterways.

It is worth mentioning that the total amount of BOD discharged to the river Nile by industrial plants equals 270 ton per day. This amount corresponds to the untreated discharge of wastewater from more than six million people. It can be concluded that these substances are discharged mainly from the industrial activities in the Greater Cairo region and in Delta (0.75 and 0.50 ton per day). The average concentration of heavy metals (HM) in the effluent is less than 5 g/1, which is slightly, more than a normal background.

The chemical industry is responsible for more than 60% of the heavy metal discharges. The high BOD load from the food processing industry is attributable to 10 sugar factories between Aswan and Cairo, for which the total BOD load was estimated at 490 ton/day in 1980. More recently the BOD load from some sugar factories has been reduced significantly due to recovery of molasses at the source. Since the economic viability of this industry is not clear, a restructuring program for the industry would need to consider both environmental and economic viability issues for the industry.

The contamination of natural water results in increased water purification costs and rates. Currently, there are a total of 63 drinking water treatment plants drawing from surface waters, 13 from the Nile and 50 from canals. In 13 of the 26 provinces, drinking water comes from unsafe sources, water samples collected from these provinces showed a high percentage of samples not complying with the bacteriological standards. This was more evident in northern delta, in Damietta, Ismailia, Port Said, Matrouh and Giza.

One of the major problems in potable water supply is the estimated 50 percent loss of water in the distribution networks. This problem costs the Government a huge amount of money every year. The annual amount of lost water in networks is estimated at 2.95 BILLION CUBIC METRES. If the estimated cost of operation and maintenance for one cubic meter is L.E. 0.45, the annual wasted fund is almost L.E. 1.3 billion. This amount is equivalent to the total annual investment of the National Organization for Potable Water, And Sanitation Drainage (NOPWASD).

Poor quality of drinking water is a concern in many parts of Egypt. This is due, in part, to the fact that sources of raw water for many areas have become increasingly polluted, and therefore require more sophisticated treatment to produce drinking water of adequate quality. Furthermore, water treatment units are not always functioning properly as a result of lacking maintenance and proper operation. Even when water treatment is satisfactory, drinking water is sometimes contaminated in leaking distribution network, which are infiltrated for example by sewage. Rooftop water storage tanks have also been identified as another source of bacterial contamination of drinking water (OSI Environment Synthesis Report p. 46).

Domestic Pollution: Available information revealed that the total wastewater flows generated by all governorates, assuming full coverage by wastewater facilities, is estimated to be 3.5 billion cubic metres per year. Approximately, 1.6 billion cubic metres per year receives treatment. By the year 2017, an additional capacity of treatment plants equivalent to 1.7 billion cubic metres is targeted (National Water Resources Plan, 2002). Although the capacity increase is significant, it will not be sufficient to cope with the future increase in wastewater production from municipal sources, and therefore, the untreated loads that will reach water bodies are not expected to decline in the coming years, as demonstrated in Table 5.

In many cases, domestic wastewater is collected from the centre of the towns and from the villages and, dumping it into a nearby irrigation canal is quite common. Therefore, domestic waste disposal significantly contributes towards water quality degradation. It is worse mentioning that no well-controlled sludge management program exists in Egypt. This may, especially in urban areas such as Greater Cairo, lead to inadequate sludge disposal, cause general environmental problem and, in the worst case, eventually influence water quality in a negative way.

The constituents of concern in domestic and municipal wastewater are: pathogens, parasites, nutrients, oxygen demanding compounds and suspended solids. In Greater Cairo and other cities, the sewerage systems also serve industrial and commercial activities. Therefore, instances of high levels of toxic substances in wastewater have been reported. As these toxic substances (heavy metals and organic micro-pollutants) are mainly attached to suspended material, most of it accumulates in the sludge. Improper sludge disposal and/or reuse may lead to contamination of surface and ground water.

In general, the bulk of treated and untreated domestic wastewater is discharged into agricultural drains. Total coliform bacteria reach 106 MPN/100 ml as recorded in some drains of Eastern Delta. It is important to mention that all drains of Upper Egypt flow back into the Nile. Many irrigation canals and agricultural drains may be contaminated with pollutants from domestic and industrial sources. Moreover, many of irrigation and agricultural drain are used for irrigation.

The total amount of domestic wastewater has been estimated at 3.6 BCM for the year 1995/96.

Approximately 24 percent of the population of Egypt is connected to sewerage services; however this value is expected to grow rapidly, due to works under construction. The population without connection to sewerage systems relies on individual means of treatment and disposal, mainly on-site treatment such as septic tanks. Often on-site solutions are ill designed and poorly maintained. There is, however, little information available to support this argument.

An assessment of water quality in Egypt indicated that the major water quality problems are pathogenic bacteria/parasites; heavy metals and pesticides. Major sources of these pollutants are the uncontrolled discharge of human, industrial and agricultural wastes. (Source – OSI Environment Synthesis Report pp. 46-47)

Agricultural Pollution resulting from Use of Agrochemicals: Agriculture is also a major water polluter. Wastewater seeping from agriculture fields is considered non-point sources of pollution. These non-point sources are, however, concentrated through collecting agricultural drains from point sources of pollution for the River Nile, the Northern Lakes or irrigation canals in case of mixing water for reuse. Moreover, these non-point sources of pollution may also influence the groundwater quality. Major pollutants in agricultural drains are salts; nutrients (phosphorus and nitrogen); pesticide residues (from irrigated fields), pathogens (from wastewater), and toxic organic and inorganic pollutants (from domestic and industrial sources) (OSI Environment Synthesis Report p. 47). Agricultural pesticides are both a potential diffuse source of water contamination.

- **Agricultural Drains**: According to the National Water Resources Plan for Egypt (NWRP 2001), the Nile River from Aswan to Delta Barrage receives wastewater discharge from 124 point sources, of which 67 are agricultural drains and the remainder is industrial sources. Figures (2, 3) show the industrial and the agricultural drain outfall points schematically.
- **Drains in Upper Egypt and South Cairo**: Physico-chemical characteristics and faecal coliform counts of 43 major drains at the tail ends, before discharge into the Nile are presented in Table 9. The parameters that are non-compliant with Law 48 are shown shaded in the table. The data indicates that out of the 43 drains, only 10 are complying with the standards set by Law 48/1982 (Article 65) regulating the quality of drainage water, which can be mixed with fresh water. This is demonstrated graphically in Figures (2 and 3) for selected parameters. The remainder of the drains exceeds the consent standards in one or more of the parameters. The worst water quality is that of Khour El-Sail Aswan, Kom Ombo, Berba and Etsa drains. In terms of organic load, it was found that the highest organic load is discharged from Kom Ombo drain (218.1 ton COD/d, 59.7 ton BOD/d). This is followed by El-Berba drain (172.7 ton COD/d; 59.7 ton BOD/d), (Table 13). The shaded values highlight the drains that are the worst cases by far. It is worth mentioning that these two drains contribute 76% of the total organic load (calculated as COD) discharged into the Nile by drains from Aswan to Delta Barrage. This is followed by Etsa drain which contributes about 11% of the total COD load (56.8 ton COD/d).
- **Drains in the Delta**: Delta drains are mainly used for discharge of predominantly untreated or poorly treated wastewater (domestic and industrial), and for drainage of agricultural areas. Therefore, they contain high concentrations of various pollutants such as organic matter (BOD, COD), nutrients, faecal bacteria, heavy metals and pesticides. The drainage water is becoming more saline; on average its salinity increased from 2,400 g/m3 in 1985 to 2,750 g/m^3 in 1995. But there are local variations. For example, in the southern part of the Nile Delta drainage water has salinity between 750 and 1,000 g/m^3, whereas the salinity in the middle parts of the Delta reaches about 2,000 g/m^3 and in the northern parts between 3,500 and 6,000 g/m^3. In a recent study published by DRI (2000), it has been estimated that the Delta and Fayoum drains receive about 13.5 BCM/year. Almost 90% of which is contributed from agricultural diffuse source, 6.2% from domestic point sources, 3.5% from domestic diffuse sources and the rest (3.5%) from industrial point sources. It was also found that Bahr El-Baqar receives the greatest part of wastewater (about 3 billion cubic metres/year). This is followed by Bahr Hados, Gharbia, Edko and El-Umoum, with an average flow of 1.75 BCM/year for each. The wastewater received by the rest of the drains is less than 0.5 BCM/year for each. In terms of organic loads, as expressed by COD and BOD values, Bahr El-Baqar drain receives the highest load followed by Abu-Keer drain. Also, El- Gharbia Main receives significant amounts of organic pollutants.

WATER LOGGING/SALINITY/SODICITY

Salinity: It is estimated that in Upper Egypt, approximately 4 bcm of drainage water returns to the Nile every year. This drainage water has a much higher salinity than the originally ingested irrigation water and contributes to an increase of salinity of the River Nile along its course from the High Aswan Dam to the Delta. Fortunately, the high mixing ratio of Nile and drainage water keeps the increase of salinity within acceptable limits. Salinity increases from 160 mg per litre at the High Aswan Dam to 250 mg per litre in Cairo. In the Delta, because of the domestic and industrial pollution from Cairo and because of intensive agriculture, salinity in the drainage and irrigation systems further increase; salinity of drainage water discharged into the Mediterranean Sea or the northern Lakes averaged 2260 mg per litre. More than half of this drainage water has a salinity <2,000 mg per litre and could be potentially reused for irrigation and drinking water supply after appropriate treatment and mixing. Due to more intensive use, salinity of the discharged drainage water may increase in the next years and re-use of drainage water may become more complicated than before. With the construction of the High Aswan Dam in 1964, silt deposits on the Nile flood plains have decreased from 24 million tons per year to 2.1 million tons per year. This decrease has been responsible for a significant increase in the use of chemical fertilizers, resulting in increased values of nutrients in canals and drains.

The salt affected soils in Egypt are located in the north, east and west of Nile Delta, soils adjacent to lakes Edko, Maryut, El-Burrullus and El Manzala; and also in some areas such as Wadi El-Natrun, Oases and El-Fayoum. This is mainly due to the wide use of flood irrigation and unaccounted-for water usage, water irrigation from the Nile is exaggerated leading to soil water logging and poor drainage of excessive water that exceeds the growing plants needs. Thus, soil salinity components reach a level causing damage to plant production and deterioration to some of the chemical and biological soil elements. Some lands become so rich in soda due to the increase in sodium element causing more degradation in physical elements. During the seventies, sedimentary soil area affected by salinity and soda was estimated to be 30 to 35% of the total Nile valley and Delta area (State of Environment Report, 2005).

The salinity measurements made by (Drainage Research Institute (DRI) in the Delta show that closer to the Mediterranean Sea, salinity in the drainage water increases, to reach level close to 10,000 mg per litre close to the coast. Although part of the salinity increase may be caused by leaching of salts from the soil, it is believed that most of this increase is caused by upward seepage of brackish groundwater. This theory is supported by observations from DRI and RIGW with regard to chemical composition (major ions) of adjacent drainage and ground water.

THREATS TO THE BIODIVERSITY

Egypt's unique geographical position at the junction between two large continents (Africa and Asia), and its inclusion as part of the Mediterranean Basin, has permanently influenced both the people and the biota of the country socially, economically and biologically.

As part of the Sahara of North Africa, Egypt has the climate of the arid Mediterranean region, with notable differences between the coastal and inland areas. Under such harsh geographical and bio climatic conditions, it is to be expected that the biotic wealth of Egypt is not only poor relative to the total area of the country, but also sparse and widely scattered.

In the process of identifying the different types of fauna and flora in Egypt, certain groups (e.g. flowering plants) have been carefully surveyed and well documented, while others (e.g. mosses and liverworts) have not received adequate attention. Each of these habitats has its unique fauna and flora and numerous land and marine areas are listed as protected sites. An estimated 18,000 species of flora and fauna are in Egypt. With regard to flora, there are 44 species of viruses, 238 bacteria, 1,260 fungi, 1,148 algae, 369 non-flowering vascular plants and 2,072 flowering plants species. The fauna include 10,000 species of insects, 1,422 other vertebrates, 755 fishes, 105 reptiles and amphibians, 470 birds and 126 species of mammals. However, until to date, there are no clear statistics that quantify the rate of biodiversity loss in Egypt. (OSI Environment Synthesis Report p. 35)

Egypt's biodiversity has faced threats from various sources. These include intensive agriculture systems, which entail the widespread use of agricultural chemicals in the form of fertilizers and pesticides. Another source of threat is the effects of industrialization. Industrialization programs have accelerated enormously in the second half of the 20th century, and have contributed to the rapid deterioration of the environment. Moreover, excessive hunting of animals and destruction of plant life have endangered the existence of several species of resident and migratory birds, as well as a number of hoofed animals (e.g. gazelles and antelopes).

Accordingly, Egypt is exerting tremendous effort to combat the threats to biodiversity through the conservation of wildlife, natural resources and natural habitat. This is clearly manifested in the declaration of 21 protected areas by prime ministerial decrees in accordance with Law 102/1983, covering about 8% of the total national surface, with plans to have this extended further to 17% by 2017.

WASTEWATER TREATMENT SYSTEMS

The treatment systems in Egypt can be divided into two basic types: aerobic and anaerobic treatment. The four most common aerobic treatment technologies are activated sludge, aerated lagoons, oxidation ponds, trickling filters and rotating biological contactors (RBC). Activated sludge and oxidation dishes represent 58% of the technologies and 72% of the total wastewater treatment capacity (El-Gohary, 2002). In Greater Cairo, the capacity of the El Gabal El Asfar secondary treatment plant (WWTP) was 3 Mm^3 per day and services 12 million people. A secondary WWTP with 0.33 Mcubic meter/day treatment capacity exists at El-Zenein and 0.4Mm^3 per day treatment plants exist at Berka (0.6 Mm^3 per day to primary standard) and Shoubra El-Kheima (about 0.6 Mm^3 per day).

5. Review of existing and planned water resource management and development projects

5.1 Introduction

In this chapter the different water use sectors are reviewed with the aim of establishing an understanding of current and future levels of development and demand.

5.2 Hydropower sector

5.2.1 Introduction

The aim of this section is to have a clear picture of the current and future demand for electricity within the Eastern Nile countries and how that demand is/going to be met. The focus has been on hydropower and the interconnection projects that are particularly related to hydropower

5.2.2 Regional Context

Demand at both the regional level is growing rapidly as summarised in Table 5-1. As far as the current situation is concerned, only in Egypt is the installed generating capacity greater than the peak demand, and here only by a small margin.

Regional demand can only be met by increasing capacity and by the sharing of capacity via an expanded interconnection. Both of these areas are reviewed and discussed in this report.

Table 5-1: Current and forecasted generation and peak demand requirements in all four countries

	Generation (GWh)					Peak demand (MW)					Annual growth (%)			
	Egypt	Ethiopia	Sudan	South Sudan	TOTAL	Egypt	Ethiopia	Sudan	South Sudan	TOTAL	Egypt	Ethiopia	Sudan	South Sudan
2012	164,628	7,869	12,737		185,234	25,000	1,398	1,853	33	28,284				
2015	196,334	14,688	14,662	474	226,158	31,880	2,956	2,947	80	37,863	5.5	4	19	53
2020	260,589	35,062	24,496	1,868	322,015	41,874	7,474	5,087	300	54,735	6.2	30	14.5	55
2025	342,626	53,209	33,448	3,173	432,456	54,402	12,636	6,613	500	74,151	6	13.8	6	13.3
2030	446,301	73,944	40,990	4,274	565,509	69,909	17,868	7,979	712	96,468	5.7	8.2	4	8.5
2035	575,478	89,047	47,381	5,479	717,385	88,947	23,556	9,476	1,033	123,012	5.4	6.3	4.8	10
2039	666,846	120,740	53,878	6,348	847,812	109,230	25,761	11,000	1,200	147,191	5.7	6	4	5

Details of regional interconnection projects are presented towards the end of this chapter.

5.2.3 Generation and Supply of Electricity in Ethiopia

5.2.3.1 Overview

Ethiopia is well endowed with huge hydropower resources as well as a significant geothermal potential for the generation of electricity. The economically exploitable potential is estimated at 45,000 MW. At the same time, per capita energy consumption is one of the lowest in the world. 17% of population have access to electricity and the existing capacity for electricity production is about 2000 MW.

The current high level of economic growth is expected to continue, resulting an in ever-increasing demand for electricity in the country. Three hydropower projects are currently under construction the Grand Ethiopian Renaissance Dam (GERD) 6000 MW, Gigle Gibe III 1870 MW and Genale Dawa 254 MW.

The Electricity sector was restructured in 2012, the former Ethiopian Electricity Power Corporation (EEPCO) split to two Power entities: the Ethiopian Electric Power (EEP) and the Ethiopian Electric Utility (EEU). EEP is in charge of Power planning, construction, operation and maintenance of the system and EEU is in charge of the distribution network construction and dealing with consumers.

5.2.3.2 Policy, regulatory, strategic and institutional frameworks

Details are provided in Annex 6.

5.2.3.3 Current and projected demand

The current (2012) was energy requirement was around 8,000 GWh and anticipated to triple by 2017 even under the low case scenario. The requirement could be close to 100,000 GWh by 2025 (high case scenario). The forecasts for generated energy and peak demand are summarised in Table 5-2.

Table 5-2: Forecast for Generated Energy and Peak Demand

Year	Total Energy Requirement (GWh)			Total Peak Demand (MW)		
	Base Case Scenario	High Case Scenario	Low Case Scenario	Base Case Scenario	High Case Scenario	Low Case Scenario
2012	7,869	8,294	7,573	1,326	1,413	1,281
2013	9,680	10,763	9,034	1,681	1,884	1,575
2014	12,371	14,171	11,272	2,157	2,483	1,975
2015	17,447	21,490	14,393	2,956	3,560	2,499
2020	45,960	56,932	34,760	7,474	9,080	5,798
2025	77,343	97,294	48,848	12,636	15,671	8,504
2030	105,827	141,098	66,263	17,868	23,331	11,817
2035	135,386	196,419	79,296	23,556	32,972	14,809

5.2.3.4 Generation Capacity

CURRENT SITUATION

The current interconnected system has a total installed capacity of 2,083 MW (end of 2012) including 87 MW of diesel plants at Dire Dawa, Awash, and Kaliti, and a Wind Power plant at Adama (51MW). The remainder is hydropower. Significantly, peak demand will surpass the current installed capacity by 2015, even under the low case scenario.

There is a total generation capacity of 8,154 MW currently under construction which will bring the total to 10,237 MW of which hydropower will represent 98%. Details of the existing and under construction plants are provided in later in this chapter.

PLANNED PROJECTS

The new Expansion Plan anticipated to add (by 2023)a further 12,414.9 MW to the already existing and under construction total of 10,237 MW, which will bring the total to 22,651.9 MW, necessary to face the rapidly increasing demand, Hydropower will represent 98% of the total installed capacity.

5.2.4 Generation and Supply of Electricity in South Sudan

5.2.4.1 Overview

Current electricity capacity available to South Sudan is about 30MW. Only 1% of the population has access to electricity. Only three states of the 10 States have electricity.

South Sudan has large Hydropower potential located on Bahr El Jabal River (shared with Uganda) in the NEL basin. There is also potential for small hydropower development all over the country. At this stage the country lacks the infrastructure and electrification is limited to major cities provided by diesel generating units using expensive fuel..

5.2.4.2 Policy, regulatory, strategic and institutional frameworks

Details are provided in Annex 6.

5.2.4.3 Current and projected demand

The available projections of demand was provided earlier.

5.2.4.4 Generation Capacity

CURRENT SITUATION

Generation capacity, all provided by diesel units, is limited to 21MW.

PLANNED PROJECTS

According to the Infrastructure Plan for South Sudan, a sum of 336 MW diesel power (sets of up to 5 MW) and 40 MW hydropower is to be in-stalled 2015-2020, and an additional 115 MW diesel power and 300 MW hydropower is to be established 2021-2025.

Feasibility Studies were completed for huge hydropower sites to be constructed during the Long Term Plan beyond (more than 2025). These include the Grand Foula project with a capacity of around 800MW, Shakuli (250MW), Lakki (250MW) and Bedden (500MW) all in the NEL basin. Between them they should generate nearly 10,000 GWh. There are no projects planned in the Eastern Nile part of the country. These are shown in Figure 5-6: Existing and planned hydropower schemes in the Eastern Nile

A project for 40 MW at Foula is under discussion to supply power to South Sudan through TL of voltage 132 KV.

Although these hydropower sites are not within EN Basin it is foreseen that they will affect the EN region if implemented (according to EAPP master plan and figure 5.1).

Figure 5.1: Forecasted Exchange of power with South Sudan

5.2.4.5 *Interconnection and Transmission Systems*

CURRENT SITUATION

South Sudan imports about 12 MW from Sudan through 33 kV Transmission system connecting Rossieres Hydropower Plant to Renk City in Upper Nile State in South Sudan;

At present there is no national electricity transmission grid providing interconnection within the South Sudan States. There are city distribution networks for Juba, Wau and others.

PLANNED PROJECTS

Regional Interconnection projects include:

- A study is underway to import electricity from Ethiopia through 220 kV TL Gambella/Malakal/Juba.
- A study under NELSAP is underway to connect South Sudan to Uganda through 400 kV TL.

5.2.5 Generation and Supply of Electricity in Sudan

5.2.5.1 Overview

Sudan has a mix of energy generation types including hydropower and thermal power plants running either steam or gas turbine units. Wind technology electricity generation has been recently implemented in the country. Sudan envisions a significant expansion of coal-fired power plants at the Red Sea.

The electricity system within Sudan consists of the main National Grid, a number of isolated off-grid systems and some existing private generation companies.

The Sudanese Electricity Transmission Company Ltd. (SETCO) is responsible for transmission system, the Sudanese Hydropower Generation Company Ltd. (SHGC) is responsible for hydropower Generation while Sudanese Electricity Transmission Company Ltd. (SEDCO) is responsible for the distribution system all under the Ministry of Water Resources and Electricity..

The Ministry of Water Resources and Electricity updated the Expansion and Investment Planning for the Electricity system until year 2031, issued in December 2013.

5.2.5.2 Policy, regulatory, strategic and institutional frameworks

The key elements of policy, regulatory, strategic and institutional frameworks can be summarised as follows:

Details are provided in Annex 6.

5.2.5.3 Current and projected demand

The current (2012) was energy requirement was just under 10,000 GWh and anticipated to more than double by 2020 even under the low case scenario. The requirement could be close to 50,000 GWh by 2031 (high case scenario). The forecasts for generated energy and peak demand are summarised in Table 5-3.

Table 5-3: Forecast for Generated Energy and Peak Demand

Year	Total Energy Requirement (GWh)				Total Peak Demand (MW)		
	Base Case Scenario	High Case Scenario	Low Case Scenario		Base Case Scenario	High Case Scenario	Low Case Scenario
2012	9,742	10,130	9,369		2,013	2,083	1,945
2013	11,241	11,995	10,509		2,295	2,433	2,162
2014	12,819	13,812	11,716		2,595	2,777	2,393
2015	14,662	16,043	13,023		2,947	3,201	2,645
2020	24,496	28,036	21,416		5,087	5,742	4,516
2021	26,066	29,719	22,662		5,351	6,024	4,724
2026	33,448	37,571	29,121		6,613	7,360	5,829
2031	40,990	46,141	35,928		7,979	8,913	7,062

5.2.5.4 Generation Capacity

CURRENT CAPACITY

Total existing generation capacity amounts to 2,898MW and includes 1617MW of hydropower generation capacity dominated by hydropower scheme at Merowe (1250MW). All hydropower is situated in the Eastern Nile Basin and details are provided later in this chapter. There is currently 850MW of thermal power with the remainder made up from wind and solar power generation.

PLANNED PROJECTS

Information of planned projects comes from the updated the Expansion and Investment Planning for the Electricity system until year 2031, issued in December 2013 by the Ministry of Water Resources and Electricity .

More than 5,200MW are planned through thermal power plants and more than 350MW from wind and solar power. Major expansion of hydropower is also planned, around 2,300MW, a large proportion of which lies in the Eastern Nile basin. Details are provided later in this chapter. The planned cumulative generating capacity for Sudan through to 2031 is shown in Figure 5.2. Given that peak demand will require a capacity of between 7,062 and 8,913MW, it is clear that it will be necessary to import power through the regional interconnection system.

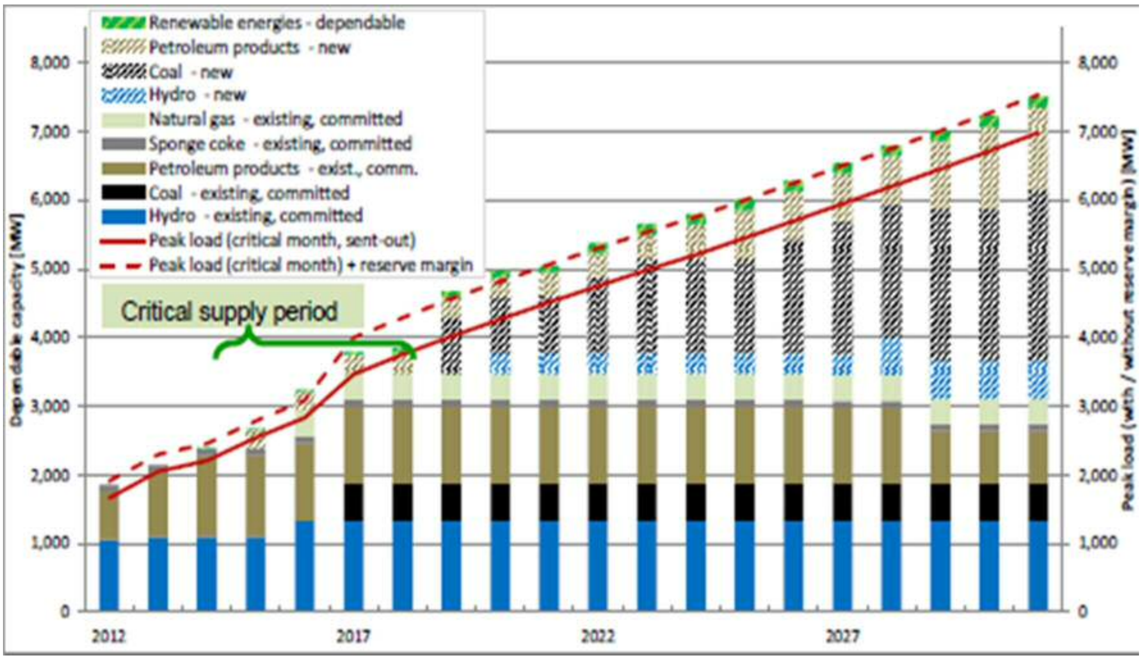


Figure 5-1: Planned Cumulative Annual Generated Energy for Sudan 2014-2031

5.2.5.5 Interconnection and Transmission Systems

CURRENT SITUATION

The electricity system within Sudan consists of the main National Grid, a number of isolated off-grid systems and some existing private generation companies. The main grid system is divided into the Khartoum, Central, Eastern and Northern areas. The towns of Atbara and Shendi in River Nile state, which were previously supplied by local off-grid generation, were connected to the National Grid as part of the Merowe transmission reinforcement scheme.

The existing transmission network is shown in Figure 5-2.

PLANNED PROJECTS

The Transmission system expansion till year 2031 has also been studied and approved by SETCO. Figures 9 is schematic for the 500 kV network structure and Figure 10 is the geographic Map for the existing and planned Transmission network up to 2031.

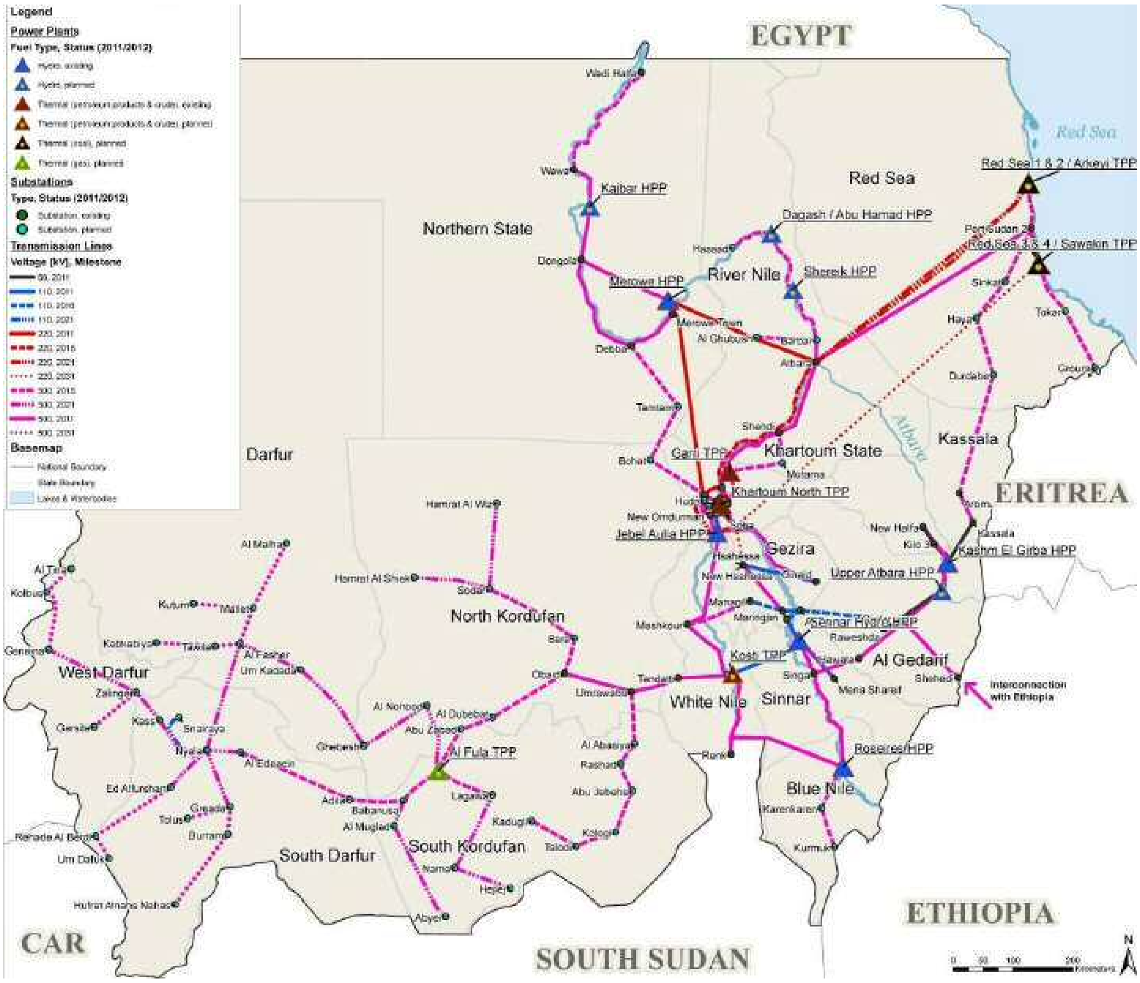


Figure 5-2 : Sudan existing and planned Transmission network till 2031

Studies for the interconnection with neighbouring countries were prepared including:

- The interconnection between Ethiopia / Sudan / Egypt to transfer a sum of 3,200 MW from Ethiopia to Sudan through a AC 500 kV OHTL and then out of the transferred energy a sum of 2000 MW be transferred to from Sudan to Egypt through DC 600 kV OHTL. Details about this project are given in the next Task 3.
- FS for the interconnection between Sudan and Egypt on:
  - Option I: 220 kV OHTL connecting Toshka substation in Egypt to Old Halfa substation in Sudan of approximately 162 Km length.
  - Option II: 500 kV OHTH connecting Nag Hammadi substation in Egypt to Algoreair substation in Sudan of approximate length 767 Km.

5.2.6 Generation and Supply of Electricity in Egypt

5.2.6.1 Overview

More than 30,000MW is currently generated in Egypt, with hydropower having a share of 9.5%.

The electricity sector in Egypt is led by the Ministry of Electricity and Renewable Energy, Under it the Egyptian Electricity Holding Company which includes 6 electricity production companies, one transmission company and 9 distribution companies, and six Authorities: Renewable Energy Authority, Hydro Power Projects Execution Authority, Nuclear Power Plant Authority, Nuclear Material Authority, and Atomic Energy Authority.

The Egyptian Electricity Utility and Consumer Protection Regulatory Agency established in 2000 to regulate and supervise the electric power activities and issue required licenses.

The Supreme Energy Council (the highest policymaking authority) oversees and guides the Egyptian energy sector and approves and monitors its implementation plans.

Some key facts are as follows:

- Situation in Year 2013
  - Installed Capacity: 30,800 MW
  - Max Load: 27,000 MW
  - No. of Consumers: 30 Million
  - Electricity Share per Capita: 1,950 Kwh
- Diversifying Energy Resources in Generation
  - Steam: 47.5%
  - Combined Cycle:39.7%
  - Hydropower:9%
  - Gas Turbine:6.6%
  - Wind and Solar:1.2%
- Renewable Energy:

On February 2008, the Supreme Energy Council approved the Egyptian Renewable Energy National Strategy to Satisfy 20% of the generated electricity by 2020 using renewable energies. This strategy includes providing 12% of the generated electricity (7200 MW) from wind energy by 2020.

On July 2012 the Cabinet approved the Egyptian Solar Plan which includes adding 3500 MW (2800 MW CSP, 700 MW PV) of Solar Energy by 2027.

- Large Wind
  - Installed capacity: 550 MW
  - Under implementation:540 MW
  - In Pipeline: 880 MW
  -
- Solar Thermal
  - In Operation: Kuraimat 140 MW Solar thermal power plant including solar field of 20 MW
- Solar Photovoltaic system:
  - Two remote settlements (100 houses + some facilities) in Matrouh Governorate were electrified by PV systems since 2010.

The Total Installed Capacity of PV Systems in Egypt is more than 10 MW for lightening, Water Pumping, Wireless Communications, Cooling and Commercial Advertisements on highways.

- Hydropower:
  - Installed capacity from hydro is 2843 MW
  - Hydro power represents 9% from the generated electrical energy

- Assuit Hydro Power Project (32 MW) is under implementation planned to be operated by 2017

- Electricity Sector Expansion and Investment Plan Up to year 2020: Three scenarios for electricity demand forecasts (medium, High and low), the medium demand scenario indicates an expected growth rate in demand of about 6.25%.

5.2.6.2 Policy, regulatory, strategic and institutional frameworks

Details are provided in Annex 6.

5.2.6.3 Current and projected demand

The EEHC's forecast of power demand under; low, medium and high growth scenarios is summarised in

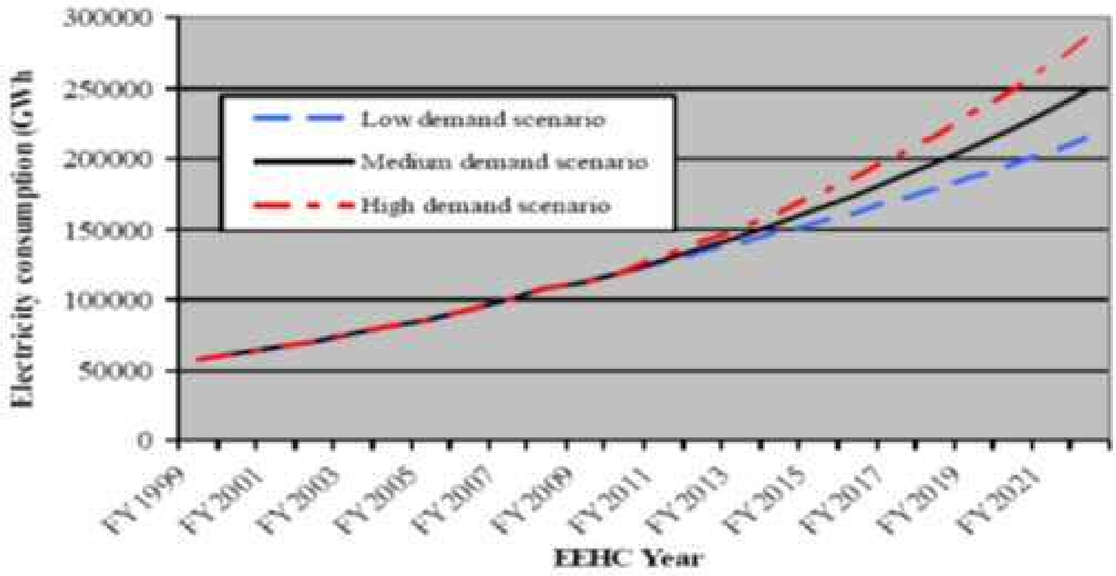


Figure 5-3: EEHC's forecasted power demand scenarios

Based on the medium scenario, EEHC needs to add about 3,000MW of electricity generation capacity annually between fiscal years (FY) 2012 and 2020 to meet its forecast of power demand, to be implemented with the participation of the private sector.

See also details in regional overview presented earlier.

5.2.6.4 Generation Capacity

CURRENT CAPACITY

The current generation capacity is 32,379MW. 2,862MW is generated by hydropower, all situated on the Main Nile. Detail are presented later in this chapter. The remainder is produced by a combination of steam turbine, gas turbine, combined cycle, photo voltaic, concentrated polar system.

PLANNED PROJECTS

Egypt has plans for the implementation of an additional 109,230 MW by 2039. This includes thermal steam power plants (54,400MW), thermal combined cycle gas turbine power plants (37,200MW), Nuclear Powe Plants (1,000MW) and wind and solar power plants (7,630MW).

No new hydropower plants are planned.

5.2.6.5 Transmission and interconnection

CURRENT SITUATION

The Egyptian electricity transmission grid is shown in Figure 5-4.

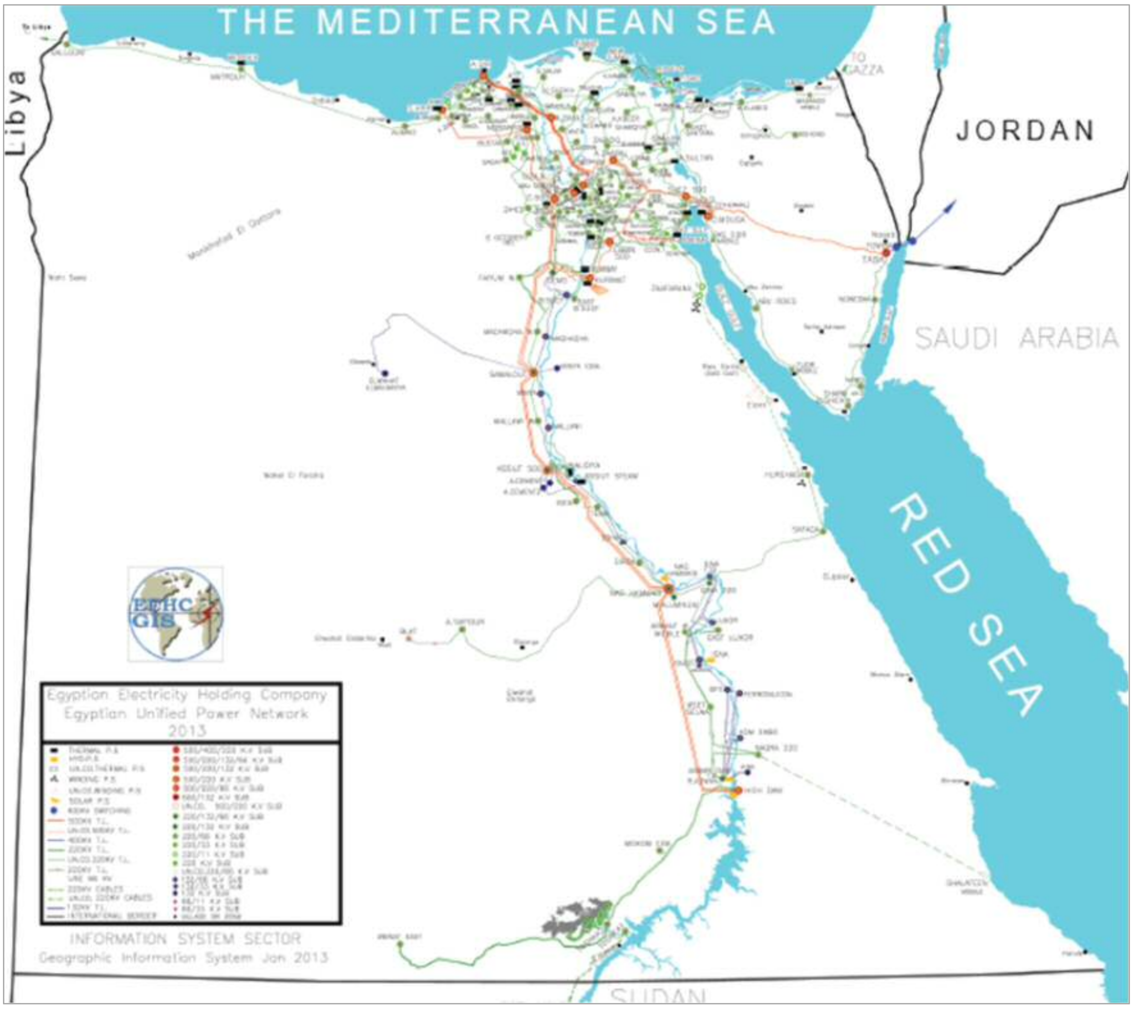


Figure 5-4: Egyptian Electricity Transmission Grid

Regional interconnection is as follows:

- **Arab Maghreb Interconnection**: Egypt-Libya since 1998. Arrangements are under preparation for Libya -Tunisia interconnection in order to achieve the interconnection between Arab Mashreq (Egypt/Libya/Tunisia/Algeria/Moroco).
- **Arab Mashreq Interconnection**: Egypt-Jordan in operation since 1998, Jordan- Syria since 2000 and Syria-Lebanon since 2009.

This has led to the interconnection between the transmission systems of Lebanon, Syria, Jordan, Egypt and Libya.

PLANNED PROJECTS

The following projects are under consideration (see also Figure 5-5)

- Feasibility Study completed of exchange of power up to 3000 MW between the two countries. Steps for implementation to be completed by 2015.
- The Axis of African Electrical Interconnection: Techno-economic feasibility study for the interconnection between Egypt and Inga Dam in Democratic Republic of Congo (DRC) passing through Central Africa and Sudan to transmit 40 GW of hydro power generated from Inga to North Africa and Europe was conducted.
- Techno-economic feasibility study for electrical energy trade between the Eastern Nile Basin Initiative (Egypt, Ethiopia, and Sudan) was completed in December 2008. The study concluded the feasibility of exporting 3200 MW from Ethiopia to Sudan (1200MW) and to Egypt (2000MW).
- Feasibility study for the interconnection between Egypt and Sudan by constructing 180KM, 220 KV overhead transmission line between the two countries is under preparation.
- The Axis of Electrical Interconnection with Europe: Discussions are under way between Egypt and Greece for the interconnection between the transmission networks of the two countries. The interconnection with Greece will be established by constructing 2000 KM, + 500 KV DC link including a submarine cable.
- Future Vision for Regional Electrical Interconnection: The study for upgrading the interconnection with Arab Maghreb Countries through Libya to 400/500 kV has been finalized in April, 2004. The study final report was presented to the concerned countries (ELTAM) , and it was agreed to implement the recommended projects for starting the National Networks (500/400KV) of Egypt and Arab Maghreb Countries. It is expected that Egypt will finalize the construction of the 500 KV Sidi Krir / El Saloom line and El Saloom 500 KV substation by year 2015.

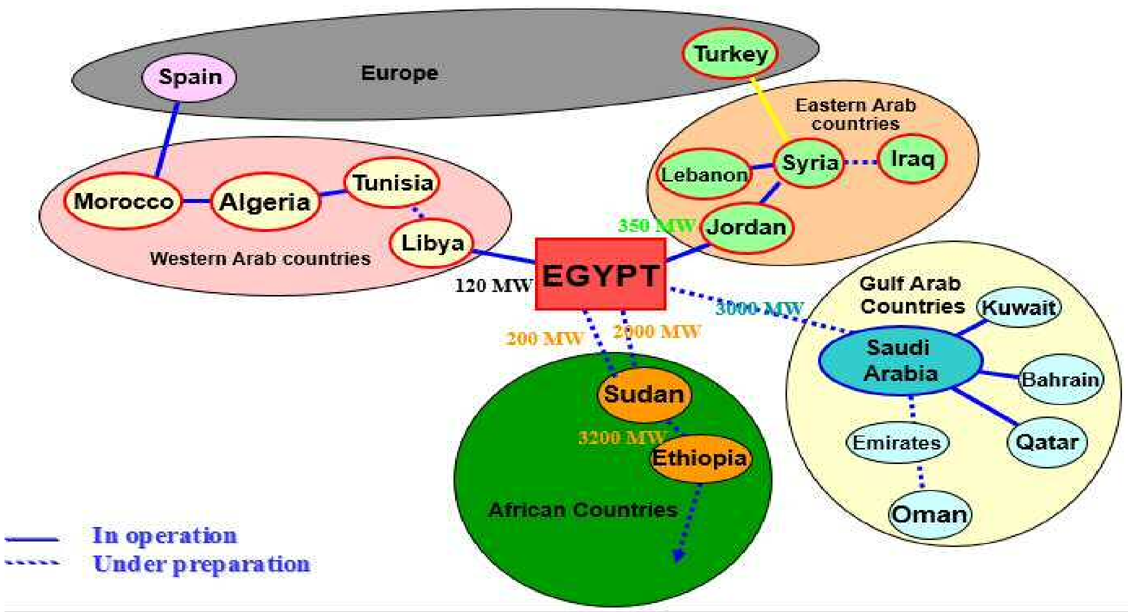


Figure 5-5:Future vison for Egyptian interconnection

5.2.7 Current and planned projects: status of development and management

5.2.7.1 Introduction

In this sub-section all of the larger (regionally significant) existing and planned hydropower schemes are detailed.

Figure 5-6 maps out both the existing and planned hydropower schemes in the basin. It should be noted that schemes already under construction are indicated as "existing" on the map.

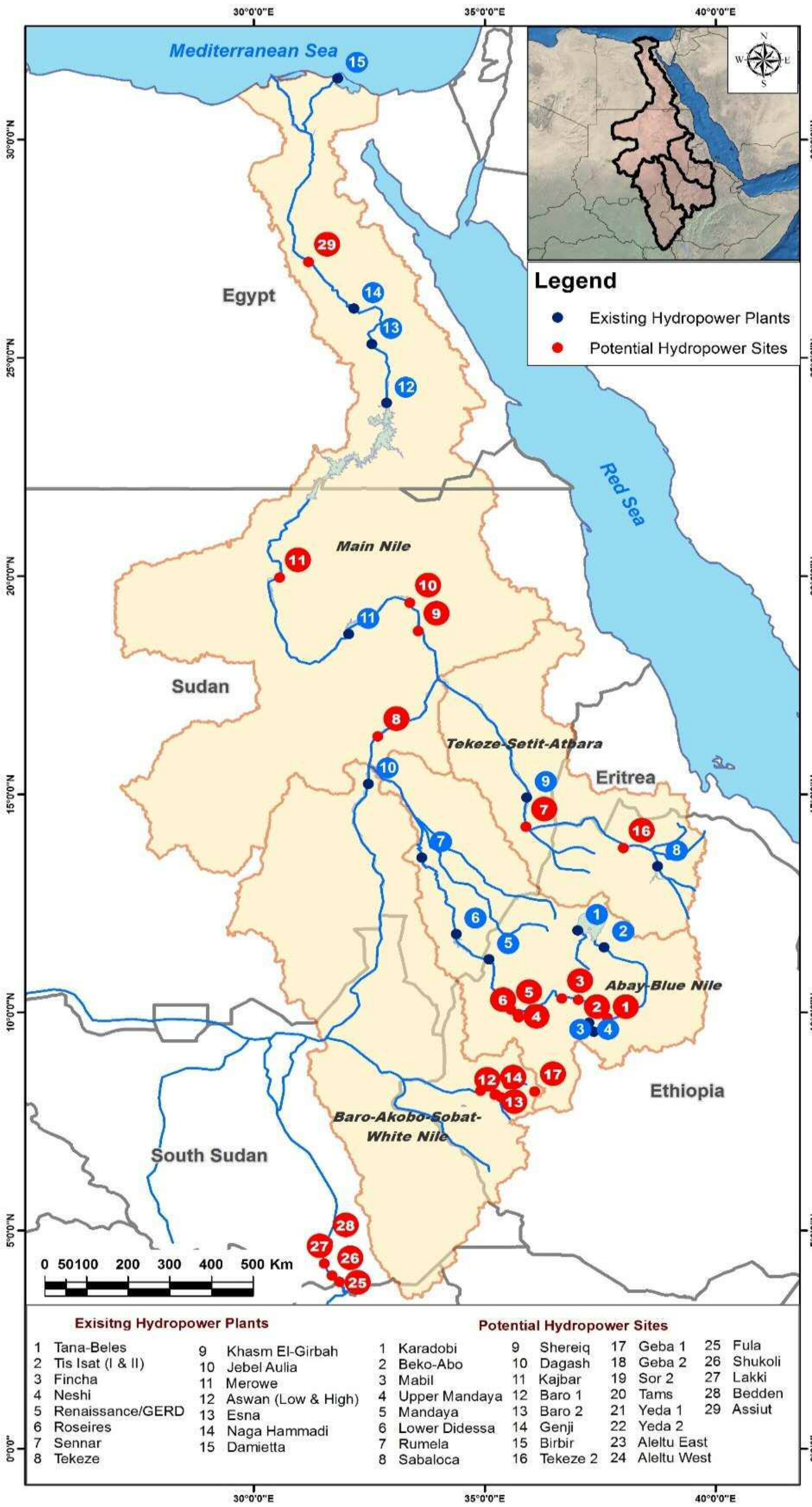


Figure 5-6: Existing and planned hydropower schemes in the Eastern Nile

5.2.7.2 Baro-Akobo-Sobat and White Nile

HYDROPOWER POTENTIAL/OVERVIEW

Existing and planned hydropower projects in the sub-basin are indicated in Figure 5-7.

