Eastern Nile Technical Regional Office

REPORT OF THE

THE ONE-SYSTEM INVENTORY
OF INFORMATION ON THE EASTERN NILE BASIN

SUB-BASIN SUMMARIES AND ANNEXES

VOLUME 1: SUMMARIES

- BLUE NILE SUB-BASIN
- TEKEZE-SETIT-ATBARA SUB-BASIN
- BARO-AKOBO-SOBAT SUB-BASIN
- MAIN NILE SUB-BASIN

VOLUME 2: ANNEXES

- BLUE NILE SUB-BASIN
- TEKEZE-SETIT-ATBARA SUB-BASIN
- BARO-AKOBO-SOBAT SUB-BASIN
- MAIN NILE SUB-BASIN

June 2009

EASTERN NILE TECHNICAL REGIONAL OFFICE
ADDIS ABABA
ETHIOPIA

FOREWORD

I have great pleasure in presenting this first trial version of the One System Inventory (OSI), a first of its kind attempt to compile useful information on the Eastern Nile Basin in one 'living document' that will be improved and updated as the Eastern Nile Subsidiary Action Program (ENSAP) advances.

The OSI was started as a small part of the Joint Multipurpose Program (JMP) Launch Phase in 2006 and the compilation of all this information in a short period of time has been a significant achievement.

The OSI is intended to be a 'living document' with constant updating and refinement as more information is available from a wide variety of sources. In fact the three Eastern Nile countries have made more information available recently, which will be incorporated into the next version of the OSI.

I welcome you to use this OSI and to help us improve it so that it truly becomes a one-stop source for key socio-economic, environmental and hydrological information on the Eastern Nile.

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Executive Director

Eastern Nile Technical Regional Office
Addis Ababa
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June 2009

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The One-System Inventory team would like to express its sincere thanks to the consultants who compiled the national thematic reports on Environment, Socio-economics and Water in 2006, and the Synthesis Reports in 2007, despite difficulties in accessing information lying with different sources in the three countries.

We would also like to acknowledge the contributions made by the participants of the Regional Workshop on the One System Inventory in Addis Ababa in November 2007, for all their detailed review, insightful comments and helpful suggestions for improving the OSI.

We are grateful to the coordinators of the Eastern Nile Subsidiary Action Program Teams (ENSAPT) in Egypt, Ethiopia and Sudan for organizing meetings in May 2009 to discuss the OSI in general and the four Trans-Boundary Sub-Basin Annexes in particular. We would like to acknowledge, with gratitude, the meticulous review and detailed comments for correction and improvement by the groups set up by the ENSAPT in the three Eastern Nile countries.

We are confident that this version of the OSI will soon be superceded by an improved version with the active support, collaboration and assistance of the ENSAP Teams and the national governments of the three countries.

Finally, we would like to acknowledge the strong and constant support and guidance from Dr. Ahmed Khalid Eldaw, first as the Regional Coordinator of the Joint Multipurpose Program (JMP) during its Launch Phase, and then as the Executive Director of ENTRO.

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INTRODUCTION

EASTERN NILE SUBSIDIARY ACTION PROGRAMME: The Eastern Nile Technical Regional Office (ENTRO) is an organization meant to plan and implement the ENSAP (Eastern Nile Subsidiary Action Program) in the three Eastern Nile Basin (ENB) countries of Egypt, Ethiopia and Sudan. ENSAP seeks to realize the NBI Shared Vision for the Eastern Nile region aimed at reducing poverty, foster economic growth and the reversal of environmental degradation.

ONE SYSTEM INVENTORY: To support its multipurpose development objectives, ENTRO began an exercise in 2006 to create a One System Inventory (OSI) to support the planning of the Joint Multipurpose Program (JMP). The OSI was to be a regional knowledge base across the three EN countries, initially focused on three themes, water resources, socio-economic and environmental issues. This information was expected to be useful for decision-makers and senior program and project coordinators at ENTRO to write terms of reference for new studies in the Inception Phase of the JMP and to aid the literature survey of these studies.

OSI DEVELOPMENT PROCESS: The process of development of the OSI is as follows:

- ***National reports:*** National consultants were appointed in 2005 to collect information but found it quite difficult to access national information. They submitted their reports in 2006, comprising all the information they were able to gather till then.
- ***Thematic reports:*** These national reports were compiled into three thematic reports, each reporting on the situation in four transboundary sub-basins, namely, the Baro-Akobo-Sobat-White Nile Sub-basin, the Abbay-Blue Nile Sub-basin, the Tekeze-Setit-Atbara Sub-basin and the Main Nile Sub-basin.
- ***Trans-boundary sub-basin reports:*** In Septemebr 2007, these thematic reports were compiled by an international consultant into four multiple-theme reports, divided according to trans-boundary sub-basins, to present issues 'without national borders'.
- ***Regional Workshop:*** The four sub-basin reports were presented in a Regional Workshop in Addis Ababa in November 2007 and several comments were received by country teams that reviewed the reports. The atmosphere in this regional meeting was quite positive and country teams acknowledged the usefulness of the information-gathering and sharing exercise of the OSI.
- ***Revised Outputs:*** Summaries of the four sub-basin reports were prepared in early 2008 and sent along with the more detailed Annexes to the three country ENSAP Teams by mid 2008 to receive corrected versions of information that were found to be incorrect or out-dated in the review done during the Regional Workshop. A CD kit was also prepared to demonstrate the interactive presentation of key data tables and maps.
- ***Country meetings:*** Meetings were organized with the country ENSAP teams in May 2009 to review and update the information in the Summaries, Annexes and CD kit. These country meetings were extremely positive and there was considerable willingness among the three countries to share all available and up-to-date information. However, time was too short for them to do much beyond providing feedback that some OSI data and information was incorrect and needed to be updated. The detailed comments from the country teams are in Appendix 1, while the action taken on the comments is given in Appendix 2. Appendix 3 gives the details of the

information contained in the four trans-boundary sub-basin Annexes that comprise Volume 2 of the OSI.

OTHER INITIATIVES AND FUTURE PLANS: The OSI was meant to be a small initiative to support the JMP. ENTRO subsequently initiated Eastern Nile Water Resources Planning Model (ENWRPM) Project, and began building an information database to feed and validate this model. Thereafter, the Nile Basin Initiative (NBI) initiated the Decision Support System (DSS) and a basin-wide information collection and model building exercise. Both used OSI information. It is expected that the OSI will be improved further and then handed over to the ENWRPM Project.

QUICK OVERVIEW OF THE EASTERN NILE BASIN

The Eastern Nile Basin is constituted of three riparian countries along the eastern Nile namely Egypt, Ethiopia and Sudan. A very small portion of Eritrea is also included in the Nile system.

EGYPT: With a total area of 997,739 square kilometres, Egypt is located in the upper north portion of the Nile, occupying the entire lower course of the Eastern Nile Basin including its mouth at the Mediterranean Sea. Egypt is bounded on the north by the Mediterranean Sea, on the east by the Gaza strip, Israel and Red Sea, on the south by Sudan and on the west by Libya. The country has a maximum length of 1,105 kilometres from north to south, with a maximum width at its southern border, stretching east-west for some 1130 kilometres. Less than 10% of its area is identified to be cultivable, the bulk of its geographical area (more than 90%) being desert where life would hardly survive. With a total area of 69,722 square kilometres the Nile watershed in Egypt accounts only 7% of the country and 4% of the Eastern Nile Basin.

ETHIOPIA: Located in the horn of Africa, Ethiopia is bounded on the northeast by Eritrea and Djibouti, on the east & south east by Somalia, on the south west by Kenya and on the west and northwest by Sudan. With total geographical area of 1,133,380 square kilometres, the highland plateau of the country (above 1,800 masl) is the heart of the country covering some 60% of its total area. The Great Rift Valley splits the Ethiopian highland plateaus diagonally in the north-eastern and south-eastern directions. The north-eastern half is largely drained by the Nile river system. The plateaus are drained by 12 major river basins and are characterized by deep valleys and canyons cut by numerous rivers and streams. Ethiopia is the source of the Tekeze, Blue Nile and Baro-Akobo Sub basins, which are believed to be the major contributor of the Nile river system. The Abbay (the Blue Nile) takes the lion's share both in terms of area (18% of the total area of the country) and water resources potential (more than 50%). Including the upper courses of the Tekeze, Abbay and Baro-Akobo Sub-basins, the Nile watershed in Ethiopia accounts for about 32% of the total geographical area of the country and 22% of the Eastern Nile Basin.