CURRENT PROJECTS

Table 5-4: Existing (and under construction) Hydropower Plants in the Baro-Akobo-Sobat and White Nile

Scheme name	River	Country	Capacity (MW)	Storage*
Jebel_Aulia	White Nile	Sudan	30	-

*'-' indicates run of river

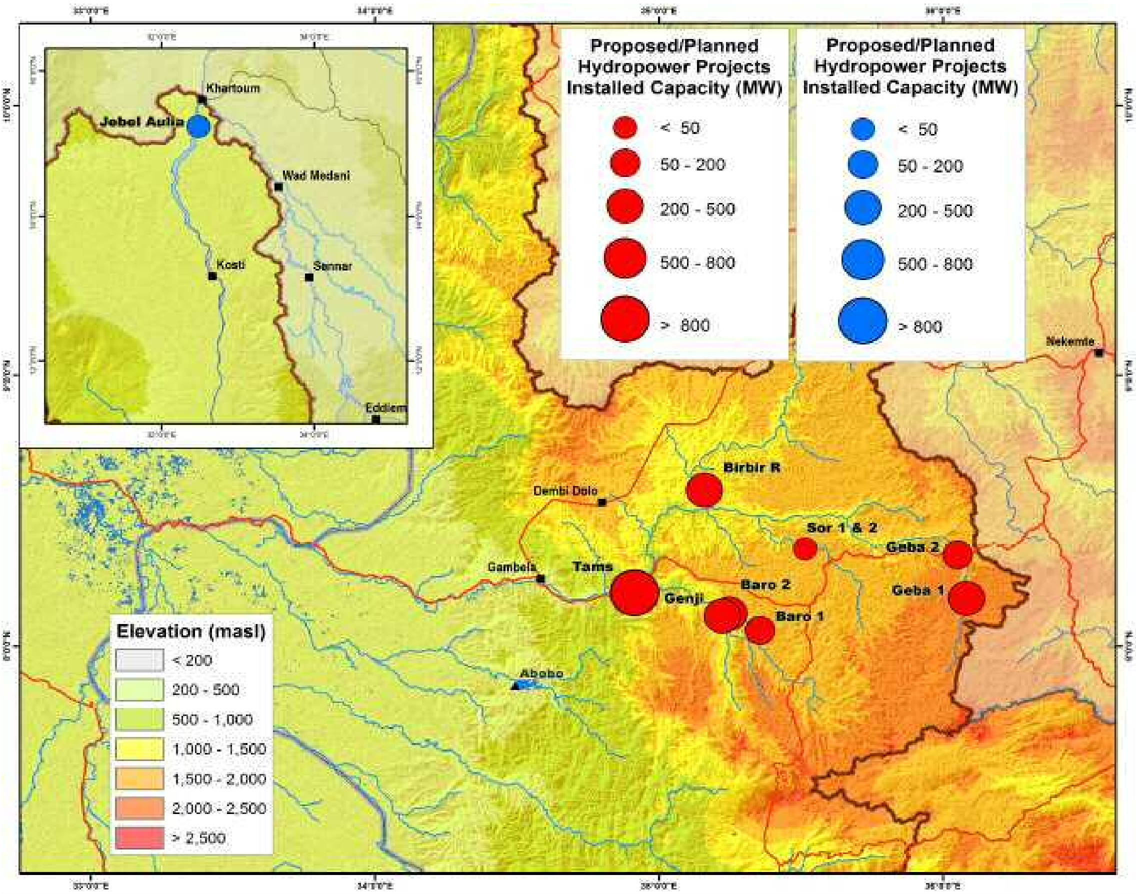


Figure 5-7: Existing and Planned Hydropower Sites in the Baro-Akobo-Sobat - White Nile Sub-basin

PLANNED PROJECTS

Table 5-5: Planned Hydropower Plants in the Baro-Akobo-Sobat and White Nile

Scheme name	River	Country	Capacity (MW)	Storage (Mm^3)	Status
Tams	Baro-Akobo	Ethiopia	1000		
Sor 2		Ethiopia	5		
Baro I		Ethiopia	166	993	
Baro II		Ethiopia	479	0	
Geba1+ 2		Ethiopia	371.5	1392	
Birbir		Ethiopia	497		

5.2.8 Abbay-Blue Nile,

Hydropower Potential/Overview

The existing and planned hydropower projects in the sub-basin are indicated in Figure 5-8.

Current projects

Table 5-6: Existing (and under construction) Hydropower Plants in the Abbay-Blue Nile

Scheme name	River	Country	Capacity (MW)	Storage (Mm^3)
Tis Abbay I	Abbay	Ethiopia	11	0
Tis Abbay II		Ethiopia	73	0
Finchaa		Ethiopia	134	790
Beles		Ethiopia	460	0
Neshe		Ethiopia	98	
Renaissance (GERD)		Ethiopia	6,000	73,000
Roseires	Blue Nile	Sudan	280	
Sennar		Sudan	26	

*'-' indicates run of river

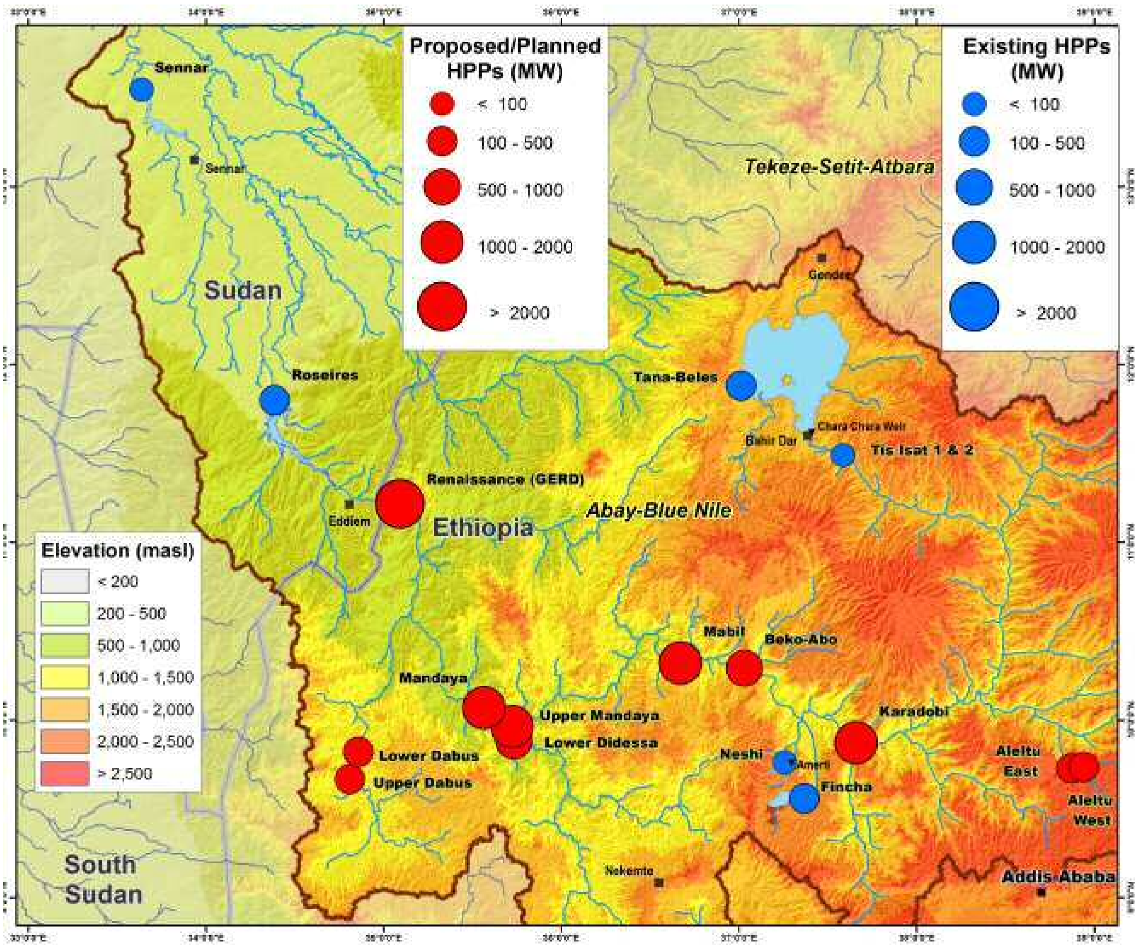


Figure 5-8: Existing and Planned Hydropower Sites in the Abbay-Blue Nile Sub-basin

Planned projects

Table 5-7: Planned Hydropower Plants in the Abbay-Blue Nile

Scheme name	River	Country	Capacity (MW)	Storage(Mm^3)	Status
Aleltu East	Abay	Ethiopia	189	520	
Aleltu West	Abay	Ethiopia	264.6	616	
Yeda1	Abay	Ethiopia	118		
Yeda 2	Abay	Ethiopia	162		
Karadobi	Abay	Ethiopia	1600	40,200	
Beko Abo	Abay	Ethiopia	935	37,500	
Lower Didessa	Didessa	Ethiopia	550		
Upper Mandaya	Abay	Ethiopia	1700	49,200	
Lower Dabus	Dabus	Ethiopia	326		
Upper Dabus	Abay	Ethiopia	189	520	

5.2.9 Tekeze-Setit-Atbara,

Hydropower Potential/Overview

The existing and planned hydropower projects in the sub-basin are indicated in Figure 5-9

Current Projects

Table 5-8: Existing (and under construction) Hydropower Plants in the Baro-Akobo-Sobat and White Nile

Scheme name	River	Country	Capacity (MW)	Storage ((Mm^3)*
Tekeze I	Tekeze	Ethiopia	300	5,350
Kashm El Girba	??	Sudan	18	

*'-' indicates run of river

Planned Projects

Table 5-9: Planned Hydropower Plants in the Baro-Akobo-Sobat and White Nile

Scheme name	River	Country	Capacity (MW)	Storage(Mm^3)	Status
Tekeze 2	??	Ethiopia	450	0	

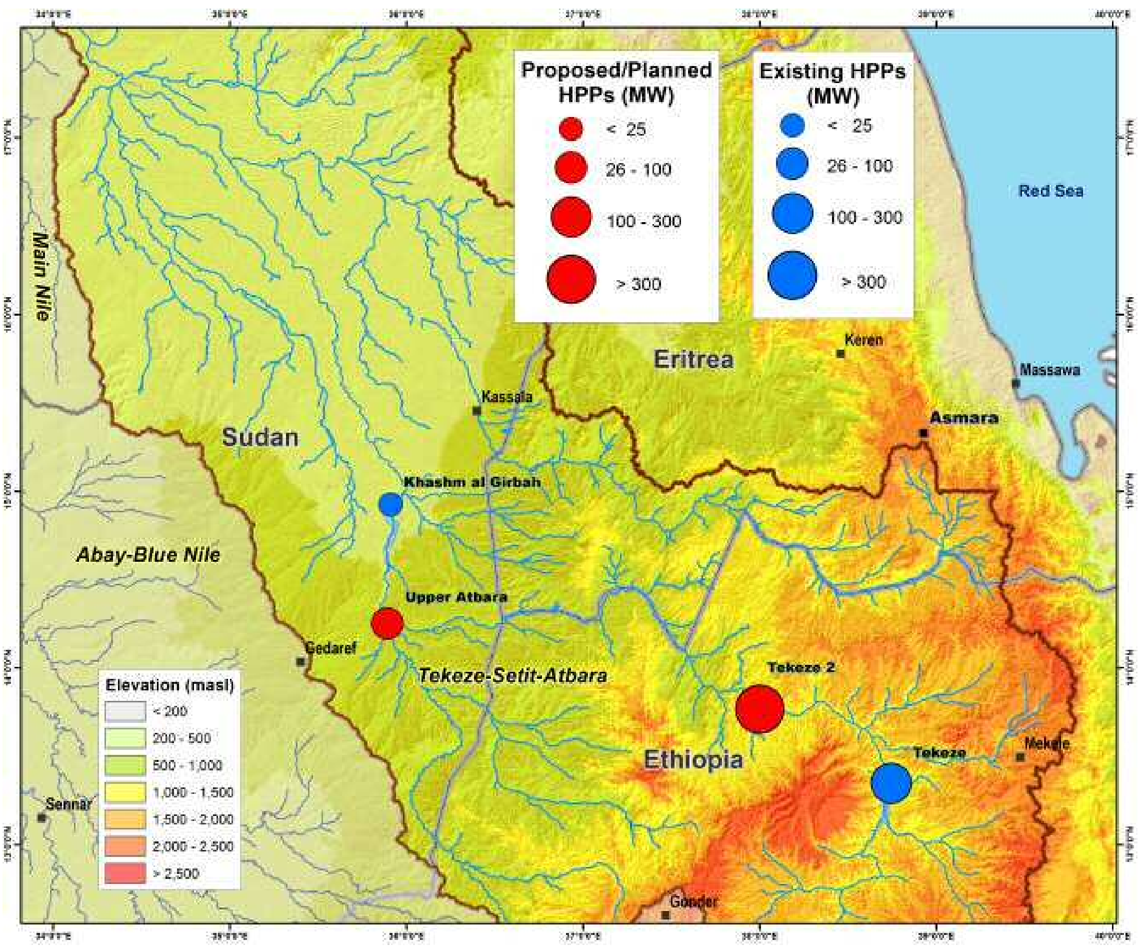


Figure 5-9: Existing and Planned Hydropower Sites in the Tekeze – Setit- Atbara Sub-basin

5.2.10 Main Nile

HYDROPOWER POTENTIAL/OVERVIEW

The existing and planned hydropower projects in the sub-basin are indicated in the map provided earlier in the chapter.

CURRENT PROJECTS

Table 5-10: Existing (and under construction) Hydropower Plants in the Baro-Akobo-Sobat and White Nile

Scheme name	River	Country	Capacity (MW)	Storage(Mm^3) *
Merowe a	Main Nile	Sudan	1,250	-
High Dam	Main Nile	Egypt	2,100	159,700
Aswan 1	Main Nile	Egypt	322	0
Aswan II	Main Nile	Egypt	270	0
Esna	Main Nile	Egypt	86	0
Naga Hamadi	Main Nile	Egypt	64	0
Diamata	Main Nile	Egypt	20	0

*'-' indicates run of river

PLANNED PROJECTS

Table 5-11: Planned Hydropower Plants in the Baro-Akobo-Sobat and White Nile

Scheme name	River	Country	Capacity (MW)	Storage(Mm^3)	Status
Shereik (Main Nile)	??	Ethiopia	420		
Kajbar	??	Ethiopia	360		
Dagash	??	Ethiopia	312		
Dal	Main Nile	Sudan	400		
Assiut	??	Ethiopia	40	0	

5.2.11 Regional Interconnection

Recently concern has been given to the interconnection and Power Trade between EN countries through NBI and EAPP through many studies. These include:

- NBI-Opportunities for Power Trade in the Nile Basin; A scoping Study- by Norconsult and Statnett financed by World Bank- January 2004
- Regional Power System Master Plan and Grid Code Study By SNC Lavalin and PB- Nov. 2011
- EAPP- Update Regional Master Plan- Under preparation by Energynet.dk and EA Energy Analysis - Draft Final report: August 2014
- ENTRO- EN Power Trade Study- Phase II- EDF-December 2008. An export from Ethiopia capacity of 1200 MW to Sudan, and 2000 MW to Egypt, is profitable for the region. See

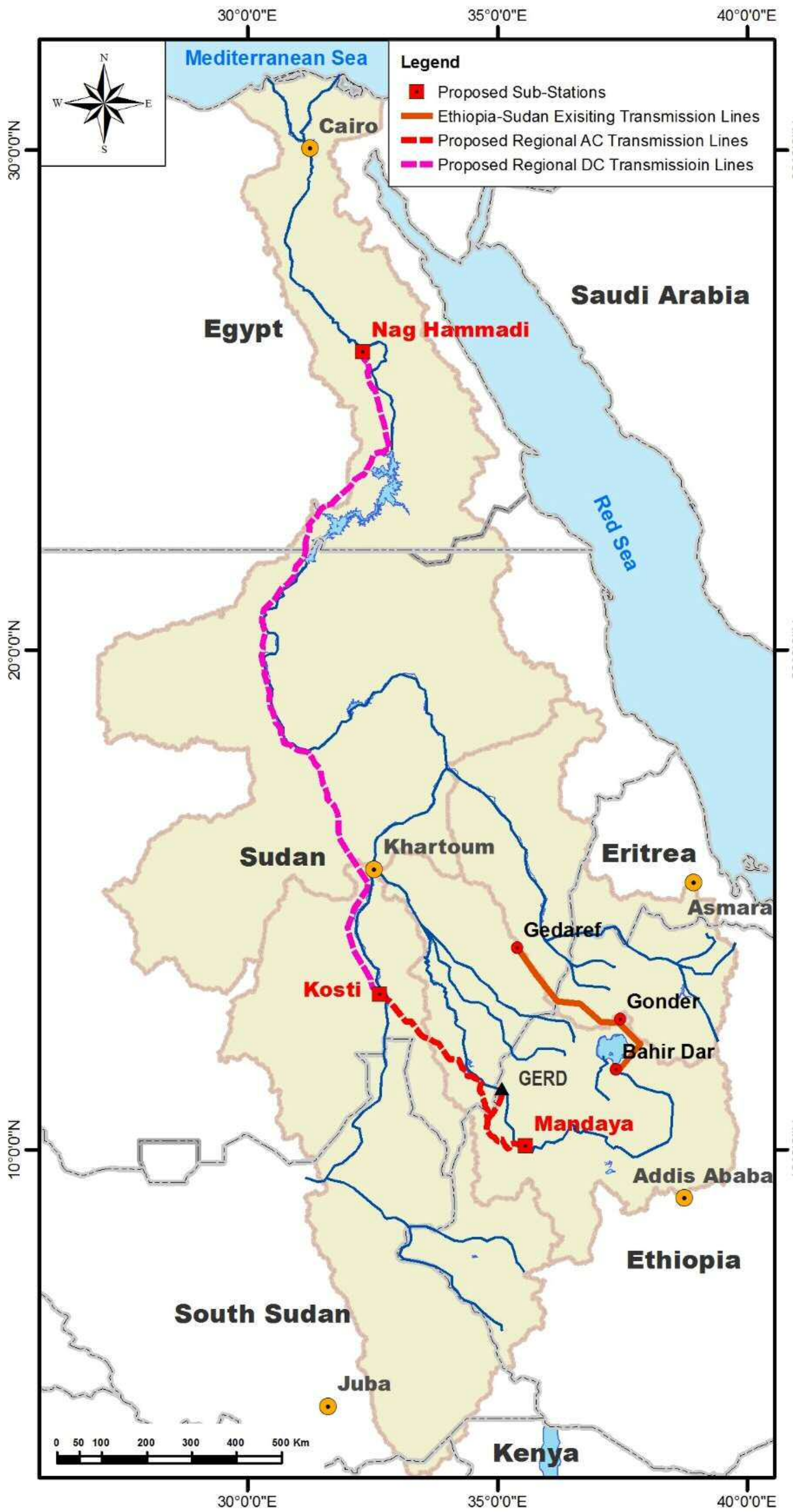


Figure 5-10: Eastern Nile Interconnection

- Transmission Interconnection (AC/DC Mix with tapping station in Sudan)
  - Ethiopia exports 3200 MW to Sudan, including 2000 MW for Egypt.
  - 500/400 kV substation located at Mandaya HHP equipped with four 500/400 kV transformers 510 MVAr each.
  - Four 500 kV AC circuits between Mandaya HPP and Kosti 500 kV substations (570 km)

  - AC/DC 2 x 1075 MW converter station located at Kosti substation in Sudan, and a SVC.
  - 600 kV DC bipolar line between Rabak and Nag Hammadi. (1650 Km)
  - A third circuit between Nag Hammadi and Asuit (Egypt reinforcement).
- Economic results
  - Investment costs are estimated about 1 860 MSD_{2006} , O&M costs are about 18 MSD_{2006} per year and revamping costs about 230 MSD_{2006} Social mitigation costs are about 16 MSD_{2006} .
  - Net present value (NPV) of the project is positive for both demand scenarios: 1 810 MSD_{2006} for medium Ethiopian demand and 2 210 MSD_{2006} for low Ethiopian demand, 10% discount rate, medium fuel price projection. About 160 MUD to 320 MUSD must be added to NPVs from CO_2 savings, if this project is eligible to Clean Development Mechanism.
  - The payback period is reached after 8 full years of operation for low Ethiopian demand and 7 full years for medium Ethiopian demand.
  - The Benefit to Cost Ratio (BCR) of the both scenarios are above 3 for a 10% discount rate, and remains superior to 2 for 8% and 12% discount rates.
  - Both scenarios have high Economic Internal Rate of Return (EIRR), respectively 18% and 17%.
  - The sensitivity analysis executed for a low Ethiopian demand including updated fuel prices projection, shows that the variant with anticipation is even more profitable, with a BCR of 4.9. High fuel prices assumption enhances the interest of the Eastern Nile Regional Power Interconnection project, with a BCR as high as 8.1.
- Construction Period is 8 years

5.2.12 Conclusions

5.2.12.1 Projects of regional significance

Based on the following preliminary screening criteria

- Hydropower project
- Within EN Sub Basin
- Have regionally significant effect (capacity above 350 MW for the generation projects and include more than one EN country for the interconnection projects).
- Recommended by the Ethiopian Power system expansion Plan and Sudan Expansion Plan and NCORE report for Knowledge-Base Development.

the projects listed below for the hydropower generation and the regional interconnection project can be considered.

Table 5-12: Future generation Projects in EN Region

Hydropower Project Name	Country	Sub Basin	Status (Ex, Uc, FS, PFS,	Planning Horizon (0-15, 15-25, 25-40)	Dev. level	Capacity (MW)
Beles	Ethiopia	Abay/Blue Nile	Ex		√	460
Tis Abay I & II			Ex		√	84
Finchaa			Ex		√	134
Amarti Neshe			Ex		√	98
Grand Renaissance			UC	15-25		6000
Tekeze I		Tekeze/Atbara	Ex		√	300
Karadobi		Abay/Blue Nile	PFS- Sep 2006	15-25		1600
Beko Abo			PFS- Sep 2010	15-25		935
Upper Mandaya			PFS- Dec 2007	15-25		1700
Lower Didessa			GERD Study - 2001	15-25		550
Yeda 1			FS -2000	15-25		118
Yeda 2			FS - 2000	15-25		162
Aleltu East			FS- Feb 1995	15-25		189
Aleltu West			PFS- Jan 1994	15-25		264.6
Upper Dabus			GERD Study - 2002	15-25		326
Baro I		Baro-Akobo / Sobat	FS- Sep 2006	15-25		166
Baro II			FS- Sep 2006	15-25		479
Genji				15-25		216
Birbir			GERD Aug 2001	15-25		467
Geba 1+ 2			FS- Feb 2005	15-25		371.5
Sor 2				15-25		5
Tams			PFS- Jan 2009	15-25		1000
Tekeze 2		Tekeze/Atbara	GERD study 2006	15-25		450
Roseires	Sudan	Abay/Blue Nile	Ex		√	280
Sennar			Ex		√	26
Khashm El Girba		Tekeze/Atbara	Ex		√	18
Jebel Aulia		White Nile	Ex		√	30
Merowe		Main Nile	Ex		√	1250
Sitet /Rumela		Tekeze/Atbara	Uc			320
Shereik		Main Nile	FS	15-25		420
Dagash			FS	15-25		312
Kajbar			FS	15-25		360
Grand Foula	South Sudan	White Nile	PFS- June 2009	25-40		800
Shokuli			PFS- June 2009	25-40		250
Lakki			PFS- June 2009	25-40		250
Bedden			PFS- June 2009	25-40		522
High Aswan Dam	Egypt	Main Nile	Ex		√	2100
Aswan 1 + 2			Ex		√	592
Esna			Ex		√	86
Nag Hammadi			Ex		√	64
Damietta			Ex		√	20
Assiut			Uc	15-25		32

Ex= Existing Uc= Under Construction FS= Feasibility Study PFS= Pre Feasibility Study

5.3 AGRICULTURE SECTOR

5.3.1 Introduction

Agriculture is the most important economic activity and plays a major role in the lives and livelihoods of most households in the EN countries, as well as contributing significantly to overall economic growth and Gross Domestic Product (GDP). A wide variety of crops are grown in the region both under rainfed and irrigation for domestic consumption and export. Rainfed agriculture, supported to some extent by small scale irrigation and water harvesting systems, is the dominant form of agriculture in the upstream countries (Ethiopia and South Sudan), whereas irrigated agriculture is dominant in the two downstream countries (Sudan and Egypt). Though there is huge potential (apart from Egypt) for rainfed agriculture, production level is low being largely subsistence and extremely vulnerable to climatic conditions and in some parts, to the disruptive impact of civil conflict.

Irrigation development is a priority in all the EN countries and is considered as an effective vehicle to mitigate the impact of climatic conditions and enhancing rural development and food security. There is approximately 5.3 million ha currently under irrigation in the region with additional 4 million ha potentially suitable for further expansion. Although, production levels in Egypt are relatively higher, the overall performance of the existing irrigation schemes in the region generally is unsatisfactory. Since water scarcity and high investment cost would be a limiting factors for expansion of irrigated areas, **intensification of both existing rainfed and irrigated agriculture is a key** for boosting production and enhancing food security in the region.

The Region is also endowed with huge potential for livestock and fisheries development. It has the largest livestock population in Africa and the existence of large water bodies (lakes, swamps, rivers, reservoirs, etc) and coastal areas offer huge opportunity for fisheries development. However, the development and contributions of the subsectors to the national economies of the countries so far is not as expected.

An overview of the agricultural sector by country and whenever possible by sub basin is presented in the following sections, highlighting:

- Existing policy, regulatory, strategic and institutional frameworks ,
- Cropping patterns and production levels (rainfed and irrigation),
- Key issues and challenges, opportunities and constraints

5.3.2 Overview of the Agriculture Sector

5.3.2.1 Introduction

Policy, regulatory and institutional and to a large extent, strategic frameworks are developed at the national and regional levels. The following abbreviated review provides an overview of these aspects at the national level. Further details can be found in Annex 7.

5.3.3 Ethiopia

5.3.3.1 Policy, regulatory, strategic and institutional frameworks

The key government institutions consist of line ministries and bureaus at the federal and regional levels respectively.. The key federal ministries involved in the agricultural sector of Ethiopia are:

- Ministry of Agriculture (MOA), and
- Ministry of Water, Irrigation and Energy (MWIE)

The federal ministries are responsible for coordinating the design and implementation of public strategies and policies, while the regional States have their own Bureaus are responsible for development and implementation of the strategies and policies set by the federal ministries. The decentralized institutional structure of the BoARDs reaches down through the woreda (district) to the kebele (lowest administrative unit) level, where there are at least three development agents working with farmers. Rural land use planning, administration, registration and certification is also the responsibility of regional authorities.

The BOARDs concerned in the different sub-basins are as follows:

- Baro-Akobo-Sobat and White Nile: Ormiya, Southern Nations Nationalities and Peoples (SNNP) and Gambella Regions
- Abbay-Blue Nile: Amhara, Oromiya and Benishangul-Gumu Regions
- Tekeze-Setit-Atbara: Amhara and Tigray Regions

Ethiopia has a consistent set of plans, policies, strategies and programs for water resources and agriculture and rural developments that reflect the importance of the sectors in the nation's development endeavour. The Agricultural Development Led Industrialization (ADLI) is the central pillar of the country's agricultural policy. ADLI is an economy and society wide strategy in which agriculture has a central role for all sort of development (MoARD, 2014). The country's economy has shown significant improvement since the implementation of ADLI and the supporting plans and programs in 1991.

The overall objective of the water resources policy is to enhance and promote all national efforts towards the efficient, equitable and optimum utilization of the available water resources of Ethiopia for significant socio-economic development on a sustainable basis, through:

- Giving priority to identification and implementation of multipurpose water development projects,
- Updating and taking follow-up action on completed Integrated River Basin Master Plans, including the master plans for Abay, Tekeze and Baro-Akobo sub basins;
- Establishing effective institutions for water management, in particular river basin management institutions and water users associations;
- Developing mechanisms and standards to prevent pollution of water resources;
- Promote watershed management, capacity building and formulation of appropriate and essential water legislations

Key agricultural and water policies and strategies of Ethiopia are included in Annex 7.

5.3.3.2 Cropping patterns and production

CROP PRODUCTION

Agriculture is the backbone of the national economy in Ethiopia, accounting for 46.3% of the GDP, 84% of exports and employing 85% of the labour force. Both industry and services are dependent on the performance of agriculture, which provides raw materials and generates foreign currency for the importation of essential inputs. In spite of its importance the agriculture sector is dominated by subsistence rain-fed agriculture, with nearly 12 million small holder houses engaged in this system and contributing approximately 95 per cent of the agricultural GDP (Ministry of Agriculture, 2014).

Almost all the subsistence farm activities are concentrated in the highly populated and degraded highlands (elevations between 1500 and 3000 masl). Family land holding size is generally small, between 0.5 and 1.5 ha and the production system is outdated. Animal traction (oxen) and family labour are used for land preparation and other farming activities to produce a wide range of crops. Livestock production is an integral part of the system, but is increasingly being restricted to stall-feeding of animals due to scarcity of land. Shortage of land due to high population density, deteriorating soil fertility due to over grazing and deforestation and rainfall volatility is the biggest challenges facing this production system. There is not much agricultural activities in the lowlands, though there is huge potential for the development of both rain fed and irrigated agriculture.

Though commercial farms are emerging, their contribution to the national production so far is still small especially within the basin. Outside of the basin, commercial farms include the public irrigated farms producing the bulk of industrial crops (sugar, cotton, tobacco) and horticulture crops in the Awash valley; state owned rain-fed farms mostly in the highlands that produce wheat and the rapidly growing private cut-flower business located in the vicinity of Addis Ababa and the rift Valley.

Within the basin, sesame producing commercial farms are largely concentrated in the Tekeze Atbara sub basin. There are also a number of large scale farm projects at various stages of advancement recently initiated by foreign investors from India, Pakistan and Saudi Arabia for production of food crops (rice) and industrial crops (sugar cane) in the Baro Akobo Sobat sub basin (Gambella Region).

CROPPING PATTERNS

There are two rain fed production seasons in Ethiopia, Meher and Belg. Meher is the production season during the major rainy months (July-October) while Belg is the production season during the short rains (January-April). In some areas (including Abbay. Blue Nile and Tekeze.Atbara sub basins) double cropping is practised by growing seasonal crops (mostly food grains and vegetables) during both Meher and Belg seasons.

The total cultivated area (Meher, Belg and commercial farms) in the country had reached 15.5 million ha in 2013, of which between 3 to 4% is under irrigation. Table 5-13 show the cultivated areas during the past 5 years. The cultivated area is showing a steady increment each year. Between 2010 and 2013 alone the total cultivated area has increased by 1 million ha. The main reason behind is population growth and to some extent expansion of commercial farms

Table 5-13 : Total Cultivated areas in Ethiopia (ha x 1000)

Crop	2009	2010	2011	2012	2013
Small holder –Meher					
Cerials	8,770	9,233	9,691	9,589	9,601
Pulses	1,585	1,489	1,358	1,619	1,863
Oil Seeds	855	781	775	881	818
Vegetables	162	138	127	160	193
Root Crops	146	212	214	200	206
Fruits	48	53	55	61	62
Chat	138	139	205	180	174
Coffee	391	395	499	552	529
Hops	24	24	22	23	23
Sugar Cane	16	19	23	22	22
Enset	279	396	302	326	351
Sub Total	**12,414**	**12,879**	**13,269**	**13,613**	**13,842**
Small holder (Belg)	NA	1,203	1,244	1,173	1,192
Commercial Farms (Meher&Belg)	NA	342	415	452	460
Total		**14,424**	**14,928**	**15,238**	**15,494**

Major crops grown in the country (including the EN basin) are:

- Cereals: These include barley, teff, sorghum, wheat, oats, millet and maize. As the major staple grains they occupy (on the average) 71 % of the total Meher cultivated area by subsistence farmers. Barley, wheat, teff and oats grow in cooler areas, while sorghum, maize and millet grow in relatively warmer areas of the country.
- Pulses: Pulses include beans, peas, chickpeas and lintels, which occupy 12% of the Meher cultivated area by subsistence farmers. They are the major sources of cheap protein for the majority of the population and grow in cooler areas,
- Oil seeds: include neug (niger seed), linseed, groundnuts, sunflower and sesame which grow in warmer areas. They occupy about 6% of the cultivated area and are the major sources input for the local oil processing plants as well as for the export market.
- Vegetables and Root crops: These occupy about 2.7% of the Meher cultivated area and grow in both cooler and warmer areas; holders living near to urban centres largely practice vegetable farming.
- Fruits: Include citruses, bananas, mangos, papaya, etc, which grow in warmer areas. They occupy only 0.4% of the cultivated area.
- Cash crops: Include coffee, chat, hops, cotton and sugarcane. They grow in warmer areas and occupy about 5.3% of the cultivated area. Coffee alone cover 4% of the cultivated area and is the major commodity for the country,
- Enset: Also known as false banana locally occupies about 2.5% of the Meher cultivated area. It grows in relatively warmer areas and is the major staple food in the south and south western parts of the country. . Within the EN, Enset grows only in the Baro Akobo Sobat sub basin

YIELDS

Despite significant improvements achieved over the past two decades, crop yields in the country are still low, as compared to world standards. Average yields of major cereals have increased by over 60% in the past years (from 1.16 ton/ha between 1995 and 2000, to 1.87 ton /ha between 2009 and 2013). The overall agricultural productivity has increased by an average of 8% in the last seven years (Ministry of agriculture, 2014). Details are provided in the Annex 8.

The major reasons for the increased yields and overall productivity is attributed to:

- Appreciating the importance of the agricultural sector to the national economy and food security, the government has demonstrated strong commitment to transform the sector by an increased budget allocation (+/- 10% of total budget).
- To enhance the productivity of small farmers and to improve food security both in the rural and urban areas, the government designed and implemented an "Agricultural Development Led Industrialization" (ADLI) strategy. The strategy aims to use agriculture as the base for the country's overall development,
- The government also introduced specific policies and provided technical and institutional support to farmers, in its drive to increase food production through intensive cultivation. These policies included fertilizer supply and distribution, improved seed supply and distribution, development of small-scale irrigation, conservation of natural resources and environment, agricultural research and extension work as well as marketing and price policy,
- Improved international market opportunities for agricultural commodities, particularly for that of oil crops and pulses.

Even though significant achievements have been recorded in the agricultural sector in the past years, poverty and food insecurity are persistent in Ethiopia. The country is not self-sufficient in food and its overall economy until recently has been too weak to purchase food on the international market to meet its needs. Many Ethiopians are too poor to buy food even when it is available; and Ethiopia’s rain-fed agriculture depends on highly variable and increasingly unpredictable climatic conditions.

Because of the government’s interventions in the agricultural sector and relatively favourable climatic conditions, dependency on food aid has reduced in the past few years. According to the Humanitarian Requirements Document (HRD) released at the end of January 2014 by the Government of Ethiopia, 2.7 million people are food insecure, and they need humanitarian assistance between January and December 2014. This is relatively small as compared to the previous years.

5.3.3.3 Irrigation sub-sector

Irrigated agriculture is considered as one of the major drive for increasing productivity and enhancing food security in Ethiopia. The country has huge water and land potential suitable for irrigation development in the 12 basins, three of which are located in the Eastern Nile. The total surface water irrigation potential of the country is estimated at 3.7 million ha (Ministry of Water, Irrigation and Energy). In addition, up to 1.1 million ha of land could be irrigated using the country’s ground water potential (EWIMI, 2010). Despite this, the country relies predominantly on rain fed subsistence agriculture, which often is affected by rainfall variability and recurrent drought and a number of other constraints. Of the total 15.5 million ha of cultivated land, a little over 500,000 ha (3.2%) is currently estimated to be under irrigation nationwide.

Depending on their size, irrigation schemes in Ethiopia are classified as:

- Small Scale Irrigation (SSI) schemes; often community-based, traditional schemes, (<200 hectares) and covering the majority (>380,000 ha) of the total irrigated area.
- Medium scale Irrigation schemes; they are either community based or public schemes, with sizes ranging from 200 to 3,000 ha.

- Large Scale Irrigation schemes; include public and private commercial farms with sizes more than 3,000 ha. They are mostly located in the Awash River Valley and for the production of industrial crops (cotton and sugarcane) and horticultural crops.

The study, design and implementation of small scale irrigation schemes are under the responsibility of the Federal Ministry of Agriculture and Water or Agricultural Bureaus of Regional States. The Federal Ministry of Water, Irrigation and Energy is responsible for the medium and large scale irrigation schemes.

The estimated area so far developed under irrigation in the EN part of Ethiopia is about 120,000 ha (ENIDS CRA Study, 2010). Of this amount, the existing large scale irrigation schemes covers only an area of 17,000 ha (10, 000 ha Fincha Sugar scheme and 7,000 ha Koga small holders irrigation scheme), whereas the remaining balance (a little over 100,000 ha) are small scale irrigation schemes, 80% of which are traditional. Details of the existing (120,00ha) and planned irrigation projects in Ethiopia are presented in Section 5,3.8.

Traditional irrigation has been practised for many years in Ethiopia. The schemes are constructed and managed by the communities by diverting water from nearby streams or small rivers. There are no water control structures and diversions are made using locally available material (stones, tree trunks, etc). They often are destroyed by flood and have to be re-built each year after the rains. Irrigation methods are either basins or furrows on unlevelled fields. Modern small scale irrigation schemes are usually constructed by NGOs or the government assistance and provided with better control and diversion structures. The study, design and operation and maintenance of small scale irrigation schemes are under the responsibilities of the Water and Agricultural Bureaus of Regional States.

Cropping pattern of small scale irrigation and rain-fed agriculture are quite similar, dominant crop are food crops (cereals, pulses) and vegetables, in schemes located near towns. Crop yields (though reported to be two to three times better than the rain fed farms) are low. The major reasons being:

- Poor design and construction,
- Poor operation and maintenance,
- Use of outdated irrigation and farming technologies,
- Inadequate research and extension services,
- Lack of credit facilities, poor market structure and information
- Lack of agricultural inputs (fertilizers, improved seed, chemicals, etc),

In order to reduce vulnerability to climate change and improve productivity of the agricultural sector, the government of Ethiopia is highly committed to **expand** irrigated agriculture. The total area of planned expansions in the three sub-basins (Abbay-Blue Nile, Baro -Akobo- Sobat and Tekeze) of the EN amounts to 1.59 million ha. Of this amount, about 300,000 ha are small scale irrigation schemes. The estimates are based on the suitability of land for irrigation using surface water only. If lands suitable for other modern methods of irrigation (sprinkler and drip) are considered, the potential irrigable areas will increase substantially. Details of existing and planned irrigation schemes are provided in 5.3.8. Except a few schemes around Lake Tana, almost all the schemes are dam dependant because of the high seasonality of the tributary rivers.

5.3.3.4 Conclusions for the concerned sub-basins within Ethiopia

Table 2-1 provides a summary of where the different crops are grown.

Table 5-14: Cropping patterns within the concerned sub-basins

Crop	Baro-Akobo-Sobat and White Nile	Abbay-Blue Nile	Tekeze-Setit-Atbara
Cereals	Wheat, teff and barley are dominant crops in the medium and highland areas, maize and sorghum grow in the lowlands by transhumant farmers	Wheat, teff and barley are dominant crops in the medium and highland areas, maize and sorghum grow in the low lands under irrigation and rainfed.	Wheat, teff and barley are dominant crops in the medium and highland areas, maize and sorghum grow in the low lands under irrigation and rainfed
Pulses	groundnuts are grown in lowland areas at household level	Beans, peas, chick peas, lintels grow in the high lands, while few groundnuts are grown in lowland areas	Not common crops
Oils seeds	Not common crops	Are common crops in medium to highland areas	Sesame is the dominant crop grown by commercial farms in the lowlands.
Vegetables	Are grown to limited extent at household level	Are dominant crops in small scale and traditional irrigation schemes	Are dominant crops in small scale and traditional irrigation schemes
Fruits	Mangos are dominant household fruits in mid to lowland areas	Grow in households and are generally confined to mid and lowland areas	Limited amount in small scale and traditional irrigation schemes
Cash crops	Sugarcane, coffee, chat grow at household level in mid and lowland areas under irrigation and rainfed.	Sugarcane, coffee, chat grow at commercial and household level in mid and lowland areas under irrigation and rainfed.	Limited Sugarcane, coffee, chat grown at household level in mid and lowland areas (irrigation and rainfed)
Enset	Is a major/common food crop growing in mid and highland areas	Not common crop	Not common crop

5.3.4 South Sudan

5.3.4.1 Policy, regulatory, strategic and institutional frameworks

The key institutions involved in the agricultural sector of South Sudan are:

- *Ministry of Agriculture, Forestry, Tourism, Animal Resources, Fisheries, Cooperatives and Rural Development (MAFTARFCRD*).
- *Ministry of Electricity, Dams, Irrigation and Water Resources (MEDIWR***).**

In August, 2013, the former Ministry of Agriculture, Forestry, Cooperatives and Rural Development (MAFCRD) and the former Ministry of Animal Resources and Fisheries (MARF), together with the Directorate General of Tourism from the former Ministry of Wildlife Conservation and Tourism, were merged into the Ministry of Agriculture, Forestry, Tourism, Animal Resources, Fisheries, Cooperatives and Rural Development (MAFTARFCRD). Likewise, the former Ministry of Water Resources and Irrigation (MWRI) was merged with the former Ministry of Electricity and Dams to form the now Ministry of Electricity, Dams, Irrigation and Water Resources (MEDIWR). Most of the key policies in place so far, were developed before the merger of the ministries.

Being a new country, the restructuring process is dynamic and various policies, reforms and regulations are still under preparation. These include the Land Policy, Land Act, irrigation policy and strategic framework, which will be key for agricultural and economic development in South Sudan. Setting clear demarcation for the roles and responsibilities of MEDIWR and MAFTARFCRD and among national, state, local government and farmer organizations is also still outstanding.

Under the agricultural policy :

- Food security has been a key issue for South Sudan
- Yields of food crops both as nutritional sources and cash crops are targeted to double. R&D and infrastructure development should be encouraged to support this,
- Smallholders, commercial farmers, processors and agribusiness operators need to be supported through extension services and agricultural education training.
- Enough support shall be given to agricultural markets, value chain development and finance

The Water Resources Policy supports social development and economic growth by promoting efficient, equitable and sustainable development and use of available water resources, and effective delivery of water and sanitation services in Southern Sudan and effective management of quantity, quality and reliability of available water resources to maximize social and economic benefits while ensuring long term environmental sustainability.

A summary of the existing key institutions, policies and strategies in relation to the agricultural sector are presented in Annex 7.

5.3.4.2 Cropping patterns and production

Crop Production

As with the other EN countries, agriculture is considered as the major drive for growth, enhancement of food security and alleviation of poverty. The country is endowed with huge land and water resources and favourable climatic conditions for agricultural development. Over 95% of the total area of South Sudan (658,842 km2) is considered suitable for agriculture, 50% of which is prime agricultural land suitable for producing a wide range of agricultural products, including annual crops such as grains, vegetables, tree crops such as coffee, tea, and fruits, livestock, fishery, and various forest products (CAMP SAR, 2013).

Following a long period of civil war and instability, levels of production are low and the contribution of agriculture to the national economy so far is insignificant, estimated at 36% of non-oil GDP in 2010 (South Sudan an Infrastructure Action Plan Document, 2012). The value of total agricultural production in South Sudan was estimated at only US$808 million in 2009 (World Bank, 2012) with 75% of this value accruing from the crop sector with the rest attributed to the livestock and fisheries sectors.

About 90% of the population lives in rural areas and is dependent on agricultural activities (crops production, livestock and fisheries) for their livelihood. The estimated land under cultivation in the country is about 2.7 million ha, which is only about 4 % of the total land area.

Cropping Patterns

Over 98% of agricultural production is rain- fed, predominantly characterized by low input and low output traditional and subsistence farming. Cropping activities, for the most part are, based on small, hand-cultivated units often farmed by women-headed households. Manual land preparation limits the area households can cultivate. Efforts are being made by the government and NGOs to promote the use of animal traction, so that larger areas would be cultivated at household level.

The most common crops grown in the six agro ecological zones of the country include sorghum, millet, maize, beans, pumpkins, cassava, sweet potatoes, groundnuts, sesame and rice. Coffee and tobacco growing is also practiced in some states. Except rice and coffee, similar crops are grown in the three states (Upper Nile, Jonglei and Eastern

Equatoria) located in the EN basin. Despite the availability of fertile land and favorable agro climatic conditions, the performance of the agricultural sector is not satisfactory.

YIELDS

Average yields fell from 0.75 t/ha in 2005 to 0.65 t/ha, in 2010 and the country's total net cereal production declined almost by 19 % to about 562,600 tonnes over the same period. (South Sudan Agricultural sector Investment Plan, 2013), much lower than the other EN countries. The result has been food insecurity in South Sudan.

Cereals, primarily sorghum and maize, millet and rice are the dominant staple crops, with sorghum cultivated by more than half of all households. South Sudan imports as much as 50% of its requirements from neighbouring countries, particularly Uganda and Kenya.

Major factors/constraints contributing to the existing poor performance of the agricultural sector, among others, include:

- Use of extremely outdated agricultural technologies; rain-fed traditional and subsistence farming, simple farm implements; small average farm sizes (0.4-1.7 hectares),large post harvest losses; lack of irrigated and commercial farms.
- Weak/ non-existent research and extension services and credit facilities to farmers,
- Lack of improved seed varieties and agricultural packages,
- Poor and inadequate infrastructure; transportation, storage and processing facility is underdeveloped and electricity services are not available in rural areas,
- Weak markets and non-existent market information systems.
- Shortage of farm labour; Close to 80% of farm labour is provided by women who combine farming with their other domestic activities. Available labour is expensive;
- Little involvement of the private sector in development and service delivery,
- Unclear and fragmented land tenure system,
- Insecurity; conflicts disrupt crop cultivation and displace farmers, causing serious food insecurity in many areas.
- Drought and flooding, particularly in the lowland areas.

The country is planning to increase the performance of the agricultural sector through both horizontal expansion and intensification of the existing cultivated areas and a Comprehensive Agricultural Development Master Plan (CAMP) is under preparation with the assistance of JICA. The Master Plan is expected to identify the agricultural potential of the country, recommend institutional set up and set priorities for development together with the resources required for implementation.

5.3.4.3 Irrigation Sub-sector

Irrigation is considered as one the major vehicle for boosting agricultural production and enhancing food security in South Sudan. With its abundant land and water resources (River Nile and its tributaries, wet lands and reach aquifers), the country is believed to have ample potential for irrigation development. However, no proper study and inventory have been conducted so far to determine the country's exact water resources and irrigation potential. Previous studies conducted in the EN region and NBI (ENIDS-CRA Study and EWUAP-Large Scale Irrigation study, NELSAP-Regional Agricultural Trade Project, etc) have not covered South Sudan in their assessment of potential irrigable areas in the Nile Basin countries. The Irrigation and Drainage Master Plan (IDMP), which among others is expected to identify the country's irrigation potential is still under preparation with the assistance of JICA and will not be ready until June 2015. In addition, the Baro Akobo-Sobat Integrated Water Resources Management and Development Study, recently launched by ENTRO, which is also expected to identify potential irrigable areas in the sub basin, has not yet been advanced. Because of these, it is found very difficult to determine the size of the country's irrigation potential and estimate the water requirement of the agricultural sector in South Sudan.

Based on the NEL Region-Multi Sector Investment Opportunity Analysis study conducted in 2012, the irrigation potential of all of South Sudan was estimated at 28,237,299 ha with around more than 10 million ha in the EN part of the country. While this estimate is clearly unrealistic based as it was only on a consideration of the land resources (the available water resources and other technical, social, environmental and financial issues have been not considered), it is evident that the potential is vast.

As per the information obtained from the South Sudan workshop participants in the Situational Analysis workshop (Khartoum, October 2014), the estimated irrigation potential in the EN part of the country is 2.65 million hectare. This is based on the IDMP Draft Progress Report 2. Despite several attempts to get hold of this report in order to understand the details behind this estimate of potential, it has not been possible to obtain. However, for the purpose of the MSOIA study, it is not the overall irrigation potential that is required but rather the irrigable area that has been identified for development at the project/scheme level(at least at the project identification phase). In the absence of such information it has been assumed that up to 165,000 (as estimated by FAO, 2013) of the overall potential could be developed in the Baro-Akabo-Sobat Sub-basin in the foreseeable future. This figure will have to be revised in line with irrigation development plans as they emerge and are made available.

The existing irrigated area in the country is limited to two schemes(Aweil and NUNIS) totalling 42,500ha. NUNIS (Northern Upper Nile Irrigation Schemes) located in the EN basin has 35,000 ha consisting some 22 small-scale irrigation along the White Nile (most currently abandoned). Rice is the main irrigated crop and current yields are low (1.3 ton/ha) (Irrigation and Drainage Master Plan preparation Task Team assessment of May 2013).

All the existing schemes require heavy rehabilitation works to bring them to the required level of operation and production. The Ministry of Electricity, Dams, Irrigation & Water Resources has conducted feasibility study and detailed design on two of the schemes to start the rehabilitation works. The Government is committed to developing the irrigation potential of the country in order to reduce vulnerability to rainfall variability.

5.3.4.4 Conclusions for the concerned sub-basins within South Sudan

The three states located in the EN Basin are Upper Nile, Jonglei and Eastern Equatoria. Crops grown in these states is almost the same as the other parts of the country.

Table 5-15: Cropping pattern in the Eastern Nile part of South Sudan

Crop	Upper Nile S.	Jonglie S.	Easter Equatoria S.
Cereals	Maize, sorghum	Maize, sorghum, bean	Maize, sorghum, bean, wheat, millet
Cash crops	groundnut, sesame, sunflower, cow pea	groundnut, sesame, tobacco, cow pea	groundnut, sesame, cow pea, banana
Vegetables	Okra, tomatoes, pumpkins, etc	Okra, egg plant, tomatoes, pumpkins,	Okra, tomatoes, pumpkins, etc
Cereals area (ha)	80,100	107,600	130,500
Average yields of Cereals (T/ha)	0.59	0.66	1.08

Source: CAMP, 2013

5.3.5 Sudan

5.3.5.1 Policy, regulatory, strategic and institutional frameworks

As per the recent restructuring, the key institutions involved in the Agricultural Sector of Sudan are;

- Ministry of Water Resources and Electricity: The Ministry, with its various technical Units and Directorates among others, is responsible for overall planning, development and management of water resources; setting policies, regulations and strategies; transboundary water issues; planning, studying and implementation of major hydropower and irrigation schemes, control/coordination of water releases for irrigation canals.

- Ministry of Agriculture and Irrigation: Which is responsible for overseeing agricultural resources (rain fed and irrigation), setting setting policies, regulations and strategies; operating and managing existing irrigation schemes and handling agricultural research and development activities,

The Green Mobilization Program, also referred as the Agriculture Revitalization Program, is the core for the Agriculture Policy. The specific objectives the programme include: Achieving food security; Reducing poverty, provide employment opportunities and increase individual income; through increasing productivity in the agricultural sector by promoting access to agricultural services and inputs to small farmers and exploiting the potential of livestock production through improving natural pasture lands.

The goal of Sudan's Policy on integrated Water Resources Management is to "*lay the foundation for a rational and efficient framework to sustain the water needs of national economic development, poverty alleviation, peace, environmental protection and social well being of the people through sustainable water resources management*".

The overall objective of the irrigation sector policy is "*to develop the huge irrigated agriculture potential for the production of food crops and raw materials needed for agro-industries, on efficient and sustainable base and without degrading the fertility of the production fields and water resources base.*" This will be achieved through the construction of new dams and heightening of the Roseires Dam to achieve horizontal and vertical expansion of irrigated agriculture; Implementation of new irrigation schemes and rehabilitation of public irrigation schemes to improve productivity and water use efficiency.

Further details are provided in Annex 7.

5.3.5.2 Cropping patterns and production

CROP PRODUCTION

Sudan is endowed with huge land and water resources and favourable climate for the development of agriculture under rainfed and irrigation conditions. Agriculture contributes a significant portion to the GDP and offers employment to 70-80% of the rural Labour force. Despite the increasing predominance of oil exports, agriculture remains an important sector in the Sudanese economy, contributing an annual average of 45 % to total GDP during years 2000 to 2010 (Khalid H.A.Siddig, et al, 2011). The value of the crop and livestock sub-sectors together contributes 80 to 90 percent of non-oil export earnings. Moreover, agriculture contributes to other activities such as transportation, agro-industries, and commerce, in the industrial, trade, and service sectors which account for a large share of the GDP. With the decline of the oil export in recent years (after the separation of the South Sudan), the country is giving more emphasis to the intensification of the agricultural sector thus, its contribution to the national economy and food security is expected to increase significantly in the coming years.

The sector is generally divided into four sub sectors:

- Traditional rain fed,
- Semi Mechanized rain fed (commercial farms),
- Irrigation and
- Livestock

Details of the irrigation sub-sector, including a brief review of irrigation technology, land tenure, cropping patterns and crop yields are provided in Annex 9.

The traditional rainfed sector provides staple food for the majority of the subsistence farmers, other domestic consumers and contributes to the export sector. The semi-subsistence-based rain-fed farming system exists mainly in Kordofan, Darfur, Sennar, and the Blue and White Nile areas. It covers 50% of the total cultivated land in the country and supports the bulk of the rural poor, estimated at 70%. The total cropped area in this system is estimated at 9 million hectares, with small farmers typically having 4.2 to 6.3 hectares cultivated for subsistence and income. The total area fluctuates annually depending on the availability of rainfall. In addition to the staple food crops (sorghum and millet), the system is also largely involved in the production of oil seeds (sesame and groundnuts). Some farmers also integrate livestock in their production plans. The smaller farms regularly produce about 90 percent of millet, 10 percent of sorghum, 48 percent of the groundnut and 28 percent of the sesame grown in the country. Almost all the gum Arabic is also produced from this sub sector.

Nevertheless, this system is characterized by low crop productivity due to use of traditional farming practices, inadequate input, research and agricultural services, erratic rainfall and recurrent draught, pests and disease infestations. Its average contribution to the total agricultural GDP is only about 16% (Siddig, 2009).

Farmers in the traditional subsector use greater levels of labour input and appear to pay much more attention to good farming practices than the private farmers in the mechanized subsector with a wider use of crop rotation, more frequent and timely sowing higher sowing rates, greater plant densities, more efficient use of land, etc. They usually receive greater returns in terms of yields per ha than the private sector. Traditional farmers have demonstrated that they are the best potential for agricultural growth in Sudan. By promoting the traditional farmers, agricultural development in Sudan will combine growth with poverty reduction because most of these farm households are poor.

Semi Mechanized Rain fed agriculture system started in the mid 1940s on a limited scale in the vicinity of Gedaref. With time the area increased to about 6 million hectares in rainfall areas ranging between 400-800 mm annually in Gedaref, Blue Nile, White Nile, Sennar and Southern Kordofan (Nuba Mountains) areas. Under this system, large parcels of land, typically more than 400 ha but sometimes ranging between 20,000 and 100,000 ha, are leased out to individuals.

The farms are run by private/commercial farmers and companies for producing sorghum, sesame, sunflower and little of short staple cotton. The subsector contributes about 3 % of the agricultural GDP and usually provides 65 percent of the sorghum and 53 percent of sesame and almost all of sunflower produced in the country (ENTRO-Economic models for the analysis of Agricultural policies of Sudan). Land preparation, seeding and most threshing on these farms are mechanized, while weeding and harvesting are done by seasonal labour. Livestock is not integrated in this farming system.

Low-cost, minimum or zero tillage combined with low-input agriculture approaches have been practised over a period of 50 years, leading to low yields of crops from the vast areas leased at very low rents from local authorities. No proper crop rotation is maintained. Investors move seamlessly from crop to crop, usually from sorghum to sesame and vice versa, depending on prices of crops, loans available and government incentives. Soil fertility has reportedly been declining because of the continued planting of sorghum without crop rotation. As the semi mechanized farms are mostly located in the alkaline clay areas, only few crops had been found suitable for cultivation in the heavy cracking clay soils, Sorghum being the principal one. The soils also pose difficulties for mechanized operations under both very dry and wet conditions.

This sub-sector suffers from a number of limitations (Idris Nur and Ali, 2007), which among others, include:

- Low Yields (use indigenous Varieties, heavy soils with poor fertility, absence of crop rotation),
- High cost of production,
- Shortage of formal credit,
- Absence of machinery services for small farmers,
- Horizontal expansion and deforestation resulting in land degradation,
- Competition for land and conflicts with traditional farmers and pastoralists.

Cropping Patterns

Sorghum, millet and maize are the main food crops. Other important produce for the domestic market includes sugarcane, dates, wheat, sunflower, pulses and forage. The principle export crops are cotton, gum arabic, sesame, groundnuts, fruits and vegetables (Sudan is the world's largest producer of Gum Arabic). Livestock represents a very important part of the national economy, as well. Its production increased during recent years as a result of better veterinary treatment, better credit policy, and higher prices both in local and international market.

In general, the total cultivated area has shown a trend of increase from 12 million ha for the 1990-95 period to 18 million ha in the period 2005 – 2010 (ENIDS-CRA, 2010). The increase occurred in the rain-fed sector due to the increase of areas cropped with sorghum, millet and sesame resulting from favourable export opportunities for farmers involved in the semi-mechanized farming system. There was no significant irrigation development since the end of the 1970’s. Harvested area in the rain-fed farming systems show high fluctuations because of recurrent droughts resulting in crop failures every four to five years. In the irrigated farming system, harvested area also fluctuates mainly because of difficulties in the maintenance of canals (removal of silt) and variations in water availability for winter crops. Table 5-16 shows the estimated percentage of crops grown by sub sector.

Table 5-16: Percentage of Crops Grown by Sub-Sector

Crop	Irrigation Sub sector (%)	Semi-Mechanized rainfed (%)	Traditional Rainfed (%)
Sorghum	25	65	10
Millet	5	5	90
Wheat	100	0	0
Cotton	99	0	1
Groundnuts	52	0	48
Sugar Cane	100	0	0
Sesame	na	53	28
Sun flower	1	99	0
Gum Arabic	0	0	100
Fruits	70+	na	na
Vegetables	70+	na	na

Source: ENTRO-Economic models for the analysis of Agricultural policies of Sudan

YIELDS

In spite of the availability of technically proven research outputs (high yielding varieties), the yields of the cereal crops (sorghum, millet and wheat) are generally low. The yield of cotton under the three production systems is also generally low. With the exception of sesame, mainly grown in the semi mechanized sector, production levels of the other crops have remained low and stagnant in the past years. Agriculture production growth thus is attributed by expansion of cultivated areas only.

The main reasons for low productivity, among others, include:

- Poor agricultural practices and the use of outdated technology,
- Recurrent draught in rainfed areas,
- Absence of adequate extension and credit facilities,
- Poor Operation and Maintenance of irrigation infrastructure and shortage of water

Agriculture is the most important potential contributor to economic growth, food security and alleviation of poverty thus, should receive considerable attention to attain sustainable growth and development. In view of the expected population increase and the limited nature of the available land and water resources for horizontal expansions, more emphasis should be given to vertical expansion (increasing productivity of the existing farms). This could be achieved through intensification and diversification of the existing agriculture, via rehabilitation and modernization, introduction of appropriate technology, provisions of input and credit facilities, improvement of research and extension services, etc.

5.3.5.3 Irrigation Sub-sector

Although, the irrigated area covers about 10% of the total cultivated area, the irrigation sub sector contributes to more than half of the total volume of the agricultural production in the country. Its importance has significantly increased in the past decades as a result of drought and rainfall variability and uncertainty in the rain fed sub sector. It contributes an average of 28 % of the total value of the agricultural production, 100% of wheat and sugar, 95% of long staple cotton, 52% ground nuts and 25% of sorghum produced in the country (Radia, 2013 and EWUAP-LSI Study, 2009). Other main irrigated crops include vegetables, fodder, maize, sunflower, roots and tubers, fruits and rice.

Traditional irrigation has been practiced for centuries in Sudan using the annual flood waters of the Nile for recession agriculture. Modern irrigation agriculture started in 1920s with the construction of Sennar Dam and the establishment of the Gezira scheme during the colonial era. After independence in 1955, the command area of Gezira was doubled to 924, 000 ha with the completion of the Mangil extension and became the largest irrigation scheme in the world under single management. The 1970's were a period of rapid irrigation expansion in Sudan due to the construction of the Rahad Scheme (126,000 ha), the New Halfa Scheme (146,138 ha), El Suki (37,800 ha), Rahad I (126,000 ha), Kenana sugar estate (37,700 ha), North-West Sennar sugar scheme (13,900 ha), Assalaya sugar scheme (14,700 ha) and a number of smaller schemes along the Blue Nile and its tributaries, White and Main Niles. Almost all these schemes have been established with similar design and management style of Gezira scheme. The completion of the Jebel Awlia Dam (1937) on the White Nile approximately 20 Km upstream of Khartoum has led to the rapid development of pumping schemes.

In Sudan, irrigated area expanded from 1 million ha in 1956 to about 1.9 million ha (including spate irrigation in Gash and Tokar deltas) by the end of the 1970's. There is no major expansion after the 1970.

Details of the existing irrigation schemes are given in Annex 9.

5.3.5.4 Conclusions for the concerned sub-basins within Sudan

Parts of all four sub-basins are to be found in Sudan. All types of farming systems are practised in all the sub basins. Irrigation is largely concentrated in the Abay-Blue Nile sub basin, while semi- mechanized farming is practiced mainly in Abay-Blue Nile and Tekeze-Atbara sub basins. Traditional rainfed farming exist in all the sub basins in areas that have above 400 mm rainfall.

5.3.6 Egypt

5.3.6.1 Policy, regulatory, strategic and institutional frameworks

The key institutions involved in the agricultural sector of Egypt are:

- The *Ministry of Water Resources and Irrigation (MWRI),* which has overall responsibility for the development and management of water resources.
- The *Ministry of Agriculture and Land Reclamation (MALR)* whose objective is to Improve food security and increase national agricultural production through maximizing the net return per unit of water.

The *Irrigation Department (ID)* is the largest of at least 8 large departments in the MWRI and consists of seven sections including:

- *Irrigation section*: operation of the network of irrigation canals and command releases from the High Aswan Dam,
- *Horizontal Expansion section*: planning, design, and construction of irrigation water supply and distribution systems serving new users (newly reclaimed areas);
- *Reservoirs and Grand Barrages section*
- *Irrigation improvement section*: planning, design and implementation of improvement in the irrigation distribution system;

- *Groundwater section*: management and protection of groundwater resources;
- *Nile protection section*: management and protection of the Nile water course;

The ***MALR*** is responsible for predicting the cropping patterns and irrigation requirements used by MWRI to allocate water among the vast network of primary and secondary irrigation canals. MALR also participates with MWRI in the irrigation and drainage improveme. The MALR includes:

- The ***Soils, Water and Environmental Research Institute (SWERI):*** responsible for performing research on the sustainable development in the agricultural sector, (policies for fertilizer and pesticides use, monitoring soil and water quality etc).
- The ***General Authority for Rehabilitation Projects and Agricultural Development (GARPAD)*****:** responsible for design and implementation of the expansion projects prior to transferring to public sector agricultural companies or private investor. Water management of these new reclaimed lands is the responsibility of the MWRI.
- The ***General Authority of Fish Resources Development (GAFRD):*** Responsible for development of fisheries and establishment of expansion projects.

Historically several policies have been formulated in Egypt to develop and manage the water resources. These policies are dynamic in nature and have led to the implementation of important projects which have allowed the expansion of cultivated areas and increment of cropping intensities.

The latest policy is the ***National Water Resources Plan 2017*** (2005), which provides an update of earlier policies and plans. The plan has set guiding principles and strategies for both public and private sectors to ensure optimum development and management of water resources. Preparation of the Policy was coordinated by the MWRI in close consultation with other ministries (Agriculture and Land Reclamation, Health, Industry and others). Further details are provided in the Annex 7.

5.3.6.2 Cropping patterns and production

CROP PRODUCTION:

Agriculture in Egypt is the most important productive sector in the economy. It provides 20% of Gross Domestic Product, 34% of the total exports, 32% of the total labor force and much of the Egyptian food Supply. Egypt is located in semi arid zone with very low, irregular and unpredictable rainfall. Annual rainfall ranges between a maximum of about 200 mm in the northern coastal region to a minimum of nearly zero in the south, with an annual average of 51 mm. Due to this, Agriculture in Egypt is almost entirely dependent on irrigation from the Nile, which is the main source of water supply. Out of 55.5 the billion cubic meters allocated to Egypt by the 1959 agreement, 84% is used for agriculture.

Egypt covers an area of about one million square kilometres, of which only 35,000 square kilometres is cultivated and permanently settled. The Nile Valley and Nile Delta are the most important regions, being the country's only cultivable areas supporting about 95% of the population. The regions were created by the sediments and deposits of the Nile for thousands of years until the construction of the High Aswan Dam in 1968. The Nile valley extends approximately 900 km from Aswan to the outskirts of Cairo. The Nile Valley is also known as Upper Egypt, while the Nile Delta region is known as Lower Egypt. The Delta consists of flat, low-lying areas, with about 200 km length from south to North, and the coastline of about 300 km long. Total area covers about 25,000 km². It is considered among the most densely populated agricultural areas in the world.

The total cultivated area in Egypt is 3.4 million ha, representing only 3 percent of the total land area. The entire crop area is irrigated, except for some rain-fed areas on the

Mediterranean coast and north Sinai. The old irrigated lands, lying in the Nile Valley and Delta with fertile alluvial soils, cover an area of 2.25 million ha. Over the past four decades, newly reclaimed desert lands amounting to 1.1 million hectares has been added to the agricultural area. The soils of these areas are sandy and calcareous, with poor organic matter and macro-and micro-nutrients. The program of desert land reclamation started in the 1980's. They are located on the western and eastern sides of the delta, the Sinai region (El Salam canal project) and west of the Nile valley in Upper Egypt (Toshka project). The land holdings are fragmented, with the average size of farm units ranging between 0.6-1.5 ha.

Egypt is not food self-sufficient. It is producing only about half of its food supplies and food imports reached about $ 10 billion in 2012 (Mohamed M Nour, 2013), and demand is expected to increase with the growing population. It imports substantial amount of wheat and varying proportions of other agricultural commodities and processed food. Leading imports in rank order of value were: 1) cereals (wheat and corn); 2) lumber; 3) beef; 4) soybeans; 5) vegetable oils; 6) feed materials (soybean meal & corn gluten feed); 7) edible beans; 8) dairy products; 9) sugar; and 10) cotton (Agricultural Economy and Policy Report, 2009). Food self-sufficiency will further reduce in the future due to population increase and an expected shift towards more export oriented crops (National Water resources Plan 2017).

CROPPIMG PATTERNS

Due to the favourable climate, plentiful water, and exceptionally fertile soils, Intensive and multiple cropping agricultural practices are common in Egypt. Cropping intensity on the average reaches 180%, meaning that about 6.0 million ha are harvested annually over 3.3 million ha of land. The high cropping intensity was made possible after the completion of the high Aswan dam in 1968 and through improved water management and cultivation of early maturing varieties.

The agricultural production can be divided in five categories: (1) cereals, (2) Fodder, (3) pulses, (4) industrial crops and (5) horticultural crops. Cropping patterns in the Delta and Upper Egypt are identical with the exception of sugar cane grown in Upper Egypt only, and rice cultivated in the Delta only. Rice cultivation in the Delta is seen as one of the means to control salinity. See figure 1 for typical cropping pattern in Egypt. Table... show area covered by major crops in the past five years.

Table 5-17: Harvested area of major food crops (Ha)

Crop	2009	2010	2011	2012	2013	Average
Wheat	1,335,295	1,287,627	1,284,946	1,336,234	1,418,708	1,332,562
Maize	983,081	968,519	888,329	1,041,345	900,000	956,255
Rice	575,467	459,525	593,185	620,285	700,000	589,692
Sorghum	141,253	140,157	156,986	142,744	141,200	144,468
Sugar cane	133,019	134,538	136,709	138,300	139,600	136,433
Soybeans	7,179	15,233	9,548	7,000	8,000	9,392
Seed Cotton	119,462	155,039	218,451	120,000	140,000	150,590
Vegetables	97,817	131,454	131,648	118,500	-	119,855

Source: FAO-STAT-2014

YIELDS

Crop yields in Egypt are considered to be high. Following the Agrarian Reforms (Green Revolution) in the early 1960s, crop yields and total production in Egypt has increased significantly over the years. For instance wheat yield has increased from 2 ton/ha in the early 80s to 6.4 ton/ha in the present day, maize from 4 ton/ha to 7.6 ton/ha, rice from 3.5 ton/ha to 9.4 ton/ha, cotton from 1 ton/ha to 2.8 ton/ha. The Green Revolution has been accomplished through two stages: land redistribution and strong control over farmers (1960 – 1980) then dissemination of technology packages (1980 – 1993). By 1993 the agricultural sector was liberalized and the Government control over farm areas, price and procurement are lifted. Input subsidies are progressively removed and the private sector involvement in processing and Trade improved. The only remaining major government involvement is in the food subsidy (in some wheat products, bread subsidy in particular). Details of yields are provided in Annex 10.

In general, the present high average yields achieved in Egypt are attributed to:

- The favourable climatic conditions for crop growth especially in the Delta;
- Adequate and reliable water supply in most areas of the irrigation system managed by a strong irrigation bureaucracy at no cost for farmers,
- Investments in irrigation and drainage infrastructure: all the irrigated area of Egypt is drained, rehabilitation and improvement of the existing infrastructures are being carried out at almost no cost for farmers;
- Effective dissemination of green revolution technology packages including improved crop varieties, fertilizers and pesticides;
- Efficient Public agricultural research centres and extension services at no charge for farmers.

5.3.6.3 Irrigation Sub sector:

The total irrigated area in Egypt is 3.35 million ha plus estimated 40,000 ha of oases. Annual cropped area is approximately 6.0 million ha and cropping intensity is 180%. The Nile is the source of irrigation water although in some oases fossil underground water is used. Details on the existing irrigation schemes in Egypt are given in Annex 10.

5.3.6.4 Conclusions for the concerned sub-basins within Egypt

In view of the fact that virtually all of Egypt's agricultural production lies within the Nile basin (Main Nile Sub-basin), it is fair to say that sections 5.3.6.1 and 5.3.6.2 above, apply in their entirety.

5.3.7 Analysis of demand

5.3.7.1 Overview,

None of the four countries is food secure and the levels of demand are increasing. The situation in each of the countries can be summarised as follows:

- **Ethiopia:** Even though high achievements have been recorded in the agricultural sector in the past years, poverty and food insecurity still persist in Ethiopia. Though the current situation has shown substantial improvement, four to six million people are chronically food insecure and depend on food aid for survival in the past years. In 2011, the country imported 1.7 million Tons of wheat (FAO STAT, 2014).
- **South Sudan**: Existing production in the country is not sufficient to satisfy the demand and the country imports as much as 50% of its requirements from neighbouring countries, particularly Uganda and Kenya. Total food imports are estimated to be in the range of USD 200-300 million a year (South Sudan an Infrastructure Action Plan Document, 2012).

The food security situation has deteriorated in recent years due to a large number of returnees, refugees from Sudan and internally displaced peoples, natural population growth, a reduced harvest (in 2011) and food price inflation caused by greater demand and tight foreign reserves following the oil shutdown (SAR-CAMP, 2013). The situation is more aggravated at present due to the recent crises in the country.

- **Sudan**: Despite the availability of large arable land both under rain fed and irrigation, Sudan is not food self-sufficient and has to import substantial amount of food crop annually to fill the gap between demand and supply. Relief aids to draught and conflict affected areas also contribute to filling the gaps. Table… below indicate the estimated cereal demand and supply balance for the year 2012.

Table 5-18: Sudan Cereal Supply/Demand Balance, January - December 2012 ('000 tones)

Crop	Production	Demand	Deficit
Sorghum	2,469	3.433	-964
Millet	385	638	-253
Maize	51	51	0
Wheat	524	2,116	-1,592
Rice	25	74	-49

Source: QUASI Special Report, 2012

- **Egypt**: Despite the availability of large irrigable land, with relatively high productivity, Egypt is not food self-sufficient. It is producing about half of its food supplies and food imports reached about $10 billion in 2012 (Mohamed M Nour, 2013), and demand is expected to increase with the growing population. It imports a substantial amount of wheat and varying proportions of other agricultural commodities and processed food. In 2011, the country imported 9.8 million tonnes of wheat, 7 million tonnes of maize, 1.1 million tonnes of soya bean and 1.1 million tonnes of sugar (FAO STAT, 1014)

5.3.8 Current and planned Irrigation Projects: status of development and management

5.3.8.1 Baro-Akobo-Sobat and White Nile

CURRENT PROJECTS

The only existing large irrigation schemes in the sub-basin are South, North and West Renk schemes in south Sudan. There are around 22 small scale irrigation schemes along the White Nile, most of which have been abandoned. The locations and extents of existing and planned schemes are shown in *Figure* **5-11**.

Small scale /Traditional schemes in the upstream part of the basin and Few private schemes in Gambela Region are emerging in Ethiopia.

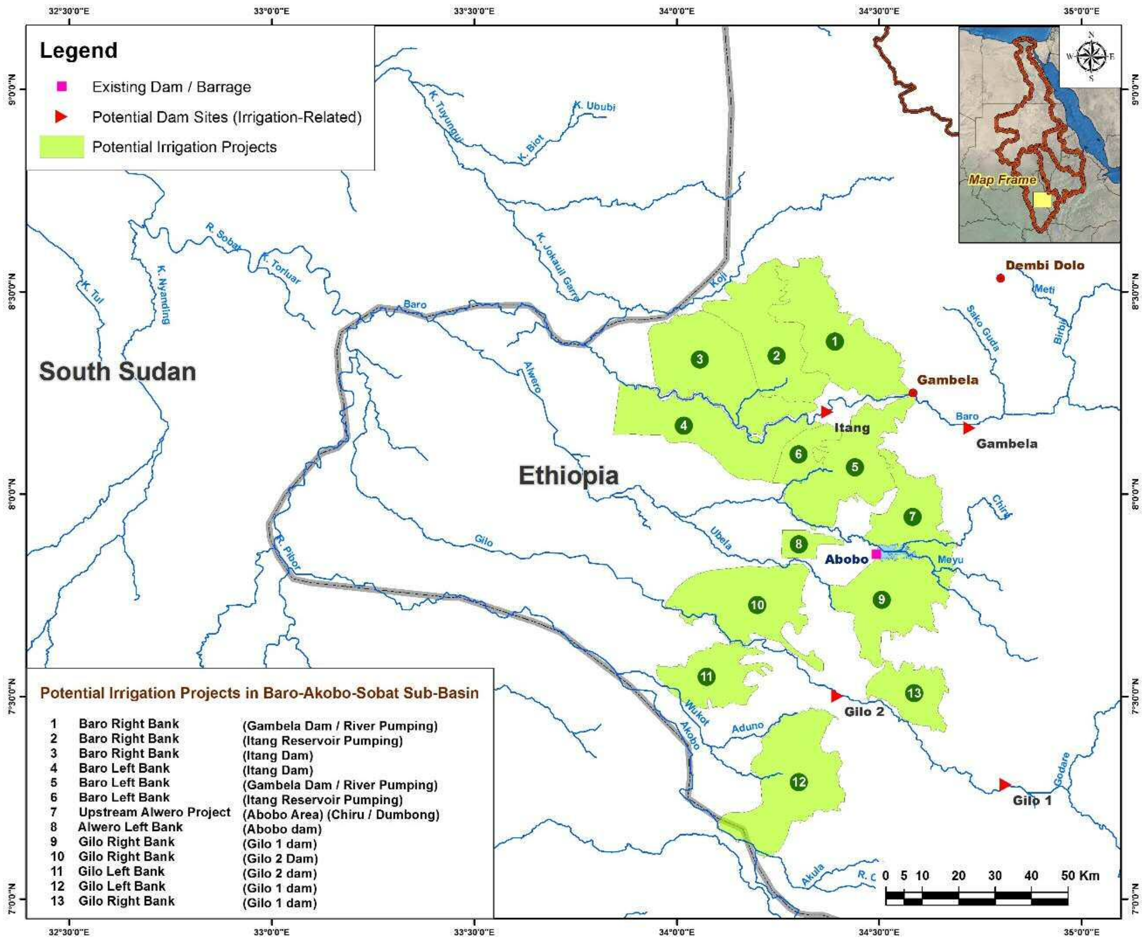


Figure 5-11: Existing and planned irrigation schemes in the Baro-Akobo-Sobat Sub-basin

Rapid expansion in the 1970s saw the establishment of sugar estate on the White Nile in Sudan.

Table 5-19: Existing irrigation Schemes in the Baro-Akobo-Sobat and White Nile

Scheme name	River	Country	Area (ha)	Estimated Water Requirement (Mm^3 /a)
NUNIS (South, North, West Renk,	White Nile	South Sudan	35,000	460
SS/traditional Schemes	Various	Ethiopia	6,000	50
Assalaya (sugar)	White Nile	Sudan	15,000	79
Kenana Sugar Estate	White Nile	Sudan	36,000	190
White Nile Sugar scheme	**White Nile**	Sudan	50,000	265
White Nile Pump Schemes	White Nile	Sudan	140,000	740
Total			**282,000**	**1,784**

PLANNED PROJECTS

The South Sudanese Government is committed to developing the irrigation potential within the basin. However, information on the exact size and locations as well as, the water requirements of the planned irrigation expansions is not available at pending the completion of the ongoing IDMP preparation.

Table 5-20: Planned irrigation Schemes in the Baro-Akobo-Sobat and White Nile

Scheme name	River	Country	Area (ha)	Estimated Water Requirement (Mm^3 /a))	Status
Baro left and Right	Baro	Ethiopia	326,566	**4,409**	Master Plan
Alwero left and right	Alwero	Ethiopia	48,265	**652**	Master Plan
Gilo left and Right	Gilo	Ethiopia	256,178	**3,458**	Master Plan
White Nile Sugar	White N.	Sudan	150,000	2,325	
Totals			781,000	10,844	

5.3.8.2 Abbay-Blue Nile,

CURRENT PROJECTS/SCHEMES

In Ethiopia the existing large scale irrigation schemes cover only an area of only 17,000 ha (see Figure 5-12). 10, 000 ha Fincha –Neshe Sugar scheme and 7,000 ha Koga small holders irrigation scheme). Other small scale irrigation schemes cover about 57,000 ha, 80% of which are traditional. From the large scale schemes, Fincha produces sugarcane under sprinkler irrigation and is one of the best performing irrigation schemes in the country. Koga is a recently implemented public small holders scheme.

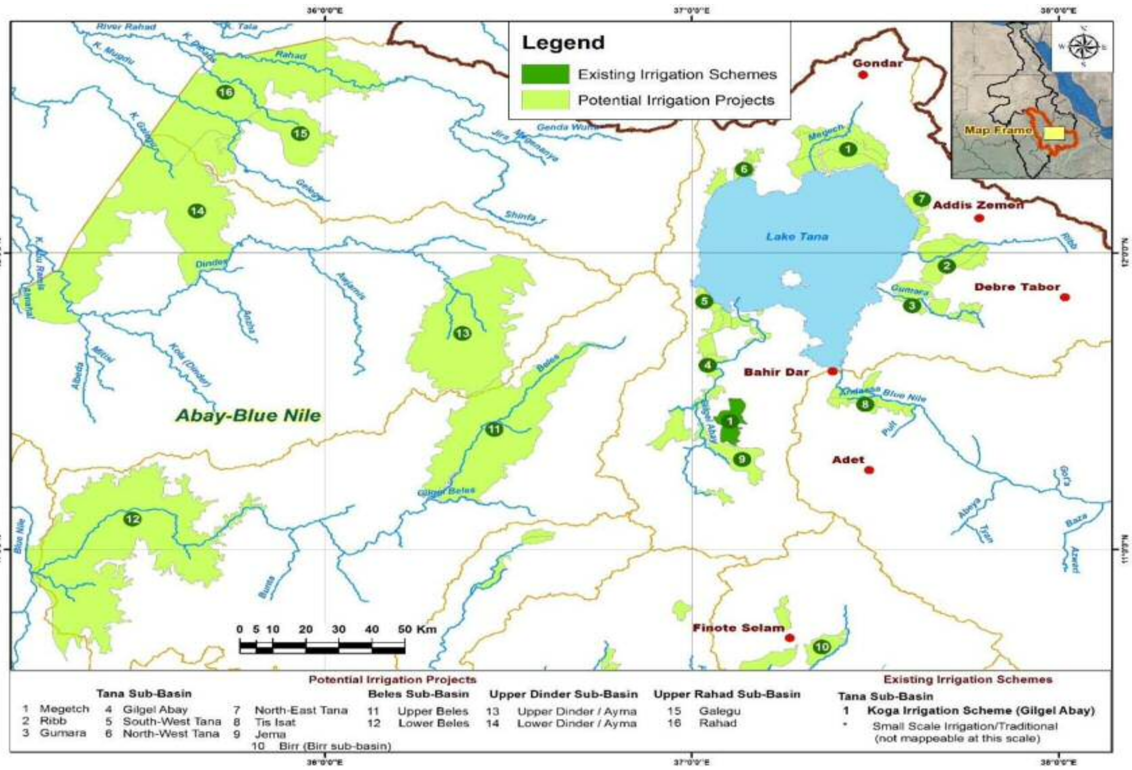


Figure 5-12: Existing and planned irrigation projects in the Abbay-Blue Nile Sub-basin; Lake Tana &d Beles Sub-basins

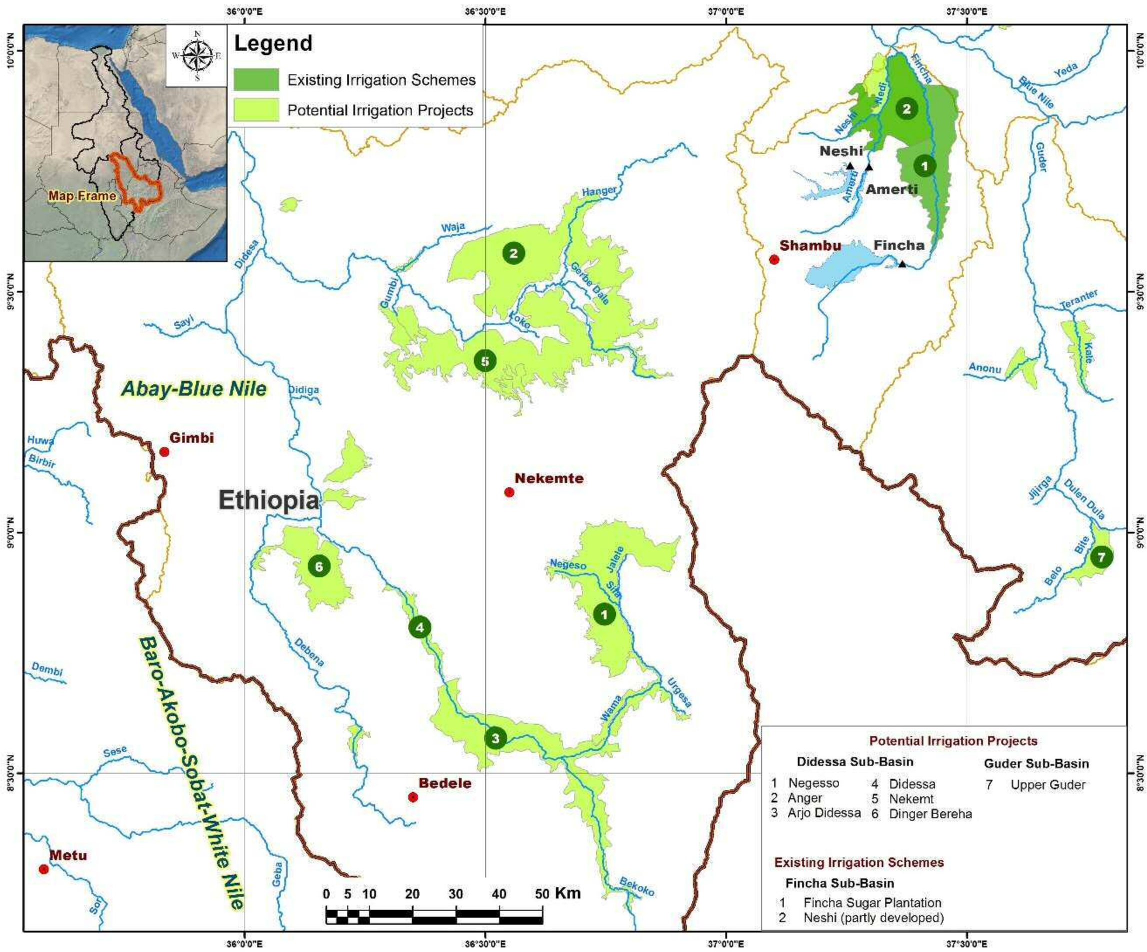


Figure 5-13: Existing and planned irrigation schemes in the Abbay-Blue Nile Sub-basin; Dedessa, Guder, Fincha Rivers

In Sudan existing schemes include the large irrigation schemes like Gezira, Rahad and Suki and pump schemes along the Blue Nile.

Table 5-21: Existing irrigation Schemes in the Abbay-Blue Nile Sub-basin

Scheme name	River	country	Area Ha	Water Requirement (Mm^3/a)
Fincha Suger	Fincha-Neshe	Ethiopia	10,000	75.3
Koga	Koga	Ethiopia	7,000	54.53
SSI/Traditional	Various	Ethiopia	57,000	399
Gezira and Managil	Blue Nile	Sudan	924,000	4,888
Rahad I	Blue Nile	Sudan	126,000	667
Suki	Blue Nile	Sudan	36,000	190
North West Sennar (Sugar)	Blue Nile	Sudan	14,000	74.4
Guneid	Blue Nile	Sudan	15,000	190.4
Abu Nama (jute)	Blue Nile	Sudan	13,000	69
Blue Nile Pump schemes	Blue Nile	Sudan	153,000	809.4
Totals			1,355	7,417

Planned Projects

Planned projects in the sub-basin are summarised in the table below.

Table 5-22: Planned iirrigation Schemes in the Abbay-Blue Nile Sub-basin

Scheme name	River	Country	Area (ha)	Water Requirement (Mm³/a)	Status
Lake Tana Sub Sub-basin					
Rib	Rib	Ethiopia	14,000	**121**	Ongoing
Megech (Seraba)	Lake Tana	Ethiopia	6,532	**52**	"
Megech - Gravity	Megech	Ethiopia	10,350	**89**	FS+Dam construction in progress
Gumara	Gumara	Ethiopia	14,100	**120**	FS completed
Tis Abbay	Blue Nile	Ethiopia	11,300	**94**	Reconnaissance
North East Tana	Lake Tana	Ethiopia	5,750	**48**	"
North West Tana	«	Ethiopia	6,720	**54**	"
South West Tana	«	Ethiopia	5,130	**42**	"
Gilgel Abbay	Gilgel Abay	Ethiopia	10,000	**81**	"
Jema	Jema	Ethiopia	7,800	**60**	"
Birr	Birr	Ethiopia	10,000	**91**	"
Small scale/ Traditional	Various streams	Ethiopia	171,000	**1,197**	"
Beles Sub sub-basin					
Upper Beles	**Beles**	Ethiopia	**53,720**	**532**	F.S. completed
Lower Beles	**Beles**	Ethiopia	85,000	851	Reconnaissance
Dedesa Sub sub-basin					
Negesso	Negesso	Ethiopia	13,800	**73**	FS completed
Anger	Anger	Ethiopia	14,450	**92**	"
Arjo-Dedesa	Dedessa	Ethiopia	**80,000**	**480**	F.S. Ongoing
Didessa pumping	«	Ethiopia	4,800	**48**	Reconnaissance
Upper Guder	Guder	Ethiopia	6,700	**37**	"
Nekemt	Anger	Ethiopia	11,200	**72**	"
Dinger Berha	Dedesa	Ethiopia	7,500	**46**	F.S completed
Dabus	Dabus	Ethiopia	10,000	**72**	F.S. Ongoing
Dindir-Rahad Sub Sub Basin					
Upper Ayma (Dindir)	DnidIr	Ethiopia	10,000	**98**	
Lower Ayma (Dinder)	Dnidir	Ethiopia	49,550	**555**	
Gelague	Gelague	Ethiopia	9,900	**108**	
Rahad	Rahad	Ethiopia	45,100	**499**	
Sub-total Ethiopia			674,402	5,612	
Rahad II	**Blue Nile**	Sudan	273,000	**2,594**	**F :S completed**
Dinder South	**"**	Sudan	24,000	**228**	**Reconnaissance**
Dinder North	**"**	Sudan	106,000	**1,007**	**«**
Great Kenana	**"**	Sudan	190,000	1,805	**F :S complted**

Roseires	"	Sudan	123,000	1,169	**Reconnaissance**
Sub-total Sudan			**716,000**	**6,802**	
Total			**1,390,402**	**12,614**	

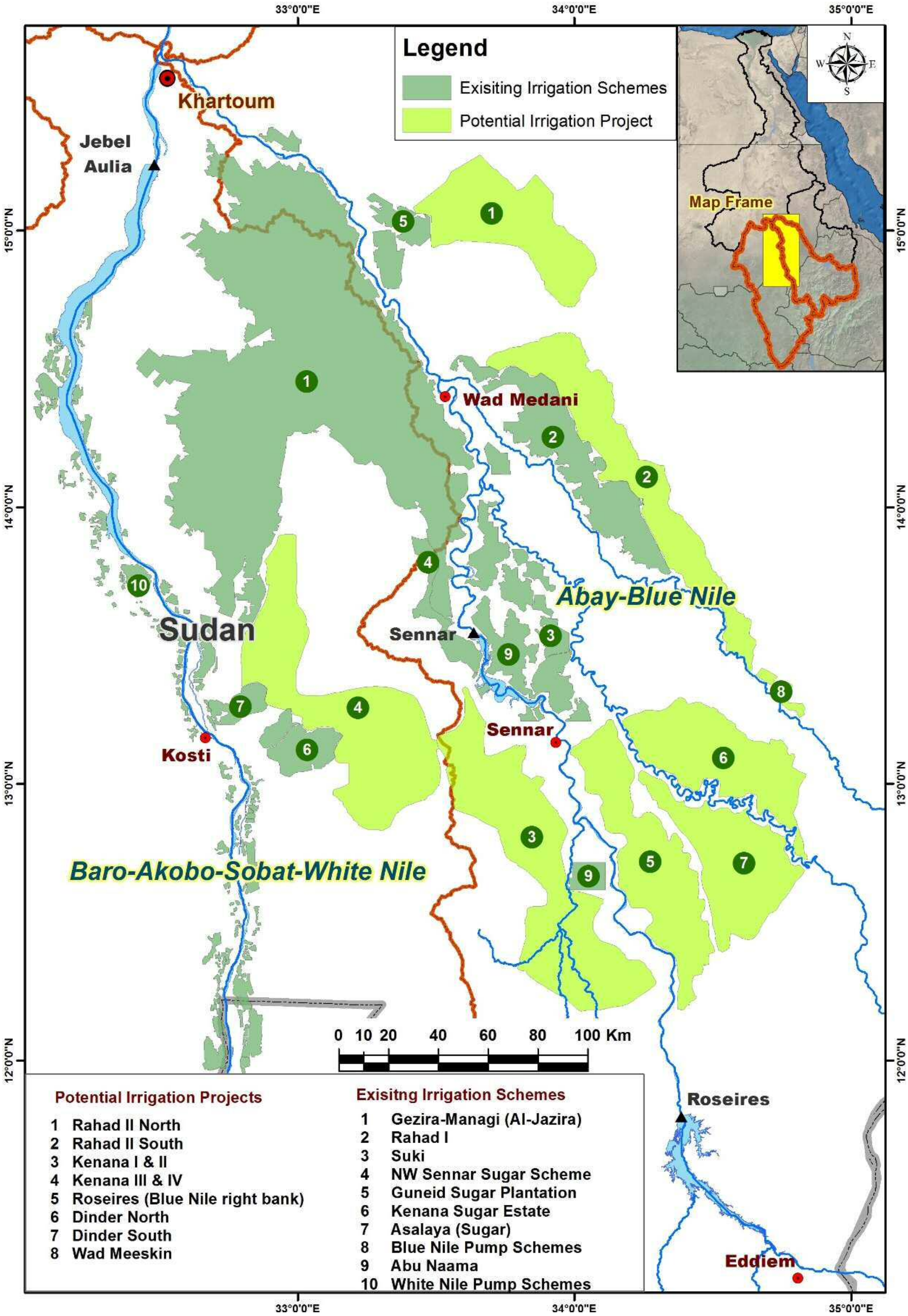


Figure 5-14: Existing and planned irrigation schemes in the Abbay-Blue Nile Sub-basin; Lower Part

5.3.8.3 Tekeze-Setit-Atbara,

CURRENT PROJECTS

Few irrigation projects have been developed in the sub-basin

Table 5-23: Existing irrigation Schemes in the Tekeze-Setit-Atbara Sub-basin

Scheme name	River	country	Area Ha	Water Requirement (Mm^3/a)
SSI/Traditional	Various	Ethiopia	40,000	280
New Halfa	Atbara	Sudan	146,000	772
Haifa Sugar	Atbara	Sudan	15,000	79
Total			**201,000**	**1,131**

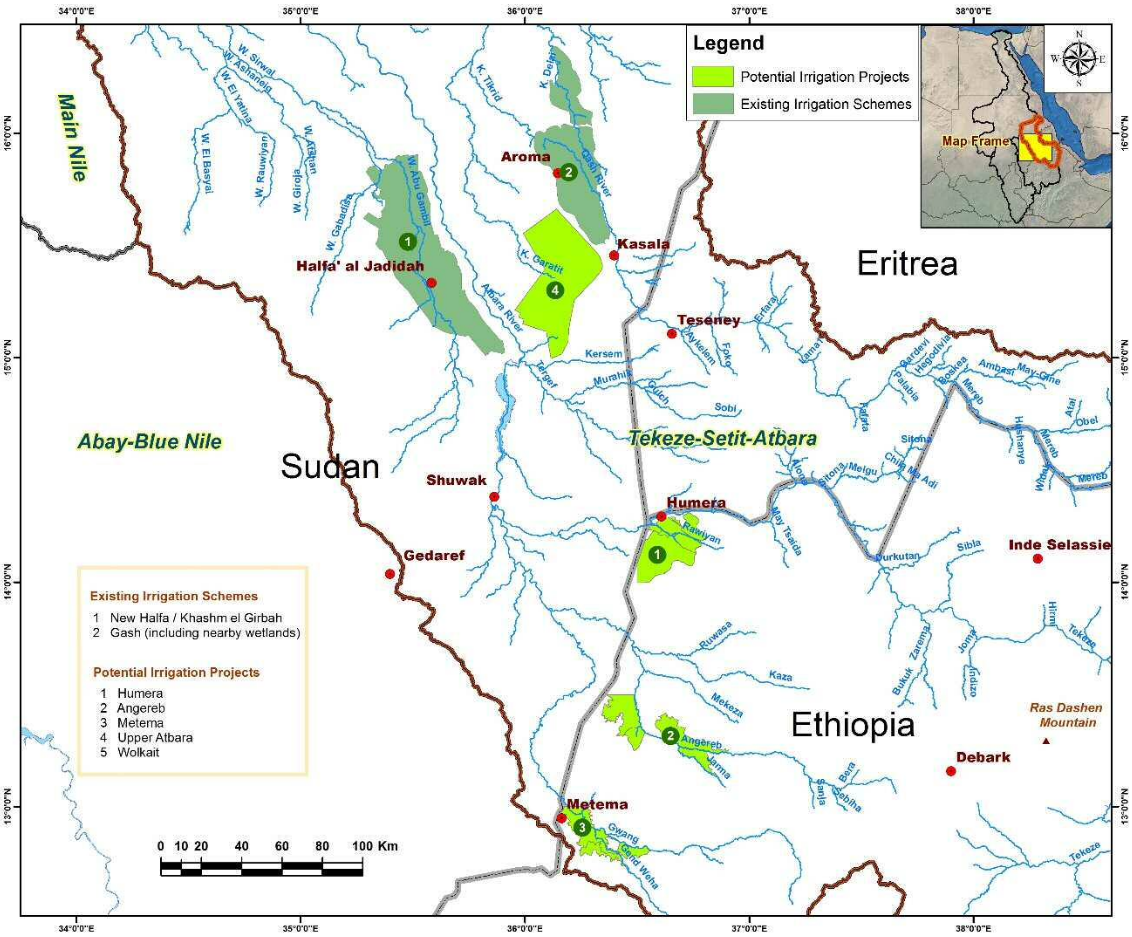


Figure 5-15: Existing and planned irrigation schemes in Tekeze-Setit-Atbara Sub-basin

PLANNED PROJECTS

Some significant schemes are planned for implementation within the Ethiopian part of the basin. Construction of a storage dame to support a project of 99,000ha in Sudan has been completed.