SUDAN: Located in the north-eastern Africa Sudan is the largest land state in the continent (2,505,800 square kilometres). It is bounded on the north by Egypt, on the east by the Red Sea, Eritrea, and Ethiopia, on the south by Kenya, Uganda and the Democratic Republic of the Congo, and on the west by the Central African Republic, Chad, and Libya. The maximum stretch in Sudan is from north to south, with a total length of 2,250 kilometres, while its maximum east-west stretch is 1,730 kilometres. About 50% of Sudan is included in the Nile watershed, while 74% of the Eastern Nile Basin is located within Sudan.

SUB-BASINS: The Eastern Nile Basin can be divided into four major sub basins; the Baro-Akobo-Sobat-White Nile Sub-basin, the Abbay-Blue Nile Sub-basin, the Tekeze-Setit-Atbara Sub-basin and the Main Nile Sub-basin (see Table 1.1).

Table 1.1: Total Area of the Sub-basins

	Area (Square kilometers)	Mean Annual Inflow (billion cubic meters)	Proportion of Nile inflow at Aswan Dam (%)
Baro-Akobo-Sobat-White Nile	468,216	26	29%
Abbay-Blue Nile	311,548	51	57%
Tekeze-Setit-Atbara	219,570	12	13%
Main Nile	656,398	0%	0%

SUMMARY: ABBAY-BLUE NILE SUB-BASIN

THIS SUMMARY contains information on the Abbay-Blue Nile sub basin and is part of the summary report of the One System Inventory prepared by ENTRO.

Figure 1.1: Abbay-Blue Nile Sub-basin: Location map

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

1. GENERAL

1.1. LOCATION OF THE SUB-BASIN

The Blue Nile sub-basin is one of the four major sub-basins in the Eastern Nile Basin, and has a total area of 311, 548 square kilometres (65% in Ethiopia and 35% in Sudan). This sub-basin extends from the western Ethiopia to the lowlands of Sudan, meeting the Main Nile at Khartoum. Around two-thirds (65%) of the sub-basin area is in Ethiopia, and one third is in Sudan. In the Sudan, the sub-basin is spread over the five states of Sinnar, Blue Nile, El-Gezeira, Gaderif and Khartoum, while in Ethiopia, it lies across the three regional states of Amhara, Beni-Shangul-Gomuz and Oromiya.

1.2. TOPOGRAPHY

Altitude: The Gelgel Abbay in the right bank of the main stem starts at the Choke Mountains in Gojjam with an altitude of above 3,800 masl. The Beshilo (a direct tributary of the Blue Nile main stem) and the Gummara & Rib Rivers (major tributaries of Lake Tana in the east) start flowing from the Guna peak, in south Gondar, with an altitude of above 4,000 masl. The major tributaries in its left bank start flowing from the central highland plateaus of north Showa with an average altitude of above 2,200 masl. In the south left bank its major tributaries like Guder, Fincha, Angar and Deddessa starts flowing from the western highland plateaus of Ethiopia with an average altitude of above 2,000 masl. Similarly tributaries in the right bank start flowing from the Gojjam highlands with peaks reaching above 3,000 masl. The Dabus in the left bank and the Rahad & Dindir in the right bank starts flowing in the mid altitude plateaus (about 2,000 masl) of west Wollega and North Gondar respectively. At the Ethio-Sudan border the altitude drops to 600 masl. At Khartoum, its mouth, the altitude drops to 400 masl.

Slope: Given the extent of the lowlands, in proportion with the mountainous relief, most of the sub-basin has a slope of less than 2.5 percent.

Relief: Two main landscape units are observed in Abbay-Blue Nile Sub-basin: (1) A mountainous relief that extends in Ethiopia and (2) a flat piedmont starting close to the Ethiopian border and extending out across the Sudanese portion. The Ethiopian Highlands are a gently undulating plateau from 2,000 to 2,500 masl with isolated volcanic remnants rising above the plateau to 3,500 to 4,200 masl. The Abbay River and its tributaries are deeply incised into the plateau leaving a series of isolated tablelands separated by deep gorges. In Ethiopia the lowlands are undulating between 600 to 1,000 masl with isolated hilly or mountain outliers rising to 2,700 masl. Towards the border with Sudan and extending westwards to the Main Nile the topography is almost flat or slightly undulating, with just the occasional granite jebel rising above the clay plain. The lowland region between the Atbara River and the Blue Nile is occupied by the Butana Plains.

1.3. CLIMATE

General: Climate in the upper course of the Blue Nile Sub-basin is of the humid and sub humid tropical type. Westerly dry moist winds cover much of the Ethiopian highland plateaus causing wet seasons in the western highlands of Ethiopia, where the upper course of the Blue Nile sub basin is located. The south has a relatively longer wet period and has a humid tropical type of climate while the northern portion, with relatively shorter wet period, has a sub-humid type of tropical climate. Climate in the lower course of the Blue Nile (beyond the Ethio-Sudan border) is hot tropical with a dominant dry spell. Further in the south where altitude is higher (in the Sude watershed) climate is of the sub humid tropical type while to the north, around Khartoum and Rosaries reservoir, climate is hot

tropical. Dry and hot tropical type of climate dominates in the further northern reaches due to the vast coverage of the Sahara desert.

Rainfall: Rainfall in the sub basin varies both seasonally and spatially. Spatial variability is both horizontal (south-north direction) and vertical (along the river course). Horizontal variation ranges from above 1,500 mm in the southern portion of its upper course to about 1,000 mm in the northern portion of its upper course. Similarly, in its lower course mean annual rainfall ranges from 700 mm (south portion at El-Damazin station) to less than 500 mm in its northern portion. Vertical variation ranges from above 1,500 mm (at the western highlands of Ethiopia) to 120 mm at Khartoum at its mouth. In the southern half of the upper course, the length of the wet spell is relatively longer, lasting for more than five months (April/May to October/November). In most of the northern part of the upper course of the Blue Nile sub basin, the wet period is limited to less than three months and seasonal variability is higher.

Temperature: Temperature and evaporation are well correlated with altitude in the Blue Nile sub basin. At high altitudes (>2,300masl) in the western highland plateau of Ethiopia mean annual temperature is in the range of 17ºC to 19.5ºC. Temperatures rise close to the Ethio-Sudan border where altitude is lowered to less than 1,000 masl, ranging from 24ºC to 26.5ºC. At its mouth, around Khartoum, altitude is below 500 masl and temperature ranges from 28.5ºC to 30.5ºC.

Evaporation: Variation of evaporation follows the same pattern as temperature. In the upper course, evaporation is less due to high altitudes. Mean annual evaporation ranges from about 1,500 mm in the Highlands of the sub-basin to more than 6,800 mm around Khartoum. Horizontal variation of evaporation is also significant. In the southern half of the upper course, mean annual evaporation is even below 1,500 mm and in the northern half, especially at its northern tip, evaporation is above 1,800 mm.

1.4. HUMIDITY

Half the sub basin has a mean annual relative humidity of above 55%. Some 16% of the basin, largely located in its mouth, is dry with mean annual relative humidity of less than 40%.

2. SOCIO-ECONOMIC CHARACTERISTICS

2.1 DEMOGRAPHIC CHARACTERISTICS

Population: The Blue Nile sub-basin has the second largest population of the four sub-basins of the EN Basin system, with an estimated population of around 43 million, which is around 27% of the total population of the EN basin. Nearly two-thirds the population of the sub-basin (30 million) is in Ethiopia, with the remaining 12 million being in Sudan.

Population Growth Rates: In the Ethiopian part of the basin, the estimated population was projected to reach 30.7 million in 2005, which is a a 35% increase after the most recent census in 1995, while in the Sudanese part of the sub-basin, the population is projected to be 12,569,769 in 2005, which is a growth of 27.1% over the 2002 estimates.

Population Density: This is defined as the total number of people per km^2. There is a considerable variation in terms of population pressure across regions and administrative zones. In the Ethiopian side, high population densities are in the Highlands (i.e. above 1,500 masl), where it generally exceeds 75 persons per km^2 whereas in the Lowlands the densities are below 25 persons per km^2. In Sudan, high population densities are located along the Blue Nile River and the main road that runs parallel to the river. The west-east band of high densities is located along the Sennar-Gederef railway line and not the main Khartoum to Port Sudan road.

Rural-urban divide: The majority of the population in Abbay River Basin is rural. Only about 10% of the estimated population of the Basin lives in urban areas. No significant variation is also observed in the pattern of residence by administrative zones located in the Basin. In the Sudanese part of the sub-basin, 35 per cent of the population is urban.

Sex ratios: The overall sex ratio of the Abbay watershed population is about a unity i.e. 100 males per 100 females on average. In the Sudanese part of the sub-basin, the sex ratio is estimated as 102 males for every 100 females.

Population age groups: Most of the population in the Abbay River watershed is in the younger age groups. The child dependency ratio, which is expressed as number of population under the age of 14 to those in the working age group (15 -64) is around 85. Old age dependency ratio, on the other hand, is the lowest: around 7 persons per 100 persons in the working age group (15 – 64 years). In the Sudanese part of the sub-basin, children under 14 years of age constitute 41% of the population, while old people (60 and above) are around 4% of the population.

Birth rates and death rates Crude birth rate in the Sudanese part of the Blue Nile sub-basin is estimated to be 37.5%, and crude death rate, 10.4%, giving a natural rate of growth of 27.1%.

Infant and child mortality: Despite showing a slight decrease between 1994 and 2,000, infant and child mortality is still the highest in all regional states and administrative zones located in the Abbay watershed. The average number of years that a newly born child is expected to live across regions indicating that the quality of life is extremely low among residents of the Basin. In the Sudanese part of the sub-basin, average infant mortality rate is reported to be 105 per 1,000 live births. Under 5 mortality on the other hand goes up to an average of 152 persons per 1,000 live births. In both the Sudanese and the Ethiopian parts of the sub-basin, there is a close relationship between the higher infant mortality and poverty rates.

Life expectancy at birth: In the Ethiopian part of the sub-basin, average life expectancy at birth ranges from 46 and 50 years for males and females. In the Sudanese part of the sub-basin, average life expectancy is 52 and 57 for males and females respectively.

Marital Status: Marriage practice depends on the culture of the different ethnic groups and religions found in that place. The majority of the ethnic groups in the Ethiopian side are the Gumuz. The Gumuz have the tradition of marrying three wives (they are mostly Muslims). Among the Christian Gumuz, marriage is one to one. The divorce rate among the Gumuz is reported to be very low (5%) compared to the Amhara.

Migration: In the Ethiopian side, migrations in the two regions are common but the purposes and degree are various. In Benishangul Gumuz, it is frequently happening and notably higher than in the rest of the country for a number of reasons. The major migration reason to the area is for resettlement. Temporary immigration took place in the past (mostly from the Sudan due to drought and conflicts, trade and other reasons). In the Amhara region, where people are considered relatively wealthier than other parts, migration is very low.

2.1. SOCIAL INFRASTRUCTURE

Literacy and education: In the Ethiopian side of the basin, more than half of the primary school age population (7 to 12 years) do not attend school[1] while secondary school enrolment[2] level is even lower Over three-fourth of the population eligible for secondary education do not enrol, and are engaged in other livelihood activities instead, partly due to poverty, which prevents parents from sending their children to school. Interestingly in Ethiopia the highest rates of enrolment are in relative remote Beneshangul-Gumuz Regional State. In Sudan high enrolment rates are clearly related to the high rates of urbanization in Khartoum and El Gezira States.

Water Supply: In Sudan, the urbanized states of Khartoum and El Gezira have better access to piped water supply than the other more rural States. In Ethiopia, water sources for the majority of households in the sub-basin are (contaminated and unsafe) rivers and ponds. Women and young girls travel 8 - 10 kilometres on average to fetch water, as fetching water is considered their responsibility. Overall, only a quarter (27-28%) of the population in Benishangul and Amhara has access to potable water.

Sanitation: In Sudan, Khartoum with its relatively low sanitation facilities and Gaderif with its high rate of no sanitation facilities follow the pattern of piped water provision. With the remaining States the relationship is not as clear. In Ethiopia, 66% of the people in Benishangul and 87% in Amhara use field or forest to defecate; 33% in Benishangul and 11% in Amhara have pit latrines. There are virtually no flush toilets.

Health: Health facilities in the sub-basin are generally inadequate to meet the demands of the population. There are only a few health centres and hospitals in each of the Ethiopian regions located in the Abbay River Basin. These existing facilities are severely under-staffed, ill equipped and under-supplied. The population versus physician ratio is far below the standard of 10,000 per physician set by the WHO. The average ratio of hospitals for the Basin in 2003 was 1.8 per 100,000 people in the region.

Energy: The principal energy source of the region is fuel wood. Cooking is the major end use and a large number of people use fuel wood for lighting. 97% of energy consumed in 2004 came from wood, 2% from agricultural residues and the remaining from modern fuels.

Community Based Organizations: In Ethiopia, the major community based organizations are at kebele and sub-kebele levels. The kebele or the sub-kebele is a basic structure

[1]The net enrolment rate in primary education is defined as the number of pupils of primary school (age 7-12 years) who are currently attending primary school divided by the total number of children in the age group 7-12 years

[2]The net enrolment ratio at secondary school level is defined as the proportion of children aged 13-18 years and is attending secondary school (grade7-12) divided by the total number of children in age group13-18 years

under the woreda administration. Each has its own administrative organ consisting of a chairperson, an assistant as well as a secretary. This organization is responsible for mobilizing people under their jurisdiction for any development work. In addition, the kebele or the sub-kebele may consist of voluntary associations like the Idir, Ikub, etc which are mainly instituted to create cooperation and mutual assistance among members.

NGOs: In Ethiopia, the bulk of the registered NGOs in the Abbay Basin is concentrated in the Amhara Region, with as many as 43 NGOs operating in the region (in 2004). But this number could be higher if 'unregistered' NGOs are taken into account.

2.2. TRANSPORT AND COMMUNICATIONS

Roads: Because of the extreme dissection of the highlands by the Abbay River and its tributaries road infrastructure is not well developed. All-weather roads tend to be confined to the ridges and plateaus between the deeply incised rivers. Other roads are generally in poor condition and on the clay plains often impassable during the rains. There are no major road linkages between Ethiopia and Sudan within the Abbay-Blue Nile Sub-basin. Dry weather tracks cross the border at three points: Bambudi on the north bank of the Abbay-Blue Nile, Bizen and Kurmuk both south of the Abbay-Blue Nile. The main roads in Ethiopia terminate at Guba (north of the River) and Assossa (south of the river).

Railways: There is one railway line in the Sudanese part of the sub-basin: Khartoum – Sennar – Gederif. No town or city in the Ethiopian regions of the Blue Nile basin is connected to a railway line.

River Transport: People cross the Abbay River in traditional boats for trade, visiting relatives, health services and other personal reasons.

Air transport: In Ethiopia, only one town in Beni-Shangul-Gumuze, four in Oromiya and six in the Amhara Region can be reached by air.

Telecommunications: Only 2% of all urban and 0.1% of all Benishangul Gumuz households have telephone facilities. There is no figure for current status. Even though very low, there are better telecommunication services in Amhara parts.

2.3. ECONOMIC ACTIVITIES

Activity Rates: An activity rate is defined as the proportion of the total economically active (employed plus unemployed) population to the total working age population. In the three Ethiopian states, the activity rate varies between 70 and 76%. For the Sudan, data is only availablefor one of the five states, the Sennar State, for which the (refined) activity rates for males and females were 73% and 8% respectively. The urban and rural activity rates for males were 69% and 75%, as compared with 11% and 7% for females.

Unemployment and underemployment: There is more unemployment in urban areas than rural areas in general. In Sudan, the unemployment rate in urban areas was 13% for males and 27% for females, as compared with 15% and 50% in the rural areas.

Cultivation: Rain fed crop cultivation is the principal activity in most of the basin where adequate rainfall is available. Thus, 78% of the rural population in the Abbay portion of the sub-basin is engaged in subsistence agriculture and agriculture-related occupations, while only a small fraction engage in non-agricultural activities. The economy, largely based on traditional methods of plough cultivation and supplemented by the hoe in the lowlands, is subsistence oriented. The lowland population practices some kind of shifting cultivation, mainly for growing sorghum. In semi-arid to arid conditions, pastoral livestock becomes predominant. Livestock as a source of livelihood is mainly important for the Sudanese side of the basin population where there exists a high concentration of cattle,

sheep, and goats. Except for the Gezira cotton farm in the Blue Nile river basin and New Halfa irrigated scheme in the Atbara-Setit, as well as the cotton and sesame plantations in the Tekeze-Setit side in Ethiopia, the largest proportion of agricultural production in the wider area of the sub-basins is geared towards satisfying consumption needs.

Farm employment: Farm employment (combining crop and livestock production) constitutes the primary source of occupation for the population. The communities along the basin (both in Ethiopia and Sudan) seems to have very limited experience in accessing cash income because of the remoteness and inaccessibility of the sub basin region from regional market centres and hence employment is concentrated in the production of primary commodities.

Irrigated agriculture: There is very little use of the basin and its tributaries for irrigation activities (except some traditional methods of water diversion).