Table 5-24: Planned irrigation Schemes in the Tekeze-Setit-Atbara

Scheme name	River	Country	Area (ha)	Water Requirement (Mm^3/a)	Status
Humera	Tekeze	Ethiopia	60,000	**1,236**	F.S completed
Angereb	Angereb	Ethiopia	16,540	**223**	Master Plan
Metema	Gend Wuha	Ethiopia	11,560	**156**	Reconnaissance
Wolkayite		Ethiopia	50,000	**775**	F.S. completed
Small scale/ Traditional	Various streams	Ethiopia	141,860	**1,419**	Reconnaissance
Upper Atbara	Atbara	Sudan	200,000	1,900	FS completed and dam construction underway
Total			**479,960**	**5,709**	

5.3.8.4 Main Nile

CURRENT PROJECTS

A huge area of land is irrigated in the main Nile basin within Egypt. Scheme details are summarised in Annex 10. In the table below, only the total for Egypt on the main Nile is provided.

Table 5-25: Existing irrigation Schemes in the Main Nile Sub-basin

Scheme name	country	Area Ha	Water Requirement (Mm^3/a)	Water Requirement (m^3/a)
Main Nile pump schemes	Sudan	197,000	650	Main Nile pump schemes
All existing schemes in Egypt (See Annex-10 for Details)	Egypt	3,345,000	57,800	All existing schemes in Egypt (See Annex 10-for Details)
Total		**3,542.000**	**58,450**	**Total**

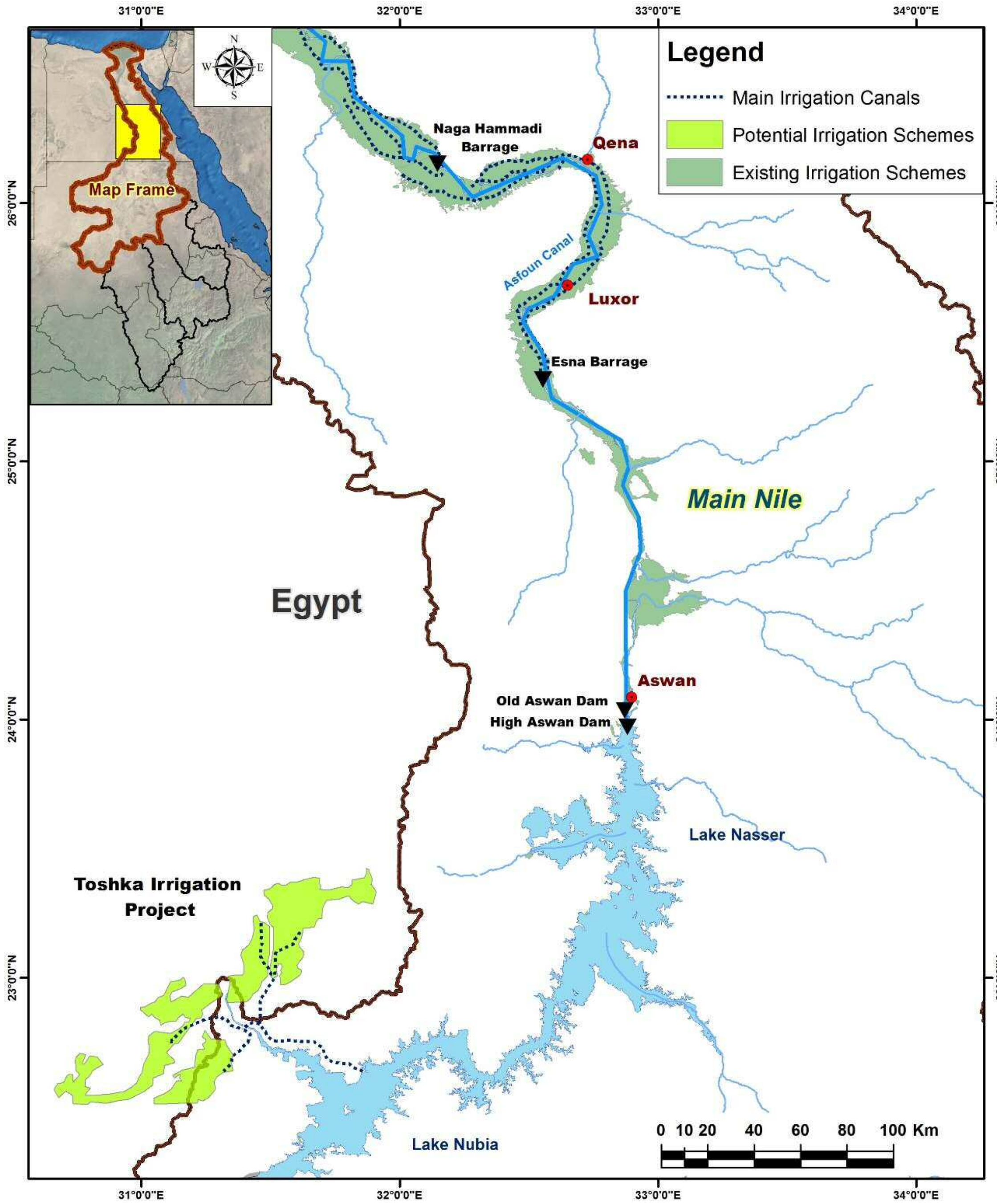


Figure 5-16: Existing and planned irrigation schemes in Main Nile Sub-basin (Aswan area)

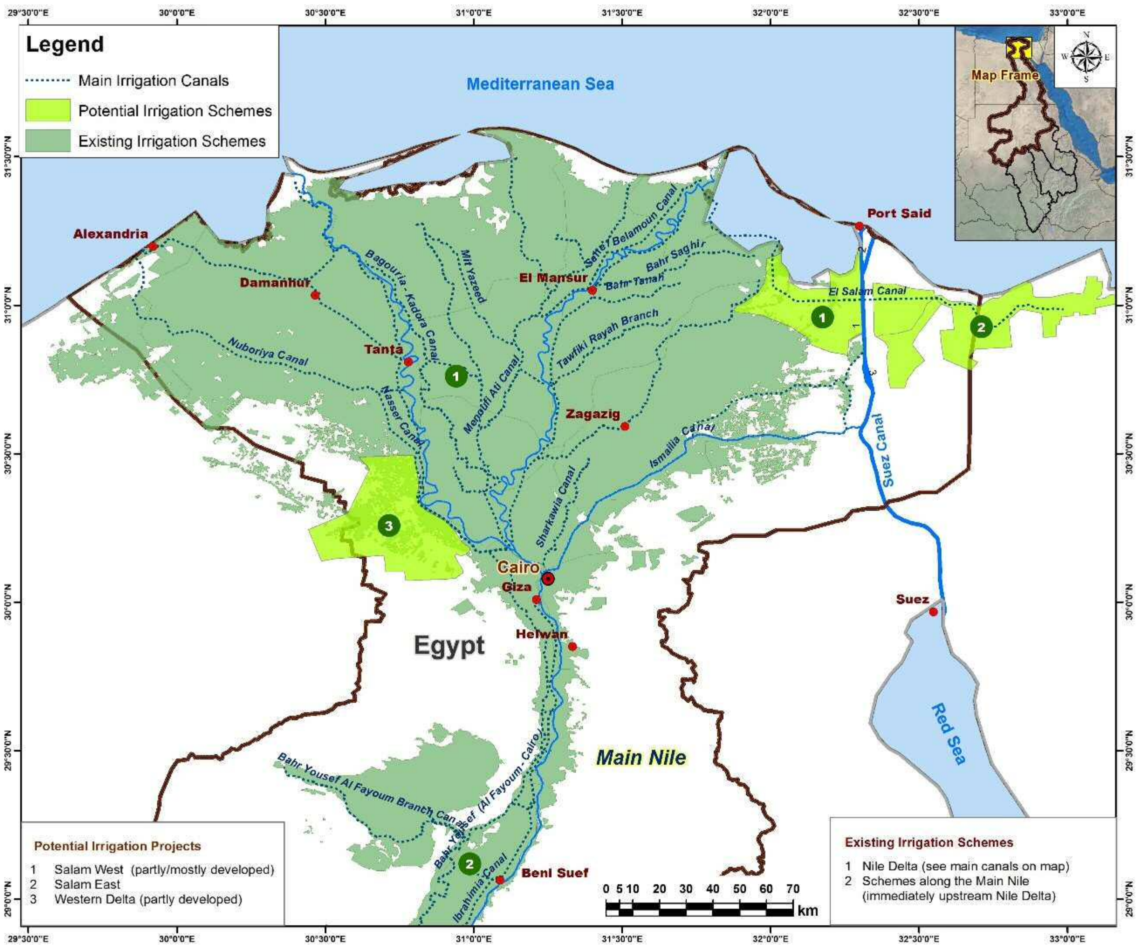


Figure 5-17: Existing and planned irrigation schemes in Main Nile Sub-basin (lower Nile)

PLANNED PROJECTS

Table 5-26: Planned irrigation Schemes in the Main Nile Sub-basin

Scheme name	River	Country	Area (ha)	Water Requirement (Mm³/a)	Status
Main Nile Sugar	M Nile	Sudan	100,000	1,555	Reconnaissance
Tushka	Nile	Egypt	226,800	5,000	NA
Upper Egypt and South Valley development	Nile«	«	431,760	8,130	NA
El Salam canal (phase 2)	Nile«	«	168,000	2,906	NA
West Delta Project	Nile«	«	107,100	1,610	NA
North Sinai Development	Nile«	«	105,000	1,500	NA
West Delta and Northern Development	Nile«	«	78,540	940	NA
Total			1,217,200	21,640	

5.3.9 Conclusions/Recommendations

Agriculture makes a large contribution to the GDP of all four countries and employ 32 to 90% of the labour force. Significant Agriculture is by far the most predominant economic activity in the Eastern Nile Sub-basin. It contributes 20 to 46 % of the portion of the export earnings also comes from the agricultural sector. A wide variety of crops are grown for export and local consumption. Crop production system ranges from largely rain fed subsistence agriculture to large irrigated schemes, the latter of which are mainly found in Egypt and Sudan, and to limited extent in Ethiopia. There are huge variations in production levels, from very low in South Sudan to relatively high in Egypt. All countries are not able to produce sufficient amount of food crops to meet the demands of the growing population and have to rely on importing significant portion of their requirements. Highly variable rainfall and recurrent draughts, use of poor agricultural/irrigation technologies and inputs, inadequate research and extension services, and absence of rural infrastructure, market and credit facilities are among the major factors contributing to the existing low production levels in the countries.

All countries in the EN consider irrigated agriculture as the major driving force for enhancing food security and increasing to the contribution of the agricultural sector to their economies. There is about 5.3 million hectares of land currently under irrigation in the EN, almost all of which is located in the two downstream countries, Sudan and Egypt. Although Ethiopia and South Sudan have huge potential, irrigation development so far is insignificant. All countries have ambitious plan for expansion of irrigation schemes. The planned expansion in the three countries Ethiopia, Egypt and Sudan alone amounts to 3.88 million hectares (Table below). The planned expansion in South Sudan is currently not known as the country is under preparation of Irrigation and Drainage Master Plan (IDMP). Estimated existing water use and additional water requirement for future expansions in the three countries are 74 and 51 BCM per annum. The future water requirement would increase substantially when the requirement of South Sudan is included.

Table 5-27 : Summary of existing and planned irrigation schemes in the Eastern Nile

Country	Existing irrigated land(ha)	Estimated Existing water use (BCM/anum)	Planned expansion Area (Ha)	Estimated Additional Water requirement (BCM/anum)
Egypt	3.35 million	58*+ 10**	1.12 million	20
Sudan	1.8 million	10 + 5***	1.17 million	13
Ethiopia	0.12 million	0.86	1.59 million	18
South Sudan	35,000	0.46	NA	NA
Total	**5.31 million**	**84.32**	**3.88 million**	**51**

* Amount includs the 4.8 BCM recycled water and 6 BCM renewable ground water use in Egypt
*- Evaporation loss at Aswan Dam
**- Evaporation loss from existing Dams in Sudan

As can be seen from the above table, the existing water use in the countries (including the consumption by the other competitive users municipality, industry, etc has almost reached to the full capacity of the River Nile. It will thus, not be possible to implement all the planned expansions as it is now, unless additional water is made available for the irrigation sector, through use of all available opportunities, which among others, include:

- Implementation of upstream water conservation projects like constructing storage dams in Ethiopia,
- Optimization of the existing Dams operations,
- Increasing water use efficiency and productivity of the existing schemes (rehabilitation and modernization, change of cropping patterns, etc) and
- Implementation of integrated joint/trans boundary projects, etc.

Moreover, except for the fast-track Irrigation Projects (Tana-Beles-Ethiopia, Upper Atbara-Sudan and West Delta-Egypt), on which the three countries in 2004 jointly identified and agreed to undertake detail feasibility studies on 100,000 ha in each country and out of this develop 20 to 30,000 ha, all the rest of the expansion projects are planned unilaterally by the countries. While this is understandable from food security and rural economy development point of view, the impact of increased upstream water abstraction on downstream water resources and vice-versa is not yet properly known. Since unilateral planning and development of irrigation expansions could be a potential source of conflict, safe irrigation expansions that have no significant detrimental effects on downstream or upstream water resources availability should be identified in a coordinated manner based on proper study and analysis. These require the continuous effort, dedications, and high level of cooperation and trust among all the four EN countries.

5.4 LIVESTOCK

5.4.1 Introduction

The Region is endowed with huge potential for livestock development. It has the largest livestock population in Africa. However, the development and contributions of the livestock sectors to the national economies of the countries so far is not as expected.

The total water requirements for the sector is significant but is spread out. Natural surface water bodies and groundwater are the main watering sources. While the development of water resources for livestock is unlikely to feature as a regional-scale water resources development project, it is important that other types of development (especially irrigation) take into account the needs of livestock farmers.

Better livestock farming practices are also a key component of watershed management interventions.

5.4.2 Ethiopia

Livestock production plays an important role in Ethiopia's economy. It contributes to 12-16% of the GDP, one-third of the agricultural GDP and 16% of the total export value (MOARD, 2013). It also contributes to the livelihood of 70% of the total population. Livestock are source of food, draft power, transport, bio-fertilizer and fuel, cash income and social prestige especially in pastoral areas. In actual sense, the livestock contribution to the national economy is much larger than it is thought when animal transport, draught power, fertilizer, etc are taken into consideration.

In the highlands, livestock is an integral part of the crop production system. Almost all house hold in some way keeps livestock at subsistence level for draft power, transport, meat, milk and as source of income. Population density and expansion of cultivated areas has limited grazing areas and heavily affected livestock production in the highlands. In the lowlands, livestock supports the livelihood of approximately 10% of the total population living in the Afar, Somali and Borena regions. Livestock is the major source of livelihood of these populations that are highly mobile in search of water and grazing. Camels are the most important animals serving as both food and means of transport. However, the lowlands are affected by recurring draught which results in heavy loss of livestock population.

Ethiopia has the largest livestock population in Africa. About 70% of the cattle are in the highlands, and the remaining 30 percent are kept by nomadic pastoralists in the lowland areas. Most of the estimated 50 million sheep and goats are raised by small farmers who used them as a major source of meat and cash income. About three-quarters of the total sheep flock is in the highlands, whereas lowland pastoralists maintain about three-quarters of the goat herd. Camels are kept in the lowlands below 1500 masl.

Table 5-28 : Livestock population in Ethiopia (millions)

Livestock	2012	2013
Cattle	53.99	54
Sheep	25.48	26.5
Goat	24	25
Horses	1.9	2
Mules	0.35	0.35
Donkeys	5.6	5.7
Camels	0.92	0.93

Source: FAO-STAT (2014)

Though the country has great livestock potential both for local use and export, its production and contribution to the national economy is not as expected due to a number of constraints. These, among others, include:

- Technical constraints- genetic limitation for production, inadequate and poor quality of feed resources, prohibitive price of crossbred heifers. The dominant local breed of cattle are the Zebu type, which have low meat and milk yields,
- Institutional constraints - Poor linkage between research, extension and technology users, inadequate extension and training service, unreliable market and unavailability of credit.
- Socio-economic constraints - Unavailability of adequate grazing land due to shrinkage and degradation of rangelands, recurrent drought and conflict especially in the lowlands. Practically all animals are range-fed. During the rainy seasons, water and grass are generally plentiful, but with the onset of the dry season, forage is generally insufficient to keep animals nourished and able to resist disease; reluctance of pastoralists to commercialize cattle because of social importance and lack of alternative assets,
- limited and periodic access to appropriate animal health services, heavy reliance on the public sector for animal health services, poor facilities for health services,
- Absence of proper marketing structure; lack of domestic and international market information system, inadequate processing and cold storage facilities, under-developed livestock transportation systems, repetitive taxation, etc. Only 2% of milk produced in the country is marketed,
- Little involvement of the private sector in processing and marketing of livestock and livestock products; only 150,000 litres of milk is processed daily

5.4.3 South Sudan

Large parts of the population in South Sudan are supported by Livestock for their livelihood. Especially in the floodplains and the semi-arid pastoral areas, livestock is the major source of livelihood for the pastoral and semi pastoral communities. In addition to its important cultural value, livestock is one of the important activities of the agricultural sector contributing approximately 15% of the GDP (Situation Analysis Report-CAMP, 2013). According to FAO's 2009 estimates, South Sudan has substantial livestock population (see table below) making the country the 7th in Africa and the 3rd in the EN countries. Given the relatively small human population, the country has also the largest livestock per capita holding in Africa. More than 85% of the households hold one or more livestock, to support their livelihood. Herds are concentrated primarily in western parts of Upper Nile state, and in East Equatoria, Jonglei and Bahr El- Ghazal states.

Table 5-29 : Livestock population in South Sudan (millions)

Livestock	2012
Cattle	11.75
Sheep	12.10
Goat	12.45
Horses	1.90
Mules	0.35
Donkeys	5.60
Camels	0.92

Source: SAR – CAMP (2013)

Livestock are mainly raised by pastoralists and semi- pastoralists, accounting for 47 and 43% of the livestock population respectively. Communities living in urban and surrounding areas keep the remaining 10% of the livestock population (SAR-CAMP, 2013). Under the pastoralist and semi-pastoralist system, production is entirely dependent on access to grazing land and watering points. This being the case, shortage of grazing land due to expansion of sedentary faming, draught and flooding is often the source of internal conflict in the country.

Nevertheless, South Sudan has significant size of livestock population, its potential has not yet been fully exploited and its contribution to income generation, food security, industrial growth and export is not as expected. Some studies indicate that the estimated value of current livestock production is equivalent to 20% of the sub-sector's potential. Market value is only limited to the sale of red meat, mostly within the immediate local rural market and adjacent urban centres. The country, which was once exporter of cattle to neighbouring countries Uganda and Kenya, is now importing meat from Uganda.

Major challenges limiting the production and exploitation the livestock sub-sector, among others, include:

- Lack of comprehensive policy, legal and regulatory frameworks,
- Poor productivity due to predominantly traditional subsistence nature of production system,
- Lack of veterinary, research and extension Services,
- Conflicts and insecurity disrupting livestock activities,
- Lack of water and pasture,
- Lack of shelter/space,
- Inadequate road infrastructure and means of transportation; absence of processing facilities,
- Lack of both skilled and unskilled man power,
- Lack to access to markets , inadequate Information and communications technologies,

5.4.4 Sudan

Next to crop production, livestock is the second most important sub-sector within the agricultural sector in Sudan. Livestock export has become an increasingly important part of the economy, competing with cash crop sales as the fastest growing non-oil export sector. This is largely due to initiatives such as the recent rehabilitation of livestock export facilities (including veterinary quarantine centres), provisions of watering points and revisions to livestock marketing and taxation policy. Sudan's close proximity to the large and expanding market of the Arab world is also an additional advantage for the growing contribution of the sub sector to the economy. After the lifting of the import ban on Horn of Africa livestock in 2009, the demand for Sudan's livestock (camels, sheep, goats and cattle) has increased in Egypt, the Arab States of the Gulf and Saudi Arabia. The sub sector comprises about 47% of the agricultural GDP for the period 2000-2008; this contribution is increasing over the years implying the increasing importance of this sub-sector (ENTRO-Economic models for the analysis of Agricultural policies of Sudan).

In Sudan, some 5% of livestock are raised by settled farmers, and 95% are raised by pastoralists who are either transhumance or nomads. The latter crossing borders into neighbouring countries in search of water and pasture for their livestock. Due to this and absence of regular census, it is difficult to estimate the exact numbers of livestock in Sudan. However, many studies indicate that, Sudan has the second largest herd in Africa. (see table below). Sudanese cattle are of two principal varieties: Baqqara and Nilotic. The Baqqara and two sub-varieties constituted about 80 percent of the country's total number of cattle.

Table 5-30 : Livestock population in South Sudan (millions)

Livestock	2012
Cattle	29.30
Sheep	39.00
Goat	30.50
Camels	4.60
Mules	0.35
Donkeys	5.60
Camels	0.92

Source: QUASI special Report (2012)

Sudan is self-sufficient in meat and other livestock products. In 2005, Sudan produced 350,000 tonnes of cattle meat and 5.5 million tonnes of cow milk making the country self-sufficient for these products. Sudan exports live animals, meat, skin and hides mainly to the Arab countries. However, several constraints deprive the country from realizing the full potential of this sub-sector (ENIDS-CRA study). Major constraints include:

- Overgrazing in some areas, particularly around settlements,
- The great distances that animals often have to travel in search of water and pasture,
- Expansion of agriculture, particularly mechanised farming, into traditional grazing land, often causing conflicts between transhumant and settled farmers;
- Draught and seasonal nutritional deficiencies;
- Prevalence of disease leading to early culling of cattle;
- Poor husbandry and veterinary services;
- Poor integration of livestock in the rotation of arable crops including absence of fodder in the rotation;
- Difficulty of marketing and processing milk due to the remoteness of grazing areas far from the centres of consumption;
- Lack of processing facilities, services and infrastructure such as research, extension, roads, and livestock markets.

5.4.5 Egypt

Livestock in Egypt is an important component of the agricultural sector, representing about 24.5% of the agricultural gross domestic product with value of more than USD 6 billion (FAO, 2011). Livestock population has shown increment in the past years. The cattle population amounts 4.95 million head, while the buffalo population reached 4.2 million head in 2013. Regarding small ruminants, the sheep population reached 5.45 million head, while the goat population exceeded 4.3 million head in 2013. The camel population is about 142,000 head, while horses and asses exceeded 4 million head in 2013 (FAO STAT 2013).

Table 5-31: Estimated livestock Population in Egypt

Livestock	2009	2010	2011	2012	2013
Cattle	4,524,950	4,728,721	4,779,743	4,946,410	4,950,000
Buffaloes	3,838,721	3,818,236	3,983,167	4,164,928	4,200,000
Sheep	5,591,580	5,529,529	5,365,065	5,429,524	5,450,000
Goats	4,139,257	4,174,986	4,258,175	4,306,258	4,350,000
Asses	3,350,000	3,350,000	3,355,000	3,355,000	3,356,000
Camels	137,112	110,571	136,930	141,537	142,000
Horses	66,215	65,965	71,087	74,042	74,050
Total	**21,647,835**	**21,778,008**	**21,949,167**	**22,417,699**	**22,522,050**

Source: FAO STAT, 2014

There are three types of livestock production systems in Egypt. These include.

- **Traditional:** is largely subsistence oriented system for the farm family and surrounding communities. It is characterized by low production inputs and outputs and holding of few animals. It is practiced for sheep, goats, cattle, and buffalo in the various agro-ecological zones.
- **Semi- intensive**: The semi-intensive sub-system depends on improved local breeds and husbandry techniques for producing raw buffalo and cow milk. Lamb and calf fattening is also practiced. Small farmers who do not own agricultural lands or control agricultural holdings are the main producers,
- **Intensive systems**: The intensive production sub-system is characterized by high inputs and outputs as well as very large livestock holdings. This sub-system operates on the production of exotic cattle and constitutes about 10% of the total animal production system. It is the source of milk for the local milk processing industries. About 60% of white meat production comes from this sub system also.

About 98 % of the livestock sub sector is run by the private sector, a large portion of which are small holder /traditional farmers. The government owns only 2% of the livestock population. The cattle population is largely concentrated in middle Egypt and middle Delta regions. While about a third of the buffalo population is found in the Middle Delta region. Sheep and goat are concentrated in upper and middle Egypt and Western Delta regions. Indigenous cattle represent about 60% of all the cattle population, while mixed-breed cattle represent about 37% and imported cattle about 3%.

The rangeland in Egypt is poor because of little rainfall unevenly distributed over limited areas. According to FAO (2010) rangelands provide only 5% of animal feed in Egypt. The main source of livestock feed is therefore, clover (berseem) cultivated on the irrigated areas. Alfalfa is also used to some extent. Up to 1.2 million ha (20% of the cultivated land) in Egypt is covered by fodder crops annually.

The cut-and-carry feeding system is associated with small scale irrigated farms (less than 1–2.5 ha) where fodder crops (berseem, alfalfa, sorghum, Sudan grass, etc.) are harvested to feed farm animals. Surplus green fodder is sold in nearby towns and villages to other livestock owners. Weeds and crop residues are also used. In large-scale dairy farms irrigated fodder crops are produced, mainly berseem in winter and sorghum and maize (corn) silage in summer. Mechanical harvesting (chopping) and hand cutting are both practiced and green fodder is fed among total mixed rations to the dairy herd, while any surplus may be made into hay which is baled and stored.

Though the livestock sub sector in Egypt is important for the economy, it is still undeveloped and the country is not self-sufficient in beef production as yet. In 2012, Egypt imported 47,600 heads of live cattle, 85, 365 tons of frozen beef, 1,800 tons of chilled beef and 49, 270 tons of frozen buffalo meat (USDA, 2012). It is estimated that import of live cattle will increase to more than 100, 000 heads in the coming years.

The large potential of the sub- sector in Egypt is largely lost due to a number of constraints, which include:

- Shortage of animal feed is the major limiting factor, causing high mortality of young animals and low daily weight gain and poor reproduction performances. This is more sever in rain fed areas, where there is inadequate use of beresem,
- Shortage of water in most range areas located far from the River Nile and irrigated areas. Animals often have to travel long distances to water points,
- Inefficient marketing channels and a lack of reliable market information, particularly for the small scale production system,
- In adequate veterinary, extension services and limited access to improved breeds, especially to small scale farmers,
- Resource degradation, due to overgrazing and poor range management,
- Intrusion of other usessuch asdry land farming on to range lands,
- Low animal product prices, not sufficient to attract investment due to competition with imported products,
- Occurrence of frequent draught in rain fed areas.

5.4.6 Conclusions

Livestock is a crucial subsistence and economic activity in all the EN countries, the region being home for the largest livestock population in Africa. It is a major means of livelihood especially for pastoralists and agro-pastoralists living in the semi-arid areas of Ethiopia, Sudan and South Sudan. Livestock potential in the region has not yet been fully exploited due to a number of constraints, which among others include; shortage of drinking water supply and pasture, inadequate research, extension and veterinary services, lack of market, absence of clear policies and adequate legislation.

5.5 URBAN WATER SUPPLY

Domestic water use varies greatly depending on the location of use. The rate of use is high in capital cities due to high standard of living and low in rural areas. The use rate also depends on the availability of water and season. For the Eastern Nile, domestic water demand is calculated for major cities as well as urban and rural areas.

The consumption of the four capital and major cities of the EN are Cairo, Addis Ababa, Juba and Khartoum is summarised in , although it should be noted that Addis Ababa is not located within the Nile Basin. The domestic water use in the cities is estimated assuming that per capita use in the cities is 150 l/d. The total water demand per year of these three cities is shown in. The table shows that the total water requirement of these three cities in a year is 642 Mm^3 /year to serve 11,724,000 people.

Table 5-32: Population and annual water use in four major cities

Major Cities	Population	Mm3/year
Addis Ababa	1,500,000	82
Cairo	9,300,000	509
Khartoum	924,000	51
Total	11,724,000	642

Source : ENTRO

There are about 159 urban centres spread over the whole EN covering an area of about 3,686 km^2 . The total population of these cities is about 7.2 million. Although the entire population does not use a constant amount of water, for this study a constant rate of water demand has been used for calculating urban domestic water use. It is assumed that per capita domestic water use in the urban centres is 90 l/day (The World's Water Volume 7). Based on this assumption total water use in the urban centres other than the capital is 236.5 Mm^3/year.

The EN has 1,533,266 km^2 of rural areas. It is found that water demand for domestic purpose is less in rural areas than in urban areas. It is assumed that per capita water demand in rural areas is 47 l/day (The World's Water Volume 7). Basin-wise water demand in the rural areas of the EN is given in 6. The table shows that the total water demand in the rural areas of the EN is 1,398 Mm^3 per year.

Table 5-33: Rural domestic water use in the Basin

Sub Basins	Population Density (hab/km²)	Rural Area (km²)	Domestic Water Use (Mm³)
Abbay-Blue Nile	66	30,704	35
Baro-Akobo-Sabat-White Nile	22	469,729	177
Tekeze-Atbara-Setite	39	230,491	154
Main Nile	75	802,342	1,032
Total		**1,533,266**	**1,398**

Note: Assumed rural Domestic Water Use is 47 l/cap/day

5.6 FLOOD MANAGEMENT

The Eastern Nile region is characterized by highly variable climate and river flows, making it prone to consequences of extremes of droughts and floods. A significant proportion of the annual runoff volume occurs during a few high rainfall months in the year, thus, requiring adequate regulation to maintain required flow during dry periods. During high rainfall periods major rivers in the region often give rise to large scale riverine flooding, particularly in floodplain areas in Sudan and Ethiopia. Severe flooding along populated areas, can have devastating effects on lives, livelihoods, and property. Infrastructure, agricultural land, and other resources at risk from floods can be vast, and include residential, commercial and industrial property, and public service infrastructure, including water supply and crops. The Eastern Nile region is particularly vulnerable to these frequent and damaging floods, causing significant loss of life and economic damages.

Flood events originating in the Blue Nile River and its tributaries are of concern to the EN riparian countries of Ethiopia, Egypt, South Sudan and Sudan. Flood events along the EN are typically caused by heavy rainfall in the Ethiopian highlands. Flood flows then concentrate in Ethiopia and Sudan before traveling downstream into Egypt. Each of the four countries is interested in being able to forecast river conditions, but the unique characteristics of the river regime in each country yield a different focus for each country with respect to forecasting needs:

In Ethiopia, localized, flash floods along Nile tributaries are of greatest concern. Example flood prone areas are Lake Tana and the Gambella plains. The Blue Nile River gorge is well entrenched, so that high flows in the gorge are generally not a safety concern. With the development of hydropower, however, there may be increased interest in hydrologic forecasting for reservoir operations.

In Sudan, the main riverine flood risk areas are located along the Blue Nile and the Main Nile. In addition, localized and flash flooding affects areas along tributaries to the Nile, such as the Atbara, Dinder and Rahad Rivers. The effects of these flash floods can be more severe when they coincide with flood flows on the Blue Nile.

In South Sudan, flood prone area in the Sobat river system due to both localized and flash flooding affects as well as river bank overtopping along the tributaries of the Sobat river cause devastating impact to the local communities.

High flows in the Nile River in Egypt affect mostly the operations of High Aswan Dam (HAD), which must be operated to prevent flood damage downstream while also preserving volume from year to year for hydropower and downstream agricultural production and water supply.

5.6.1 Flood-Affected Communities Around Lake Tana

The flood impacted communities are lake Tana include 3 adminstrative zones as part of the Amhara region. These are mainly the Fogera and Dembia floodplains which are part South Gonder and north Gonder asminstrative zones. The Amhara National Regional State (ANRS) is located in north-central and north-western Ethiopia, occupying a land mass of approximately 170 152 km2. The region is divided into 11 administrative zones, which are further subdivided into 106 woredas. The 11 administrative zones are: North Gonder, South Gonder, West Gojjam, East Gojjam, Awie, Wag Hemra, North Wollo, South Wollo, Oromia, North Shewa and Bahir Dar City special zone. Table 5-1 profiles the woredas and kebeles that have been identified as most at risk from flooding in the Amhara Region:

Table 5-34: Flood-Prone Woredas around Lake Tana

Zone	Woreda	Population		
		Rural	Urban	Total
South Gonder	Fogera	49 224	464 071	513 295
North Gonder	Dembiya	274 756	31 915	306 671
Bahir Dar	Bahir Dar City	--	159 955	159 955

Source: Annual Statistical Bulletin, BFED, 2003

The general assessment of flood exposure and vulnerability in Lake Tana reveals the following:

- Flooding in urban areas around lake Tana is mainly derived from heavy rainfall and stormwater runoff. Lack of adequate drainage system is the main cause of flooding.
- Most communities at risk from flooding in rural Amhara are located in low-lying flood plains. Floods are a necessary annual occurrence and, for the most part, communities have adequate knowledge of how to live with, and benefit from them. There is less capacity in these communities to deal with serious floods, however.

5.6.2 Flood-Affected Communities in Gambella

The Gambella plain lies in south-western Ethiopia and is part of the Baro-Akobo river basin. The Gambella plain, which makes up the western half of the Baro-Akobo basin, is characterized by rivers that originate from highlands around Gore and Masha in the east. Major rivers in the areas are Baro, Akobo, and Gilo. The two most important causes of flooding in the Gambella area are flooding resulting from rivers overflowing their banks and flooding due to inadequate drainage. Riverine flooding is further aggravated by backwater effects from the Pibor and Sobat rivers. The city of Gambella is subject to occasional flooding caused by overflow of the Baro river and some of its tributaries. There are also other cities located on the north of the Baro river that are occasionally flooded. Table 5-2 provides relevant information.

Table 5-35: Flood Damage to the Gambella Area

Woreda	Year	Population affected	Woreda	Year	Population affected
Gambella	1993	6 157	Itang	1993	28 431
	1995	27 207		1995	33 906
	1996	10 000		1996	24 267
Abobo	1993	500	Jikao	1993	27 236
	1995	33 906		1995	19 910
	1996	-		1996	10 000
Gog & Jor	1993	9 000	Akobo	1993	12 921
	1995	8 510		1995	17 641
	1996	22 500		1996	18 000

5.6.3 Flood-Affected Communities, Blue Nile and Main Nile, Sudan

Over the last years, heavy flooding was experienced in Sudan in 1998, 1999, 2001, 2002 and 2003. Socioeconomic impacts of these floods included the displacement of large communities, the loss of agricultural crops, damage to agricultural inputs such as seeds and pumps, deterioration of health conditions due to the increased incidence of malaria and diarrhoea diseases, and disruption of social services such as education and health.

Prior to this period, the country experienced very severe floods in 1878, 1946, and 1988. The 1988 flood is still vivid in the memories of many people to the effect that frequently flood levels are compared to the levels in that year to give a visual impression of the severity of flooding. The serious floods in 1988 were the first of a series of high floods to affect the country. These floods were caused by both riverine floods and flash floods. Flood impacts included loss of crops, cattle and agricultural machinery, loss of houses and property, displacement of larger communities, deteriorating health conditions and disruption of social life.

It is estimated that a total of 256 local communities adjacent to the river banks of the Blue and Main Nile are flood prone areas. However Table 5-3 describes the highly vulnerable flood prone areas in the Blue Nile and Atbara rivers in Sudan.

Table 5-36: . Summary of high risk flood prone areas in the Blue Nile and Atbara Rivers

State	Locality	Target Community	Target population estimates
Blue Nile	Gissan	Seven villages	22,440
	Damazin	Azuhur Extension	13?900
Sinnar	Singa	Elsabounabi village Umbaneen village	10,000 11,000
Khartoum	Khartoum	Tuti Island	18?000
	Khartoum North	Wawoosi village	6,000
River Nile	Addamar	Seedon	9,300
		Abaka	7,000
Total			**97,640**

5.6.4 Tuti Island, Khartoum State

As an island, Tuti Island has always been threatened by floods. The floods of 1946, 1975, 1988, 1994, 1998 and 2001 were particularly severe. What sets Tuti Island apart is the way in which the community has mobilized their own resources and capacities to manage floods. The island has become a model case for resisting resettlement as a flood mitigation measure.

At the beginning of the rainy season (from late June) people will reinforce all sand levees with sand bags. All openings that are used as access roads to the river's edge during the dry season will be closed and fortified. In a normal year, the water level will inundate up to some 80 m from the bank. It will inundate lower ground and can remain there for up to 3 months. Water-logging, with its associated problems of malaria, flies and other water-borne diseases, is considered one of the main problems of flooding on the island.

5.6.5 EN Flood Preparedness and early warning project

5.6.5.1 Overview

The Flood Preparedness and Early Warning Project is one of the fast-track projects identified for priority action under ENSAP. The project was completed in December 2011 and focuses on floodplain management and flood mitigation planning; flood forecasting and warning; and emergency response and preparedness at regional, national, local and community levels with a goal of reducing human suffering which is caused by frequent flooding while preserving the environmental benefits of floods. The specific objective of FPEW I has been to establish a regional institutional basis and to strengthen the existing capacities of the EN countries in flood forecasting, mitigation and management, promoting regional cooperation as well as to enhance the readiness of the EN countries to subsequent implementation of the subsequent phases of FPEW projects. It comprised of three key components, namely, (i) regional coordination, (ii) pilot flood preparedness and emergency response, and (iii) flood forecasting warning and communication system. The regional coordination component enabled putting in place an institutional mechanism for establishing inter-country coordination. The pilot flood preparedness and emergency response component strengthened flood preparedness and flood mitigation planning at national and local levels through flood-risk mapping; assessment of information needs by the community for effective response; and facilitated improved flood mitigation plans and mechanisms aimed at protecting property and assets. The flood forecasting warning and communication system component was aimed at improving flood forecasting institutions and developing a detailed design for EN flood forecasting, warning and communication system.

5.6.5.2 Project Achievements

DEVELOPMENT OF FLOOD FORECASTING WARNING AND COMMUNICATION SYSTEM

The project utilized already available knowledge in the region to develop Numerical Weather Prediction (NWP) models, and flood forecasting models. This has created link among Ministry of water affairs, universities, meteorological agencies and ENTRO which created common ground to work together. The involvement of educational institutions in this process also created opportunities for graduate students to conduct research in the area of flood management in the region.

Flood forecasting messages were officially issued to the communities, community leaders and to experts at higher administrative level in three EN countries. The warning messages were commented on by the local officials and, accordingly improved. The results from the developed early warning system were found to be very encouraging to be taken over beyond the pilot phase as well as to replicate to other flood prone areas in the region.

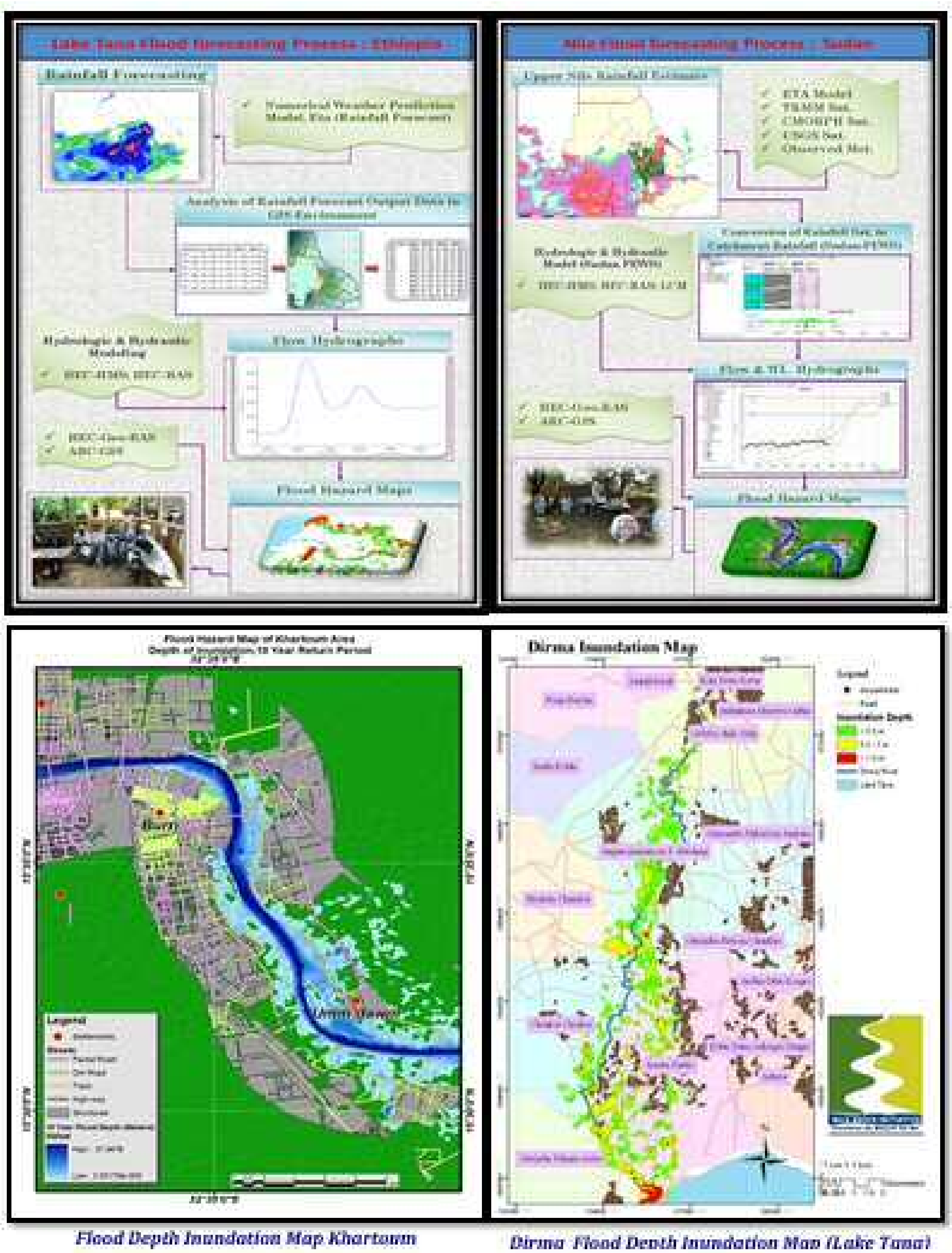


Figure 5-18: EN Flood Season Monitoring and Operationalization of Flood Forecasting Tools

Flood season monitoring in the EN started during the wet season of 2010 and the process continued up to 2014. The monitoring activities is coordinated by ENTRO headquarters. Prior to the flood season, a team is formed which comprises members from the National flood coordination unit and ENTRO staff and the setup of the activities including the responsibilities of team members, mode of communication were identified. Other logistic support for community participation in the process were also availed by ENTRO. The ENTRO regional forecasting unit received daily data to support the forecast from the National forecast centers. ENTRO staff then produce rainfall forecasts using the Numerical

Weather Prediction ETA Model and flood forecast using the set of hydrologic and hydraulic models. The daily forecast report is then issued and shared with the National Forecast centers. The National forecast centres communicate the forecast message with all the relevant agencies including Federal, State and Local Government. A weekly forecast Bulletin is also produced and disseminated to all relevant stakeholders as means to create more awareness on flood disaster management program in the EN and as alternative approach to promote data and information sharing.

COMMUNITY PREPAREDNESS AND EARLY RESPONSE PLAN

The objective of this component is to strengthen the resilience and capacities of flood impacted communities within the EN in coping with flood disaster. Due to budget and time frame limitation of Phase 1 of the project, 8 pilot communities were selected to work on in each of Ethiopia and Sudan. Two consultancy services were commissioned for preparing community action plan to the pilot communities. The approach followed in recruiting the consultant is to work with existing non-governmental organization that have existing presence at National Levels in areas of disaster relief and disaster management. The major activities identified and highlighted in the plan of action included: Enhancing Community Participation and Use of Early Warning System, Reduce the impact of physical isolation due to floods, Upgrade community preparedness and response capabilities, Enhance community awareness and build capacity of community to prepare for and manage the incidence of floods. Training to the local communities were offered as part of the program. Surveillance equipment such as colour coded poles, boats, temporary shelters, mobile phones, tents were procured and delivered to the pilot communities according to the need assessment and first priority non-structural intervention recommended as part of the community action plan. To evaluate the effectiveness of these pilot intervention two consultancy services "Community Surveillance" were commissioned during the flood season of 2010 .

Boat Delivery for Flood Depth In Pilot Community Sudan

Boat Waiting for Emergency Response Lake Tana

Mobile Phone Delivery to Singa Pilot Community Member

Sheni River Overflow on Fogera Floodplains

SPECIAL STUDIES AND CAPACITY BUILDING ACTIVITIES

A number of special studies and training activities were delivered during phase 1 of the project. Among the list of special studies, the most important one are briefly described below:

SPECIAL STUDY ON VOLUNTARY RESETTLEMENT (SUDAN)

Voluntary resettlement of villages in flood risk areas along the Blue Nile and Main Nile has been a policy option particularly for the Government of Sudan. Although alternative sites have been allocated in several cases, policy implementation has been met with varying successes. Success has depended on communities satisfaction on the accessibility to their fields, and on the prior provision of services at the new settlement sites, failure to provide adequate services at the new sites and in some cases location of new site at a greater distance from fields that make them unattractive destinations for resettlement had been the most common causes of failure. In general, inadequate funding has been a significant obstacle to the successful implementation of this policy. Technical assistance was provided under the project in enhancing the existing policy and for building capacity in participatory voluntary resettlement.

FLOOD RISK MAPPING FOR PILOT COMMUNITIES IN ETHIOPIA AND SUDAN

The flood risk mapping for pilot areas was the results of multi-disciplinary study that include topographic data collection and surveying, terrain modeling, hydrologic analysis, hydraulic modeling and analysis, flood hazard mapping, economic data collection and damage analysis, and vulnerability and risk assessment. The maps convey the most basic information about the general vicinity in which flooding can be expected with varying frequencies, enabling local communities to make immediate use of these maps to identify areas of focus for flood protection, preparedness, warning, and future development guidelines.

PREPARATION OF FLOOD EMBANKMENT DESIGN MANUALS

Proper embankment design procedure and practices Operation and maintenance manual was prepared to fill the knowledge gap both in Ethiopia and Sudan. The manual identifies a set of design standards and procedures to be used for the planning, design, construction and maintenance of flood protection embankment mainly associated with irrigation and land development projects in flood plain areas.

5.6.6 Impact of Regulation Upstream on the Floodplains of the Blue Nile and Main Nile river Systems in Sudan

Historically, the flow of the Blue Nile reaches its maximum volume during the rainy season from June to September, and it supplies two third of the water of the Nile proper. Server flooding along the Blue Nile could have devastation effect on people's lives and property. On the other hand flooding along the BN has beneficial environmental effects as it supply the floodplain with fertile soil. It is estimated that , the livelihood of 147 local communities along the Blue Nile river in Sudan are totally dependent on recession agriculture within the floodplains of the Blue Nile River system. On annual basis, there is about 90,000 hectares of floodplain areas inundated along the BN river from Deim station (Ethiopian Sudan boarder) to Khartoum. Such inundation reaches its peak during the months of August and early September and river stages start to recede late September offering a great opportunity for recession agriculture. Hence the impact of regulation upstream could significantly reduce flooding and downstream and its devastating nature. However, there is an urgent need to study the impact of regulation from two perspectives. On one hand effect of regulation on the environmental benefits of floodplains and recession agriculture and on the other hand its positive impact in reducing the devastating effect of flood and damages.

5.7 WATERSHED AND NATURAL RESOURCES MANAGEMENT PROJECTS

5.7.1 Introduction

The objective of the Eastern Nile Watershed Management Programme is to provide continued and enhanced support the sustainable watershed management of the Eastern Nile Basin in order to:

- Improve the living conditions of the people;
- Create alternative livelihoods;
- Enhance agricultural productivity;
- Protect the environment and in the long term reduce sediment transport and siltation of infrastructure;
- Prepare for sustainable development oriented investments.

The overriding regional significance of this will be its contribution to enhanced food security and poverty alleviation in the region and its long term contribution to arresting the following aspects of degradation of the natural resource base.

- Soil erosion by water and its complement high sediment loads in streams and rivers together with soil nutrient depletion are the two major land degradation processes. These have major impacts on agricultural production and thus on peoples' livelihoods. Agricultural production forgone is caused by soil erosion, dung/crop residue burning and crop removal through:
  - Reduced moisture-holding capacity and nutrient loss from soil erosion.
  - Nutrient breaches due to the burning of dung and crop residues and grain removal.

The total amount of soil eroded each year in the Eastern Nile Basin is estimated at 447 million tons with 68 %, 22 % and 10 % eroded in the Abbay, Atbara-Tekeze and Baro-Akobo Sub-basins respectively. Of the total, 151 million tons (33 %) is from cultivated land and 201 million tons (76%) is from mainly communal grazing and settlement areas. The area of cultivated land whose use is considered to be unsustainable is estimated at 4.7 million ha.

With the natural increase in population the area under cropland will increase. Whilst some of the expansion will occur as infilling on suitable land, much will take place on land marginal for crop production because of shallow soils and steep slopes. In the absence of substantial watershed management interventions it is estimated that by 2025 cropland will expand by some 2.93 million ha in Ethiopia in the Eastern Nile Basin (Benefits of Watershed Management in the Context of JMP, July 2007). The potential for increased erosion and soil loss in the EN Basin, specifically the Abbay-Blue Nile sub-basin, is therefore substantial.

Based on these figures it is clear that the Abbay sub-basin has the highest levels of soil erosion in the EN Basin, more than three times higher than the Atbara-Tekeze sub-basin. This is not surprising given that the Abbay sub-basin also has the second highest population after the Main Nile sub-basin. The population of in the Ethiopian highlands is also projected to increase significantly over the next 15-20 years. Therefore in terms of priorities, the focus of catchment management programmes should therefore be in the Abbay sub-basin, followed by the Atbara-Tekeze and the Baro-Akobo-Sobat sub-basins.

5.7.2 Poverty and Natural Resource Base Nexus

There are complex relationships between poverty and the natural resource base in each of the four sub-basins. Poverty is both a cause and a resultant of natural resource degradation (Scherr, 1999). In all of the four sub-basins poverty is most prevalent amongst the rural households whose livelihoods depend on agriculture. Nevertheless, the determinants and context of poverty are not confined to natural resource degradation but encompass other aspects of livelihoods, such as education, health, access to knowledge and information, and the wider socio-economic framework of markets, prices, technology, credit, government development polices and strategies. This suggests that simply approaching poverty reduction by arresting resource degradation through technical measures may be insufficient if the other determinants and issues related to the broader socio-economic framework are not addressed (Benefits of Watershed Management in the Context of JMP, July 2007). This has important implications for the selection of investment projects in the EN Basin.

Research has shown that Watershed Management interventions can have a substantial impact on arresting degradation of the natural resource base both on cropland and also on non-cropland. This is a vital entry point in breaking the cycle of poverty and resource degradation and attacks one of the root causes of poverty in the Eastern Nile Sub-basin.

Conservation of the non-croplands through enclosure and tree enrichment planting can provide not only direct benefits to communities in terms of increased livestock feed and improved livestock productivity and increased supply of fuel wood and timber, but also an increase in wild plants of food and medicinal values that are of considerable importance to the most disadvantaged community members such as female headed households.

5.7.3 Benefits of watershed management in the EN Basin

The potential benefit of investing in watershed management project in the EN Basin is that the benefits extend across political boundaries and accrue to the Eastern Nile Basin as a whole. Currently there is little trans-boundary trade between Ethiopia and Sudan but the expansion of economic development in the Sub-basin on both sides of the border, coupled with an extension of cross-border road-links, the potential for increasing integration of the Sub-regional economies of both countries becomes possible.

Focus of watershed management initiatives in terms of location and priority should be informed by an understanding of the nature of the problem. As indicated above, the majority of the sediment load generated in the EN Basin is from the Abbay sub-basin, which accounts for almost 70% of the total sediment load. Addressing soil erosion at its source, namely in the Ethiopian Highlands, would therefore have significant trans-boundary benefits. In addition, combined with other elements, the programme would also assist Ethiopia to address rural poverty in the Ethiopian Highlands. The other area for investment is the Baro-Atbara-Sobat sub-basin.

ABBAY-BLUE NILE SUB-BASIN

- The quantifiable benefits of reduced erosion in the Ethiopian Highlands and sediment loads in the Eastern Nile river system include reducing costs in Sudan associated with dredging of power intakes and irrigation canals and improved power generation potential.

- The reduced sediment loads in the Rahad and Dinder Rivers could reduce the siltation of the maya'a wetlands in Sudan and thus reduce the incidence and extent of flooding and the damage this causes to crop production. They could also contribute to a reduction in the sedimentation of the Meroe Dam and to an increase in its economic life.
- Support to the establishment of the Dinder-Alatish Transboundary Park could facilitate the increased effectiveness of biodiversity conservation of this important area of fauna and flora. It could also increase the potential for eco-tourism and increased employment opportunities for people in and around the Park. It could also provide a tangible example of the benefits of trans-boundary cooperation between Sudan and Ethiopia. A similar example of trans-boundary cooperation could be an intervention to develop a plan for the sustainable management and development of the Rahad-Dinder Wetlands. This would require a cross-border study and the development of a catchment management plan. It also has clear linkages with the establishment of the Transboundary Park as much of the information on hydro-ecology will contribute to an effective Park management plan.
- A reduction of Abbay-Blue Nile and Tekeze-Atbara River systems' sediment load could also contribute to a reduction in the rate of loss of live storage in High Aswan Dam and the loss of potential irrigation water and power generation for Egypt.

BARO-ATBARA-SOBAT SUB-BASIN

- In the Baro-Sobat-White Nile River systems the quantifiable benefits to reduced erosion in the Ethiopian Highlands and sediment loads are limited. However, the rapid and uncontrolled loss of forest cover in the Ethiopian Highlands could have significant impacts of the hydrology of the Baro-Sobat River system. At the small catchment level these are likely to result in increased flood and given the relatively small size of the Baro-Akobo catchment area would impact on the flooded grasslands of both Ethiopia and Sudan. As these are vital components in the livelihood systems of both the Anuak cultivators and the Nuer pastoralists sever disruption to their economies could result. Strategic Land use Zoning of the high forest together with the watershed management components could contribute to reducing any potential negative impacts of increased flooding.
- Support to the trans-boundary collaborative wildlife and habitat survey and assessment of the areas encompassing the Gambella and the Boma National Parks could contribute to enhanced wildlife and habitat conservation. It could also establish the institutional mechanisms for continuing cooperative measures. The basis would be established for developing Park Management Plans that complement each other. There could be increased potential for "Eco-tourism and thus increased employment opportunities for Park inhabitants on both sides of the border. It could also provide a tangible example of the benefits of trans-boundary cooperation between Sudan and Ethiopia.

5.7.4 Key Elements of a Long-term Watershed Management Strategy

The 2007 CAR Report identifies a number of key watershed management issues that have a bearing on the design and implementation of watershed management programmes and projects in the EN Basin. These include:

- Developing a standardised and co-ordinated watershed management data collection and information sharing system for each of the four EN countries;
- Developing a standardised and co-ordinated monitoring and evaluation programme for watershed management activities for each of the EN countries;

- Undertaking research into the complex relationships between soil erosion (water and wind), deposition, sediment delivery to river systems, impact on agricultural productivity and the impact that has on sustainable livelihoods;
- Undertaking surveys and studies on the complex hydro-ecological-livelihoods systems to obtain a deeper understanding of these relationships to enable more effective and sustainable development planning;
- Undertaking surveys and studies and developing mechanisms and institutions for cooperative conservation of genetic, species and habitat biodiversity resources;
- Capacity Building in the fields of (but not limited to) Watershed Management Planning, Relationships between Land degradation and Livelihoods, Relationships between wetlands environmental, hydrological and livelihoods functions, and undertaking Monitoring, Evaluation and Impact Studies;
- There must institutional support provided to ENTRO to enable effective programme coordination, support cooperative mechanisms and to enhance confidence building and trust among the Riparians. Support will also be required at the National level to enable effective coordination with a trans-boundary context the various activities that will form part of the long-term cooperative programme.

5.7.5 Key Watershed Management Issues

The Benefits of Watershed Management in the Context of JMP Report (July 2007) lists a number of key watershed management issues that need to be addressed so as to enable the implementation of an effective watershed management programme in the EN Basin. The key issues are listed below.

COOPERATION AND COORDINATION AMONG RIPARIAN COUNTRIES

More effective cooperation and coordination between the riparian countries is essential if the Eastern Nile Basin's natural resource base is to be managed in ways that help improve the quality of life of the inhabitants. In strategic terms it is vital that riparian cooperation and coordination is strengthened through trans-boundary activities including establishing a watershed management data and information system, monitoring of watershed management interventions, supporting erosion-sedimentation research, undertaking longer-term hydro-ecological-livelihood studies and institutional capacity building.

ENHANCE AND EXPAND THE WATERSHED MANAGEMENT KNOWLEDGE BASE

There are considerable data gaps and imperfectly understood science of many aspects of watershed management. Another important area of watershed management and developing interventions to enhance sustainable livelihoods is the important role wetlands play in livelihood strategies. Wetlands comprise complex hydro-ecological systems and are of considerable importance to household and community livelihoods in Ethiopia, South Sudan and Sudan. As well as their importance to supporting livelihoods wetlands also provide important hydrological functions in the river systems as well as having considerable importance in terms of biodiversity conservation. Complex trade-offs between conservation and development of wetlands will be necessary if the twin goals of sustainable livelihoods and biodiversity conservation are to be met. This is also an area where research is required if sustainable development interventions of wetlands re to be prescribed. Data and knowledge gaps will require cooperative solutions in terms of shared information and data collection, harmonization of data collection and research methods and the integration of information and research results into policy formation.

Develop effective cooperative systems of monitoring and evaluation of on-going and future watershed management interventions

There will be a need to monitor the impacts of watershed management projects on household and community livelihoods. There is considerable scope for knowledge sharing amongst the three Riparians on experiences gained and lessons learnt in terms of watershed management. This will enable solutions to be rapidly developed to address problems that emerge from the monitoring and evaluation activities.

Capacity building and institutional strengthening

The need for capacity building across a wide range of disciplines and subjects at all levels was identified as a key need in the Trans-boundary Analysis of the CRA as a key pre-requisite for effective trans-boundary watershed management data collection, multi-disciplinary watershed management research and monitoring and evaluation of watershed management activities.

5.7.6 Trans-boundary biodiversity and natural resource hotspots under threat

The Trans-boundary Analysis identified a number of important biodiversity hotspots that are under considerable pressure from expanding human activities. Three areas in particular involve National Parks or Biosphere Reserves that are trans-boundary in nature, namely:

- Wadi Allaqi, located on the border between Egypt and The Sudan;
- Dinder National Park (Sudan) and Alatish Regional Park (Ethiopia), located adjacent to each other across the Sudan-Ethiopia border;
- Gambella (Ethiopia) and Boma National Park (South Sudan), which are key areas that fall within the migration of the White-eared Kob between South Sudan and Ethiopia.

Rahad-Dinder Wetlands

The Rahad-Dinder wetlands comprise a large number of ox-bow lakes and cutoff meanders along and between the Rahad and Dinder Rivers known as *mayas*. They are found at various stages of sedimentation: from pristine small lakes through to those completely filled with sediment. The sedimentation is due to the high sediment loads of the two rivers originating in the Ethiopian Highlands.

These wetlands provide a number of environmental services and products. Unlike the valley-bottom wetlands of the Ethiopian Highlands they are not cultivated. The numbers of people and livestock using the *maya'as* as source of water are considerable. Also many people are using them as a source of medicinal plants. The sediment trapping properties of the wetlands has both costs and benefits. Sediment trapped in the mayas reduces downstream sediment loads. On the other hand increasing rates of sedimentation of the *mayas* reduces their flood buffering capacity leading to higher flood peaks.

The area between the Rahad and Dinder Rivers is subject to frequent flooding causing extensive damage to crops. An examination of the Africover (2003) map of the area between the Rahad and Dinder Rivers indicates that there are some 414,180 ha of large-scale semi-mechanized farms (SMF's) and 46,000 ha of traditional farms: a total of 460,180 ha. Assuming that 40 percent of this area is flooded and crops destroyed every 4 years gives an estimated area of 165,700 ha of SMF's and 18,400 ha of traditional farms affected. This provides an indication of the value of the *maya* wetlands flood buffering services.

DINDER NATIONAL PARK AND THE ALATISH REGIONAL PARK

The Dinder National Park, which was proclaimed in 1935 is located within three States: Sennar, Blue Nile and Gedarif. It boundaries follow to the north of the Rahad in the north, to the south of the Dinder in the south and the Ethiopian border to the east, and covers an area of 8,960 km2. It is also a designated Biosphere Reserve and has been designated under the Ramsar Convention as an international Wetland. Immediately across the border within Ethiopia the Amahra Regional State has designated an area as the Alatish Regional Park. The Dinder National Park has a high level of biodiversity with over 160 species of birds, 27 species of large mammals and unknown number of small mammals. It comprises the last extensive tract of woodland in eastern Sudan.

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

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

The Alatish Park covers an area of 2,666 km2 to the north of the Dinder River, which forms its southern boundary, and to the south of the Gelegu River that forms its northern boundary. The Alatish and other ephemeral streams drain the central area. Its altitude ranges from 500 to 900 masl. The area is intact with no permanent settlement, although Fellata pastoralists enter the Park in the dry season with over 10,000 head of livestock. The Gumuz people have settled to the south of the Park and practice hunting and fishing along the Dinder River. Settlement is increasing and agriculture expanding along the northern boundary and numbers are being swelled by migrants from other parts of Amhara region. There is an urgent need to collaborate with the Beneshangul-Gumuz Regional government and with the Government of Sudan to secure the area. The Ethiopian Wildlife Conservation Organization has strongly recommended that the Alatish Park been proclaimed a National park and that in the future it should form part of a Transboundary Park with the Dinder National Park. There is also an urgent need to develop a park management plan in participation with local communities.

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

5.7.7 Harmonisation and co-ordination of policies and data

In order to facilitate and support regional co-operation and maximise trans-boundary benefits, policies relating to watershed management must be harmonised between countries in the EN Basin. The policies should be informed by current and future research data presented in a form that can be understood by politicians and decision makers.

- **Cooperative activities involving coordination: basin-wide information exchange and database**

  Data collection systems should be harmonized across the Eastern Nile Basin.

- **Coordinated basin-wide impact monitoring and evaluation of watershed management activities**

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

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

  The CAR 2007 Report comments on the size and complexity of the EN Basin. There is therefore a potential danger that it may take a considerable amount of time to develop an effective basin wide monitoring and evaluation system. It may be more practical to develop a series of sub-basin level monitoring and evaluation systems, staring with the key sub-basins and catchments within these sub-basins. These would include the Abbay and the Baro-Akobo-Sobat.

- **Cooperative Research into Complex Resource Degradation-Livelihood Strategy-Poverty Linkages**

  The research into physical processes should be linked to research into the impacts of resource degradation on household and community livelihood strategies and coping mechanisms and abilities to incorporate sustainable land management technologies into their livelihood systems. Important elements to be determined are the complex relationships between resource degradation and poverty. It is important that the research results feed into the policy making process as well as the review of on-going and proposed watershed management interventions.

- **Detailed Studies and Planning for the Sustainable Management of Wetlands**

  The need to develop a deeper understanding of the various roles and functions of wetlands in the Eastern Nile Basin has been identified above. This will be achieved through collaborative trans-boundary studies into the various types of wetlands in the Abbay-Blue Nile and Baro-Akobo Sub-basins. A holistic approach will be used to gain an understanding of the wetlands in the context of the watershed at different scales. Thus the relationships between upland land use and wetland hydrology and their dynamics will be an important element of the studies. The results of the studies should feed into the policy making and review process and into the design of development programmes to ensure that "lessons learnt" are fully incorporated.

- **Surveys and studies to support cooperative biodiversity conservation**

  Three biodiversity "hotspots" were identified as under threat: (i) the Wadi Allaqi located in Egypt and Sudan, (ii) the Dinder and Alatish Parks located in Sudan and Ethiopia, and (iii) the area between and including the Gambella and Boma National Parks in Sudan and Ethiopia. The ecological systems of the three areas are inextricably linked across the international borders. Detailed wildlife inventories and livelihood surveys are required as a basis for developing joint long-term trans-boundary conservation management plans for these areas. The livelihoods studies will provide essential data upon how to involve the local communities in the management activities. Capacity building will also be an important element of the surveys and studies to ensure subsequent effective conservation management.

- **Hydro-ecological-livelihoods study in the Baro-Sobat-White Nile sub-basin**

  The Baro-Sobat-White Nile Sub-basin is the most isolated of the four Sub-basins. The Sub-basin Lowlands have seen nearly two decades of civil war with the resulting breakdown in physical, economic and social infrastructure. Under the Comprehensive Peace Agreement (PCA) the region is now initiating development programmes to support sustainable livelihoods development and reduce vulnerability to external shocks. The Sub-basin exhibits a complex system of hydrology and ecology that strongly influences the livelihood systems of the peoples of the Sub-basin.

  There are immense problems in the Sub-basin of initiating and sustaining all aspects of rural and urban development, reducing poverty, developing sustainable livelihoods and restoring economic and social networks. In terms of watershed management and seeking to achieve sustainable livelihoods the key challenges include:

  - The need to obtain a detailed knowledge of the complex hydrology-ecology systems in the whole of the Sobat-White Nile Sub-basin (in both Ethiopia and South Sudan).
  - The need to obtain a detailed knowledge of the relationships between the hydrology-ecology and livelihood systems and their dynamics, as a basis for effective and sustainable development planning and implementation.
  - The need to determine the potential impacts of upstream hydrological developments (dams, hydro-power, irrigation) on the sensitive hydrological-ecological and livelihood systems downstream in both Ethiopia and South Sudan.
  - The need to make a full inventory and status assessment of the habitat and species bio-diversity as a basis for effective and sustainable conservation planning.

5.7.8 Capacity Building

Capacity building has been identified as a key pre-requisite to sustainable watershed management cooperation in the Eastern Nile Basin. Institutional strengthening would be achieved through improved communication, information exchange and specific training. These would be implemented through specially commissioned courses, regional training workshops, linkages to universities and national research institutes and civil society organizations involved in watershed management activities. Capacity building is also an important element of all activities and programmes involving data and information collection, monitoring and evaluation, land degradation-livelihoods research and wetland studies.

5.7.9 Institutional Strengthening

Institutional strengthening will be supported at various levels. At the Basin-wide level ENTRO is the key institution for coordination of the whole Cooperative Watershed Management Programme. The Programme is one of some complexity in comparison with the CRA and ENTRO will require substantial strengthening in terms of resources and technical expertise. The wide range of cooperative activities and of national actors and stakeholders in the programme will require a considerable degree of coordination at the national level. This will require strengthening of the national coordinating institutions.

5.7.10 Key requirements for effective watershed management

The key requirements listed below are based on the findings of the study undertaken by ENTRO, Benefits of Watershed Management in the Context of JMP (July 2007).

EFFECTIVE GRASSROOTS PARTICIPATION

- Experience has shown that the implementation of successful and sustainable projects and investment requires buy-in and ownership from locally communities. A sense of ownership is created only through their genuine participation in planning and decision making. Motivation for genuine participation and buy-in can only be achieved if there are tangible benefits for local communities. Many benefits can be achieved through integrated watershed management for improvement of livelihoods.
- It is becoming increasingly apparent that a more consensual approach to natural resource management is a more effective solution for harmonizing interests of resource users, managers and regulators. Allowing and facilitating local communities to develop their own resource management systems is proving a more effective, economic and efficient approach than central or regional government control.
- The requirement of genuine participation sets preconditions to the organizational structure and approach of watershed management projects. Emerging lessons from watershed management projects in Ethiopia, Sudan and elsewhere include the following:
  - A participatory project cannot be target-driven right from its start. In its initial phase, the project design should focus on the process of establishing participation rather than on seeking to achieve physical targets. It also requires appropriate institutional development at community-level; appropriate in the sense that institutions are created (or strengthened if already existing) to respond to the emerging needs, and may therefore differ from place to place. It is important to strive for a simple organizational and coordination structure, based on existing structures and clearly stipulating linkages with higher levels;
  - Institutional arrangements are required that allow for multi-disciplinary and multi-agency collaboration and across ministries, contributing to breaking through single sector approaches.
- From this it is clear that the identification and selection of investment opportunities involves an assessment of both the hard (design and technical aspects) and soft (institutional, capacity and community aspects) components of the project.

BUNDLES VS. SINGLE PROJECT

- Given the cross-sectoral, sustainable livelihoods and poverty focus of the Watershed Management with its stated objective of tackling the underlying problems of natural resource degradation in the East Nile Sub-basins, it is necessary to for projects to be composed of a "bundle" of interventions, as opposed to the concept of a single project intervention. The "bundles" consist of technological, institutional and policy components that should seek to complement each other where possible in a synergistic way.

TRADITIONAL AGRICULTURAL VS. COMMERCIAL AGRICULTURE

- Based on the information available the highest incidence of poverty in Ethiopia, South Sudan and The Sudan is within the traditional agricultural smallholder sector. Therefore by targeting this sector (rather than the commercial agricultural sector) a proportionally greater impact can be achieved in reducing the numbers of households living below the poverty line.

- A recent study by IFPRI and The Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA)(Omamo et al., 2006) that covered all of the counties in the EN Basin found that the largest poverty reductions will come not from growth in export sub-sectors but from growth in those sub-sectors for which demand is the greatest – such a crop staples, livestock products, oil seeds and fruits and vegetables.
- Research undertaken in Ethiopia by Daio et al. (2006) confirmed these findings. The study found that interventions that increase the accessible supply of fuel wood (on-farm tree planting) and the reduction in its consumption (using fuel efficient stoves) can have consider impacts on reducing the work loads of women and children. In addition, there can be positive impacts on their health and well-being through the reduction in smoke inhalation thus reducing the incidence of respiratory diseases. These interventions can also be linked to Watershed Management programmes.

UNDERSTAND THE LOCAL CONDITIONS

- The identification of appropriate technical interventions requires a thorough knowledge and understanding of the local livelihood strategies and land use systems so as to ensure that the proposed intervention/s supports rather than impacts negatively on the local socio-economic and environmental system.
- At the micro/mini watershed level technical interventions will need to be developed in an integrated manner that takes into account the nested nature of watersheds and the associated hydraulic system. For example the development of small dams should be integrated into other components of the watershed management plan with catchment management interventions being implemented in the upper micro-catchments and moving progressively downstream. Similarly, external water-harvesting measures will need to be similarly planned and executed. In-field water harvesting measures will need to be integrated with soil fertility enhancing measures if full benefits are to be achieved. Proposed interventions should range beyond soil and water conservation technologies and include inter-linked technologies related to crop, animal and tree husbandry.
- For example, a Strategic Land Use Planning and Zoning Plan for the High Forest areas of the Ethiopian Highlands could clearly delineate areas for small-holder and large-scale commercial agricultural development based on stakeholder participation and sustainable land suitability principals. Similarly, areas for Community Forests can also be clearly delineated on the same basis. Clear and transparently developed land use zoning can allow for sustainable development and management of the Forest and Land resources at the local level.

UNDERSTAND THE COSTS AND TIMEFRAMES INVOLVED

- The implementation of watershed management programmes can have substantial costs in terms of labour for construction or establishment. For a number of the interventions it takes a number of years for benefits to be realized (on-farm and community tree planting) or benefits only slowly accrue (SWC measures). This information must be communicated to local communities.

MAXIMISE THE INDIRECT BENEFITS OF WATERSHED MANAGEMENT

- Watershed management can result in a number of indirect benefits. Measures to maximise these benefits should be included in the project design. The potential benefits include:
- Infrastructure development

- Supporting interventions associated with Watershed Management programmes can also have substantial benefits to households and communities. These include measures to increase market accessibility and integration such as feeder roads and extension of telecommunications. These can have significant positive impacts by reducing market transaction costs thus benefiting both producers and consumers. These interventions can also enable an expansion of local economic multipliers which, in turn, can increase employment opportunities in small urban centres for rural and urban households.

CAPACITY BUILDING AND TRAINING

Capacity building and training interventions can result in a number of positive benefits at the local level. Increased access to improved technologies (with increased support to extension and research services) combined with access to literacy and skills training have been shown to be strongly correlated with increased adoption of improved agronomic technologies. Support to the Extension Service with improved information linkages between farmers and research can increase the relevance of agricultural research to the traditional small-holder sector. Increased road accessibility and skills training can also enable rural households to have better access to non-farm employment opportunities.

CREDIT AND FUNDING

Increased access to micro credit can provide an important enabling environment for farmer's to adopt improved technologies, in particular fertilizer and improved seeds. Credit together with support for small enterprise training can also enable the development of small enterprises in the small urban centres further increasing employment opportunities.

5.8 WATER USE BY OTHERS USES

5.8.1 Fisheries sector

5.8.1.1 Ethiopia

OVERVIEW

Ethiopia is a land locked country with no marine coastline, thus fisheries are entirely dependent on fresh inland water bodies (lakes, reservoirs and rivers). It has no significant aquaculture development also. Lake Tana (the largest lake and fish source), Rift Valley Lakes (Ziway, Langano, Hawassa, Shalla, Chamo and Abiyata and reservoirs constructed for hydro power production (Koka, Melka Wakena, Gilgel Gibe, Tekeze) are the major sources of fish. These waters have an estimated annual fish potential of 51,500 ton, which can meet 44 percent of the projected demand in 2015, based solely on population size (FAO, 2003). If factors other than population (relatively cheaper prices of fish, increased income, improved supply and distribution network) are considered, the projected demand could increase by 15 to 20%. In view of this, the present water bodies or fish supply sources will not be able to meet the demand. This calls for an increasing focus on enhancement of artificial water bodies and development of aquaculture.

Fishing on all these water bodies for local consumption is taking place. Fishing for commercial production is mainly concentrated on lakes Chamo, Ziway and Tana (only Tana is within the basin). Fish sizes in these lakes are declining due to over exploitation. The main fish species are Nile tilapia, Nile perch, Barbus and Catfish. Nile perch represent about 60 % of the catch. Fish consumption is seasonal. Demand rises substantially during the fasting season and days of the Ethiopian Orthodox religion. Demand is higher than supply during the two months of main fasting season and vice versa during the non-fasting periods. In general Ethiopians do not consume large quantities of fish, although preference for fish is increasing especially by high income groups. Overall, per capita fish consumption is very low (as little as 200 g/year), but in areas with sufficient and regular supply, consumption can reach up to 10 KG/year (FAO, 2003).

Fishing techniques are extremely primitive, with very few motorized boats (limited to a very small number on Lake Tana). The predominant boat is the reed (papyrus) tanqwa. It is even difficult to obtain certain materials for nets (lead rope and floats). Gill nets are the most common, but there is also some use of line-fishing (the latter for Nile perch). Traps, scoop nets and baskets are also used, particularly in the rivers (Ann Gordon, Sewmehon, Melaku, 2010).

CONSTRAINTS

With the increasing demand, prospects for fishery development in Ethiopia are promising as long as the major constraints are addressed properly. These include:

- Establishing/expanding small scale commercial aquaculture;
- Improving research, technology and extension services;
- Expanding and improving support infrastructure such as access roads, landing and onshore processing facilities;
- Expanding distribution networks; and
- Strengthening the government fishery administration in the areas of effective resource monitoring, coordination, planning and control of the industry

5.8.1.2 South Sudan

OVERVIEW

Like Ethiopia, South Sudan is a land-locked country, thus has no coastal fishery. All fisheries are based on inland fresh water bodies consisting of the major rivers (Nile, Sobat) and the vast wet lands (Sudd, Mechar). Though, the contribution fishery to the GDP is low, substantial size of the population are engaged in fishing activities. According to a 2010 baseline survey report on agriculture and animal resources in South Sudan, about 14 % of households in South Sudan, particularly those in the Sudd area and along the River Nile and its tributaries, are engaged in fishery as a source of livelihood.

Fish is a primary source of cheaper protein and accounts for about 4 percent of food consumption in South Sudan (Agricultural Sector Investment Plan, 2013). The potential catches for the country are unknown, and estimates vary widely. However, many studies indicate the fisheries production potential to be in the range of 100,000 to 300,000 metric tons per year. No proper field assessments and inventory have been undertaken so far to support these figures. Moreover, due to the subsistence nature of the fishing activities, it is very difficult to estimate catches at household level. According to the SAR of the Comprehensive Agriculture Master Plan preliminary estimates, the consumption of fish in South Sudan is far higher than generally recognized at about 17 kg/person/year, which is comparable with neighbouring countries. To supply this consumption level the catch must be in the order of 140,000 tones and definitely much more due to post -harvest losses (losses resulting from lack of refrigeration, poor weather condition and insect infestation of dried fish are expected to be substantial). Table… below shows the estimated consumption of different fish products in the country.

Table 5-37: fish Consumption in South Sudan

Product	Tonnes	Kg/year/cap
Salted	4,618	0.56
Dried fish	79,732	9.65
Fresh fish	59.031	7.15
Total	143,381	17.36

Source: SAR-CCAMP, 2013

Access to fishing is open, with no control on the number of fishers or entry. Fishing method is predominantly subsistence and traditional; using hooks or locally made nets. The caches are sold in local markets as fresh, dried or salted products. Smocked fish are also produced to some extent in areas where there is sufficient fire wood. Though fresh fish products are more preferable, much of the catch is dried due shortage of ice, transportation and cold storage facilities. Large amounts of fish (mostly smocked) are being imported to South Sudan from Uganda. Frozen and canned fish products are also imported from a number of other countries for sale in supermarkets. Reliable data on the exact figures of import are not available.

In addition to river and lake fishing, there is significant potential for aquaculture development, especially in part of the Green Belt (stretch across Southern Greater Equatoria), where there are year round water supplies, suitable terrain (many clay soil areas and gravity fed water supplies) and an almost ideal climate for aquaculture. However, currently there is little aquaculture development in the country, due to a number of constraints which include; land tenure uncertainty, lack of hatcheries, no feed mills and shortage of skills. There are about 38 ponds currently operating in the country, most of which are concentrated in CE and WE States (CAMP, 213). Great efforts have been made to introduce village level aquaculture largely through NGOs which provide technical support, land and some limited funds. Potential fish production from the aquaculture sector could reach as high as 250,000 tons per year, if well developed and managed (FAO Country Report, 2012). Among others, technology and skills transfer from neighbouring countries such as Uganda and Kenya and from that of Egypt from the EN countries would probably be the best way to advance the sector in the short term.

CONSTRAINTS

Nevertheless, South Sudan has huge fishery potential its development and contribution to the national economy has been deterred by a number of constraints, which among others, include:

- Absence of policy, regulatory and strategic frameworks and incentives,
- Use of poor subsistence nature technologies,
- Lack of cold storage facilities due to weak or total absence of power supply,
- Little involvement of the private sector and absence of effective processing technologies,
- Inadequate transport infrastructure and market chains,
- Lack of skilled man power and inadequate research and extension facilities.

The Directorate of Fisheries and Aquaculture Development (DoFAD) in the former MARF now MAFTARFCRD is responsible for the development of fisheries in South Sudan. By the Constitution, management of the fishery in the states is delegated to the State Authorities

5.8.1.3 Sudan

OVERVIEW

Fishing is another important sector of the national economy in Sudan. The average yearly production averages around 33,000 tons, from which sea fish represent about 1,500 tons. Perch is the most important fresh-water fish, which is caught mostly in the Nile River.

The principal source of fish in Sudan is the Nile River system. In central and northern Sudan, several lakes and reservoirs have been formed by the existing dams on the Nile and its tributaries: the 180-kilometer section of Aswan Dam Reservoir (Lake Nubia) on the main Nile in Sudan and the reservoirs behind the Roseires, Sennar and Marowe Dams on the Blue Nile, the Jebel Aulia Dam on the White Nile, and the Khashm al Girba Dam on the Atbara tributary of the main Nile. The Gebel Aulia Reservoir has a fish potential of 15, 000 tons/year and production of 13, 000 tons/year (86.7%). Roseires Reservoir has a potential of 1, 700 tons/year and fish landings of 1, 500 tons/year (88.2%). Sennar Reservoir has an estimated fish capacity of 1, 100 tons/year and an actual fish yield of 1, 000 tons/year (91%). Lake Nubia's potential is 5,100 tons/year, but is able to produce only 1, 000 tons of fish annually (19.6%). Production from other Nile River localities has been estimated at 4, 000 tons/year (FAO Country Profile, 2009).

Three main sub sectors identified in the fishery sector are subsistence, artisanal, and commercial fisheries. Subsistence fishing accounts for the large part and is found in practically all of the inland waters of Sudan, but especially in the isolated areas where the Nile and its tributaries seasonally overspill their banks and create innumerable lagoons and backwaters; about 10 - 11 000 tons of fish are believed to be caught in these waters by traditional method (spear, line and cast nets used from the banks or from canoes and papyrus rafts). The artisanal sector exists alongside subsistence activities, principally on the Jebel Aulia reservoir and the lower reaches of the White Nile before the confluence with the Blue Nile; typically, the artisanal fisherman owns a one oar-propelled boat of traditional design. Commercial activities are, as yet, little developed but market orientated fisheries have been established on dam impoundments and reservoirs relatively close to urban centers; a few motorized craft are now in use. All production and commercial activities are practiced by the private, semi-private and cooperative sectors.

The principal species taken in these fisheries are the large and highly prized Nile perch, Labeo, Tilapia and Alestes species. The majority of the catch is consumed fresh, the balance being crudely sun-dried, generally without salting. As a result of inadequate transport, distribution and marketing facilities, lack of ice and poor handling methods, fish quality standards are often extremely low; about a fifth of the entire catch is believed to be lost as a consequence. Generally, fish prices are high relative meat which is more widely available. Apart from the subsistence areas, the bulk of fish consumption is heavily concentrated in Khartoum.

The country's second source of fish, the Red Sea coastal area, was relatively unexploited until the late 1970s. Annual production amounts to about 1, 500 tons of fish, shellfish (including pearl oysters), and other marine life. Fishing for shrimp on a small commercial scale also takes place. 6-7 metre long dhows (mostly unmotorized) and few slender canoes are employed for catching fish. The main landing point is Port Sudan. Fishing operations are largely artisan and of a subsistence nature and are concentrated in near-shore areas. Commercial fisheries are confined to indigenous firms.

The Fisheries sector presently makes only a marginal contribution to the Sudanese economy; accounting for only 0.4% of the GDP (FAO Country Profile, 2009). Fishing is regarded as an occupation of rather lowly status and the relatively few persons are engaged in the venture. The aquaculture industry is not developed as yet.

CONSTRAINTS

In general, the fisheries sector in Sudan is not yet fully exploited, the major constraints being:

- Lack of trained personnel and modern fishing experience,
- Lack of fishing equipment and vessels,
- High post-harvest losses resulting from improper handling at source and during distribution,
- Lack of marketing chains and Inadequate planning,
- Insufficient infrastructure facilities and institutional capacities.

5.8.1.4 Egypt

INTRODUCTION

The fishing sector in Egypt can be divided into the marine, inland and aquaculture sub-sectors; While the marine sub-sector is very important for the country it is not presented here.

INLAND SUB-SECTOR:

Fishing under this sub sector is carried out in the in land waters which consist, more than 10 relatively large lakes, the great reservoir behind the Aswan High Dam (Lake Nasser), the Nile River and irrigation canals and some small water bodies in the western part of the country. In 2009, fish production from this sub sector was 260, 000 tons representing about 24% of the total fish production in Egypt. Fishing in the ten lakes yields about two thirds of the inland catch, while fishing in the Nile River System represent about one third.

Inland fisheries produce different kinds of species. The four main species, which represent more than two thirds of the total production from inland fisheries, include: tilapia (40 percent), catfish (15 percent), grass carp (10 percent) and mullets (6 percent) (FAO, 2010). Two of the ten lakes (Qarun and Wadi Al Raiyan) have no outlet and contain brackish water and produce mostly marine species.

There is a large number of small boats of different size (more than 21 300), being used in inland fisheries. Of these, more than 12, 000 are operating on the Nile System. As these boats do not travel far, there is also a large number of landing sites. Along the River Nile alone, there are more than 700 registered landing sites and countless unregistered sites.

AQUACULTURE SUB-SECTOR:

Under this sub sector, fish is produced in ponds /fish farms that have a size of between 2 to 8 ha. It is also produced integrated with rice farms. Aquaculture is currently the largest source of fish supply in Egypt, with over 99 percent produced from privately owned farms. In 2009, the total fish produced from this sub sector was 705,000 tons, almost 65% of the total fish produced in the country. The Ministry of Agriculture and Land Reclamation is targeting a harvest of 1 million tons from aquaculture alone, by year 2017 (National Water Resources Plan 2017).

The development and expansion of modern aquaculture began in Egypt two decades ago and has shown significant growth in the past few years. Annual production from aquaculture increased by more than 10 times, between 1990 and 2008, at an average annual growth rate of 14.4 percent (FAO, 2010). Egypt is the 1st in Africa and 11th in the world in aquaculture production (Abdel Rahman, 2010).

Aquaculture considered as the only viable option for reducing the gap between supply and demand of fish in Egypt. The rapid development in aquaculture has also created a large number of jobs for farm technicians and skilled labor. More than 750, 000 individuals including men, women and children are directly employed. The expansion of aquaculture has succeeded in reducing and stabilizing the cost of fish in Egypt allowing accessibility to the poorer rural population to healthy and affordable animal protein.

Most of the farms are located in the northern and eastern parts of the Nile Delta where they utilize both brackish and freshwater. The majority (85%) of fish farms are semi-intensive type, about 10 percent are intensive (cage culture in fresh water) and the rest 5 percent are under rice-fish culture. Because of competition for land and water with other agricultural activities, intensive aquaculture, in earthen ponds and tanks, is also developing rapidly at present days. Both marine and fresh water species are produced tilapia being the dominant. It accounts for more than half of all fish produced through aquaculture. other species include mullets, carps and cat fish. Egypt is the world second in regard to tilapia production, next to China and first in mullet production.

CONSTRAINTS:

Existing constraints for the development of the fisheries sector include:

- Use of backward fishing technologies; Most fishers are artisanal, and operate gillnets, trammel nets and long lines from small boats,
- Lack of skilled personnel and in adequate knowledge and management of the fisheries potential,
- Weak institutional and legal framework for the sector,
- Lack of research and extension facilities,
- Pollution, infestation of wild plants, illegal fishing, etc.,
- Little involvement of the private sector.

5.8.1.5 Conclusions for the MSOIA

The fisheries sub sector is an important source of cheap protein for poor communities and a major economic activity for those living around the major lakes and reservoirs, along the River Nile and coastal areas. In addition to these water bodies, there is also good potential for aquaculture development especially by the private sector in all countries.. Inadequate modern fishing equipment, shortage of transport, cold storage facilities and market chain, lack of technical staff and inadequate legislations are among the major constraints for fisheries development in the EN.

The present rate of fishing in many of the natural water bodies in basin is excessive. Given that fish stocks are decreasing because of over-fishing, capture fisheries alone cannot be considered as a sustainable future for the fisheries.

Therefore, at present, a potential for growth of aquaculture exists. It would help alleviating the pressure on the region's natural fish stocks, while it would allow to keep (or even increase) the current level of fish production thus guaranteeing fish exports to international markets and supply to national markets.

Regarding the future, the situation is more worrying and the potential for aquaculture much more evident. In effect, the regional balance between fish production and consumption appears clearly negative, meaning that regional consumption and fish exports would adversely compete. The decline in the situation decline between now and 2030 can be explained by two main factors: firstly the demographic increase (more people is more fish demand); and secondly the wishwillingness of some countries to improve the national diet, especially access to protein, through increasing individual fish consumption (more fish for each people)

Land shortage Fisheries and/or fish farming components to improve food security and livelihoods

There is good experience for aquaculture development in Egypt that could be up scaled to the other EN countries

5.9 MULTIPURPOSE WATER RESOURCE DEVELOPMENT PROJECTS

Multipurpose storage investments such as hydropower development, expanded irrigated agriculture, watershed management and flood control within the various sub-basins can bring major benefits to the inhabitants of the sub-basins and the national economies.

Appropriate management interventions can lead to a reduction of the vulnerability of the affected communities to extremes in rainfall variability. Management as well as regulation of water resources is a critical factor underlying efforts to promote growth and raise incomes.

The rationale behind the promotion of the multipurpose approach is that water resources development and management should be taken from a cross-sectoral perspective. Competing projects, when considered only from the point of view of the primary sector for which they are being developed may be ranked very differently from when a truly cross-sectoral analysis is undertaken.

Clearly, when impoundments are envisaged at the core of a development, it would be wise to make use of the storage for urban water supply and the regulated flow for the generation of hydropower and irrigation. This is typical of the classic multipurpose projects and the envisage EN projects of this type must be analysed from the multipurpose perspective.

However, there are also other aspects of the multipurpose approach. These include consideration and inclusion of flood management, watershed management, wetland management and the inclusion of other sectors such as fisheries, livestock farming, aquaculture, tourism etc.

One of the key criteria that should be used when comparing regional projects is the degree to which benefits can be generated for a wide range of users at the national and regional levels.

6. GIS platform and baseline mapping

The ENTRO GIS platform is being utilised and further developed as part of this study. One of the tangible outputs will be the generation of an Atlas to accompany this Situational Analysis. The following maps are to be found in the atlas:

1. General
   - Location Map of the Easter Nile Sub-Basins
   - Eastern Nile Sub-Basins
2. Eastern Nile Admin Areas
   - Abay-Blue Nile Sub-Basin: Admin Areas
   - Baro-Akobo-Sobat-White Nile Sub-Basin: Admin Areas
   - Tekeze-Setit-Atbara Sub-Basin: Admin Areas
   - Main Nile Sub-Basin: Admin Areas
3. Physical Setting
   - Surfacial Geology (see reference maps)
   - Relief & Drainage
   - Abay-Blue Nile Sub-Basin
   - Baro-Akobo-Sobat-White Nile Sub-Basin
   - Tekeze-Setit-Atbara Sub-Basin
   - Main Nile Sub-Basin
   - Soils (see reference maps)
4. Climate & Hydrology
   - EN Mean Annual Rainfall
   - EN Mean Annual Temperature
   - EN Mean Annual Potential Evapotranspiration
   - EN Aridity Index
   - EN Groundwater Resources
5. Landcover-Landuse
   - EN Landcover-Landuse (MODIS Product)
   - EN Landcover-Landuse (Globcover; ESA's product)
6. Irrigation
   - Irrigation Projects in Tana-Beles and Upper Dinder & Rahad Sub-Basins
   - Irrigation Projects in Didessa, Fincha & Guder Sub-Basins
   - Irrigation Projects in Blue Nile Sub-Basin
   - Irrigation Projects Baro-Akobo-Sobat Sub-Basin
   - Irrigation Projects in Tekeze-Setit-Atbara Sub-Basin
   - Main Nile Irrigation Projects (immediately d/s Aswan Dam)
   - Nile Delta Irrigation Projects
7. Hydropower
   - Eastern Nile Hydropower Sites
   - Eastern Nile Power-Systems Interconnection Map
   - Hydro-Power Projects in Abay-Blue Nile Sub-Basin
   - Hydro-Power Projects in Tekeze-Setit-Atbara Sub-Basin
   - Hydro-Power Projects in Baro-Akobo-Sobat Sub-Basin
8. Development Areas / Environmental Hot Spots
   - Abay-Upper Blue Nile Irrigation Projects / Environmental Hot Spots

- Baro-Akobo-Sobat Irrigation Projects / Environmental Hot Spots

9. Reference Maps

- Surface Geology
- Soils
- Landscape
- Demography

7. Water resource analysis

7.1 INTRODUCTION

The analytical framework to be used in this study comprises four parts. These are:

- Configuration of the base case scenario and water balance analysis by sub-basin;
- Scoping of the investment options and optimization analysis of the EN water resources basin wide;
- Detailed river system simulation and trade off analysis among optimized development options; and
- Economic valuation of potential development options of multi-sector nature.

The base line scenario and water availability in the basin is assessed using the calibrated Soil and Water Assessment Tool (SWAT) Hydrological model. The model is calibrated using historical data for the period (1964-2002). Section 7.4 provides a brief description of the model, the calibration procedure, water availability and water balance by a sub-basin.

The scoping of multi-sector investment for the entire EN basin as one unit is based on the ENMOS optimization tool. Detailed description of the ENMOS model will be provided under a separate report as part of the analytical framework.

The trade-off analysis will be carried out using River System Simulation Model (RIVERWARE). Detailed description of Ribasim and modelling results will be provided in separate report as part of the analytical framework.

The objective of this chapter of the report is to first outline the basic features of the water system modelling including water demands, inflow nodes and reservoir nodes included in the analytical framework, and then to highlight the water availability under the base case conditions model using SWAT hydrologic model.

7.2 WATER SYSTEM MODELLING FOR THE ABBAY BLUE NILE SUBABSIN

The Abbay-Blue Nile sub-basin is modelled from Lake Tana to the confluence with the White Nile at Khartoum. The historical and existing modelled network consists of fourteen inflow locations, three diversion locations and three reservoir sites. *Figure* **7-1** shows schematic for the Abbay-Blue-Nile-Subbasin.

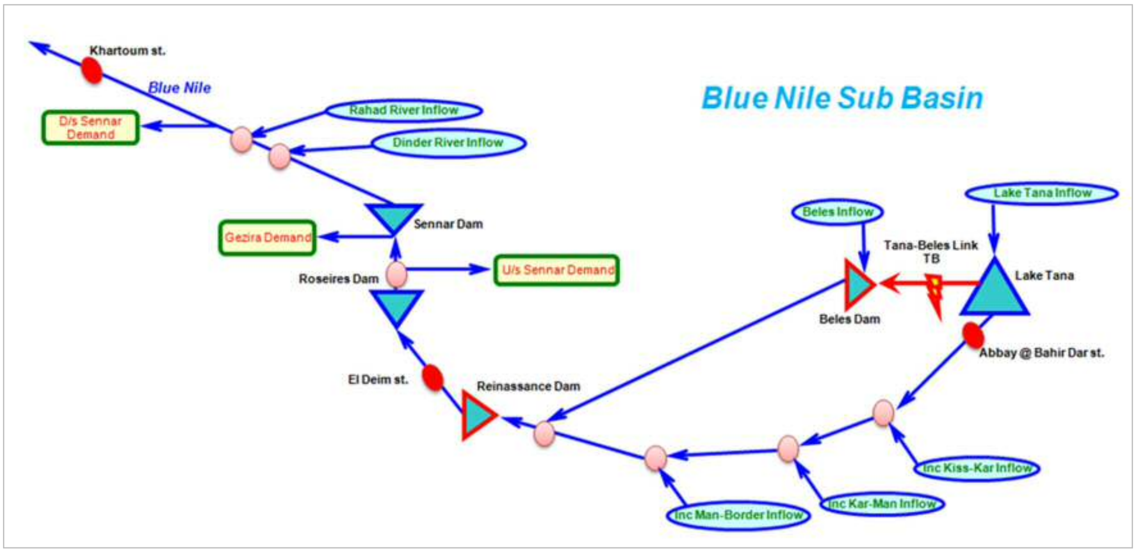


Figure 7-1. Model Schematic of the Blue Nile Sub-Basin

7.2.1 Major Water Abstraction and Demands

Irrigation water abstraction under the base case scenarios were lumped into three major abstraction nodes. These are:

- Upstream Sennar Demand,
- Gezira Managil Demand, and
- Downstream Sennar Demand.

Table **7-1** provides average monthly values for these three abstraction nodes.

Table 7-1. Demands on the Blue Nile

	Upstream Sennar Demand	Downstream Sennar Demand	Gezira Managil Demand
	cms	cms	cms
January	82.78	7.25	185.58
February	67.46	7.51	202.34
March	66.33	8.1	190.86
April	44.69	10.42	118.13
May	34.87	11.72	30.78
June	35.09	12.39	44.49
July	77.06	12.54	180.89
August	97.39	9.04	268.64
September	93.75	7.22	258.55
October	132.38	10.28	337.76
November	148.2	11.35	321.77
December	141.85	10.11	249.6

7.2.2 Reservoir Data

Reservoirs on the Blue Nile include the Roseries and Sennar reservoirs and of course Lake Tana, which is a regulated natural lake. Elevation-Volume-Surface Area relationships, evaporation rates for these water bodies as well as power generation characteristics were obtained from the ENTRO knowledge base and are summarized below.

7.2.2.1 Lake Tana Operations

Operational rules for Lake Tana were based on the Elevation-Discharge relationships extracted from Tana-Beles Study project and summarized as shown in Table 6.2 below.

Table 7-2: Elevation-Discharge Relationship for Lake Tana

Elevation (m)	Discharge (cms)
1783.5	0
1784.5	40
1785.0	56
1785.5	80
1786.0	107
1786.5	132
1787.0	165
1787.5	204
1788.0	260
1788.5	397

The Tana-Beles hydropower project was completed in May 2010 and is included in the baseline model, but not in the historical calibration model. The project diverts water directly from Lake Tana and is represented as such in the models. The relationship between the diverted flow and intake elevation for the diversion is defined in the Beles Multipurpose Level 1 Design Report from the Ethiopian Electric Power Corporation.

The hydropower generation is modelled as an in-line power plant. The head variation is essentially fixed and therefore a unique relationship exists between flow and energy generated through the turbines.

Table 7-3. Tana-Beles Hydropower Generation

Flow (cms)	Power (MW)
0	0.0
77	213.1
160	423.0

7.2.2.2 Operation of Roseries Dam

Operational rules for Roseries Dam are based on descriptions provided by ENTRO through the EN Power study report for the heightening of the Roseries Dam. Due to the large seasonal fluctuation, relatively small storage volume, and high amount of sediment accumulating in Roseries, the operational criteria is specified to draw down the reservoir starting in mid-January and maintain a minimum elevation until the peak flow has passed in September. Therefore, meeting target elevation criteria is the primary guiding principle of the operation of Roseries Dam.