Livestock rearing: In the rainfed small-scale systems and on the large irrigation schemes livestock are an important component and livelihood strategy despite the small number per household. They provide additional sources of income and thus help to spread the risks associated with rainfed cropping. In the highlands they are a valuable source of soil nutrients and in fuelwood scare areas of fuel. In Sudan dung is not used as farmers believe they are a source of weeds. With the restoration of exports to Middle East livestock production makes a significant contribution to the agricultural GDP.

Fishing: Fishing is indispensable to the economy of the Baro-Akobo River, on the Ethiopian side (Hussein and Yared, 2003). Intensive fishing is done on perennial and seasonal swamp areas during the dry season, although it is currently mainly for subsistence in the main river channels and floodplain areas. The basin has high potential for flood plain aquaculture, although it currently lacks aquaculture technologies.

Mining: The existence of gold and gold mining is long known in the Benishangul Gumuz region. Currently, traditional gold mining (by panning) is widespread in Benishangul Gumuz region in general, but very limited in the Mandaya project affected woredas. There are estimated to be around 50,000 traditional gold miners currently, who extract about 180 kg of gold per year on average.

Hunting: As everywhere in the nation, hunting is illegal unless one has a licence to hunt, but local authorities admit that some illegal hunting may be taking place. Hunting is known to be a traditional and cultural practice in the area with antelopes, porcupines, monkeys and other animals being hunted for food, using spears and arrows. Hunting among the Gumuz has social esteem where hunters occupy high status in the community.

Trade and other services: Although there is trade in the Ethiopian side of the sub-basin, there is no well organized market structure and market places except in few places in Benishangul Gumuz. On the other hand, in Amhara project woredas' markets seem better organized.

2.4. LIVELIHOOD CHARACTERISTICS

A large proportion of the Blue Nile sub-basin remains characteristically rural, which perhaps best explains the livelihood structures of the inhabitants in general. Agriculture, rain-fed, irrigated and shifting, and migratory pastoralism form the livelihood base of the population and the mainstay of the economy in the sub basin. Sedentary agriculture, (rain-fed and irrigated), and shifting cultivation, and migratory pastoralism constitute the basic livelihood strategies in the Sudan portion of the Blue Nile sub basin, with variations in the size of groups engaged in the activities. In the same area, artisan gold mining also employs a small labour force, entirely comprising members of the Berta ethnic group, albeit in small numbers. Within the Sudan a substantial proportion of the population in the Blue

Nile Sub-basin live and work on the large irrigation schemes and semi-mechanized farms or in service and processing industries related to these developments. Many in the past followed pastoralist and agro-pastoralist livelihoods, but who for one reason or another lost their livestock and became sedentary.

2.5. AGRICULTURE AND PEOPLE

Sedentary mixed farming and shifting cultivation (slash and burn) constitute the two important types of traditional agriculture practiced in the Abbay-Blue Nile region of the sub-basin. Furthermore, pastoralism also forms a means of livelihood for some of the population in the region, with variations in the size of groups practicing it, the Blue Nile accounting for the greater number of pastoralists.

Major ethnic groups: Within the sub-basin the political boundary between Sudan and Ethiopia is mirrored by socio-cultural and physical boundaries. Within Ethiopia the Amhara in the Amhara region, and the Oromo in Oromiyo region tends to be predominant, while it is more mixed in Benishangul-Gumuz, with the Jebelaw/Koma/Mao (29%), Gumuz (25%) and Amhara (20%) being the main groups. In Sudan, the Blue Nile Basin is dominated by adherents of traditional beliefs, followed by Christians, while a certain number of Muslims are also known to exist. There is greater ethnic diversity in the southern zone of the Blue Nile Basin in the Sudan.

Major livelihood activities of ethnic groups: A number of groups of ethnic people retain their original way of life, although now somewhat altered. The Rufa'a al-Hoi are an Arab speaking Muslim nomadic people with sheep, cattle and camels and are divided into two groups: the northern Badiya located on the Blue Nile (dry season) and who move north towards the Dinder River (wet season); and the southern Badiya who used to move between the Yabus (in the dry season) and the Gezira/Managil schemes In the wet season). The Kenana are also Arab speaking pastoralists who move between the Blue Nile northwards beyond the Dinder River. They come into contact with the northern Badiya group of Rufa'a el-Hoi along the Blue Nile. The Fulani are in fact a mixture of many ethnic groups from West Africa who moved into the Funj in the mid 1940's, were expelled to western Sudan in 1954 but have since returned. The Ingessana is a name given to the people living in the Ingessana Hills with a distinctive language and culture. They are predominantly agriculturalists cultivating the foothills. There are also a number of smaller groups who practice sedentary agriculture, including the Berta, Gumuz and Burun.

Main Agricultural Land Use Systems: Three broad systems can be identified: (i) rainfed cropping, (ii) irrigated cropping and (iii) extensive livestock production (Table 2.1).

Table 2.1: Main Agricultural Systems in the Blue Nile Sub-basin

Main Category	Scale of operations	Tenure type	Main Components	Location
RAINFED CROPPING	Small-scale traditional; sedentary	State land: Individual and Communal use rights	Cropping (Cereals, pulses, oil seeds) Small Livestock holdings (Communal grazing, crop residues)	Ethiopia: Highlands
	Small-scale traditional; shifting	State land: Individual and Communal use rights	Cropping (cereals, pulses): Small livestock holdings (Communal grazing, crop residues)	Ethiopia & Sudan: Lowlands
	Large-scale: Semi-mechanized	State land: Medium-term Leases	Cropping (Sorghum, cotton, sesame)	Ethiopia & Sudan:

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

2.6. FORESTRY AND AGRO-FORESTRY

Forestry Contribution to the Economy: In Sudan in the Abbay-Blue Nile Sub-basin approximately 10.7 million cubic meters of wood fuel and charcoal are consumed, forming about 80 percent of the total energy consumption. In rural areas, woodlands provide all building materials, 33% of the national livestock feed as browse, and a number of non-timber forest products, the most important of which is gum arabic. In addition to these products the woodlands give a number of services which have no direct monetary values such as environmental protection, increase in crop production, conservation of soil fertility, biodiversity, protection of cultural heritage, forming habitat for wildlife and eco-tourism attraction. The contribution of forestry sector to the GDP is around 3 percent in 1999 but taking into account the outputs collected/consumed by local communities the forestry sector's contribution to the national economy is around 12% of the national GDP.

The situation is similar in the Ethiopian portion of the sub-basin, with some 23.4 million m^3per year of fuelwood and charcoal (wood equivalent) being consumed (65% of domestic energy consumption). Browse is of little importance in the Ethiopian Highland livestock systems. However, resins are of importance in the Lowlands north of the Abbay River.

Agro-forestry: In Sudan the main components of agro-forestry are the harvesting of Gum Arabic and browse for livestock as mentioned above. The Gum Arabic Belt (GAB) in the Abbay-Blue Nile Sub-basin comprises the major part of the low rainfall woodland savannah zone extending from the border with Ethiopia to the Main Nile almost all on clay soils. In Ethiopia agro-forestry takes the form of planted trees (invariably Eucalyptus spp.) around the homestead and indigenous trees left in croplands. In the Highland areas north of the Abbay River Eucalyptus spp. dominate on-farm trees comprising nearly 90 percent of all on-farm trees. In the Highlands south of the Abbay River the proportion of Eucalyptus spp. fall to about 40 percent of on-farm trees and to virtually zero in the Lowlands, with indigenous and cash crop trees (mainly coffee in the Highlands) making up the remainder. Trees in croplands are generally moderately to heavily pollarded for timber, fuelwood, forage and to reduce shade.

2.7. POVERTY PROFILE

In 2004 in Ethiopia, 47.5% of all rural households were estimated to be poor, and growing. A third of the Ethiopian rural population are considered destitute (more acute than merely being poor) in 2003, as indicated by frequency of famine, declining food consumption, increasing malnutrition and associated health status. Also, wealth and poverty are not distributed equally among various social groups. There is a strong link between poverty and gender, age as well as other characteristics of the population living in the Abbay River Basin. These households are victims of poverty mainly due to shortage of labour power to engage in productive activities. Thus, some segments of the rural population have a higher chance of being poor or destitute, due to socio-economic differentials.

Poverty Lines: The basis for determining the poverty lines in Ethiopia and Sudan are different and thus can not be compared with each other.

Estimates of Poverty: In Sudan, Gezira and Blue Nile States have lower poverty rates than Gaderef and Sinner States. In Ethiopia poverty rates in Amhara and Oromiya Regional States are similar, but those in Beneshangul-Gumuz region are significantly higher.