Table 7-4: Roseries Dam Target Elevation to be revised based on Roseries heightening

Month	Target Elevation (masl)
Jan	478.78
Feb	475.13
Mar	472.39
Apr	469.78
May	467.09
Jun	467.00
Jul	467.00
Aug	467.00
Sep	471.67
Oct	481.00
Nov	481.00
Dec	481.00

7.2.2.3 Operation of Sennar Dam

Operational rules for Sennar Dam are also based on descriptions provided by the EN Power Trade Study Project documents. Similar to Roseries Dam, a primary operational objective of this reservoir is to achieve drawdown and refill to certain levels on specified dates. In addition, the Gezira Managil diversion takes water directly from the reservoir for agriculture purposes. The minimum diversion elevation of the Gezira Managil diversion is 417 masl and therefore demands can be met when the storage level is greater than this level. All water in the reservoir above this elevation is considered available for diversion. After this objective is met, the reservoir operates to meet the monthly target elevations shown

Table 7-5. Sennar Dam Target Elevation

Month	Target Elevation (masl)
Jan	421.70
Feb	421.70
Mar	421.70
Apr	421.70
May	417.00
Jun	417.00
Jul	417.00
Aug	417.00
Sep	418.65
Oct	421.70
Nov	421.70
Dec	421.70

7.2.3 Stream Gauge Data

A complete set of stream gauge data was available for the following stations: Abbay at Bahir Dar; Abbay at Kessie, El Diem station at the Ethiopia-Sudan boarder and Khartoum station just upstream of the confluence with the White Nile. Historical release data from any of the reservoirs on the Blue Nile is inadequate for calibration purposes.

7.2.4 Blue Nile Environmental Requirements

Environmental flow requirement for the Blue Nile river system include the minimum flow to maintain the operation of the pumping station downstream and were extracted from the pre-feasibility studies under the EN Power Trade Study.

Table 7-6. Environmental Demands in the Blue Nile

Month	Environmental Demand (cms)
Jan	64.40
Feb	64.40
Mar	64.40
Apr	64.40
May	64.40
Jun	64.40
Jul	128.80
Aug	643.80
Sep	193.20
Oct	128.80
Nov	64.40
Dec	64.40

7.3 Baro-Akobo-Sobat

The Baro-Akobo-Sobat sub-basin is a complex network of streams originating in the Ethiopian Highlands and draining into the White Nile above Malakal. The only existing hydraulic structures in the river system are the Alwero/Abobo dam, constructed 20 years ago, and the SOR hydropower Plant (5MW). Several potential reservoir sites exist in the sub-basin. Complete hydrologic data for the period of 1956 to 1990 exists only in isolated stream gauges on the Baro at Gambella and the Sobat at Hillel Doleib. The tributaries of the Baro River are described with several time series of headwater data obtained through ENTRO in a spreadsheet titled BAS_Schematic.xlsx which was developed through the WP II, Stage II data source described earlier but the Pibor is only defined near the outlet into the Sobat.

The gauge on the Sobat at Hillel Doleib provides a calibration point immediately before the confluence with the While Nile. A complicating factor in the Baro-Akobo-Sobat sub-basin is the spills that occur to the Machar Marshes to the Adura River during times of high runoff. This water spilled to the marsh is typically removed from the system due to evapotranspiration, but some outflow from the marsh can also return to the White Nile below the Malakal Gauge.

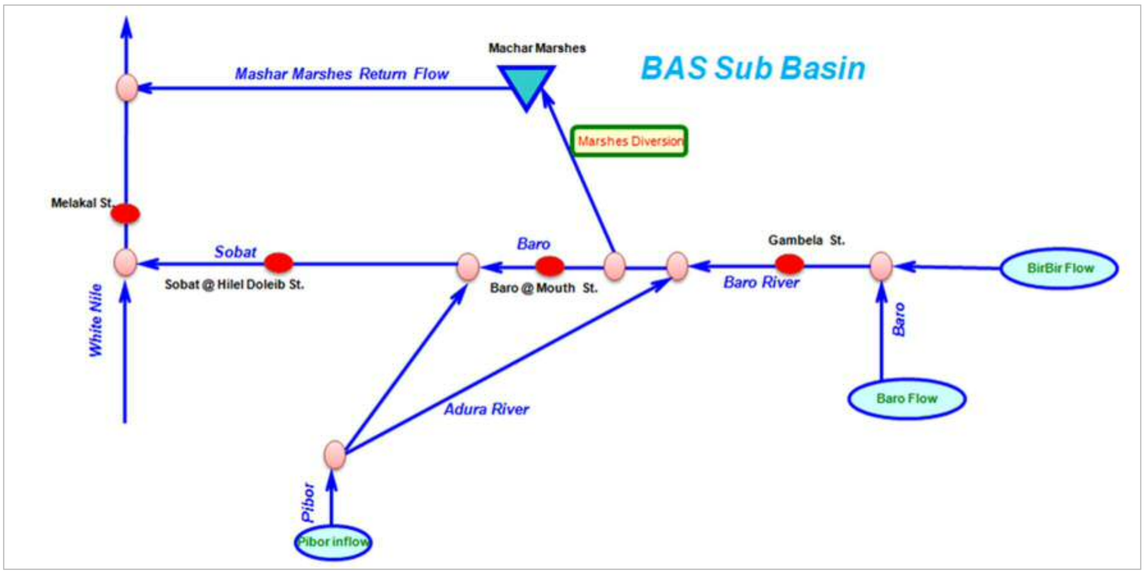


Figure 7-2. Model Schematic of the Baro-Akobo-Sobat Sub-Basin

7.3.1 Demands

No historical quantified consumptive use data was identified and therefore are not included in the Base Case Scenario.

7.3.2 Reservoir Data

The only existing dam structure is the Abobo Dam in the Alwero tributary that contributes to the Pibor River. Since there is insufficient data describing the headwaters of the Pibor River, the model does not include this structure in the calibration model or baseline models. Inflows from Pibor are assumed near the confluence with the Sobat.

7.3.3 Stream Gauge Data

Three principal stream gauges are used for calibration of the Base Case Scenario. The gauge on the Baro at Gambella measures the runoff from several tributaries including the Gumero, Birbir, Sore, Sese, Geba and the Baro and the gauge at the mouth of the Baro measures the total contribution of the Baro to the Sobat after various losses have taken place. The gauge on the Sobat at Hillet Doleib records flows immediately before the river flows into the White Nile.

7.4 Tekeze-Setit-Atbara

The Tekeze-Setit-Atbara sub-basin is the last significant tributary to the Nile River. This tributary has the highest seasonal variation of the entire basin and had the least amount of data available describing its characteristics. The Atbara River originates just north of Lake Tana. The primary tributary to the Atbara River is the Tekeze/Setit, which forms part of the border between Eritrea and Ethiopia and originates in the high mountains of northern Ethiopia. The principal reservoirs in the sub-basin are the Khashm El Girba Dam just downstream of the confluence of the rivers and the Tekeze Dam on the Tekeze River. The Tekeze Reservoir was not constructed until after the modelled calibration period, therefore is not included in the calibration model but is included in the baseline and scenario models. The primary consumptive use is a direct diversion from the Khashm El Girba Dam.

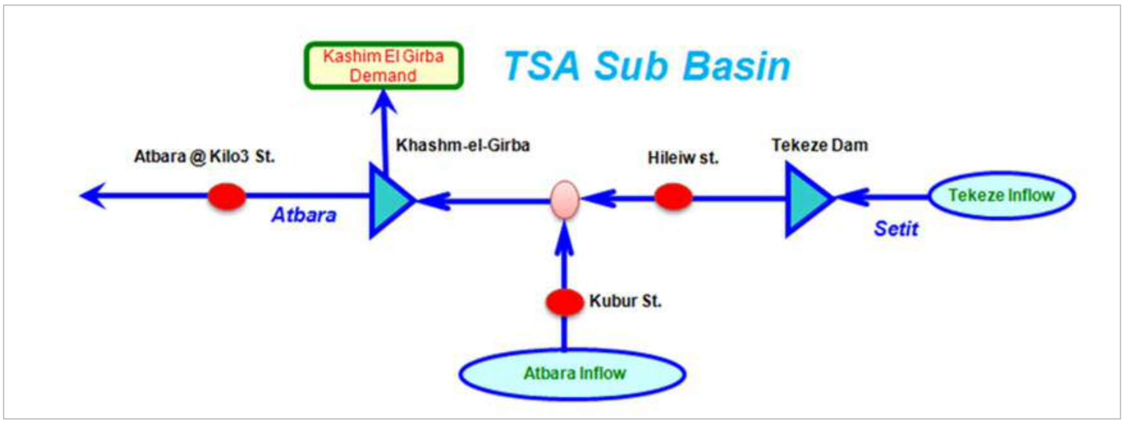


Figure 7-3. Model Schematic of the Tekeze-Setit-Atbara Sub-Basin

7.4.1 Demands

Data from the Kashim El Girba Demand location were extracted from the MIKE Basins model. These demands were simple repeating patterns and no data on historical inter-annual variability was available.

Table 7-7. Demands on the Tekeze-Setit-Atbara

Month	Khashm El Gibra Demand (cms)
Jan	42.24
Feb	39.78
Mar	27.43
Apr	16.89
May	19.44
Jun	40.83
Jul	45.56
Aug	51.35
Sep	51.82
Oct	55.41
Nov	46.73
Dec	45.23

7.4.2 Reservoir Data

Reservoirs on the Tekeze-Setit-Atbara include the Khashm El Girba Reservoir and Tekeze Reservoir. Although data describing these reservoirs were compiled from a variety of sources including the EN Power Trade Study and the feasibility study for Tekeze Dam, significant uncertainty on the operation of these reservoirs remains.

7.4.2.1 Khashm El Girba Operations

Physical characteristics of Khashm El Girba Reservoir were extracted from the Power Trade Study Reports. This include the elevation-storage-surface area curves, reservoir evaporation rates, and turbine characteristics. Operations were assumed to primarily meet the Khashm El Girba demands and then to achieve the target elevations specified in the High Aswan system diagram final.xlsm spreadsheet, adjusted to limit the drawdown as specified in the NEC 2003 report.

Table 7-8. Khashm El Girba Dam Target Elevation

Month	Target Elevation (masl)
Jan	474.00
Feb	474.00
Mar	474.00
Apr	474.00
May	474.00
Jun	463.50
Jul	463.50
Aug	463.50
Sep	474.00
Oct	474.00
Nov	474.00
Dec	474.00

Power is generated through a low head turbine as water is released to the Khashm El Girba Demand directly from the reservoir. This is modelled in RiverWare as an in-line power plant with a linear turbine release-power relationship ramping up to the maximum discharge of 116 cms and a flow power capacity of 7.6 MW.

7.4.2.2 Tekeze Dam Operations

Physical Characteristics describing the elevation-storage-surface area relationships and reservoir evaporation rates for the Tekeze dam were obtained through the feasibility study document for Tekezi Dam. Turbine characteristics of target and maximum power generation were extracted from the same document. No operational guidelines could be located, therefore a method was developed to operate this reservoir to primarily meet a target power generation of 112 MW, with a maximum power capacity of 300 MW. To accomplish this operation, a rule was written that specifies a turbine release to meet the power generation objective, followed by a flood control rule that spills any water in excess of a specified elevation. A maximum pool elevation of 1140 masl and a minimum operation level of 1096 masl was used as the range over which power could be generated. The RiverWare spill method of regulatedSpillCalc was selected to allow rules to explicitly assign the turbine release and the spill volumes to maintain the maximum pool elevation. A RiverWare method of plant Power Equation was selected to calculate the power given a plant efficiency of 95%.

7.4.3 Stream Gauge Data

Stream gauge data for the Tekeze-Setit-Atbara sub-basin exists for the Atbara at Kilometre 3. This provides a continuous record for calibration of the historical upstream conditions and assumptions. Records of outflows from of Khashm El Girba dam exist, but were considered too incomplete to be used for calibration purposes.

7.4.4 Tekeze-Setit-Atbara Environmental Requirements

An additional augmentation check is available on the release from each of the reservoirs to meet downstream environmental requirements. These demands are specified in the EN Power Trade Study and are uniform for both the Tekeze and the Khashm El Girba reservoirs.

Table 7-9. Environmental Demands in the Tekeze-Setit-Atbara

Month	Environmental Demand (cms)
Jan	2.47
Feb	1.59
Mar	2.43
Apr	3.72
May	3.57
Jun	9.07
Jul	22.77
Aug	22.77
Sep	22.77
Oct	20.30
Nov	8.58
Dec	4.74

7.5 White Nile from Malakal to Khartoum

The White Nile at Malakal represents the upstream boundary of the modelled region. This gauge represents the combined flows from the Sobat and the outflows from the Sudd marshes. The lower extent of this reach is at the confluence with the Blue Nile at Khartoum. The Jebel Aulia Dam is the only dam in this reach along with two diversion locations.

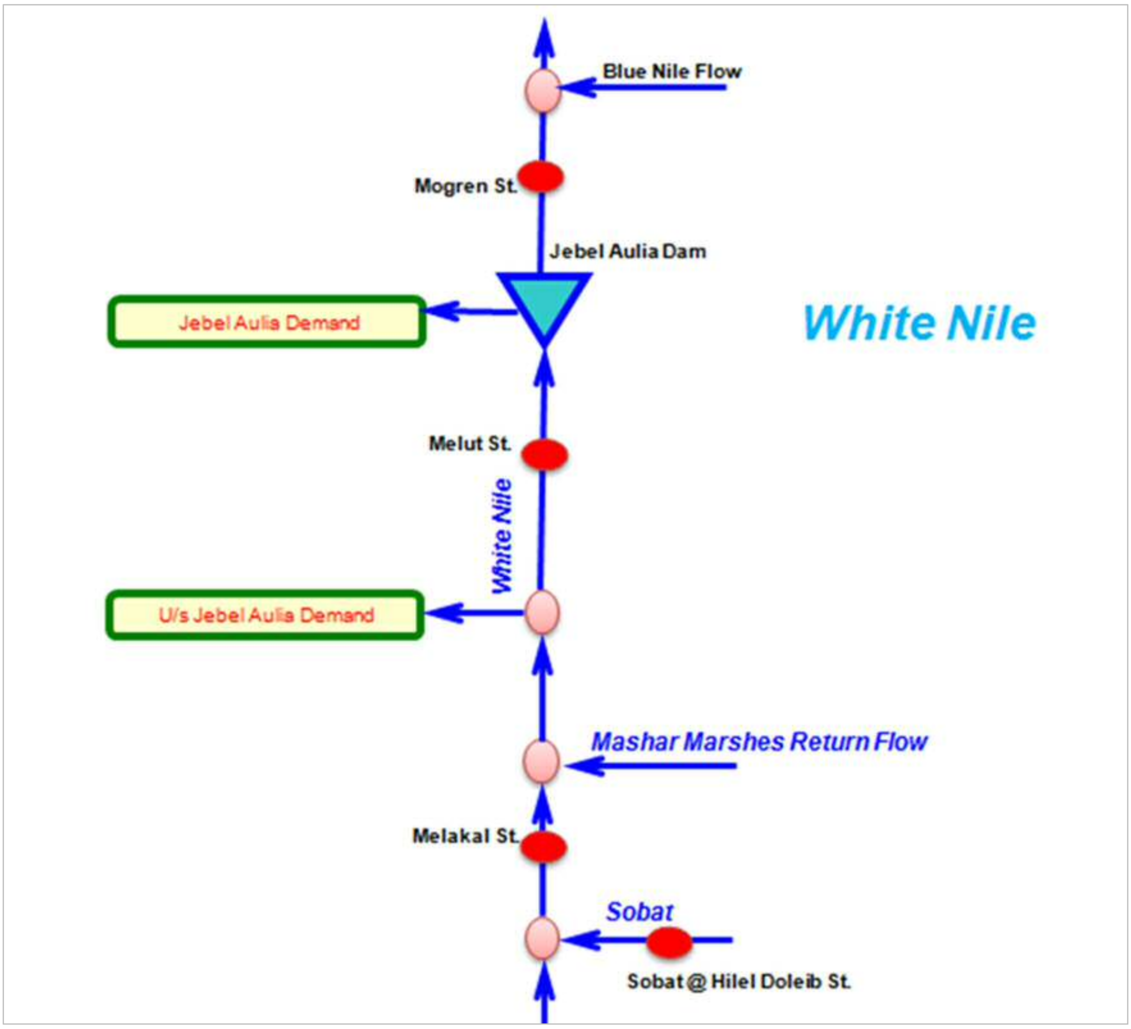


Figure 7-4. Model Schematic of the White Nile Sub-basin

7.5.1 Hydrological Inflows

Hydrologic inflows to this reach are strictly from catchment areas entering the reach. The gauge at Malakal combines the outflows from the Sobat with the outflows from the Sudd. The historical outflows from the Sudd are ungauged, but can be back-calculated by subtracting the flows on the Sobat at Hillel Doleib from the flows at Malakal. For the purposes of calibration, this provides a perfectly reconciled flow at Malakal. Additional inflows from the Machar Marshes are possible downstream of the Malakal gauge, however the magnitudes of these flows are historically insignificant and not deemed reliable for any planning purposes. These return flows are considered zeros in the current model, but links have been maintained so they can be easily enhanced for future studies. No intervening inflows are assumed on the remainder of the While Nile before reaching the confluence with the Blue Nile, however losses due to evaporation losses and seepage are accounted for upstream of the Mogren Gauge. The values assigned to these losses are discussed further in the calibration section of this report.

7.5.2 Demands

Two demand locations are included on the While Nile between Malakal and Khartoum. Diversions upstream of Jebel Aulia and diversions directly from Jebel Aulia are quantified as average monthly demands.

Table 7-10. Demands on the White Nile Between Malakal and Khartoum

Month	u/s of Jebel Aulia (cms)	Jebel Aulia Demand (cms)
Jan	9.05	20.91
Feb	9.83	24.72
Mar	10.73	28.00
Apr	12.01	31.25
May	12.04	32.99
Jun	12.27	35.58
Jul	9.30	69.22
Aug	6.74	71.91
Sep	10.41	135.65
Oct	10.50	155.89
Nov	10.15	135.35
Dec	8.75	36.99

7.5.3 Reservoir Data

The physical characteristics of the elevation-storage-surface area for the Jebel Aulia Reservoir were obtained from a Project document for Jabel Reservoir Operation and the evaporation coefficients were obtained from the EN Power Trade Study Reports. The operation of the reservoir was understood through the NEC 2003 study and target elevations were developed to reflect the basic logic.

Table 7-11. Jebel Aulia Dam Target Elevation

Month	Target Elevation (masl)
Jan	377.40
Feb	377.40
Mar	376.87
Apr	375.43
May	373.94
Jun	372.50
Jul	376.50
Aug	376.50
Sep	377.40
Oct	377.40
Nov	377.40
Dec	377.40

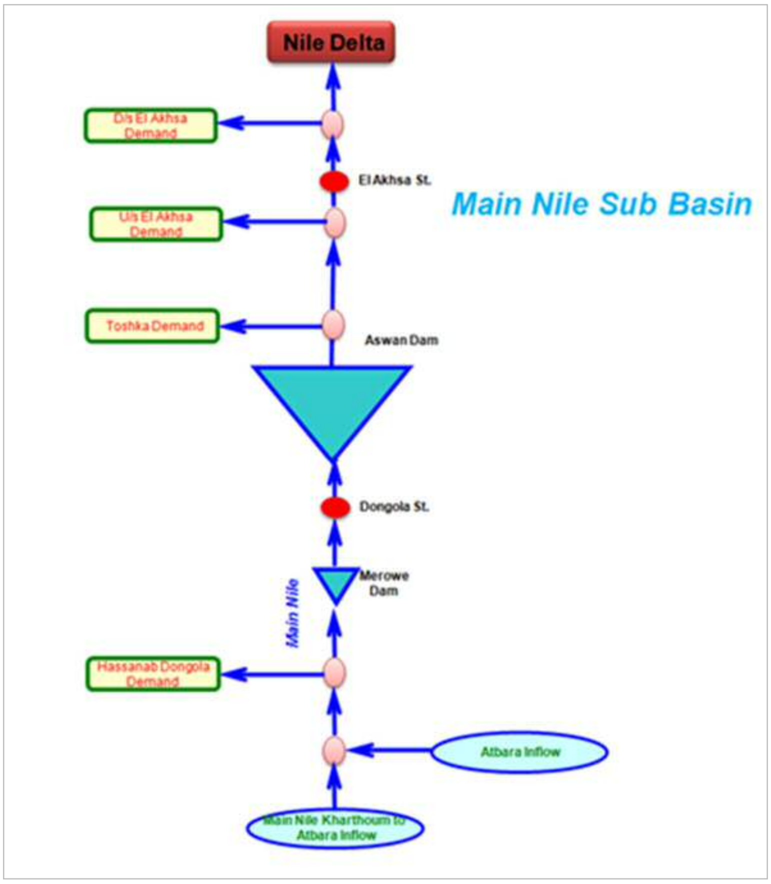
The NEC study described how the management of the Jebel Aulia Dam depends on the timing of the peak flood on the Blue Nile. The filling of the reservoir starts at the beginning of July and continues to 376.5 masl at the end of the month. It is then held constant for one month until the peak flood of the Blue Nile has passed. In a monthly time step model, the only real effect of this policy is the target elevation at the end of the month of September. A rule was incorporated to evaluate if the peak flow at the Khartoum Soba gauge has passed, and if so, set the outflows from the Jebel Aulia dam immediately to meet the refill volume. If the peak flow at the beginning of September has not passed, then set the September target to the half-way point with the goal of achieving the refill volume by the end of October.

7.5.4 Stream Gauge Data

Historical stream gauge records exist for three locations on the While Nile. The Flows at Malakal, flows at the Melut Gauge upstream of Jebel Aulia, and flows the Mogren Gauge downstream of Jebel Aulia. As described above, the flows at Malakal are used to determine the presumed outflows from the Sudd. Although both the Melut and the Mogren gauges can be used as calibration locations due to the robust flow record, it is important to note that the Melut Gauge is potentially affected by the elevation of the Jebel Aulia Reservoir and the Mogren gauge is reported to be affected by backwater effects of the flood inflows of the Blue Nile (Hydrology of the Nile) and thus affects calibration results.

7.6 Main Nile

The Main Nile is considered to be the reach below the confluence of the White and Blue Nile to the Delta and outflow the Mediterranean Sea. The Atbara joins the Nile in this reach befor the Nile passes through the High Aswan Dam near the Sudan-Egypt border. The recently constructed Merowe Dam was constructed upstream of the High Aswan dam and is therefore included in the Baseline and Scenario models, but not in the historical calibration model. There are five modelled demand locations that represent aggregations of many water users in this region.



Four demand locations are modelled in on the Main Nile that represent aggregate consumptive uses along this reach. This includes: irrigation demand in the reach between Khartoum to Hasanab (Tamaniat-Hasanab Demand); Irrigation abstraction in the main nile reach between Hasanab to Dongola; irrigation abstraction in upper Egypt represented by upstream of Elkhass abstraction node; and irrigation abstraction downstream El Khass which include irrigation for the Delta Area in Egypt.

Figure 7-5. Model Schematic Main Nile Sub-basin

Average monthly demands are provided in Table 7-12.

Table 7-12. Demands on the Main Nile

Month	Tamaniat-Hassanab Demand (cms)	Hassanab-Dongola Demand (cms)	u/s of El Akhsas (cms)	d/s of El Akhsas (cms)
Jan	18.85	28.21	104.41	0.00
Feb	12.85	19.33	583.21	0.00
Mar	5.34	8.10	531.34	0.00
Apr	4.63	6.94	538.84	0.00
May	7.17	10.75	745.41	0.00
Jun	14.81	22.21	983.59	0.00
Jul	13.44	20.15	844.91	0.00
Aug	10.75	16.08	713.17	0.00
Sep	20.37	30.54	490.38	0.00
Oct	25.08	37.61	433.54	0.00
Nov	25.92	38.87	436.30	0.00
Dec	23.26	34.93	305.84	0.00

An additional demand location for the Toshka project is modelled immediately below the High Aswan Dam. The volume of this diversion is a function of the pool elevation in Lake Nasser/Lake Nubia, and therefore could be modelled using an unregulated spillway. The value of the flow resulting from this unregulated spillway is then set as the depletion from the reach immediately below the dam.

Table 7-13. Elevation-Based Diversion to the Toshka Project

Pool Elevation (masl)	Toshka Diversion (cms)
178.0	0.0
178.5	6.0
179.0	19.0
179.5	37.3
180.0	60.3
180.5	87.5
181.0	118.6
181.5	153.3
182.0	191.5
182.5	233.0
183.0	277.8
183.5	325.6
184.0	376.4

7.6.1 Reservoir Data

The two main dams included as part of the base case model are the High Aswan Dam and the Merowe Dam.

7.6.1.1 Merowe Dam Operations

The Merowe Dam was constructed recently and the data describing the elevation-volume-surface area was acquired through the EN Power Trade Study reports and from the public web-site (http://www.merowedam.gov.sd/en/index.php).

Operational criteria of the Merowe Dam were not identified and it has therefore been assumed that the dam is operated to meet the primary objective of hydropower generation. A method was developed to operate this reservoir to primarily meet a target power generation of 625 MW, with a maximum power capacity of 1250 MW. To accomplish this operation, a rule was written that specifies a turbine release to meet the power generation objective, followed by a flood control rule that spills any water in excess of a specified elevation. A maximum pool elevation of 300 masl and a minimum operation level of 284.90 masl was used as the range over which power could be generated. The RiverWare spill method of regulatedSpillCalc was selected to allow rules to explicitly assign the turbine release and the spill volumes to maintain the maximum pool elevation.

7.6.1.2 High Aswan Dam Operations

The physical characteristics for the High Aswan Dam and Lake Nasser/Lake Nubia were extracted from the EN Power Trade Study and the Egypt Country Master Plans. The includes the turbine characteristics including explicit relationships between operating head, turbine releases and power generation.

Table 7-14. High Aswan Inflow States

Inflow State	Flow Range (Millard m3/Month)	Flow Range (cms)
1	Above	
	11.50	4364.00
2	11.50	4364.00
	9.80	3718.88
3	9.80	3718.88
	7.80	2959.93
4	7.80	2959.93
	6.00	2276.87
5	6.00	2276.87
	0.00	0.00

In addition to the inflow ranges, current reservoir pool elevations are identified and categorized into four elevation zones including an Upper Conservation Storage Zone, Lower Conservation Storage Zone, Buffer Storage Zone and Inactive Storage as shown in *Figure* **7-6**. Elevations above 178 masl include Toshka releases.

Releases from High Aswan are then determined as a function of both the pool elevation and the inflow state of the reservoir.

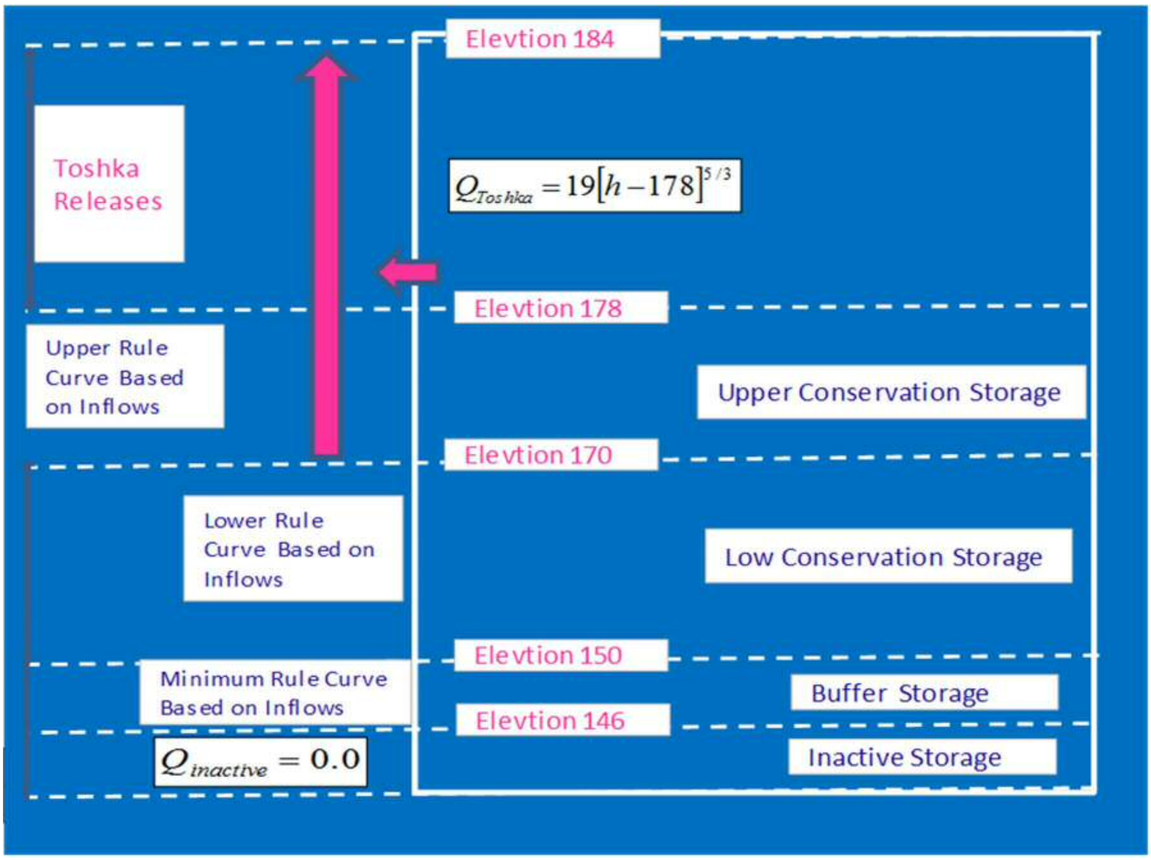


Figure 7-6: High Aswan Dam Operation Zones

7.6.2 Base Case Scenario Model Calibration and Validation

The results of riverware model calibration for the base case are shown in Figures 7.7 to 7.16 for key gauging stations. These are the Blue Nile at El Deim, Blue Nile at Khartoum, Sobat at Hillet Dolieb, Atbara at Kilo 3 and Main Nile at Dongola. Figure 7.7 shows a plot of the modelled and historical observed flows at these key stations for the period 1960 to 1990. Figure 7.8 provide a scatter plot of observed versus simulated flows. As can be seen from the plot, the Riverware simulation shows a relatively good fit between observed simulated flows at these key stations. Further refinement and sensitivity analysis of model results will be performed under the scenario analysis.

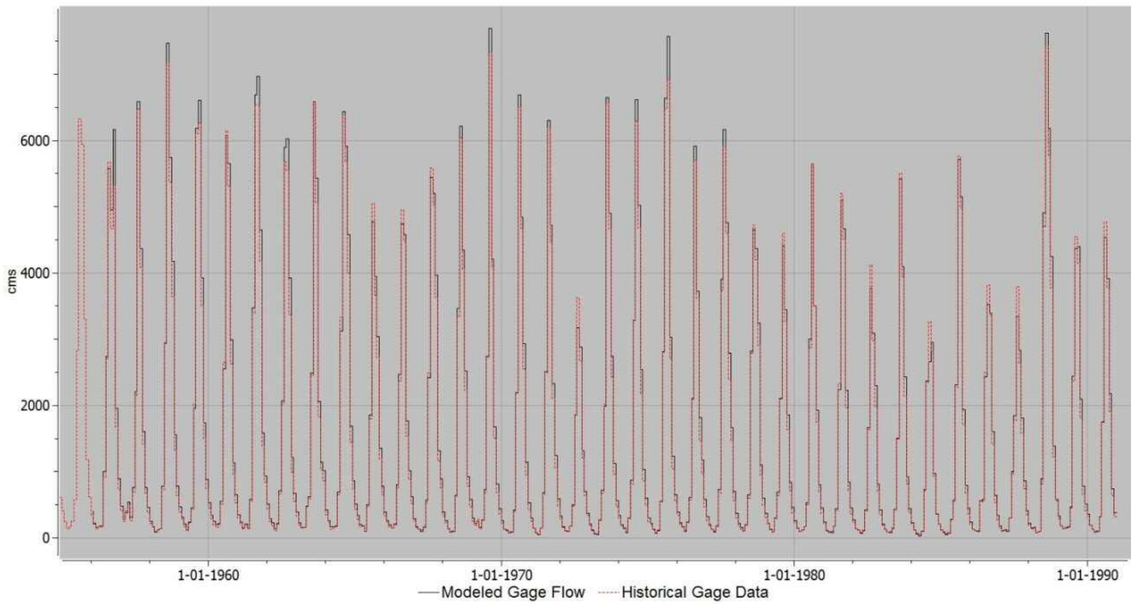


Figure 7-7: Time Series Calibration of the Blue Nile at El Diem Gauge

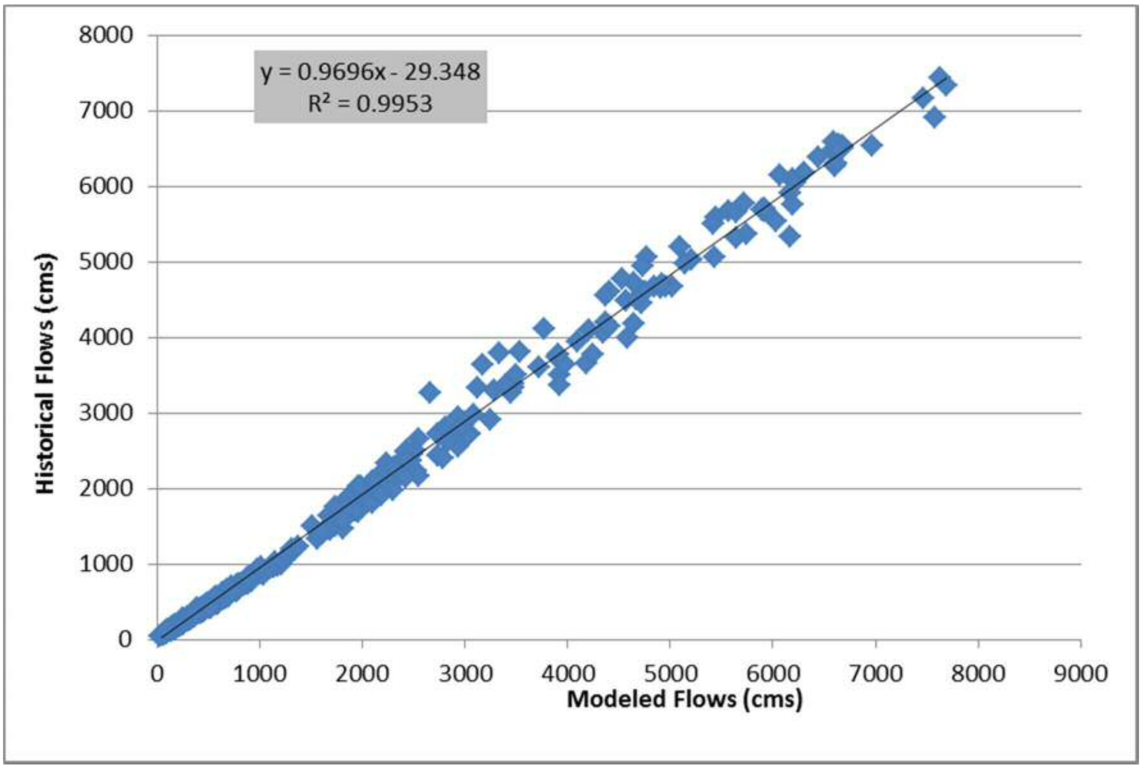


Figure 7-8: Modelled vs. Historical Calibration of the Blue Nile at El Diem

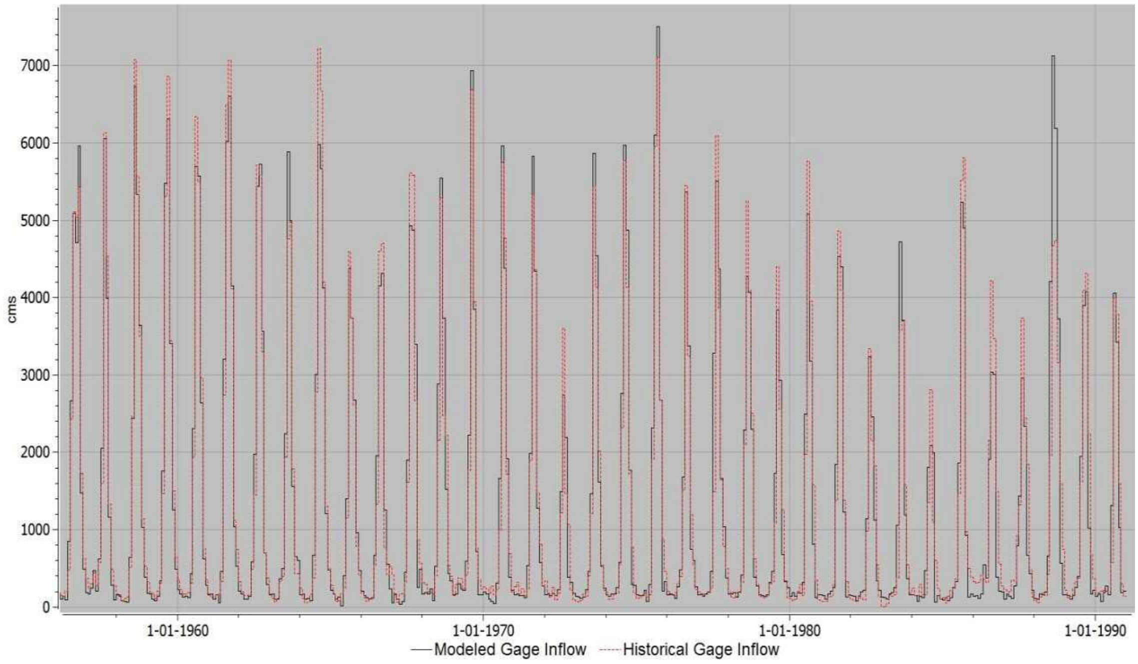


Figure 7-9: Time Series Calibration of the Blue Nile Khartoum and Soba Gauge

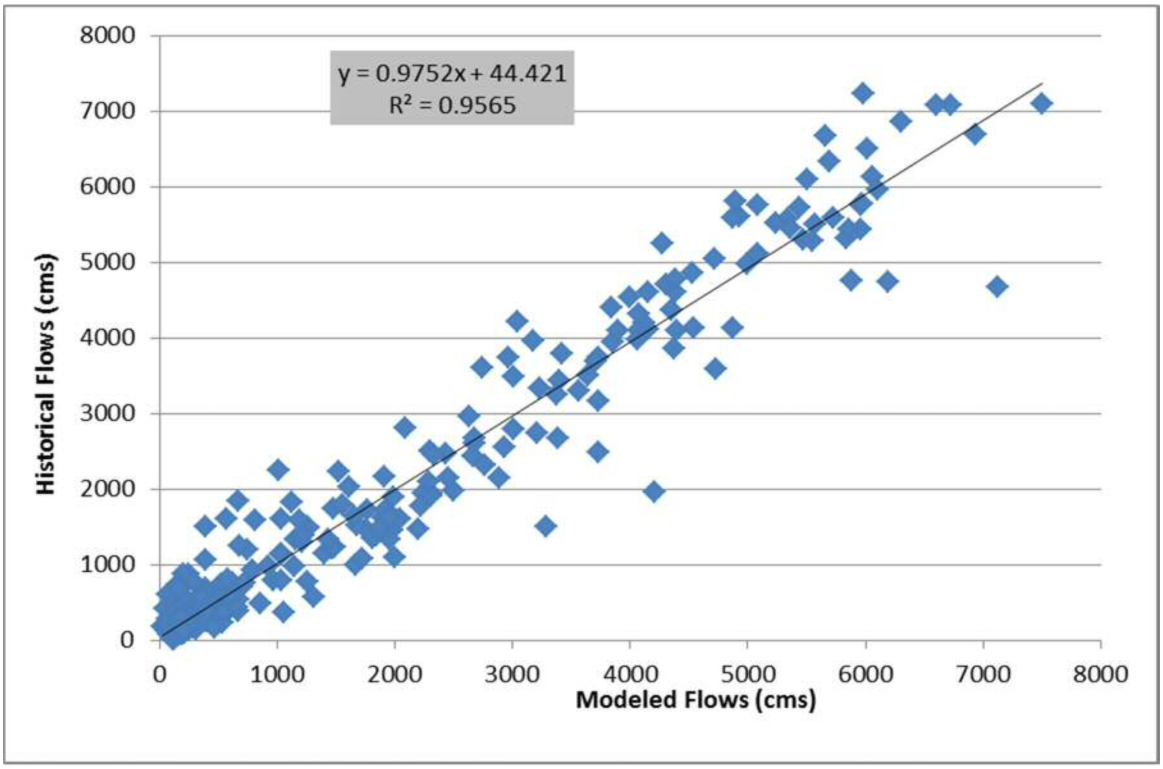


Figure 7-10: Modelled vs. Historical Calibration of the Blue Nile Khartoum and Soba Gauge

Figures 7.9 and 7.10 shows the results of model calibration for at El-Deim and Khartoum station Along the Blue Nile River System.

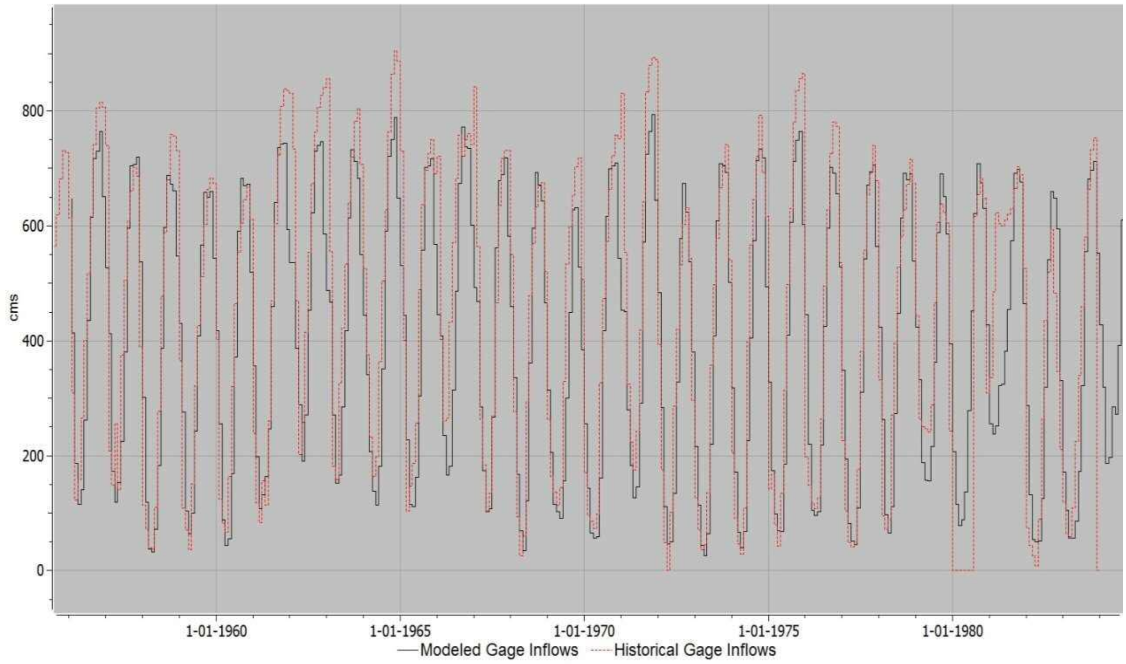


Figure 7-11. Time Series Calibration of the Sobat River at Hillel Doleib

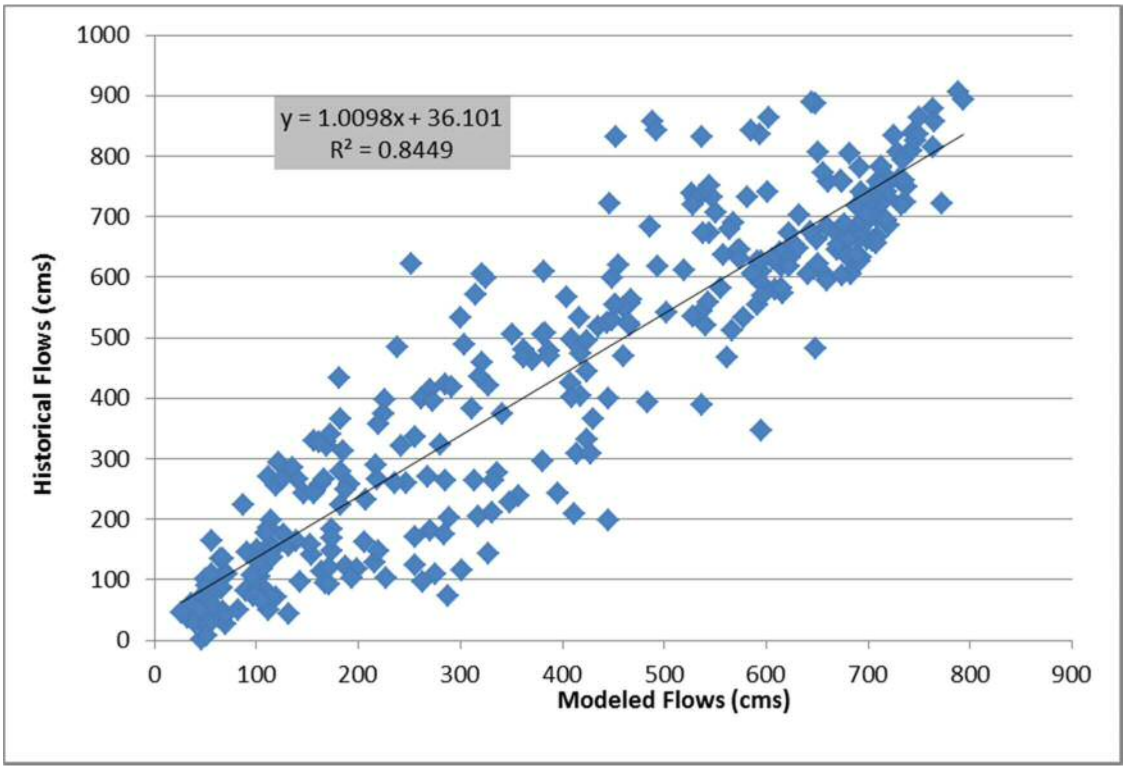


Figure 7-12. Modelled vs. Historical Calibration of the Sobat River at Hillel Doleib

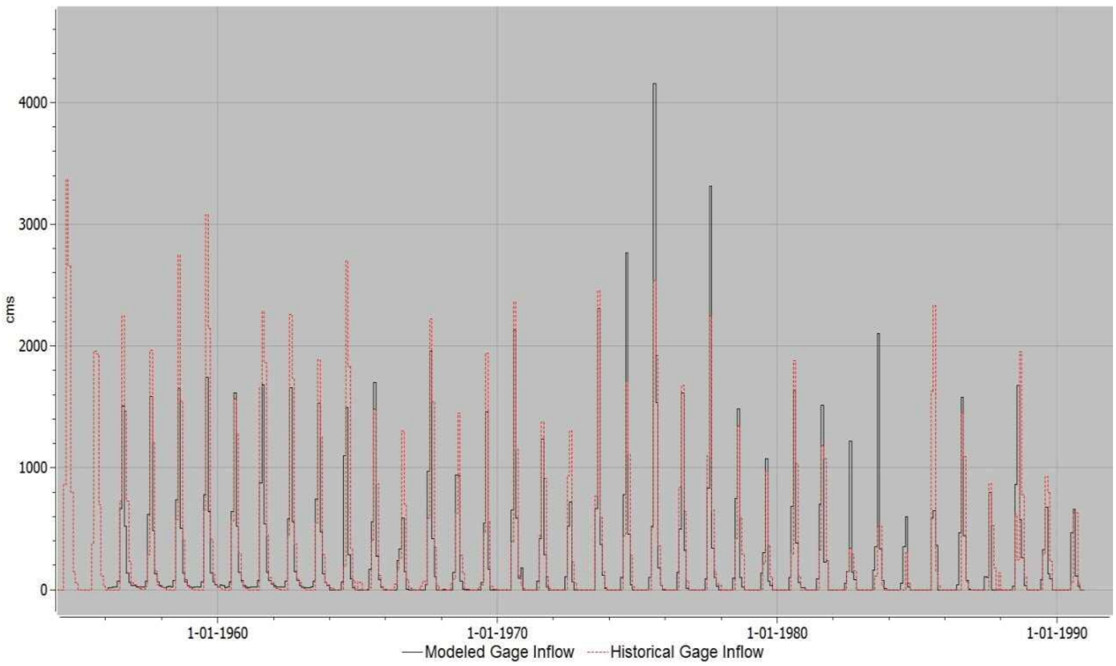


Figure 7-13. Time Series Calibration of the Atbara River at Kilometer 3

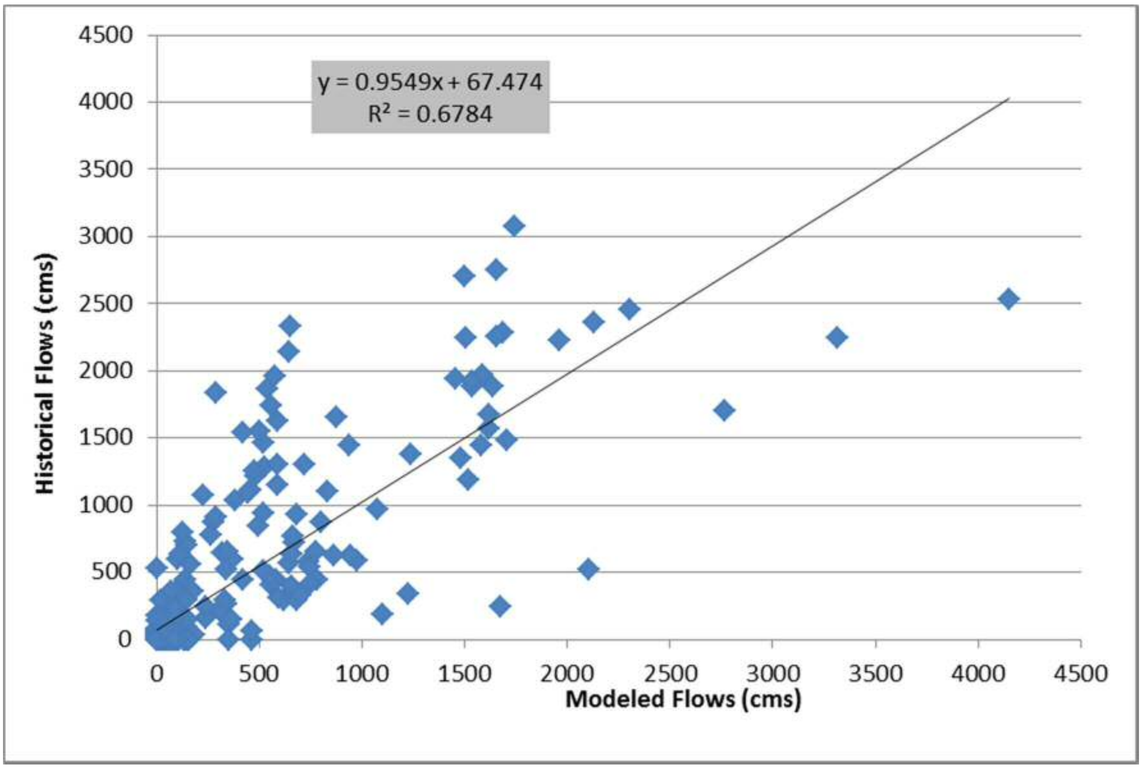


Figure 7-14. Modelled vs. Historical Calibration at the Atbara at Kilometer 3

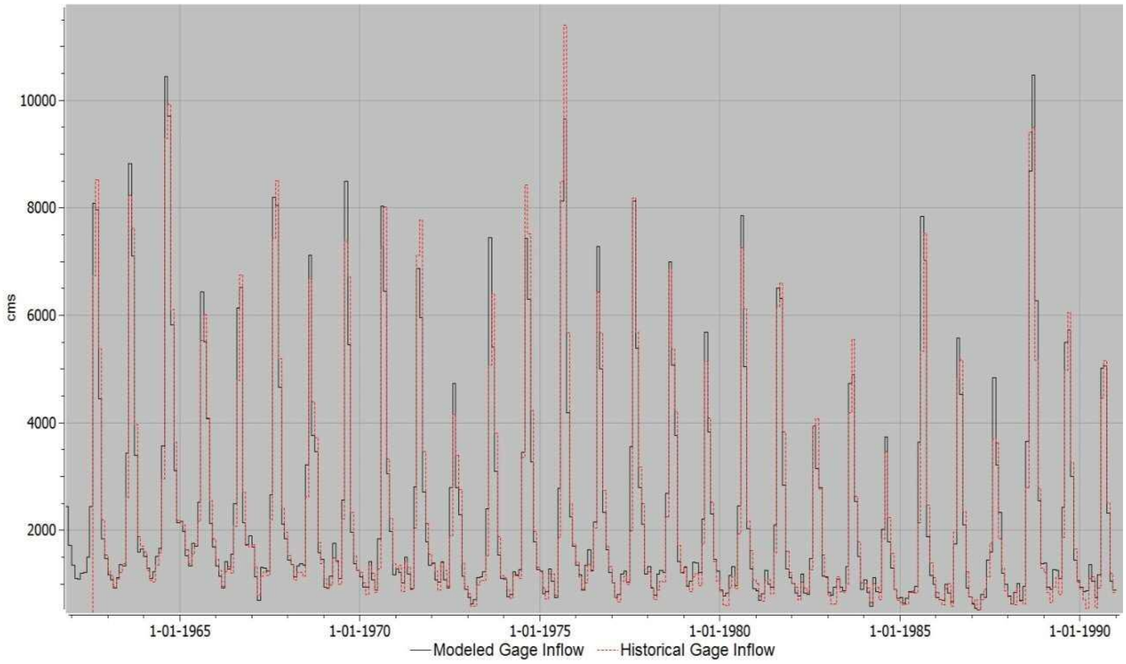


Figure 7-15. Time Series Calibration of the Main Nile at Dongola

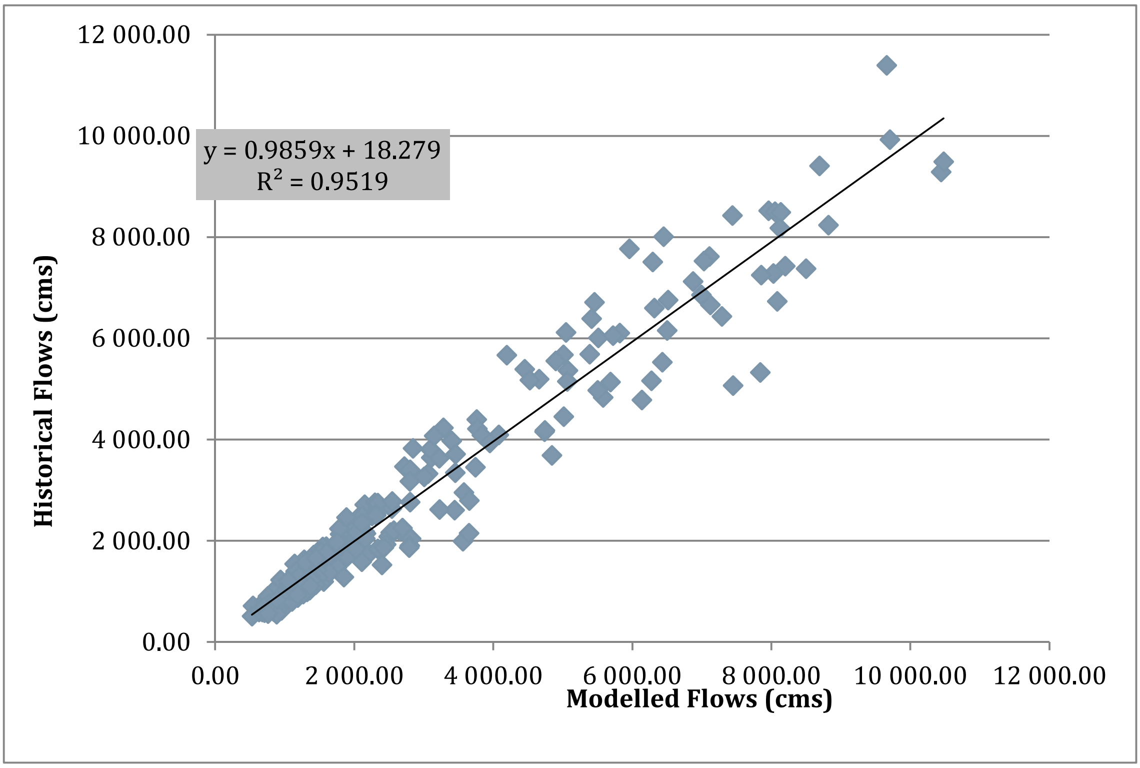


Figure 7-16. Modelled vs. Historical Calibration of the Main Nile at Dongola

7.6.3 Water Balance Analysis

The calibrated and validated model has been simulated from 1960 to 2000 to estimate the water balance and their distribution among the four sub-basins of the ENB. From long term simulation results, it has been found that annual average flow was 49,503 Mm^3 for the Abbay-Blue Nile sub-basin, 28,247 Mm3 for the Baro-Akobo-Sobat-White Nile sub-basin and 11,762 Mm^3 for the Tekeze-Atbara-Setite sub-basin. The annual average flow that comes to the Aswan High Dam is 84,727 Mm^3 among which the Abbay-Blue Nile sub-basin contributes 55%, while 32% comes from the White Nile sub-basin and 13% from the Tekeze-Atbara-Setite sub-basin. In the Blue Nile, 80% of flow is observed during July, August, September and October and the peak is found in August. In the White Nile, the flow does not vary widely throughout the year and the minimum flow is found in July. In the Tekeze-Atbara-Setite sub-basin, 95% of flow is found in July, August, September and October, the peak is found in August-September and the flow is almost zero in the dry season. In the Main Nile, 70% of flow is observed in July and November and the peak is observed in August-September.

The variability of stream flow for different year has been also analysed using flow duration curves. The annual flow duration curves for the four sub-basins of ENB are shown in figure 11. From the flow duration curve, it has been found that the 50% dependable flows are 47,000 Mm3, 28,000 Mm3, 10,700 Mm3 and 81,000 Mm3 for the Abbay-BN, BAS-WN, TAS and MN sub-basin respectively while 75% dependable flows are 38,000 Mm3, 26,500 Mm3, 6,200 Mm3 and 65,500 Mm3 respectively for the above four sub-basins respectively.

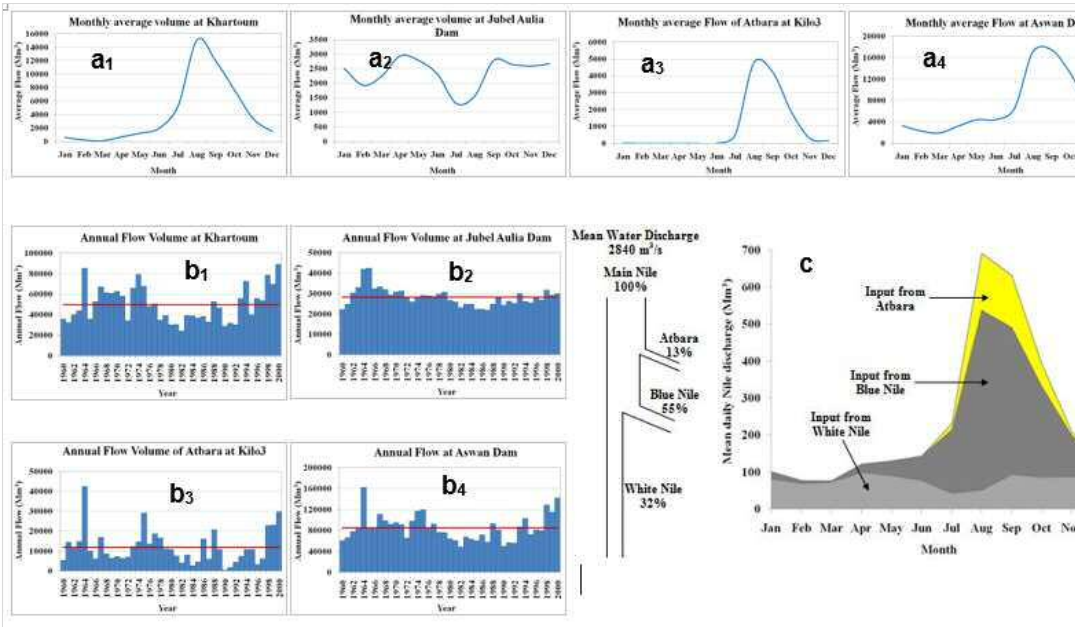


Figure 7-17: Monthly average and annual flows for Blue Nile, Whitel Nile, Atbara and Main Nile

a1, a2, a3 and a4 shows average flows and b1, b2, b3 and b4 shows annual flows for Blue Nile at Khartoum, White Nile downstream of Jubel Aulia dam, Atbara at kilo3 and Nile at Aswan dam. Their contribution are shown in c.

The average annual precipitation for the Abbay BN, BAS-WN, TAS and MN sub-basin is 988 mm, 729 mm, 425 mm and 40 mm respectively. The water falls as precipitation, losses through evapotranspiration and percolation and rest of the water contribute to stream flow as surface runoff. The evapotranspiration loss is 848 mm, 560 mm, 311 mm and 257 mm respectively for the above four sub-basins. The evapotranspiration for the Main Nile sub-basin is higher than the precipitation because the Main Nile sub-basin receives inflow from other three sub-basins of ENB and the evaporation from rivers and reservoirs also counted to estimate total evapotranspiration. The rest amount of water percolates down and contributes to the stream flow.

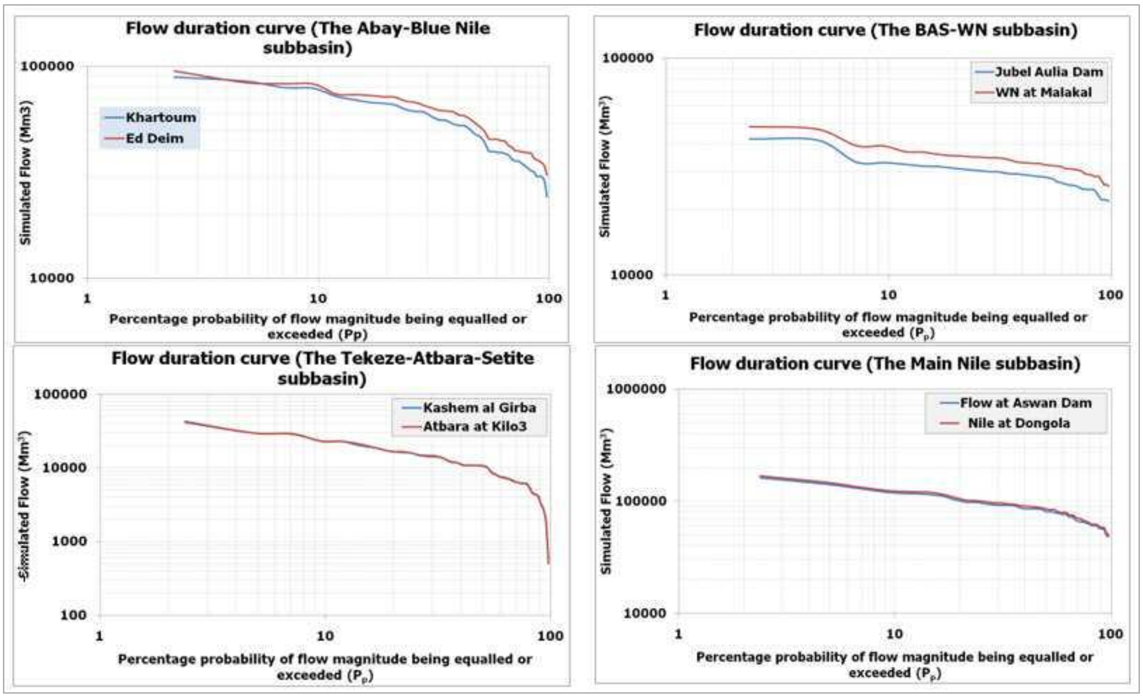


Figure 7-18: Flow duration curve for the four sub-basins of ENB

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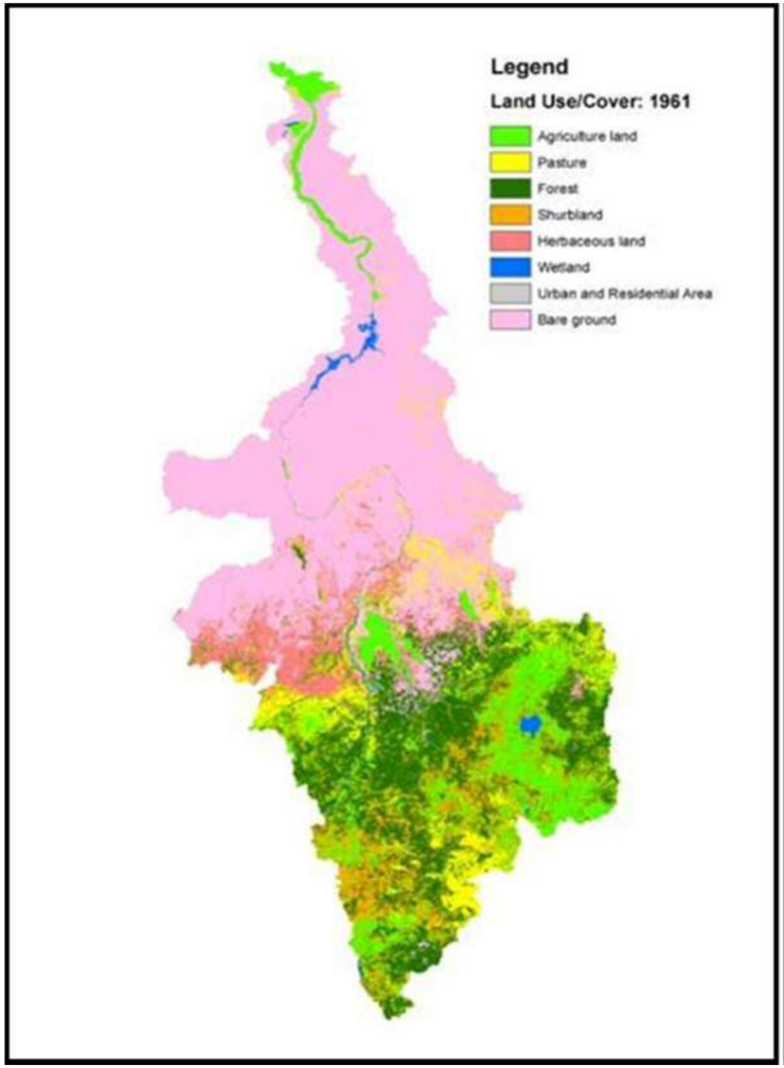
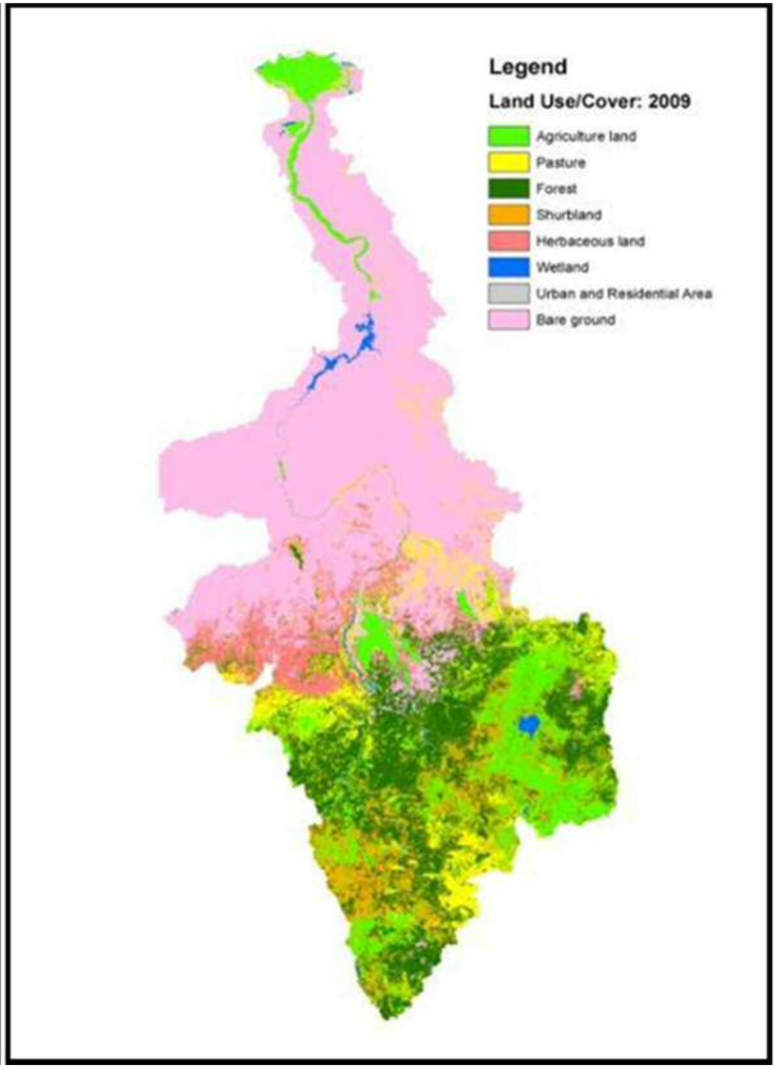
ANNEXES

Annex 1: Change in vegetative cover and land use between 1961 (left and 2009 (right)





Annex 2: Summary of Institutions and Responsibilities related to Environmental and Social Management

	Egypt	Ethiopia	Sudan	South Sudan
Potentially Relevant Institutions	• Ministry of State for Envrionmental Affairs • Egyptian Environmental Affairs Agency (EEAA) • Ministry of Health and Population • Ministry of water Resources and Irrigation • Ministry of Electricity and Energy • Ministry of Local Development • Ministry of Tourism • Ministry of Industry • Ministry of Housing Utilities and Urban Communities • Ministry of Interior • Ministry of Manpower • Ministry of Agriculture & Land Reclamation • Ministry of Petroleum • Ministry of Foreign Affairs • Egyptian General Authority for Land Survey	• Environmental Protection Authority (EPA) • Ministry of Water Resources Development • Ministry of Agriculture and Rural Development • Ministry of Finance and Economic Development • Ministry of Health • Institute of Biodiversity Conservation • Ethiopian Electric Power Corporation • Water Supply and Sewerage Services • Abbay River Basin Authority • Regional Governments • Woreda Administration & Agriculture and Rural Development Offices • Municipalities • Kebele Administrations • Ministry of Capacity Building	• Ministry of Environment, Forestry, and Physical Development • Higher Council for Environmental and Natural Resources (HCENR) • Ministry of Water Resources • Ministry of Agriculture and Irrigation • Forests National Corporation • Ministry of Environment and Physical Development • Ministry of Tourism and Wildlife • Ministry of International Cooperation • Ministry of Social Welfare, Women and Child Affairs • State Council for Environment and Natural Resources • Wildlife Conservation General Administration • Antiquities and Museums National Corporation • Dams Implementation Unit • National Land Commission • Institute of Environmental Studies • Sudanese Association for Combating Desertification • Wildlife Society • Environmentalist Society • Sudan Environmental Conservation Society • Civil Society	• Ministry of Environment, Wildlife Conservation and Tourism (MEWCT) • Directorate of Environmental Affairs • Directorate of Wildlife Conservation • Directorate of Tourism • State-level Institutions

Summary Table of Articles, Policies, and Laws Related to Environmental and Social Management

	Egypt	Ethiopia	Sudan	South Sudan
Relevant Constitutional Articles	Provisional Constitution of the Arab Republic of Egypt, 2011 (based on Constitution of 1971) • Article 4 – economic development, social justice, and rights to property • Article 8 – equality of opportunity for citizens • Article 23 – fair distribution of wealth and higher living standards • Article 27 – participation • Article 29 – ownership • Article 34 – expropriation • Article 40 – equality before the law • Article 59 – safeguarding the environment • Article 151 – international treaties	The Constitution of Federal Democratic Republic of Ethiopia, 1995 • Article 25 – Right to Equality • Article 26 – Right to Privacy • Article 40 – Right to Property • Article 41 – Economic, Social and Cultural Rights • Article 42 – Rights of Labour • Article 43 – Right to Development • Article 44 – Environmental Rights • Article 86 – Principles for External Relations • Article 89 – Economic Objectives • Article 90 – Social Objectives • Article 91 – Cultural Objectives • Article 92 – Environmental Objectives	Comprehensive Peace Agreement, 2005 (including Machakos Protocol, 2002) Interim National Constitution of the Republic of Sudan, 2005 • Article 7 – equality of citizens • Article 10 – economic development, eradication of poverty, equitable distribution of wealth • Article 11 – clean and diverse environmental, sustainable utilization of natural resources • Article 12 – social justice • Article 17 – promote international cooperation and economic integration • Article 23 – duties to preserve natural environment • Article 43 – right to own property, expropriation • Article 185 – principles for equitable sharing of resources and common wealth • Article 186 – land regulation	Interim Constitution of Southern Sudan, 2005
Policies, Plans, and Strategies	• National Environmental Action Plan (2002-2017) • National Water Resources Plan (2005)	• Environmental Policy of Ethiopia, 1997 • Water Resources Policy, 1999 • Water Sector Strategy, 2001 • Water Sector development Programme, 2000 • Sustainable Development and Poverty Reduction Program	• National Plan for Environmental Management 2007 • Forest Policy, 1986, updated Statement in 2006 • National Water Policy (1992) • National Water Policy (Draft) of 2000	• Forest Policy, 2007 • Official circular, 2006 • Ministerial Decree, 2006
Main EIA Requirement/Environmental Management Law	• Law No. 4/1994 for the Protection of the Environment, amended by Law No. 9/2009)	• Proclamation No. 300/2002 Environmental Pollution Control • Proclamation No. 299/2002 Environmental Impact Assessment Proclamation • Proclamation No. 295/2002 Establishment of Environmental Protection Organs	• Environmental Protection Act, 2001	• Investment Act, 2004

	Egypt	Ethiopia	Sudan	South Sudan
EIA Guidelines	• Guidelines of Principles and Procedures for Environmental Impact Assessment, 2009	• Environmental Impact Assessment Guideline Document, 2000		
Other Environmental Laws, Regulations, and Decrees	• Law No. 117/1983 on Cultural Heritage • Law No. 102/1983 on Natural Protectorates • Law No. 124/1983 on Fisheries • Law No. 48/1982 on Protection of Nile and its Waterways • Law No. 137/1981 on Labor • Law No. 27/1978 on Public Water Sources • Law No. 31/1976 on Public Cleanliness • Law No. 66/1973 on Transport Air Pollution • Law No. 38/1967 on Public Cleanliness • Law No. 53/1966 on Agriculture • Law No. 93/1962 on Wastewater and Drainage	• Proclamation No. 513/2007 Solid Waste Management • Proclamation No. 9/1995 • Proclamation No. 94/1994 Forestry Conservation, Development, and Utilization • Proclamation No. 92/1994 Water Resources Utilization • Penal Code Proclamation 1957	• Forests and Renewable Natural Resources Act, 2002 • Seeds Law 1990 • Forests Act No. 14, 1989 • Environmental Health Act, 1975 • Law No. 37/1974 on Pesticides • Law No. 18/1974 on Quarantines • Freshwater Fisheries Act, 1954	• Forestry Commission Act, 2004 • Forestry Training Centre Act, 2004 • Timber Utilization and Management Act, 2003 • Customary law
Social/Resettlement Laws, Regulations, and Decrees	• Egyptian Civil Code • Law No. 3/1993 Physical Planning Law • Prime Ministerial Decree No. 160/1991 • Prime Ministerial Decree No. 2166/1994 • Law No. 27/1956 • Law No. 557/1954 • Law No. 10/1990 for the Expropriation of Ownership for Public Interest • Decree No. 358/2008	• Civil Code of Ethiopia • Proclamation No. 455/2005 on Expropriation of Land Holdings for Public Purposes and Payment of Compensation • Council of Ministers Regulation No. 135/2007 on Expropriation and Compensation • Proclamation No. 456/2005 on Rural Land Administration and Land Use • Plan for Accelerated and Sustained Development to Eradicate Poverty	• Land Registration and Settlement Act, 1925 • Land Acquisition Act, 1930 • Unregistered Land Act, 1970 • The Civil Transactions Act, 1984 • Urban Planning and Land Disposal Act, 1994 • Central Forest Act, 1932 • Provincial Forest Act, 1932	
			• Various land laws and land tenure arrangements at national and Southern Sudan levels	

National Environmental Legislation and Implementation Responsibilities; Principal Environmental Laws, Decrees, and Regulations - Egypt

Environmental Law	Date	Authority	Decress/Regulations	Implementing Agency
Law No. 4 on Environment	1994	Establishment of EEAA and Environmental Trust Fund; requirement of ESIA, regulation of air pollution, hazardous waste management, and marine pollution	Decres No. 338 of 1995 (Executive Regulations)	MoEA, EEAA
Law No. 117 on Cultural Heritage	1983	Preservation and management of cultural heritage	Presidential Decree No. 2828 of 1971 (cultural heritage)	Ministry of Culture, SCA
Law No. 102 on Natural Protectorates	1983	Designation and management of natural protectorates	Decrees designating sites	MoEA, EEAA
Law No. 124 on Fisheries	1983	Management and protection of fisheries and marine animals		Ministry of Agriculture and Land Reclamation
Law No. 48 on Protection of Nile and its Waterways	1982	Control of pollution of surface waters	Decree No. 8 of 1983 (standards for wastewater discharges to surface waters)	Ministry of Public works and Water Resources
Law No. 137 on Labor	1981	Control of work place safety and environment		Ministry of Manpower and immigration
Law No. 27 on Public Water Sources	1978	Protection of public water sources for drinking and domestic purposes	Decree No. 27 of 1966 (Supreme Com. for Water) Annex IV of 1975 (Standards for potable water)	Ministry of Health and Population Supreme Committee for Water
Law no. 31 on Public Cleanliness	1976	Control of solid waste management (amends Law No. 38 of 1967)		Ministry of Housing, Utilities, and Urban Communities
Law No. 66 on Transport Air Pollution	1973	Control of air pollution from transportation sources	Decress No. 864 of 1969 (Supreme Committee) Decree No. 470 of 1971 (ambient air standards)	Ministry of Health and Population Supremem Committee for Protection of Air
Law No. 38 on Public Cleanliness	1967	Control of solid waste management (including hazardous waste)	Decress No. 134 of 1968 (waste from domestic and industrial sources)	Ministry of Housing, Utilities, and Urban Communities
Law No. 53 on Agriculture	1966	Regulation of purchase, importation, and handling of pesticides	Decree No. 50 of 1966 (registration and licensing requirements)	Ministry of Agriculture and Land Reclamation
Law No. 93 on Wastewater and Drainage	1962	Control of wastewater discharges and drainage to public sewers	Decree No. 643 of 1962 (standards for wastewater discharges to public sewers)	Ministry of Housing, Utilities, and Urban Communities

Principal Environmental Laws, Decrees, and Regulations - Ethiopia

Environmental Law	Date	Authority	Implementing Agency
Proclamation No. 513 Solid Waste Management	2007	Stipulates planning and movement of solid waste, standards for specific materials	EPA
Proclamation No. 300 Environmental Pollution Control	2002	General control of waste and pollution sources, state necessity for sectoral pollution standards	EPA
Proclamation No. 299 EIA Proclamation	2002	Requirement of EIA for development projects and public instruments	EPA
Proclamation No. 295 Establishment of Environmental Protection Organs	2002	Establishment of EPA and Environmental Council, designation of objectives, powers, and duties	
Water Resources Management Policy	1998	Environmental protection of water resources, appropriate water allocation	MoWRI
Environmental Policy of Ethiopia	1997	Definition of environment and natural resource base, sectoral policy guidelines	
Proclamation No. 9	1995	Definition of the Environment	
Proclamation No. 94 Forestry Conservation, Development, and Utilization	1994	Designation of forests, rules for conservation, management, and use	Ministry of Natural Resources Development and Environmental Protection
Proclamation No. 92 Water Resources Utilization	1994	Introduction of water permits	
Penal Code Proclamation	1957	Regulation of waste, water, and soil pollution	

Principal Environmental Laws, Decrees, and Regulations - Sudan

Environmental Law	Date	Authority	Implementing Agency
Forestry Commission Act	2003	Established forest commission for regulation, management, and utilization of forests	Forestry Commission
Environmental Protection Act	2001	Framework environmental law, compliance with international conventions	HCENR
Seeds Law	1990		Ministry of Agriculture
Forests Act No. 14	1989		
Environmental Health Act	1975	Measures for water pollution control and drinking water safety	By Locality
Law No. 37 on Pesticides	1974		Ministry of Agriculture
Law No. 18 on Quarantines	1974		Ministry of Agriculture
Freshwater Fisheries Act	1954	Regulate introduction of species, use of chemicals and equipment, licensing issues	Ministry of Agriculture, Food, and Natural Resources

Annex 3: Project Environmental Review Matrix

Project	Environmental Studies Conducted	Comments
Baro-Akobo-Sobat (BAS) Multipurpose Water Resources Development Project	Environmental and Social Baseline Knowledge Base	Part of the preparation of a state of knowledge of the BAS, a study of social and environmental baseline was conducted.
	Wetlands and Biodiversity Knowledge Base	Special study to collect data from all sources on wetlands and biodiversity, identify gaps, & propose scope of work to fill gaps.
	SSEA Planned for development of IWRDP	Planned as the first study in the BAS MPWRDP appraised by AfDB
Eastern Nile Irrigation and Drainage Study Project-ENIDS	ESIA of Dinger Beraha Irrigation Project in Ethiopia	Part of the feasibility studies
	ESIA of Wad Maskeen Irrigation Project in Sudan	Part of the feasibility studies
Eastern Nile Planning Model-ENPM	Environmental and Social Criteria as part of MCA	Social and environmental indicators have been identified and will be used in the MCAT
	Knowledge Base Development	Knowledge base on EN environmental and social issues is under development
Eastern Nile Power Trade Study Project-ENPTSP	ENPTSP SESA	Strategic Environmental and Social Assessment was conducted on the Power Trade options in the EN region
	ENPTSP IEIA-Mandaya	Initial Environmental and social Evaluation as part of the pre-feasibility studies
	ENPTSP IEIA-Border	Initial Environmental and social Evaluation as part of the pre-feasibility studies
	ENPTSPIEIA-Dal	Initial Environmental and social Evaluation as part of the pre-feasibility studies
	ENPTSP ESIA Transmission Line Ethiopia-Sudan-Egypt	Initial Environmental and social Evaluation as part of the pre-feasibility studies
Ethiopia Sudan power Interconnection	phase 1 ESIA	Environmental and social Assessment (ESIA) as part of the feasibility study of the transmission line
	RAP of Ethiopia	Resettlement action plan for Ethiopia
	RAP of Sudan	Resettlement action plan for Sudan
	Monitoring	Assist in monitoring of RAP implementation in Ethiopia and Sudan
Eastern Nile Flood Preparedness and Early Warning FPEW	FPEW Technical Background Paper, Vol. 1, EA	Environmental and Social Assessment for the project
Eastern Nile Joint Multipurpose Project-JMP	OSI Environment Theme (EN)	Environmental and social consideration in the launch phase strengthened.
	SICAS	Stakeholder Involvement and Communication Strategy developed.
	JMP-1 ID SSEA Stage I	JMP-1 identification phase SSEA was conducted but not finalized.
Eastern Nile Watershed Project-WP	CRA (EN)	Cooperative Regional Assessments and Distributive Analysis reports serve as strategic documents considering watershed project identification considering environmental and social issues
	PIP: SEAssessment	SEA Ethiopia National Fast Track Projects
	ESMF	Environment and Social Management Framework for Sudan Fast Track Projects
	Gender	Gender involvement through identification of and involvement of women in various livelihood watershed activities has been achieved in fast track projects. Additionally gender involvement in all consultation and project activities has been of primary focus.
Institutional strengthening project	ESMF	Environment and Social Management Framework for ISP
Eastern Nile Cooperation for Results-ENCORE	ESMF	Environment and Social Management Framework for the upcoming ENCORE
Other	SEIA Karadobi EMF Tana Beles Baro-1 EIA Baro-2 EIA	Various environmental and social studies from national project feasibility studies which are also being considered at the regional level

Annex 4: Country review of socio-economic conditions

ETHIOPIA

The population of Ethiopia was estimated to be 96.6 million making it the most populated country in the EN Basin. Of this total 17 % were urban. The majority of the population is therefore rural. The largest city in Ethiopia is the capital Addis Ababa, with a population of ~ 3 million (2011). The population is projected to increase to 118.6 million by 2030. In terms of age structure, 44.2 % of the population were between the ages of 0-14, 53% between 15-64 (the economically active age group) and only 2.8% were 65 years and older. Ethiopia falls within the Low Human Development grouping of countries and was ranked 174 out of 187 countries with a HDI of 0.363. Life expectancy at birth in 2014 is estimated to be 60.75 years compared to 59.3 in 2011. The infant mortality rate in 2014 is estimated to be 55.77 death/1 000 live births. This represents a significant improvement from the 2011 estimate of 75.29 deaths/1,000 live births (2011 est.). The maternal mortality rate in 2014 also decreased from 450 deaths/100 000 live births in 2008 to 350 in 2014. The total dependency ratio is estimated to be a high 83.5% in 2014. The youth and elderly dependency ratios are 77.2 % and 6.3 % respectively.

The number of children underweight under the age of 5 years was estimated to be 29.2% in 2014 compared to 34.6% in 2005. Access to medical specialists is poor, with 0.03 physicians/1,000 population (2009). In terms of services, 96.8 % of the urban population has access to improved water supplies, while the figure for rural population is only 42.1 %. However, only 27.4 % of the urban population has access to improved sanitation facilities. The figure for the rural population is 22.8 %. Access to clean water for rural communities and sanitation for both rural and urban communities is therefore a challenge facing Ethiopia. Of relevance to the study, bacterial and protozoal diarrhoea and typhoid fever (water borne diseases), malaria and dengue fever (vector borne diseases) and schistosomiasis (a water contact disease) are listed as major infectious diseases.

Gross national income (GNI) per capita, (constant 2005 PPP $) was US$ 971. The dependency ratio was 79.2%. In terms of poverty, 6.1% of the population was vulnerable to poverty, while 72.3% were in severe poverty. A longer term analysis (World Bank, 2005) indicates that overall poverty declined only marginally between 1990 and 2004 (from 38.4 to 36.2 %) due in large measure to no or even slightly negative growth in the agricultural sector. Vulnerability to poverty is in Ethiopia is therefore still high. A 2004 World Bank study estimated that two out three Ethiopians will be poor for five out the next ten years. Drought and highly variable rainfall are the major sources of vulnerability as are highly volatile inter-annual cereal prices. In addition, ~ 75 % of the population is estimated to be at risk to malaria and there is an increasing incidence of HIV/AIDS in rural areas. Both present significant vulnerability risks.

The index mundi data indicates that the literacy rate in 2014 was estimated to be 39%. The majority of the population in Ethiopia is therefore regarded as illiterate. The literacy levels for females (28.9%) are however significantly lower than the figure for males (49.1%) (2007 est.).

In terms of employment, the agricultural sector, which accounts for 80% of employment, remains a key source of growth. However, the agricultural sector faces a number of major challenges. Rural livelihoods remain extremely vulnerable to meteorological shocks, as food production is mainly rain-fed. In addition, despite improvements, productivity levels remain low and the marketing infrastructure is weak. In addition, the rising cost of key agricultural inputs (*e.g.* chemical fertiliser) and soil erosion due to over-cultivation and limited investment in land improvement pose a major challenge to sustainable agricultural output. There has also been a general decline in per capita food production as high population growth rates have contributed to a decline in farm size. As a result approximately 4.5 million people remain dependent on food relief. Despite these constraints the potential for growth in agriculture in Ethiopia is significant, specifically given that less than 15% of the arable land is cultivated and productivity is amongst the lowest in sub-Saharan Africa. However, weather conditions remain a critical factor. In terms of its natural resource base, Ethiopia's ecological system is fragile and vulnerable to climate change. Key challenges include soil degradation, deforestation and loss of biodiversity, which have been compounded by population pressure on land, especially in the highlands. However, while the government's existing policy and institutional framework for natural-resource management at the federal and regional level has been strengthened, enforcement of the laws remains weak. In this regard weak capacity in environmental management and enforcement remain key challenges (Ethiopia Country Paper, 2012).

Despite Ethiopia's National Gender Action Plan, which provides a framework for mainstreaming gender issues into key development and sector policies, significant gender inequality continues to exist, particularly in terms of enrolment at post-primary and tertiary education, economic empowerment and political representation (Ethiopia Country Paper, 2012).

SOUTH SUDAN

The Republic of South Sudan gained independence on July 9, 2011. The present population of South Sudan is estimated to be 11.5 million in 2014. The majority of the population is rural, ~ 82%. The largest city in South Sudan is the capital Juba, with an estimated population of 296 000 in 2011. However, based in information collected during the Country Consultations (May-June 2014) the population is likely to be closer to 1 million.

In terms of age structure, 45.8 % of the population were between the ages of 0-14, 52.2 between 15-64 (the economically active age group) and only 2.1% were 65 years and older. Literacy rates are very low with only 27% of the population regarded as literate. There are also major discrepancies between literacy rates for males and females, with only 16% of females being literate compared to 40% for males.

No information was provided on life expectancy at birth. The infant mortality rate in 2014 is estimated to be 68.16 deaths/1 000 live births. The maternal mortality rate in South Sudan is significantly higher than the other three countries in the EN Basin, estimated at 2 054 deaths/1 00 000 live births (2006 est.) The total dependency ratio is estimated to be a high 82.8 % in 2014. The youth and elderly dependency ratios are 76.4 % and 6.4 % respectively.

The number of children underweight under the age of 5 years was estimated to be 32.5 % (2006 est.). This figure is the highest in the EN Basin. In terms of services, 63.4 % of the urban population has access to improved water supplies, while the figure for rural population is 55 %. However, only 15.7 % of the urban population has access to improved sanitation facilities. The figure for the rural population is 7.3 %. Access to clean water and sanitation for both urban and rural communities is therefore a challenge facing South Sudan. Of relevance to the study, bacterial and protozoal diarrhoea and typhoid fever (water borne diseases), malaria and dengue fever (vector borne diseases) and schistosomiasis (a water contact disease) are listed as major infectious diseases.

Subsistence rain-fed agriculture and the raising of livestock, mainly cattle, are the principal livelihood systems for more than 95 % of the population. The livelihood systems are heavily dependent on timely and ample rainfall and access to water in the dry season. Poverty and vulnerability are widespread, with the poverty rate estimated to be ~ 51 % (Nihal Fernando and Walter Garvey, World Bank, 2013).

The potential for agriculture is large, with an estimated 70 % of the total land area—647 000 km^2—considered suitable for agriculture (World Bank 2011). Subsistence agriculture under rain-fed conditions presently covers an estimated 2.6 million hectare (ha) (approximately 6.19 million feddans), which constitutes on 5.7 % of the land that is suitable for agriculture. Irrigated agriculture is insignificant and is limited to ~ 2 000 ha located in the Renk scheme in Upper Nile State. Three other public irrigation schemes exist, namely the Mangalla (Central Equatoria) and Penykou (Jonglei) schemes, which are derelict, and the partly rehabilitated Aweil scheme (Northern Bahr el Ghazal), which is largely dysfunctional. Securing water for the roughly estimated 10 million head of livestock, mainly cattle, in the dry season and in areas where rainfall is marginal is a major problem and a source of serious social conflict. Fishing is a primary source of livelihood for about 12-15 % of the population, and water resources development for livestock and fisheries offers a significant economic potential to support food security and poverty alleviation in the new country (Nihal Fernando and Walter Garvey, World Bank, 2013).

Despite the richness of South Sudan's natural resources, many South Sudanese continue to depend on external food assistance. Enhancing food security, increasing financial returns to the farmer and the economy from agriculture, and improving livelihoods of the people, including returning and conflict-affected people, are urgent priorities, and development opportunities in the water sector can play a vital role in reaching these goals (Nihal Fernando and Walter Garvey, World Bank, 2013).

SUDAN

The population of Sudan in 2014 following partition in 2011 is estimated to be ~ 35.5 million, of which 33.2 were urban. The population is projected to increase to 66.9 million by 2030 (UNDP Human Development Report, 2011). Khartoum, the capital, with a population of 4.6 million (2011 est.) is the largest city in Sudan. The rate of urbanisation is estimated to be 2.6 % annual rate of change (2010-15 est.). In terms of age structure, 40.8 % of the population are between the age of 0-14, 55.9% fall with the economically active defined range of 15-64, and 3.3 % are 65 years and older. The median age is 10.1 years. The median age for males and females are similar to each other and the total figure, namely 18.9 and 19.4 years respectively (2014 est.).

Sudan falls within the Low Human Development grouping of countries and is ranked 169 out of 187 countries in 2011 with a HDI of 0.408. The index mundi data indicates that the literacy rate is 71.9%. For males the literacy rate is 80.7 % while for females the literacy rate is lower, namely 63.2% (2011 est.).The total dependency ratio is estimated to be 58.3% in 2014. The youth and elderly dependency ratios are 49.1 % and 9.3 % respectively. Life expectancy at birth in 2014 is estimated to be 63.32 years compared to 61.5 years in 2011. The infant mortality rate in 2014 is estimated to be 52.86 death/1 000 live births, compared to 55.63 in 2011. The maternal mortality rate in 2014 decreased marginally from 750 deaths/1 00 000 live births in 2008 to 730 in 2014. The total dependency ratio is estimated to be a high 79% in 2014. The youth and elderly dependency ratios are 73.1 % and 5.9 % respectively. Access to medical services is poor, with 0.28 physicians/1,000 population (2009).

In terms of services, 66 % of the urban population has access to improved water supplies, while the figure for rural population is only 50.2 % (2012 est.). In addition only 43.9 % of the urban population has access to improved sanitation facilities. The figure for the rural population is 13.4 %. Access to clean water and sanitation is therefore a challenge facing Sudan. Of relevance to the study, bacterial and protozoal diarrhoea and typhoid fever (water borne diseases), malaria and dengue fever (vector borne diseases) and schistosomiasis (a water contact disease) are listed as major infectious diseases.

Following the independence of South Sudan in 2011 there has been a slowdown in economic growth which is attributable to the loss of population (20%) and oil revenues (75%). Due to the loss of oil revenues, the revival of the agricultural sector is critical for overall economic growth and poverty reduction in Northern Sudan, particularly in rural areas. The contribution of agriculture to Sudan's GDP increased from 31.2% in 2010 to 34.1% in 2011 and is expected to rise further to 39.4% in 2012. Agriculture is also the key sector in terms of employment, with 45% of youth and 42% of adults directly employed in the sector. Sudan also faces critical environmental challenges, including severe land degradation, deforestation, desertification and other impacts of climate change that threaten the prospects of lasting peace and sustainable development. The country paper notes that poverty remains the main cause of the extensive use of marginal land, water and forest resources, further burdening the already fragile and limited environment base. According to the CBS 2009 baseline household survey, 46.5% of Sudanese are considered poor. Poverty reduction in Sudan will therefore continue to remain a serious challenge. Gender inequality is also striking in Sudan in the sense that women are not equal to men in terms of education, literacy, and quality of life, as reflected in the data on literacy and maternal mortality rates. Many social factors constrain women's labour force participation and employment in Sudan. Generally, women tend to be full time homemakers, and traditions and culture limit their mobility (Sudan Country Report, 2012).

EGYPT

The population of Egypt is estimated to be 86.9 million in 2014, of which 43.5% were urban. The majority of the population lives along the Nile in an area that makes up 5% of the country's total area. The two largest cities in Egypt are Cairo and Alexandria with populations of 11 and 4.5 million respectively (2011 estimates). The rural population makes up approximately 56% of the total population. The population is expected to increase to 106.5 million by 2030 (UNDP Human Development Report, 2011). In terms of age structure, 32.1% of the population are between the age of 0-14, 62.9% fall with the economically active defined range of 15-64, and 5% are 65 years and older. The median age is 25.1 years. Literacy rates are high, with 81.7 % of the population regarded as literate. There are however significant discrepancies between the literacy rates for males and females, with only 65.8 % of females being literate compared to 81.7 % for males.

Egypt falls within the Medium Human Development grouping of countries and was ranked 113 out of 187 countries in 2011 with a Human Development Index (HDI)[9] of 0.644. The life expectancy at birth in 2014 is estimated to be 73.45 and increase from the 2011 figure of 68.7 years. The infant mortality rate in 2014 was 22.41 deaths/1,000 live births, while the maternal mortality rate was 66 deaths/100,000 live births (2014). The number of children under the age of 5 years underweight was 6.8%

[9] : Human Development Index (HDI): Is a composite index measuring average achievement in three basic dimensions of human development—a long and healthy life, knowledge and a decent standard of living.

(2008)(www.indexmundi.com). The total dependency ratio is estimated to be 58.3% in 2014. The youth and elderly dependency ratios are 49.1 % and 9.3 % respectively.

In terms of services, 100% of the urban population has access to improved water supplies, while the figure for rural population is 98.8%. 97.8 % of the urban population also has access to improved sanitation facilities, compared to 94.4% of the rural population. Both urban and rural communities in Egypt therefore have good access to improved water and sanitation services.

In terms of health, the World Health Organization (WHO) 2011 report indicates that most of the population has relatively easy access to health care. Nevertheless, equity and access to health care for rural populations remains a challenge. Of relevance to the study, bacterial diarrhoea and typhoid fever (water borne diseases), and schistosomiasis, a water contact disease, are listed as one of the major infectious diseases.

In terms of poverty, 7.2% of the population was vulnerable to poverty[10], while 1% was in severe poverty[11]. Although the MDG target on extreme poverty reduction has been achieved, general poverty remains daunting. Approximately 25% of all Egyptians are poor, according to the Household Income and Expenditure Survey of 2011 (against 21.6% in 2008). Social justice and income distribution, notably in rural and slum areas, are major challenges in a society where large regional disparities occur. Rural Upper Egypt is the most deprived with 51% of its residents now considered poor compared with 43% in 2008. About 44% of those aged between 18 and 29 in Upper Egypt are considered poor. The social and political unrest, together with the economic slow-down in 2011 is likely to hamper the government's efforts to reduce poverty levels. The growing Informal sector, labour rights, wages, women's participation and child labour also remain major challenges.