3. NATURAL RESOURCES AND ENVIRONMENTAL ISSUES

3.1. GEOLOGY

Overview: The Highlands of the sub-basin is composed of basic rocks, mainly basalts, while the Ethiopian lowlands are mainly composed of Basement Complex rocks as well as metamorphic rocks, such as gneisses and marble. Where the Abbay has cut through the basalts there are restricted areas of limestones and then sandstones before the Basement Complex is reached. The main part of the Sudan Lowlands is underlain by deep unconsolidated colluvial sediments of tertiary and Quarternary age. To the north are older Basement Complex rocks and the Nubian Sandstones. The Nubian Sandstones are located in the northwest corner and overly uncomfortably the Basement Complex rocks and comprise mainly sandstones, siltstones and conglomerates.

The Abbay River does not carry much coarse or medium grained sand. Instead the alluvium comprises silt, very fine micaceous quartz sand, and channel lag gravels.

Minerals: The Precambrian rocks falling within the Abbay Basin contain a significant proportion of greenstone rocks; these are ancient meta-sediments, marbles, and meta-volcanics having a low grade of metamorphism. The main green stone belt forms a broad swathe, about 20 to 50 kilometres wide, and orientated north south, which intersects the Abbay River along a strip which is east of Najo, and west of Gimbi. This suite of rocks contains gold, and other base metals, disseminated within minor quartz veins. To date, no vein deposits have been found that are large enough to sustain gold mines.

3.2. SOILS

The Vertisol – Nitisol boundary runs almost along the international boundary. Nitisols (24%) dominate the western Highlands whilst shallower and more infertile Leptosols (19%) occupy the eastern Highlands. Vertisols (29%) dominate the unconsolidated sediments of the Sudan plains. On the flat plateaus in the Ethiopian Highlands are extensive areas of Vertisols. On the deep soils in the high rainfall areas around Lake Tana there are extensive areas of Luvisols. Soils in the Border area are broadly classified as Nitosols and Alfisols, two of the nine major soil groups covering the Abbay Basin. These units are capable of cultivation but their acidity reduces the availability of nutrients like phosphorus, calcium and magnesium. Soils formed in the eastern part of the basin form the basaltic rock cap are deep, productive, well structured and inherently well-drained agricultural soils. Those soils formed in the western part of the basin form the underlying strata are somewhat less productive and are classified into a variety of major soils including Nitosols and Vertisols (black cracking clay soils). Other major soils found within the basin include Rendzinas (derived from calcareous deposits) and Lithosols (shallow rocky soils).

3.3. LAND USE AND LAND COVER

Woodlands and shrublands cover some 28% and grasslands 25% of the sub-basin. Sedentary rainfed cropping covers nearly 26 % of the area mainly located in the Ethiopian Highlands. In Sudan, semi-mechanized farms cover 10% but irrigated cultivated land is only 2.6%.

3.4. VEGETATION

Vegetation Types: The main types of vegetation found in the sub-basin are semi-desert scrub and grassland, acacia thornland (alternating with grassland), Acacia seyal-Balanites Savanna (above 570 mm rainfall area to the escarpment with Highland Ethiopia),

Terminalia-Combretum (Deciduous) woodland (in the higher rainfall areas, generally with above 700 mm mean annual rainfall) and Lowland bamboo (Oxytenanthera abyssinica).

Forests Types: There are several forms of forests

Riverine/riverain forests lie along both banks of the Blue Nile as detached areas, forming a very unique forest ecosystem covering a vast area and are of vital economic importance for the economy of Sudan and its nature conservation. In the Lowlands (below 1,500 masl) pure stands of riverine woodland – "sunt" – are increasingly under pressure, while in the upper parts of the sub-basin these are varied and have been little studied.

Montane High Forest: These represent less than 2 % of the basin and are now much fragmented and located in relatively small patches.

Undifferentiated Afro-montane Forest (Transitional Broadleaf Forest): These are found as dispersed patches of forest in areas southwest and southeast of Lake Tana north of the Abbay River and in West Wellega south of the Abbay.

Mixed Juniper-Podocarpus Upland Evergreen Forest: The main canopy species are J.procera and P. gracilor between 20 and 30 meters high, with a well developed strata of small to medium trees, chiefly O. europaea cuspidata, Allophylus abyssinicus, Celtis africana, Croton macrostachyus, Dombeya spp., Ekebergia capensis, Olea hochstetteri and Prunus africana.

Single dominant Montane Dry Evergreen (Juniperus procera) Forest: This type of forest is found on the plateaus and hills in North and South Wello, North and South Gonder and North Shewa between 1,600 and 3,200 masl. Annual rainfall is between 500 and 1,500 mm and often but not always bi-modal in distribution.

Mountain Woodlands: Found at higher altitudes above 2,500 masl, and common species are A. abyssinica, Protea, Cussonia, Hagenia abyssinica, Erica arborea, and Hypericum.

Afro-alpine Grasslands and Erica Woodland: Generally found above 3,200 masl, where mean annual temperature is generally below 11 degrees C and frost will occur most nights.

3.5. WETLANDS

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

3.6. WILDLIFE

Dinder National Park: In the lower course of the sub basin, the Dinder National Park covering an area of about 8900 kilometres preserves natural wildlife migration corridor between the lower and the upper part of the sub basin. The park is the last remaining wildlife sanctuary in the south-eastern clay plains. It supports a population of Tiang, Reedbuck, waterbuck, bushbuck, Pribi, roan antelope, warthog, buffalo, greater kudu and red fronted 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. In this sub basin in general, there has been severe reduction in wildlife habitats and numbers due to the conversion of large areas of land for agricultural use. This has particularly affected the more densely populated and human favored higher and cooler altitude areas in its upper

course. Introduction of state farms and settlement activities in the lower altitude plain areas have also affected the life of wildlife.

3.7. FISHERIES

The upper course of the Blue Nile sub basin has limited fish reserves in both lake and riverine systems. Lake Tana, on the other hand, has the most important fish resource. Fishing is carried out on a subsistence basis and limited commercial purposes both in the main river channels and many of the floodplain lakes. Virtually, every family that lives near water fishes to supplement its diet. 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 in the upper sub-basin of the Blue Nile. Neither the number of fishery operations nor evaluation of their catch is available.

3.8. BIODIVERSITY

Ethiopia occupies a unique position in the world with regard to plant and animal diversity. There is a high level of endemism within the country with 99 endemic animals and about 800 endemic plants. However, the ability of Ethiopia to maintain this high degree of inherent biodiversity is now under threat as human use moves insatiably into the few remaining areas. EWNHS (1996) has identified that, of the 16 endemic bird species within Ethiopia, half of these are still found in the upper course of the Blue Nile sub basin, of these two (the Ankober Serin and Harwood's Francolin) are categorized as vulnerable in the list of globally threatened species. Wild habitats are shrinking and apart from those savannah woodland areas in the northwest part of this upper course of the sub basin, or those areas that have tsetse fly infestation few habitats remain intact. Urgent action is needed to address this problem of shrinking habitat and biodiversity loss before extinctions occur.

3.9. MAJOR ENVIRONMENTAL ISSUES RELATED TO WATER

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 located on the clay plains north and south of the Blue Nile the key soil degradation problem is nutrient mining. 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.

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 3,100 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. 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.

Water-related diseases: The major concern is malaria which is increasing, is difficult to control, and has the potential to infect a very large population in epidemic outbreaks. The

other water related diseases are Schistosomiasis, Typhoid, Diarrhea, Helminthiasis, Leshimaniasis, Onch ocerchiasis.

Soil degradation: 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: Most sheet erosion in the Sub-basin occurs in the Ethiopian Highlands. Some sheet erosion occurs within Sudan, mainly on and around the rock hills (Jebels), which have become devoid of vegetative cover. Most of this is deposited on the footslope and does not enter the drainage system. Some water induced soil movement also occurs on the flat clay plains, but given the poorly developed surface drainage system little sediment reaches the main rivers. Four main areas of high sheet erosion are found in the Abbay Basin: (1) The steep slopes around Mount Choke in East and West Gojam; (2) north and east of the Abbay River in the Lake Tana Basin; (3) in the upper Jema sub-basin in South Wello on the high hills north and west of Debre Birhan and (4) 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.

Gully erosion: In Ethiopia, there is no information on gully distribution, density, erosion rates and sediment delivery ratios though some very recent research has provided information of gulley erosion rates, sediment yields and sediment delivery ratios in northern Ethiopia. This reports 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. In Sudan, the main erosion problem in the Blue Nile Sub-basin is gully erosion along the Blue Nile and Dinder Rivers producing kerib land.