In terms of gender, women are marginalized by economic, social and political obstacles. They are the most vulnerable group in the labour market since the highest percentage of women work in the informal sector, or are non-wage family workers. Culture and tradition are obstacles to women's full participation in Egypt's economic, social and political life. Nevertheless, women's access to education has improved (Egypt Country Report, 2012).

In terms of resource management, despite increased investment and targeted government policies, progress on environmental sustainability has been slow. The high population growth rates pose a heavy burden on Egypt's natural resources, particularly water. In this regard the implementation of a national water management plan will be crucial for organizing the supply and demand of available water. On the energy front renewable energy represents a potential growth area for Egypt, specifically wind and solar energy. In this regard the government aims to obtain 20% of its energy from renewable sources by 2020. It has a five-year plan (2012-17), aimed at positioning Egypt as a top generator of solar energy in North Africa (Egypt Country Report, 2012).

The Egyptian economy has traditionally relied heavily on the agriculture sector as a source of growth, both in terms of contribution to GDP as well as a source of employment to a significant part of the Egyptian labour force. Following the completion of the High Aswan Dam (HAD) in 1968, the agriculture sector accounted for 30% of GDP, 25% of export earnings and 47% of employment. However, this dominance has declined gradually over the years and the share of agriculture in GDP and export was each about 20% in 1990. This share now accounts for 16% in GDP, 20% in export and about 34% employment. Despite the decline in the share of sector's contribution to the national GDP the agricultural sector remains crucial to the future of Egypt's economy. Agriculture in Egypt is entirely dependent on irrigation from the Nile which is the main source of water supply. It has the largest irrigated area (3.3 million ha) in the EN sub basin. There is also a plan to extend the irrigated area substantially. A secure and guaranteed water supply from the Nile is therefore critical to the well-being of Egypt and its economy (Egypt Country Paper, 2006).

10 : Population vulnerable to poverty: Percentage of the population at risk of suffering multiple deprivations—that is, those with a deprivation score of 20–33 percent.

11 Population in severe poverty: Percentage of the population in severe multidimensional poverty—thatis, those with a deprivation score of 50 percent or more.

Annex 6: Policy, Institutional, legal and regulatory Frameworks for the Electricity Sector

	Ethiopia	South Sudan	Sudan	Egypt
Main policies covering the electricity sector	1994 National Energy Policy 2006 Plan for Accelerated and Sustained Development to End Poverty (PASDEP)	NA	2007 Energy Policy -within 25 Year Economic and Social Strategy	Strategy of the MoEE adopted by the Cabinet: Increase the use of efficient fossil-fuel generation technology Large scale development of Renewable resources with the goal of having 20% of the installed capacity in the form of renewable by 2020. Increasing efforts for more efficient use of electricity.
Main legislation covering the electricity sector	1997 Proclamation No 86/1997 (Electricity Law) Electricity Operations Council of Ministers Regulations No. 49/1999 2002 Investment Proclamation No.280/2002 (restricts private sector involvement in transmission and distribution through national grid)	NA	2010 Presidential Decree No. 22 -replaced Electricity Act, of 2001.	New Electricity Law is under preparation (waiting for Parliament ratification) Law No. 12 of 1976 establishing Egyptian Electricity Authority together with modifications. Law No. 36 of 1984 (removed monopoly for generation) Law No. 100 of 1996 (BOOT projects) Law No. 164 of 2000 (establishment of EEHC) and decrees
Authority supervising the operations of the sector and responsible for policy formulation	Ministry of Water and Energy	Ministry of Electricity, Dams, Irrigation & Water Resources	Ministry of Water Resources and Electricity (Government of National Unity),	Ministry of Electricity and Energy
Independent Regulatory Authority	Ethiopian Electricity Agency (EEA) established in 1997	No	Electricity Regulatory Authority established in 2001	Egyptian Electric Utility and Consumer Protection Regulatory Agency (EEUCPRA) established in 2000
Market structure	Vertical integration; transition to single buyer market envisaged	No	Unbundling of vertically integrated utility decided in June 2010.	Unbundling, EETC as single buyer; in transition to competitive multiple buyer market
Utilities	Ethiopian Electric Power Corporation (EEPCo) (100% state owned)	South Sudan Electricity Company (SSEC), (100% state owned)	Sudanese Electricity Transmission Company Ltd. (SETCO) Sudanese Hydropower Generation Company Ltd. (SHGC) Sudanese Electricity Transmission Company Ltd. (SEDCO	Egyptian Electricity Holding Company (EEHC) (100% state owned); Generation: 6 companies affiliated to EEHC, 3 IPPs; Transmission: Egyptian Electricity Transmission Company (EETC) affiliated to EEHC; Distribution: 9 companies affiliated to EEHC, 7 private

Private sector participation	None, private sector participation explicitly promoted in Investment Proclamation No. 37/1997 and regulated by Electricity Law of 1997; transmission and supply of electric energy through the integrated national grid is exclusively reserved for the Government	No	Few off-grid private operators; private generation and distribution permitted by Electricity Act	3 private generation companies and 7 private distribution companies; private transmission companies not envisaged
Licensing for generation, transmission and distribution, sales, export/import	Yes; according to Electricity Law licences required for generation, transmission, distribution; also investment permits required from Regulator. Currently EEPCo is the only license holder	NA	No	Yes; licenses required for construction, management, operation, maintenance of generation, transmission, distribution, sale
Rules on import and export of electricity	Transmission and supply of electric energy through the integrated national grid is exclusively reserved for the Government (Investment Proclamation No. 37/1997, (Part II Art. 5); bilateral agreements with Djibouti and Sudan, MOU with Kenya	NA	No regulations concerning cross-border trade; controlled by Ministry of Electricity and Dams	Current power trade implemented by EEHC under supervision of Ministry; no specific regulations; no information on regulations in Draft Electricity Law available
Open access to transmission and distribution networks	No	No	No	Presently no; In future yes, envisaged in new Electricity Law under new market structure
Transparent pricing principles for transmission access, wheeling, ancillary services	Yes; tariff principles for generation, transmission, distribution, wheeling charges set out in Ministers Regulation No. 49/2005; tariffs subject to approval by Parliament following assessment by EEA; import/export tariffs negotiated by EEPCo	No	No	Not yet; EEHC via the Ministry proposes tariffs to the Cabinet for approval; import and export tariffs are negotiated by EEHC; tariff setting principles envisaged in new Electricity Law
Grid code	Yes	No	Yes	No
Foreign private investment	Foreign investors particular encouraged to invest in hydro power plants by Ethiopian Investment Commission; Investment legislation provides adequate protection and incentives for investment	NA	Foreign investment not excluded by law; investment legislation provides adequate protection and incentives for investment, but is not always enforced	Foreign investment in the power sector not excluded by law; investment legislation provides adequate protection and incentives for investment

Annex 7: Key institutions, policies and strategies, related to the Agricultural sector in the riparian countries

Table A1.1 : Key Institutions, policies and strategies related to the Agriculture Sector In Ethiopia

Key Institutions, policies and strategies	Remark
Key Institutions	
Federal Ministry of Water, Irrigation and Energy (MWIE)	The Ministry has powers and duties to prepare plans, policies and strategies to guide the proper utilisation of the country's water resources for development purposes. Responsible for planning, study and implementation of medium/large scale irrigation schemes.
Federal Ministry of Agriculture and Rural Development (MoARD); Regional Bureaus (BoARD)	**Mission**: Create market – led modern agriculture and a society free from poverty. MoARD has overall responsibility for agricultural and rural development policies, strategies and plans, including the management of agricultural research and extension services, natural resource management, input and output marketing, disaster risk management and food security (DRMFS), and private investment support including support to small-scale irrigation.
Agricultural Transformation Agency (ATA)	ATA was established by Federal Regulation in December 2010 as a catalyst for positive, transformational, and sustainable change. The primary aim of the Agency is to promote agricultural sector transformation by supporting existing structures of government, private sector and other non-governmental partners to address systemic bottlenecks in delivering on a priority national agenda for achieving growth and food security.
Key Policies and Strategies	
Water Resources Policy	**Overall objective**: to enhance and promote all national efforts towards the efficient, equitable and optimum utilization of the available water resources of Ethiopia for significant socio-economic development on a sustainable basis.
Strategy	Give priority to identification and implementation of multipurpose water development projects for maximizing benefits and reducing costs; update and take follow-up action on completed Integrated River Basin Master Plans, including the master plans for Abay, Tekeze and Baro-Akobo sub basins; Establish effective institutions for water management (RBOs and WUAs, prevention of pollution of water resources, promotion of watershed management, development of capacity building programs and essential water legislation.
Irrigation Policy	**Overall objective**: to develop the huge irrigated agriculture potential for the production of food crops and raw materials for agro industries, on efficient and sustainable basis and without degrading the fertility of the production fields and water resources base.
Strategy	Initiate the planning and implementation of a comprehensive, well coordinated and targeted medium and large scale irrigation development program to reduce vulnerability to climate; Improving the preparation and design of irrigation projects including environmental and social impact assessment; increase of government's budget allocation; improved viability of of irrigation schemes, promotion of credit facilities and bank loans and cost recovery mechanisms.
Agriculture Policy	The policy framework is based on the concept of Agricultural Development-Led Industrialization (ADLI) which has been the central pillar of Ethiopia's development vision since the 1990s.
Strategy	Since 1991, the Government has been implementing its strategy of ADLI that sees agriculture as the engine for growth. Its main thrust has been to: intensify aagriculture through enhancing farmers access to fertilizers, improved seeds, animal draught power and credit as well as dissemination of technology packages through extension programs; promotion of better use of land and water resources; improvement of access to domestic and export markets; provision of rural infrastructure; and Voluntary resettlement (population transfer from the saturated food insecure highland farming system to the currently little utilized lowlands with sufficient rainfall)
The Plan for Accelerated Sustainable Development and Eradication of Poverty (PASDEP, 2006-2009)	In the agricultural sector, it called for: (i) market-based agricultural development; (ii) increased private sector investment; (iii) specialized support services for differentiated agro-ecological zones; (iv) improved rural-urban linkages; and (v) special efforts to support pastoral development. These objectives were underpinned by investments to improve rural infrastructure, enhance access to financial services, promote irrigation development, ensure land tenure security, and improve the performance of agricultural markets.
The Five-Year Growth and Transformation Plan (FYGTP) for 2010/11 to 2014/15	FYGTP succeeded both PASDEP and the previous five-year development plan. The plan aims to reach all of the MDGs through: (i) continuing rapid economic growth; (ii) expanding access to, and improving the quality of social services; and (iii) infrastructure development. Agriculture is seen as the key driver of economic development with particular attention given to scaling-up best agricultural practices to provide a foundation for expansion of the industrial sector.

Source: MoARD, MoWIE, ATA and ENIDS CRA Study

Table A1.2: Key Institutions, policies and strategies related to the Agriculture Sector In South Sudan

Key Institutions, policies and strategies	Remark
Key Institutions	
Ministry of Agriculture, Forestry, Tourism, Animal Resources, Fisheries, Cooperatives and Rural Development (MAFTARFCRD)	Vision: Food security for all the people of the Republic of South Sudan, enjoying improved quality of life and environment. Mission: To create an enabling environment for the transformation of agriculture from a subsistence system into a modern, socially and economically sustainable system through science-based, market-oriented, competitive and profitable farming while maintaining the natural resources for the benefit of future generations of South Sudanese people.
Ministry of Electricity, Dams, Irrigation and Water Resources (MEDIWR)	Among others, the Ministry has regulatory mandate to ensure conservation, development and management of water resources, and provision as well as sustainability of power and urban and rural water and sanitation services.
Key Policies/Documents	
South Sudan Development Plan (SSDP), 2011-2013	The overall objective of this plan was to ensure that by 2014 South Sudan is a united and peaceful new nation, building strong foundations for good governance, economic prosperity and enhanced quality of life for all.
Policies on crops sub-sector:	Yields of food crops both as nutritional sources and cash crops are targeted to double. R&D and infrastructure development should be encouraged to support this.
Policies on agricultural production support services:	Smallholders, commercial farmers, processors and agribusiness operators need to be supported through extension services and agricultural education training.
Policies in support of agricultural markets, value chain development and finance	Commercial farming and agribusiness requires well-developed agricultural markets for both inputs and produce.
Policies on food security and nutrition:	Food security has been a key issue for South Sudan and it is mentioned in the National Food Security Action Plan (NAFSAP) 2008-2011.
Policies on forestry development and management:	Sustainable development of forest resources needs to be reinforced.
Policies on the role of agriculture and forestry for socio-economic change and social justice:	Young people will be provided with access to training, credit, information technology, etc.
Policies on sustainable agriculture, environment and climate change:	In order to cope with the risks of climate changes, the ministry will support diversification of crops, environmental conservation, etc.
Policy coordination and monitoring and evaluation:	Since agricultural development requires coordination of different central ministries, different tiers of government and other stakeholders at all levels, an Inter-Ministerial Committee will monitor and evaluate the implementation of the Agricultural Sector Policy Framework.
Livestock and Fisheries	Productive livestock and fisheries sectors contributing 5% annually to improvement in food security, household income, job creation and the national Gross Domestic Product; to accelerate socio-economic development of the South Sudanese and enhance the livelihoods and food security of livestock and fisheries producers.
Water Resources Policy (2007)	Support social development and economic growth by promoting efficient, equitable and sustainable development and use of available water resources, and effective delivery of water and sanitation services in Southern Sudan.
Water Resources Management Policy (2007)	Promote effective management of quantity, quality and reliability of available water resources in order to maximize social and economic benefits while ensuring long term environmental sustainability.

Source: CAMP, 2013

Table A1.3 : Key Institutions, policies and strategies related to the Agriculture Sector In Sudan

Key Institutions, policies and strategies	Remarks
Key Institutions	
Ministry of Irrigation and Water Resources	The main mission of this Ministry is to establish laws, rules and regulations concerning water resources in general, and water supply and sanitation
Key Policies and Strategies	
Agricultural Policy	The Green Mobilization Program, also referred as the Agriculture Revitalization Program, is the core for the Agriculture Policy. The specific objectives the programme include: Achieving food security; Reducing poverty by 50% by the end of 2010, provide employment opportunities and increase individual income; Achieving balanced development for all the regions of the Sudan to encourage stability in the rural areas; Development and protection of the natural resources for sustainable production; Increasing and diversifying agricultural exports of crops and animals; Maximizing value added in the agriculture at the production stage and in the backward (inputs) and forward (marketing) economic chains.
Strategies	Increasing productivity in the rain-fed sector by promoting access to agricultural services and inputs to small farmers; exploiting the potential of livestock production through improving natural pasture lands, expansion of extension and veterinary services, increasing watering points and improving livestock market and market information services; expansion of irrigation schemes through full utilization of Sudan's share of the 1959 bi-lateral agreement with Egypt, the water savings expected from the modernization of existing irrigation schemes or reallocation of water from the non-functioning schemes and from the development of groundwater namely the Nubian aquifer; and development of commercial farming through promotion of the private sector.
Water Resources Policy	The goal of Sudan's Policy on integrated Water Resources Management is to "lay the foundation for a rational and efficient framework to sustain the water needs of national economic development, poverty alleviation, peace, environmental protection and social well being of the people through sustainable water resources management".
Strategies	Set up mechanisms for continuous assessment of surface and groundwater resources availability and quality, monitoring and dissemination of water data using modern and efficient technology; Prepare strategies and plans based on the concept of integrated water resources management; Enhance cooperation between the States; Develop economic criteria for balancing costs and socio-economic benefits of water utilization; Empowerment of water users groups and promotion of stakeholders participation; Control pollution of ground water and surface waters; Strengthen water conservation measures to enhance water availability for environmental purposes and for pastoralists and rain-fed agriculture (water harvesting); Address the problem of sedimentation in dams and irrigation structures; Enlargement of existing reservoirs (i.e. Roseires) and construction of new dams on the Nile, the Atbara sub-basin and on seasonal streams (wadis).
Irrigation Policy	The overall objective of the irrigation sector policy is "to develop the huge irrigated agriculture potential for the production of food crops and raw materials needed for agro-industries, on efficient and sustainable base and without degrading the fertility of the production fields and water resources base."
Strategy	Implementation of new dams and heightening of the Roseires dam to achieve horizontal and vertical expansion of irrigated agriculture; Implementation of new irrigation schemes, such as Upper Atbara, Rahad phase 2 and Great Kenana on the Blue Nile and rehabilitation of public irrigation schemes to improve productivity and water use efficiency; Increase utilization of pumps to expand production of winter crops, mainly wheat along the Main Nile; Utilize the renewable groundwater and harvest wadis for livestock and agriculture; Adopt mitigation measures to minimize sedimentation in dams; Promote the participation of farmers in the Gezira irrigation scheme and other public schemes through the establishment of WUAs
The Gezira Act, 2005	The Federal Parliament adopted the new Gezira Act in July 2005, which gave new responsibilities to Water Users Associations and private sector while reducing significantly the role of the Government. The Act guarantees free crops choice, transfers title and long-term lease deeds to farmers, privatises marketing activities and re focuses the Sudan Gezira Board on agricultural research and technology transfer. The Act has major implications on marketing, credit input supply, water management and maintenance of the irrigation assets.

Table A1.4 : Key Institutions, policies and strategies related to the Agriculture Sector In Egypt

Key Institutions, policies and strategies	Remarks
Key Institutions	
Ministry of Water Resources and Irrigation	The Ministry of Water Resources and Irrigation (MWRI) has the overall responsibility of the development and management of water resources.
MWRI-MED	Responsible for lifting water for irrigation and drainage for groundwater abstraction.
MWRI-Drainage Department	The Egyptian Public Authority for Drainage Projects (EPADP) is responsible for the implementation of open and subsurface drainage projects as well as the maintenance, rehabilitation, renewal, and replacement of existing ones.
Survey Department	The Survey Authority is responsible for the national cadastre and land registration scheme in Egypt. The activities include the registration of the current agricultural lands and also the future horizontal expansion areas.
Nile Water Sector (NWS)	Is in charge of the Nile levels from external sources up to Lake Nasser. Responsible for negotiation with the Nile basin countries, planning for future projects, coordinating with local organizations associated with Nile water (Ministry of Foreign Affairs, etc.).
National Water Research Centre (NWRC)	Research arm of MWRI and includes twelve institutes specializing in: drainage, water resources development, hydraulics, channel maintenance, water management, construction, groundwater, survey and shore protection, environment, climate change.
The Regional Centre for Training and Water Studies (RCTWS)	Organization in charge of continuous and on-the-job training within MWRI.
Ministry of Agriculture and Land Reclamation (MALR)	Objective: Improve food security and increase national agricultural production through maximizing the net return per unit of water. Responsible for predicting cropping patterns and irrigation requirements used by MWRI for water allocation to the vast network of primary and secondary irrigation canals. MALR works with MWRI in irrigation and drainage improvement projects including on-farm improvements
Soils, Water and Environmental Research Institute (SWERI)	Responsible for performing research on the sustainable development in the agricultural sector, establishing policies for fertilizer and pesticides use, classifying water resources and soils; and monitoring soil and water quality for agricultural uses.
General Authority for Rehabilitation Projects and Agricultural Development (GARPAD)	Charged with the design and implementation of the expansion projects prior to transferring to public sector agricultural companies or private investor. Water management of these new reclaimed lands is the responsibility of the MWRI.
General Authority of Fish Resources Development (GAFRD) in the MALR	Responsible of development of fisheries and establishment of both horizontal and vertical expansion projects in this field.
Key Policies and Strategies	
Agricultural Policy	The principal objective of the policy was the transition from a highly interventionist and controlled economy to one that is more decentralized and market oriented through removal of crop area assignments and delivery quotas, abolition of feed and fertilizer subsidies, promotion of the private sector, liberalize land rents etc
Agricultural Strategy	Continue the policy of liberalization, depending on the availability of water increase the irrigation area to 3.4 million feddan (1.4 M Ha) by 2017, improve food security, increase farmers participation in the management of irrigation schemes
National water Resources Plan 2017 (NWRP, 2005)	The main objectives of this policy are to increase economic growth and employment; increase the inhabited areas outside the Nile Valley and the Delta by developing new cities, the Eastern Delta and Sinai (El Salam canal), new valley areas. Also to provide safe drinking water and adequate sanitation, protect the Nile and other fresh water resources from pollution. It aims to improve the water use efficiency, productivity, and protection of water resources in Egypt. The policy considers both water quality and water availability to achieve a match between water supply and demand.
Water Strategy	Increase water supply through rain water harvesting, ground water development, drainage reuse and desalinization; Improve water management through user participation, new technologies and privatization; improve water quality; Improve coordination with other agencies and international cooperation, public awareness;

Source: ENIDS-CRA study, 2010, Egypt National Water Resources Plan 2017

Annex 8: Crop Yields

ETHIOPIA

Average yields of major cereals in Ethiopia (quintal/ha)

Period	1995-2000	2000-2005	2009-2013
Teff	9	11	12.7
Maize	15	18	26
Sorghum	12	14	19.6
Barley	9	10	16.3
Wheat	13	14	19.1
Average	**11.6**	**13.4**	**18.74**

(Average by 5 years period)
Source Central Statistics Agency (1 quintal=100kg)

The overall agricultural productivity has increased by an average of 8% in the last seven years (Ministry of agriculture, 2014). Total estimated production of grain crops (cereals, pulses and oil crops) and the trend of productivity increase in the past five years is shown in the table below.

Production of major grains (1000 Quintals)

Season	2009	2010	2011	2012	2013
Peasant Meher	171,137	180,750	203,485	218,570	231,288
Peasant Belg	NA	7,749	13,165	9,008	9,533
Commercial farms(Meher&Belg)	NA	5,202	8,522	9,327	9,870
Total		193,701	225,172	236,905	250,691

Source: Central Statistics Agency *(1 quintal=100kg)*

SUDAN

Average yields of major crops in Sudan (Quintal / ha)

Crop	1990-1995	1995-2000	2000 - 2005	2006-10	2011
Sorghum (rain-fed)	6.1	5.7	6.4	4.5	4.1
Sesame (rain-fed)	4.2	7.6	7.0	NA	NA
Millet (rain fed)	NA	NA	NA	3.0	2.8
Wheat (irrigated)	16.4	18.7	24.2	NA	NA
Cotton (irrigated)	13.1	11.6	14.4	NA	NA

Source: ENIDS CRA Study, 2010 and QUASI, 2012. (quintal=100 kg)

Annex 9: Irrigation in the Sudan

EXISTING IRRIGATION SCHEMES

Traditional irrigation has been practised for centuries in Sudan using the annual flood waters of the Nile for recession agriculture. Modern irrigation agriculture started in 1920s with the construction of Sennar Dam and the establishment of the Gezira scheme during the colonial era. After independence in 1955, the command area of Gezira was doubled to 924, 000 ha with the completion of the Mangil extension and became the largest irrigation scheme in the world under single management. The 1970's were a period of rapid irrigation expansion in Sudan due to the construction of the Rahad Scheme (126,000 ha), the New Halfa Scheme (146,138 ha), El Suki (37,800 ha), Rahad I (126,000 ha), Kenana sugar estate (37,700 ha), North-West Sennar sugar scheme (13,900 ha), Assalaya sugar scheme (14,700 ha) and a number of smaller schemes along the Blue Nile and its tributaries, White and Main Niles. Almost all these schemes have been established with similar design and management style of Gezira scheme. The completion of the Jebel Awlia Dam (1937) on the White Nile approximately 20 Km upstream of Khartoum has led to the rapid development of pumping schemes.

In Sudan, irrigated area expanded from 1 million ha in 1956 to about 1.9 million ha (including spate irrigation in Gash and Tokar deltas) by the end of the 1970's. There is no major expansion after the 1970s.

Existing Irrigation schemes in Sudan

Name of scheme	Area (x 1,000 ha)	Sub-Basin
Gezira and Managil	924	Blue Nile
Rahad I	126	Blue Nile
Suki	36	Blue Nile
North West Sennar (Sugar)	14	Blue Nile
Guneid	36	Blue Nile
Abu Nama (jute)	13	Blue Nile
Blue Nile Pump schemes	153	Blue Nile
Assalaya (Sugar)	15	White Nile
Kenana Sugar Estate	36	White Nile
White Nile Pump Schemes	197	White Nile
Main Nile Pump Schemes	122	Main Nile
New Halfa	146	Tekeze-Atbara
TOTAL	**1,817**	

Source: ENIDS-CRA Study, 2010

IRRIGATION AND DRAINAGE TECHNOLOGY:

The Nile and its tributaries are the source of water for 93 percent of irrigated agriculture, and of this the Blue Nile accounted for about 67 percent. Gravity flow is the main form of irrigation, but about one-third of the irrigated areas are served by pumps (Agriculture Policy Document, 2011).

In most schemes water distribution system includes four levels: main canal, major canals, minor canals and field canals locally known as Abu Ishrin (Abu 20). Gravity flow is continuous in all canals and farmers practice night irrigation although minor canals are often designed for storing night water. Field application method is basin irrigation; farms are divided into small basin units that are irrigated until there is free standing of water throughout the field. Irrigation efficiency is poor and with impeded drainage of Sudan vertisols, excess water cannot be evacuated. Attempts to introducing furrow irrigation in the Gezira and Rahad I irrigation schemes have not been promising. In Kenana private sugar estate furrows of up to a kilometre length are used for irrigating sugarcane. This length is good for efficient operation of farm machineries, but its efficiency from field water application point of view is questionable.

The drainage system consists of open drains. Minor drains run parallel to minor canals. They discharge into the major or collector drains, which follow the lines of natural drainage until the nearest River. In some cases major drains terminate in large local depressions where water accumulates and then evaporate.

LAND TENURE:

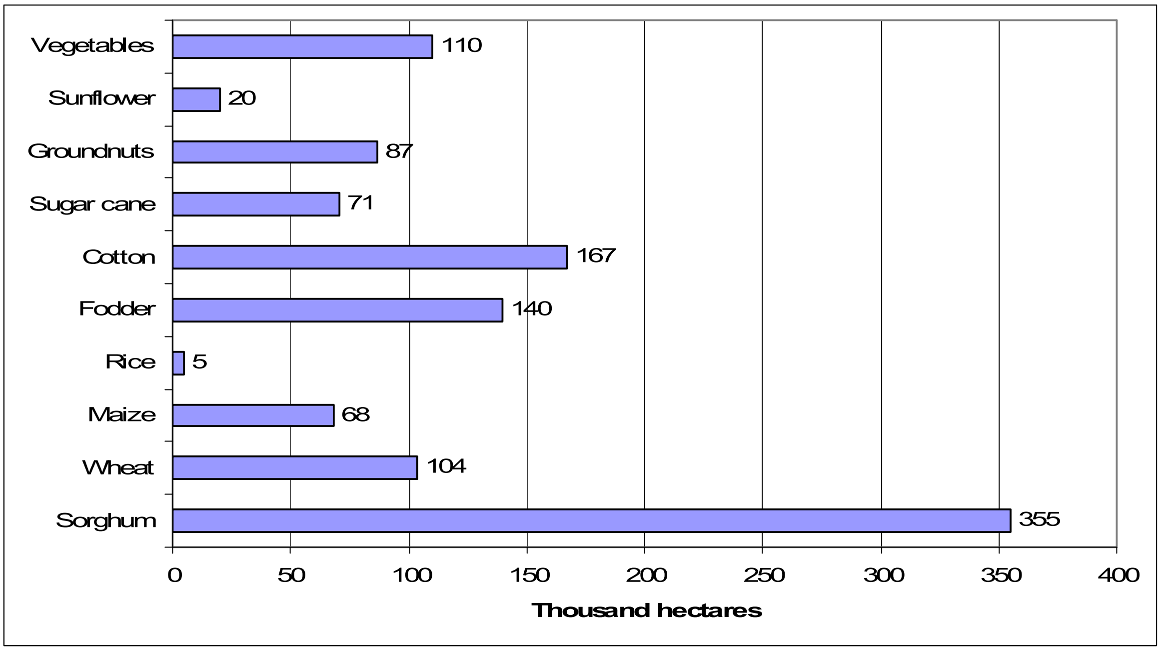
About 90 percent of the existing irrigated areas are public schemes, while the remaining 10 percent belongs to private farmers and cooperatives. In public irrigation schemes, land belongs to the government and farmers are tenants. Irrigated land is parceled out in average plots of approximately 15-20 feddans to tenants who are effectively under fixed rental contract. This tenancy size is considered to be too small to allow mechanized agriculture and too large for efficient application of labour intensive technology. Studies estimated that 85% of the labour of the entire scheme was done by hired labourers, and only one third of the tenants work full time on their tenancies. Tenant farmers are not allowed to sell or rent their tenancy, in full or in part, except with the consent of the government.

They have little freedom to determine the cropping pattern or the technique of production, which are decided by the project management. They produce the crops according to the system of rotation determined by the management by using inputs supplied by the management and hand over the cash-crop produce to the management who sell them and, after deducting the cost of inputs and a variety of service charges, pay the tenant the residual proceeds. The tenant system was designed in the 1920's, and has become increasingly unsatisfactory and criticised for being one of the major reason for the poor productivity of the irrigation sub sector.

CROPPING PATTERN:

While the total area equipped for irrigation in Sudan is about 1.817 Million ha, on the average only, about 1.1 million ha (60 %) of the total area was actually irrigated (ENIDS - CRA study, 2010). The major reasons for the low cropping intensity are deterioration of infrastructures, a complex mix of technical, financial and institutional problems and shortage of water resulting from reduced storage capacities of the existing dams because of siltation. There is a significant variation in cropping patterns of from year to year. The graph below shows the cropping patterns of irrigated crops in full or partial (spate) irrigation schemes. Cereal crops occupy about 50% of the cropped areas followed by industrial crops (30 %) and fodder (12 %).

Irrigation cropping pattern by category of crops for Sudan



Source ENIDS CRA Study, 2010

Crop Yields:

Average yields in the irrigated areas are higher than in the rainfed areas but are still below their potential, especially compared with yields obtained at research stations and by productive farmers. The table below makes a comparison between yields in Gezira Research Station and farmer's yields in the Gezira, Rahad I and New Halfa irrigation schemes.

Comparison of research and farmers yields in Sudan irrigation schemes

Crops	Farmers yields (Ton/ha)	Research yields (Ton/ha)
Seed Cotton, extra long	1.2 - 1.7	4.0
Seed Cotton, medium	1.7 - 2.0	6.1
Sorghum (hybrid)	1.2 - 2.4	6.4
Wheat	1.4 - 2.0	4.8
Groundnut	2.5 - 3.0	4.8

Source: ENIDS-CRA Study, 2010

The major constraints to irrigation productivity in Sudan include:

- Sedimentation in the canals and hydraulic structures; Consequences of the sedimentation problem are generally: decrease in conveyance capacity of canals, difficulties in supplying water to parts of the schemes (tail-end effect) and reductions in cropped area. In short, sedimentation affects yields through decrease of reliability and equity of irrigation water supply. At least 70% of the maintenance budget is spent on sediment removal and this is not able to cope with the problem. For the Gezira scheme alone, the Ministry of Irrigation and Water Resources estimates the annual silt removal should be 16 MCM. The origin of this problem lies in erosion of the Ethiopian highlands. The problem is expected to improve substantially after the completion of GERD, which is currently under construction.

- Outdated tenancy has long been identified as a constraint to productivity. As discussed in the previous sections, the tenant size is too small to allow mechanised farming techniques but too large for improved labour technology. Tenants have to rely on share cropping system to cope with labour financing. Tenants have little freedom to choose their cropping patterns. This leads to low yields and low productivity.
- Under capacity of tenant farmers for financing the costs of hired labour, machineries and agricultural inputs such as fertilizers, improved seeds and pesticides due to lack of credit facilities.
- Lack of water in the cold season, from mid-October to mid-November, is considered a constraint. This is the most appropriate time to sow wheat or other winter crops, when cotton should receive its most critical watering and when groundnuts and sorghum are receiving their last irrigation before ripening.
- Poor operation and management; water not being delivered at the right time and amount, the water delivery is centrally controlled using indenting or 'fixed-rate arranged scheduling', which is too rigid and crumbles when there is little supply of water to control. Changing from upstream centrally controlled to downstream user control, through canal automation is essential.
- Use of outdated irrigation and agricultural technologies; basin irrigation method is widely used which is less water efficient, intensive land levelling work is essential to change the system to furrow irrigation. With efficiencies of 90 to 95%, and high uniformity, drip and centre pivot irrigation systems definitely worth consideration in the future modernization of the irrigation schemes. Both centre pivot and linear move irrigation are already widely used in the private sector with good back up services.
- Little involvement of the end users in the operation, maintenance and management (OMM) of the irrigation schemes, Water Users Associations (WUAs) need to be established and strengthened to participate in the management, operation and maintenance of the irrigation at all levels of the canal system. Capacity building through extension services, formal and informal trainings, stud tours to best practice sites within and outside the basin is essential to all personnel (farmers, WUAs, engineers and management staff) involved in the OMM of the schemes.

The government has already started addressing some of the issues. After the implementation of the 2005 Gezira Act, the largest scheme, Gezira, has experienced a complete change in management in 2009/10, effectively privatizing the Scheme and transferring the responsibility for irrigation to land-owner. Farmers are free to choose cropping patterns and Water-user associations are developing control of the irrigation system. The management of the third largest scheme, Rahad has also been transferred to Kenana Sugar Private Company as of 2010.

PLANNED IRRIGATION EXPANSIONS:

In view of the importance irrigated agriculture to the national economy and food security, expansion of irrigation schemes in Sudan is among the priorities. List of the major planned irrigation schemes and their current status is shown in the table below.

The total area of the planned irrigation schemes amounts to 1.16 million ha. During the country consultations, the Consultants were informed that priority schemes for initial development are Rahad II, Great Kenana and Upper Atbara Schemes. They are planned for development using the currently unutilized Sudan's share of the Nile water, which is estimated at 3.5 BCM. To achieve this, heightening of the Roseires Dam by 10 meters is completed and a Dam on Atbara River is in its final stage of completions. The GERD in Ethiopia will also offer additional storage capacity to Sudan upon its completion.

Feasibility study of the three priority schemes is already completed and the detail design is currently going on by the Dam Implementation Unit (DIU) of the Ministry of Water and Energy. The Upper Atbara Scheme is one of the Fast Track Project, regionally identified for implementation, following the decision made by the Eastern Nile Committee of Ministers (ENCOM), in 2004.

Planned Irrigation Schemes in Sudan

Irrigation Scheme	Area (ha)	Sub -Basin	Status
Rahad II	210,000	Blue Nile	F.S. Completed, detail design going on
Great Kenana	420,000	"	"
Roseires	195,600	"	Pre feasibility
Dinder South	67,000	"	"
Dinder North	168,900	"	"
Upper Atbara	99,000	Tekeze-Atbara	F.S completed, Dam construction on Atbara River under completion
Total	**1,160,500**		

Source: ENIDS CRA Study, 2010

EXISTING AND PLANNED WATER USE:

According to the 1959 Agreement signed between Sudan and Egypt, out of the average annual flow of the Nile at Aswan of 84 BCM, Egypt has an annual guarantee of 55.5 BCM and Sudan 18.5 BCM. The remaining 10 BCM are the estimated water losses through evaporation in the reservoir of the High Aswan Dam. Sudan is using its share for irrigating the existing schemes and the future planned expansions. Irrigated agriculture is by far the major user of water in Sudan. Reliable data on water use by individual schemes is not available, but according to the 2007 Country Strategy on Integrated Water Resources Management Document of the Ministry of Irrigation and Water Resources, the total water used by the existing schemes plus other uses and evaporation from the existing reservoirs is estimated at 14.5 BCM (measured at Aswan). ENIDS-CRA estimated the amount to be 15 BCM, which is not far from the estimates of the strategic document. This shows that Sudan is not currently using its full share of the Nile water, which is attributed to the reduced storage capacity of the existing dams due to siltation.

The estimated evaporation loss from the existing dams in Sudan is 4.5 BCM (An Independent Report of the Scoping Study Team to ENCOM, 2008). The estimated amount for domestic uses is 0.8 BCM (ENTRO-Eeconomic models for the analysis of Agricultural policies of Sudan).The total water utilized for irrigation alone is thus, about 9.7 BCM. As per the estimated average cropping intensity of 60%, the cultivated area annually is about 1.1 million ha. This gives the average annual water consumption of the existing irrigation schemes to be around 8,818 m^3/ha.

The estimated future water requirement for the planned irrigation schemes is about 12 BCM. Future requirement for other uses is estimated at 2 BCM. This will bring the total estimated water requirement of existing and future irrigation schemes and other uses to about 29 BCM (see table below for details).

Estimated water use of existing and planned irrigation schemes in Sudan

Name of scheme	Existing Schemes (x 1,000 ha)	Current Water use-MCM (60% cropping intensity)	Planned Schemes (X 1000 ha)	Future Water Use-MCM
Blue Nile Sub-Basin				
Gezira and Managil	924			
Rahad I	126			
Suki	36			
North West Sennar (Sugar)	14			
Guneid	36			
Abu Nama (jute)	13			
Blue Nile Pump schemes	153			
Rahad II			210,000	1,995
Dinder South			67,000	637
Dinder North			168,900	1,604
Great Kenana			420,000	3,990
Roseires			195,600	1,858
Sub Total	1,302	6,889	1,061,500	10,084
Baro- Akobo-Sobat and White Nile Sub-Basin				
Assalaya (Sugar)	15			
Kenana Sugar Estate	36			
White Nile Pump Schemes	197			
Sub Total	248	1312		
Tekeze -Atbara Sub-Basin				
New Halfa	146			
Upper Atbara			99	1,880
Sub Total	146	772	99	1,880
Main Nile				
Main Nile Pump Schemes	122			
Sub Total	122	646	-	-
TOTAL	1,818	9,618	1,160.5	11,964
Other uses and Evaporation from existing dams				
Roseires		330		
Sennar		580		
Gebel Aulia		3,450		
Khasm EL Girba		120		
Domestic		800		400
Other dams				1,550
Sub Total		5,280		1,950
Total		14,898		13,914

ENIDS CRA Study, 2010, Scoping Study, 2008

Annex 10: Irrigation in Egypt

EXISTING IRRIGATION SCHEMES

The total irrigated area in Egypt is 3.35 million ha plus estimated 40,000 ha of oases. Annual cropped area is approx 6.0 million ha and cropping intensity is 180%. The Nile is the source of irrigation water; in some oases fossil underground water is used. The table below provides details on the existing irrigation schemes in Egypt.

Existing Irrigated areas in Egypt

Name of command area	Area x 1,000 ha	Location
El Ibrahimiya	645	Upper Egypt, Nile Valley
Naga hamadi El sharkia	43	"
Naga hamadi El Gharbia	179	"
El Kalabia	72	"
Asfun	29	"
Direct intakes	174	"
El Raiyah El Monofi	309	Upstream of Delta Barrage
El RaiyahEl Bihiri	502	"
El Raiyah Al Nasri	32	"
El Raiyah Al Tawfiki	282	"
Ismailiya canal	244	"
Direct intakes	127	"
El Raiyah El Abasi	329	East Delta, Domiatta Branch
El Mansoria	136	"
Direct intakes	77	"
Mahmoudia (pumping)	120	West Delta, Rosetta Branch
Direct intakes	45	"
Total	3,345	

Source: ENIDS CRA study (2010)

IRRIGATION AND DRAINAGE SYSTEM

All the irrigation water comes from the River Nile controlled by High Aswan Dam (HAD). The Dam, when completed in 1968, has a maximum storage capacity of 168.9 BCM. Downstream of the Dam eight barrages have been constructed across the Nile to control the water level and distribution to the irrigated areas. Major canals take off water upstream of the barrages to serve the Irrigation Directorates. Depending on the slope and the location of the next order canal, the Major Canals are provided with a number of head regulators. Branch canals take off from the main canal and deliver water to smaller distributary canals (Marawas) which has continuous flows. The last orders of canals are the Masquas, which distribute water to the field. Since the water level in the canals is lower than the field levels, water has to be raised by 0.5 to 1.5 meters by means of diesel pumps or the traditional water wheels.

Field water application methods are either small basins or furrows for row crops. In spite of the wide spread use of surface irrigation, the overall efficiency is more than 70%, which is relatively high. This is achieved not because of the efficiency of the irrigation system, but is due to the use of recycled water several times. Otherwise, Irrigation efficiencies (conveyance, distribution and field level) are low because of operational losses, night irrigation and poor land leveling.

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The irrigation system in the new lands (reclaimed desert land) is based on a cascade of pumping stations from the main canals to the fields, with a total lift of up to 50 m. Surface irrigation is banned by law in the reclaimed areas which are located at the end of the systems and are more at risk of water shortage. Farmers must use sprinkler or drip irrigation which are also more suitable for the sandy soils of these areas.

In order to avoid water logging and salinity problems, drainage water from the irrigated fields are collected and disposed by an extensive drainage network. Field drains, which are either open or closed sub surface drains collect excess water from the fields and dispose in to collector drains, which in turn convey the drainage water into main drains. The main drains discharge into the River Nile, main irrigation canals, inland and costal lakes or directly into the sea. In most cases drainage water is conveyed by gravity but in some cases pumping is used for disposal or recycling of the drainage water for irrigation use.

Sub surface drainage is considered as a major means for improving soil conditions and sustain productivity. There is a program for installing sub surface drainage over 2.7 million ha of agricultural land of which more than 80 % is already completed (National Water Resources Plan 2017). As the result, water logging and salt affected areas have reduced from 1.2 million ha in 1970 to 250,000 ha by 2010. Salinity remains a problem in the Delta where no ground water is pumped. Extensive areas of irrigated land experience low crop yields because of salinity and water logging. The situation is more aggravated towards the north due to saline intrusion from the sea and the use of drainage water. Up to 30% loss of yield is estimated in this area (NWRP 2017).

Re cycling of Drainage Water

In order to cope with the increasing water shortage, recycling of the drainage water by mixing it with fresh water is widely practiced in Egypt. The official reuse of drainage water 1997 was about 3.5 BCM, in 2010, the amount increased to about 4.8 BCM (ENIDS-CRA Study); it is planned to increase this amount to 8.9 BCM by 2017. Reuse of agricultural drainage water in the Nile Delta has been adopted as an official policy since the late seventies. The policy calls for recycling agricultural drainage water by pumping it from main and branch drains and mixing it with fresh water in main and branch canals. There has been a decreasing trend in the amounts of water pumped into the sea due to a significant increase in the amounts of drainage water reused recently. However, quality of drainage water is poor as it contains too much salt and agro chemicals and pollutants from industrial and municipal sources. Recycling should be done with extreme prequations and would necessitate stronger legislations to protect water bodies and agricultural lands downstream of the mixing points. Recycling will also increase the irrigation requirement due to the increase of the leaching requirements. For this reason a number of reuse pumping stations have been closed in the past. The recommendation now is to reuse drains in the upper part of the system, where they are less polluted.

Irrigation Improvement Program

Egypt has been implementing the Irrigation Improvement Programs (IIP) and Integrated Irrigation Improvement Program (IIIP), since the 1980s. The overall objective of the programs is to increase the water use efficiency in old lands and improve the water distribution (quantity, quality, equity and timeliness) amongst the farmers and thereby, improve the productivity of the irrigation schemes. Major components of the Programs include: renovation and improvement of Branch canals with downstream control structures, conversion from rotational to continuous flow, *mesqua* improvement to raised lined or pipe canals and improvement of the involvement of farmers in the operation and maintenance of irrigation schemes through the establishment of Water User Associations (WUAs). Surveys indicate that the program has increased the overall irrigation efficiencies by 5 % and resulted in increases of net farm profits between 30% and 50%. The total area planned for improvement under the program by the end of 2017 is 1.47 million ha (National Water Resources Plan 2017). However, as per the present implementation speed of 40 to 60,000 ha/year, the total area covered will not be more than one million ha.

In general, the major indicated measures to improve the overall water use efficiency in agriculture, in the National Water Resources Plan 2017 are to:

- Prioritize efficiency measures in effective areas,
- Continue IIP and IIIP and related activities to rehabilitate the water control and distribution system,
- Provide Irrigation Advisor Services, including to all new lands,
- Line canal stretches that have high leakage losses,
- Apply laser land levelling wherever possible and required to increase field application efficiencies,
- Use modern irrigation techniques in the new lands and gradually introduce the same to the traditionally irrigated old lands also,
- Improve O&M activities through participation of the private sector and WUAs,

1. Promote safe utilization of drainage water and use of high salt tolerant crops.

PLANNED HORIZONTAL EXPANSIONS:

In order to decrease the population pressure in the Nile Valley and Delta and increase the contribution of the agricultural sector to the national economy, horizontal expansion of irrigation schemes is one of the major policies of Egypt. The total planned expansion is 1.12 million ha, that require an estimated 20 BCM of water (ENIDS-CRA Study). Updated figures.

Water scarcity is considered as a serious constraint for the implementation of the planned expansions. Egypt is already approaching to the full utilization of its share of the Nile (55.5 BCM). Further more water availability to the irrigation sector is expected to decrease in the future due to competition from other sectors (industry, municipality). The National Water Resources Plan 2017 indicates that water availability will decrease from 11,400 m^3/ha in 1997 to 8100 m^3/ha in 2017, in the irrigation sector. This will have serious impact on cropping intensities, yields and farmers income in general, unless measures are taken to increase water availability. The strategic measures set by the National Water Resources Plan 2017 to increase supply are:

- Upstream water conservation projects: This include saving of evaporation losses from Sudd and Mechar marshes in South Sudan to increase the Nile flow by estimated amount of 4 BCM. This was proposed in the past and the construction of Jonglie Canal, which bypasses a large portion of Sudd started in mid 70s. The project was halted in 1983 and its completion at present is far from certain due to resistance from the local population and serious environmental concerns. Planned expansions using this source thus, have to be delayed or cancelled.
- Changing of the operation of High Aswan Dam: Preliminary studies indicate up to 2 BCM/year can be saved through change in reservoir operation. This is a feasible option that should be looked seriously. The construction of GERD in Ethiopia in particular would be an additional advantage for implementing this option,
- Reduction of losses to sinks: This is reducing outflows (drainage and others) from the Nile System to desert areas, inland and costal lakes and the sea to improve the overall efficiency of the system. It is planned to reduce outflows by 26% (from 13.1 to 9.7 BCM), in year 2017. This is achieved through improvement of irrigation efficiencies and reuse of drainage water and treated waste water.
- Improving the existing water use efficiency in the irrigation schemes, through IIP and IIIP and reuse of drainage water.

- Changing crop types and cropping patterns: use of salt tolerant crop varieties will allow the use more saline drainage water, use of short duration and draught resistant crop varieties and minimizing high water consuming crops such as rice and sugarcane will reduce water requirements,
- Other options include the use of the renewable and non-renewable ground water potential in the Nile Valley and Delta, Western and Senai deserts and Nubian sandstones and use of treated water from domestic and industrial wastes and the use of desalinized brackish and sea waters. There is estimated 11.3 BCM groundwater potential and Use of treated water has reached 1.5 BCM in 2010.

EXISTING AND PLANNED WATER USE:

The amount of water used by the agricultural sector in 2010 is approx 58 BCM which include crop and leaching requirements, deep percolations to shallow ground water, surface drainage and other losses. Of this amount 4.8 BCM are reused drainage water and 6 BCM are renewable groundwater (seepage from the Nile). The average unit water diverted per Ha from areas served by the Nile is 58 BCM/ 3.35 Million Ha equal to 17,300 m^3/Ha/year (ENIDS-CRA Study, 2010). The total figure also agrees with the estimate of the Egyptian National Water Resources Plan 1997 to 2017.

As per the 2010 ENIDs-CRA Study, the estimated total water requirement for the 1.12 million ha planned expansion projects is 20 BCM per annum. This will bring the total water requirement for both the existing and planned expansions to about 78 BCM. According to the NWRP, the projected water demand of the agricultural sector by year 2017 is 64 BCM. This is planned to be achieved by the full or partial implementation of the interventions discussed in the previous section. Improving the irrigation efficiency, use of salt tolerant and early maturing crops is expected to reduce the irrigation water requirement/ ha substantially. The table below shows the details.

Area and water requirements of existing and planned irrigation expansion projects in Egypt

Irrigation Schemes	Net Area (Ha)	Unit water demandt (m^3/ha/year)	Annual water requirement (BCM)	
			ENIDS-CRA	NWRP 2017
Existing	3,345,000	17,280	57.8	57.8
Expansion Expansion Projects				
Tushka	226,800	22,000	5.0	
Upper Egypt and South Valley development	431,760	18,830	8.13	
El Salam canal (phase 2)	168,000	17,300	2,906	
West Delta Project	107,100	15,000	1.61	
North Sinai Development	105,000	14,290	1.5	
West Delta and Northern Development	78,540	11,970	0.94	
Sub Total	1,117,200		20.07	
Total	4,462,200		77.87	64

Source: ENIDS-CRA Study, 2010 and NWRP 2017