River bank erosion: 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.

Suspended Sediment in the Blue Nile River System: From the data on suspended sediment discharge at three key stations on the main Abbay River, it appears that most of it comes from the tributaries located in the south and west parts of the basin. Infrequent, unsystematic and incomplete suspended sediment data for the El Deim gauging station just across the border in Sudan is available. This has been analyzed by Group 1 of the NBCBN/River Morphology Research Cluster. They estimate long-term mean suspended sediment at El Diem to be 123M tons, and the annual sediment yield for the Abbay Basin to be 700 tonnes per year. But the data also show that there is no significant difference between the sediment yields of small and large catchments, with the mean of the small catchments close to that of the large catchments. This would indicate that there is little or no storage of sediment within the Abbay River system, a factor normally attributed to declining sediment yields with increasing catchment areas. This is to be expected given the steep gradients in both tributary and main rivers. Given the relatively high sediment delivery ratios and very similar sediment yields it would appear that the Abbay River system is also relatively efficient in delivering and removing eroded sediment from the landscape.

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 – in turn, reducing their effective capacities, shortening their service lives, and raising maintenance costs. The two main dams in the Blue Nile Basin, the Roseires and the Sennar, are affected by siltation. High sediment loads in the rivers used as sources for domestic and industrial water supplies cause problems and additional expenditures for water treatment plants.

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.

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.

Degradation of Herbaceous Biomass: An indicator of overgrazing can be determined by examining the livestock feed energy balance at the wereda level. Energy requirements of all livestock are computed using energy requirements for maintenance, draught power and lactation, and balanced against estimates of energy supply from natural pastures and crop residues. The main areas of livestock feed deficits in Ethiopia are the upper slopes of Mount Choke in East and West Gojam, the eastern weredas in North Shewa and South Wello, with more isolated areas in East and West Wellega. These areas are largely coincident with the areas of high soil erosion hazard.

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

Extent and Degradation of Wetlands: In Ethiopia, a recent survey and inventory of wetlands in the Amahra Region found that many of these wetlands were under threat due to land degradation and sedimentation, and the lack of bylaws and community rules regarding their use. Many are used for dry season grazing, hay production, thatching grass and grass mats (cheffe). In the area between Gimbe and Nejo within the Dabus and Abbay Sub-basins many wetlands are used for cultivation. Because of severe degradation on the upland granite soils the wetlands have become vital elements in sustaining peoples' livelihoods. However, in some areas there have been reports of over-draining of these wetlands leading to the destruction of their delicate hydrography and loss of value for cultivation.

In the Sudan, the main wetlands in the Blue Nile Sub-basin are located on and between the Dinder and Rahad Rivers and are locally known as "maya'as". These are depressions along and between the rivers. The area way from the river is covered with fossil streams

and rivers. The depressions are abandoned meanders which have formed forming "ox-bow" lakes. These lakes however are ephemeral as they gradually silt up, fill with swamp vegetation and then as they silt up dry out. The vast majority of these wetlands are found outside the Dinder National park and most are within large to medium semi-mechanized farms. The greatest danger to the Dinder-Rahad wetlands are from agriculture.This area is frequently subject to severe flooding. Wetlands have the capacity to "buffers" flood peaks allowing the flow to pass through the system more easily. Many of the Dinder-Rahad wetlands are now cut-off from the main river systems by the expansion of large-scale rainfed agriculture. It is not known how far this is responsible for the recent flooding and far they are due to silting up of small lakes and ponds from sediment derived from the Ethiopian highlands.

Loss of biodiversity: 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, but this is currently under threat. The Dinder and the Rahad Rivers and their tributaries drain the Park. Due to the abrupt change in gradient, a large number of cut-off meanders have been formed locally called Maya'as. 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. The Alatish Regional Park in Quara wereda of North Gonder Zone, Ethiopia, almost opposite the Dinder national Park in the Sudan, represents the Sudan-Guinea Biome. The Park has been gazetted as a Regional Park and demarcated. But it lacks national legislation and international recognition. Also, while the northern and eastern sides have a 2 kilometres buffer zone, 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. In addition, people enter the Park area to collect honey, gums and resins.

4. HYDROLOGY AND WATER INFRASTRUCTURE

4.1. SURFACE HYDROLOGY

Watershed physiography: The Blue Nile drains the Gojjam highlands (part of the Central highland plateaus of Ethiopia) in its right bank and the North Gondar, South Wollo and North Showa highland plateaus (also part of the central highland plateaus of Ethiopia) in its left bank. The Blue Nile after entering the gorge, flows in a clockwise spiral and in a general south direction, collecting runoff from major tributaries such as Beshilo, Walaka, and Jemma on the left bank and the Abbaya, Suha, and Muga on its right bank. From the Addis-Bihar Dar highway bridge the Blue Nile flows in a general westerly direction following the same clockwise direction and collects runoff from the west Showa and Wollega highland plateaus (part of the western highland plateaus of Ethiopia) on its left bank through major tributaries such as Muger, Fincha, Angar, Deddessa, and Dabus and on its right bank collecting runoff from the Gojjam highland plateaus (part of the Central and western highland plateaus of Ethiopia) through major tributaries such as Yeda, Chemoga, Birr, Fettam, Dura and Beles. From Lake Tana to the Ethio-Sudan border the Blue Nile traverses a total distance of about 1,000 kilometres with an average river bed slope of 2%. Downstream of the border, the Blue Nile is intercepted by the Rosaries reservoir after traversing some 100 kilometres in to the Sudanese land. No major tributaries join the system in this reach. Downstream of the Rosaries dam is the Sennar dam which is located on the main stem of the system. Two major tributaries entering the system downstream of the Sennar reservoir are the Dinder and Rahad, both of which originate from the north western highland plateaus of Gondar in Ethiopia. The Blue Nile forms a confluence with the White Nile at Khartoum to create the main Nile system.

Catchments: The sub-basin is divided into 10 3rd order catchments and 103 6th order catchments using the Pfafstetter system.

4.2. RUNOFF

The Lake Tana Watershed: Lake Tana is a highland lake at an average altitude of 1,800 masl, whih constitutes one of the major sub watersheds in the sub basin. It is fed by four major tributaries, Gelgel Abbay in the South, Rib & Gummara in the east and Megech in the north. At its outlet, its southern tip at Bahir Dar, a regulating weir known as Chara-Chara weir has been constructed to regulate outflow for the generation of hydropower at Tiss Abbay, a natural fall located some 30 kilometres downstream of the Lake outlet in the main stem of the Blue Nile sub basin.

The Deddessa, Dabus and Angar Rivers: These are the three major rivers meeting the main stem of the Blue Nile downstream of the Kessie station in its left bank. The mean annual contribution of Deddessa River is averaged at 4.6 bcm, the Angar at 1.8 bm^3 and that of the Dabus at 3.2 bcm.

The Beles River: The Beles River has two major tributaries, upper Beles and the Gelgel Beles. At the mouth the mean annual contribution of the Beles River to the main stem of the Blue Nile is averaged at 1.6 bcm. It is the last major tributary of the Blue Nile before the border in its right bank.

Blue Nile at the Ethio-Sudan Border: The time series for the annual inflow shows a general increasing trend for recent recording periods which might be due to the regulation of Lake Tana at the Chara-Chara weir.

Blue Nile at Roseires: No significant tributaries join the main stem of the Blue Nile between the border and the Roseires station. The mean annual inflow entering the

Roseires dam from the Blue Nile averages 49.30 bcm, which is less by 1.73 bcm compared to the inflow (51.03bcm) recorded at the Ethio-Sudan border.

Blue Nile Downstream of Sennar Reservoir: The Rahad and Dinder Rivers originating from the north-western highlands of Ethiopia joins the main stem of the Blue Nile downstream of the Sennar Reservoir with mean annual inflow of 4.0 bcm. Hydrologic variability in these two rivers is considerably high. The runoff is concentrated in the wet period (June – Oct) with little flow coming in November and December. Almost no flow enters the Blue Nile in the months of January to May.

Blue Nile at Khartoum: The long-term inflow mean annual flow averages 48.7 bcm (usually taken as 50 bcm). With nearly 45% of hydrologic variability, more than 80% of the mean annual inflow at Khartoum station is concentrated in the wet season from July to October. Hydrologic variability in the dry season is averaged at about 50% and the annual series has a hydrologic variability of 30%. The White Nile from the south makes a confluence with the Blue Nile at Khartoum. The mean annual inflow carried by the White Nile to the Blue Nile averages 25 bcm, which makes the mean annual inflow in to the main Nile passing the node at Khartoum 73.3 bcm.

Runoff in the sub-basin: Although the Abbay Basin is the second largest drainage area in Ethiopia, it has the highest runoff, estimated to be 51 cubic kilometre per year. The Abbay Basin accounts for 50 percent of water runoff in Ethiopia. It also contributes 62 percent of the Nile discharge into Lake Nasser/Nubia and 72 % of the total Ethiopian contribution to the Nile waters. Comparing the mean monthly discharges of Abbay River at Lake Tana and at the Sudan border indicate that there is a 10 times increase in discharge between that at Lake Tana and at the Sudan border. The highest runoff areas are located to the southwest of Mount Choke, the East Wellega and the West Wellega Highlands. The Didessa, Dabus, Middle Abbay and Beles Catchments have the highest runoff rates. The Beshilo, Durame and Dinder-Rahad have significantly lower rates.

Seasonal variations in flow: There are considerable seasonal variations in flow of the Blue Nile, with the lowest flow being in February and the peak flow in August. In contrast to the White Nile the flow is highly seasonal being concentrated between July and October. The peak flow at Roseires occurs in August whilst that at Lake Tana outlet is September indicating that the downstream tributaries are peaking earlier. Similarly, there are considerable variations in annual discharge.

4.3. INDICATIVE WATER BALANCE OF THE SUB-BASIN

The indicative water balance for the Blue Nile system that accounts for abstractions in the system (but not evaporation), shows that the Blue Nile provides a mean annual inflow of 51 bcm at the border and 49.3 bcm at the Roseires station. Most of the irrigation abstractions in the Sudan are made from the Sennar reservoir and through pumping downstream of the Sennar reservoir. Mean annual abstraction for the reach beneath the Roseires dam and Khartoum averages 6.38 bcm. The Rahad and Dindir rivers contribute man annual inflow of 4.0 bcm to the Blue Nile main stem downstream of the Sennar reservoir, making the mean annual inflow of the Blue Nile before Khartoum 55.3 bcm. After accounting the abstractions for irrigation, mean annual inflow reaching the Khartoum node is 48.92 bcm.

4.4. GROUNDWATER

In the highlands ground water is almost exclusively confined to consolidated rocks, which include basalts, limestone and sandstone and metamorphic basement rocks. The retention capacity of these rocks is low and any groundwater is linked to the occurrence of fractures

within these rocks. The presence of a thick basalt cap overlaying the normally better yielding sedimentary rocks restricts possible recharge of these areas and limits exploitation of shallow aquifers, such as springs and wells. The presence of deep gorges along the Abbey escarpment also provides relatively free drainage for the aquifers which may emerge as springs in the lower slopes. This effectively draws the groundwater table down deeper in the locality of the escarpment which significantly reduces the potential storage ability of the aquifers.

On the Sudan plains the hydro-geological system comprises two aquifers: an upper and a lower. The upper aquifer includes mainly the Upper Geezer Formation, the upper part of the Lower Geezer formation in the area between the Blue and White Nile, and the upper part of the Lower Motorman Formation to the north of the Blue Nile. The lower aquifer is developed mainly in the deeper Nubian Sandstones. The water storage in the lower aquifer is some eight times that of the upper aquifer. Except for a few isolated localities water quality is free from impurities for drinking and irrigation requirements.

4.5. DAMS AND RESERVOIRS

Existing Dams and Reservoirs: The Blue Nile system currently has four reservoirs, three man made and one natural, which make up the existing water resources infrastructure. The two reservoirs in the Ethiopian highlands are Lake Tana and Finch reservoirs, and the other two reservoirs are Rosaries and Sennar, located in the Sudanese land upstream of the Khartoum station.

Outflow from the natural reservoir of Lake Tana is regulated by the Chara-Chara regulation weir. The Roseires reservoir is located some 100kilometers downstream of the Ethio-Sudan border on the main stem of the Blue Nile, and is largely used for irrigation and hydropower. The Sennar reservoir is used mainly to regulate the inflow from the Roseires reservoir for developing irrigation and hydropower.

Potential Water Infrastructure Identified: Four major reservoirs in the main stem of the Blue Nile (Border, Mandaya, Mabil and Karadobi) are reservoirs envisaged largely for hydropower development. Quite a number of reservoirs in the highland tributaries of the Blue Nile sub basin in its upper course, including the Tana natural reservoir, are envisaged for the development of irrigated agriculture in the system although no reservoir development is envisaged in the lower course of the sub basin. Despite problems of land degradation, the sub basin has considerable potential both for hydropower and irrigated agriculture developments.

4.6. HYDROPOWER AND TRANSMISSION

Installed Capacity: The four hydropower plants existing in the system are, the Tiss Abbay (I & II) and Fincha hydropower plants in Ethiopia and the Roseires & Sennar hydropower plants in Sudan.. The installed capacity of Tiss Abbay I&II is 72 MW while the Fincha is 78 MW. The installed capacity of Roseires and Sennar hydropower plants are 280 MW and 15 MW respectively.

Proposed Interconnections and/or Transmission Lines: The high potential for hydropower, in the upper course of the sub basin, is largely derived from its topography. The upper course alone (Abbay in Ethiopia) has more than 70,000GWH/year hydropower potential and only about 1% has been tapped so far. Both the Tiss Abbay (I&II) and the Fincha hydropower plants are connected to the national grid system of Ethiopia, while the Roseires and Sennar hydropower plants are connected in to the national grid of the Sudan. So far there is no power transmission connection between the two national grids.

SUMMARY: TEKEZE-SETITE-ATBARA SUB-BASIN

THIS ANNEXE contains information on the Tekeze-Setit-Atbara Sub Basin and is part of the summary report of the One System Inventory prepared by ENTRO.

Figure 1.1: Tekeze-Setite-Atbara Sub-basin: Location Map

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

1. GENERAL

1.1 LOCATION OF THE SUB-BASIN

The Tekeze-Setite-Atbara (TSA) sub-basin is one of the four major sub-basins in the Eastern Nile Basin, and is located at most north-eastern portion of the Eastern Nile Basin. Geographically, the sub-basin extends from 150 47' 40" to the north down to 30 25' 52" in the south, and from 290 24' 43" to the west up to 360 18' 27" to the east.

A greater proportion of sub-basin area (60%) is in Sudan and only 40% is in Ethiopia. In the Sudan the sub-basin covers 8 States whilst in Ethiopia it covers two Regional States, the equivalent level of administration.

1.2 TOPOGRAPHY

Altitude: Altitude in the sub basin ranges from above 3,500 (4,620 masl at Ras Dashen) to less than 200 masl at Atbara, its mouth (Tekeze Master Plan Project, Vol, VII, May 1998). A third (33%) of the sub-basin lies below 500 masl, another third (31%) from 500 to 1,000 masl, and the remaining third (36%) is divided as follows: 12% is at an elevation of 1,000 to 1,500 masl, 13% from 1,500 to 2,000 masl and the remaining 11% lies at an altitude above 2,000 masl.

Slope: Nearly 65% of the land in the TSA sub basin has a slope of less than 5%, which is largely the middle and lower courses of the sub basin in Sudan. Some 12% of the sub basin has land slope ranging from 5 - 10%, while 9% of the area has land slope ranging from 10% to 15%. The remaining portion of the sub basin is characterized to have land slope of greater than 15%.

Landforms: The TSA sub-basin as a whole is characterized by the dominance of steep land and more than 50 % of the basin has slope gradient of over 30%. The dominant landform in the basin is steep hilly land, with which one third of the basin is covered. Sloping land (gradients 8-30%) covers about 14% and level land (<8%) about 16%. The composite landforms, which combine two or more major landforms, cover 18% of the basin. Really flat land (<2% gradient) occurs in only 5 % of the basin.

Relief: Two main landscape units are observed in the TSA sub-basin: A mountainous relief that extents in Ethiopia and Eritrea and a flat piedmont starting close to the Ethiopian border and extending across the Sudanese portion.

Mountainous relief: The incised nature of the Tekeze River in the Ethiopian highlands mirrors that of the Abay River. But the Tekeze basin also has isolated volcano necks that contrast sharply with the surrounding undulating relief. Extremely rugged topography exists where the highlands are cut into a number of blocks by deeply incised gorges of the Tekeze River and its tributaries.

Flat piedmont: In proportion with the mountainous relief, most of the sub-basin is characterized by slopes lower than 2.5 percent. In the Ethiopian and Sudan Lowlands the topography is almost flat or slightly undulating becoming more undulating to the east.

1.3 CLIMATE

The TSA sub-basin has four climatic zones, (i) moist sub humid, largely prevails in high altitude areas (>2,500 masl) of the northern highland massive of Ethiopia; (ii) dry sub humid, in the central part of the upper course of the sub basin, (iii) semi-arid, virtually

covering more than 80% of the upper course of the sub basin, and (iv) arid, in the low-lying areas of the middle and lower courses of the sub basin in Sudan.

The wet period in the upper course of this sub basin is confined to two months extending from June/July to July/August, while the dry period is dominant in the middle and lower course of the sub basin as a result of the vast Sahara Desert.

Rainfall: The mean annual rainfall in the TSA sub-basin is substantially lower than the Baro-Akobo and Blue Nile sub-basins, and varies from 1,000 mm in the northern highlands of the Tekeze watershed, to 700 mm at Humera station (at the Ethio- Sudan border) in the middle course, to less than 400 mm at El-Girba station in Sudan and to only 20 mm at the Atbara station, at the mouth of the sub basin.

Temperature: Mean annual temperature is a pleasant 18ºC for a large proportion of the highland plateau, around 25 ºC in the western low-lying area of the sub basin, around 25ºC at the border with Sudan, rising to 30ºC in the downstream reach of the sub basin, around the Girba reservoir and in its immediate upstream reach, but exceeds 30ºC in the lower course of the Atbara, the mouth of the sub basin. The minimum monthly temperature ranges between 3 and 21^0C and occurs in the December – February period, while maximum mean monthly values occur in March – April and range between 19 and 43^0C.

Evaporation: Mean annual potential evapo-transpiration (PE) follows similar trend as that of temperature, ranging from below 2,000 mm per annum in the highland plateaus of the sub basin, to between 2,000 and 3,000 mm in the valleys of these highland plateaus, and rising to 6,000 mm at Atbara, the mouth of the sub basin.

1.4 HUMIDITY

Nearly 80% of the sub basin has a mean annual relative humidity of less than 55%. It is higher in the 20% of the sub basin lying in the highland plateaus of the Simian (North) mountains of Ethiopia.

2. SOCIO-ECONOMIC CHARACTERISTICS

2.1 DEMOGRAPHIC CHARACTERISTICS

Population: As the Tekeze-Atbara Sub-basin crosses two national boundaries (Ethiopia and Sudan), its population is made up of two groups: One group inhabits the upper reaches of the Tekeze River and the other group occupies the lower portion of the sub basin. The first group lives in Ethiopia, mainly in Amhara and Tigray regional states while the second group lives in the Sudan comprising the three states of Nahr Elnil, Kassala and Elgadarif. Total population of the sub-basin is estimated to be 8.47 million. This makes the sub basin the third largest populated region of the three sub basins of the Nile River, after the Main Nile and Abbay-Blue Nile Sub-basins. Some 75% of the sub-basin's population lives in Ethiopia. In Sudan, Kassala followed by Gederef State have the highest population totals.

Population growth rates: The population growth rate from 1984 to 1994 was 2.6 in the Ethiopian side of the sub-basin and 2.5 on the Sudanese side. Urban population growth rates are substantially larger than rural rates in all states, but those in Sudan are higher than in Ethiopia.

Population Density: The Tekeze-Atbara Sub-basin has uneven population distribution, with the Ethiopian Highlands being more densely populated compared to the down-stream lowlands in the Sudan. Thus, population densities vary from 3.3 persons per square kilometres in Red Sea State to 76.8 persons per square kilometres in Tigray Regional State. The Ethiopian side of the Tekeze Basin has an average population density of 59 persons per km^2 but no data are available for the Sudanese side of the sub basin.

Birth and death rates: The crude birth rates are around three times the crude death rates in all the states of the sub-basin, and are fairly similar across the states of Sudan and Ethiopia with the exception of Gederef, which has the highest crude birth rates

Rural-urban divide: Most (83%) of the sub-basin's population is rural. The highest urban proportion is found in Kassala State closely followed by Nahr Al-Neil State.

Sex ratios: The sex ratio on the Ethiopian side is at parity (that is 100 males per 100 females) whereas on the Sudanese side there is a slight excess of males over females (i.e., 103 males per 100 females). There are, however, variations across the states.

Population age group: Age- wise, the population throughout the sub basin is typically pyramidal, having a large base (indicating the predominance of the relatively younger persons under the age of 15) and gradual reduction of population concentration from middle through the uppermost section of the pyramid, signalling higher child dependency ratio. Old persons (aged 65+ in Ethiopia and 60+ in Sudan) account 8 % of the basin population on the Ethiopia side and 4.5 % on the Sudanese side.

Infant Mortality: While rates are generally high, the Ethiopian side appears to be even higher (123 deaths per 1000 live births in Tigray region in 1994) than the Sudanese side (112 deaths per 1000 live births in 1993). There are, however, regional variations.

Life Expectancy at Birth: Life expectancy is higher in Sudan than Ethiopia, and higher for females than males in both countries.

Ethnic groups: A number of ethnic groups occupy the basin. The Ethiopian portion of the basin is predominantly inhabited by the Amharas (89.7 %) and the Tigreans (94.8 %), although there are also other smaller ethnic groups. The lower reaches of the basin in Sudan has diverse population groups.

2.2 ACCESS TO SOCIAL INFRASTRUCTURE

Literacy and education: There are significant differences in literacy and primary school enrolment rates between Nile State and the others, with the former considerably above the sub-basin average. Female literacy rates are below those for males everywhere. The Tekeze area on the Ethiopian side has low school primary and secondary enrolment ratios compared to the Sudanese portion of the basin, where basic education coverage for both boys and girls are higher.

Water supply: The WHO standard of 20 litres a day per person is rarely met in the sub-basin because of water shortage or the cost of provision. Only a minority of Ethiopians has an access to potable water. Urban areas have better water supply service than rural. In 2001, only around a third of the population in the Ethiopian regional states of Amhara had access to safe drinking water, which is around the national water supply average of 31%. But more than 50% of the population in Tigray were reported to have access in 2004. In Sudan the Nile State is well above the national average with respect to access to piped water, unlike other states.

Sanitation: Around 60% of the population in the Ethiopian states of Amhara and Tigray reported not having access to sanitation facilities, while the corresponding proportions in the Sudanese states ranged from 13.5% (Nahr Al-Nil) to 60% (Gederef). Of those who had access, pit latrines were most prevalent in both countries, followed by flush toilets.

Health Facilities: There are few health centres and hospitals in each of the regions located in the Tekeze River Basin. Hospitals in the regions are also equipped with limited hospital beds and specialized staff. Very few private clinics and health centres are available in the two regions located in the Tekeze River Basin. But the health coverage in Tigray is relatively high while that in Tigray region is well below full coverage. The Sudan side of the Tekeze-Atbara Basin population seems to enjoy a relatively better coverage of health services.

2.3 TRANSPORT AND COMMUNICATIONS

Roads: In the Ethiopian side of the sub-basin, only one asphalted road, crossing the north-eastern upper portion of the basin stretching south-wards to Addis Ababa, connects the sub-basin with the rest of the country. Further down in the west there are all-weather gravel roads connecting Tigray region in the north and Amhara region in the south of the basin, while an all-weather gravel road connects parts of north-western Ethiopia with that of south-eastern Sudan allowing movement of goods (fuel and agricultural products) and people between the two countries. The length of all-weather roads in the Ethiopian side of the sub-basin is significantly greater than dry-weather roads, but this may only be a reflection of the degree to which dry weather roads have been mapped. The Sudanese side of the basin is better served with road infrastructure. There is one all-season road connecting the basin (Nahr Elnil state) with Khartoum. Within Sudan there are two primary (asphalt) roads (1) Khartoum to Port Sudan and (2) from Atbara to Haiya (under construction) and one all-weather secondary road. Other roads are generally in poor condition and on the clay plains often impassable during the rains. There is one major road linkage between Ethiopia and Sudan within the Tekeze-Atbara Sub-basin through Metema from Gonder to Gederef on the main Khartoum to Port Said road.

Railways: In Sudan, Atbara town is the centre of railways and there are many railways connecting the state with other regions. In Ethiopia, the basin population lives far off from the only railway line serving the eastern part of the country, from Addis Ababa to Djibouti.

2.4 ECONOMIC ACTIVITIES

Activity rate: Activity rate is defined as the proportion of the total economically active (employed plus unemployed) population to the total working age population. Accordingly, the basin states of Amhara, and Tigray in Ethiopia respectively have an activity rate of 76.6%, and 71.4%; whereas in Sudan the two basin states of Nahr Elnil and Kassala have male activity rate of 67.5% and 74.1% respectively. This indicates that the overwhelming majority of the economically active population is engaged in some form of livelihood activities.

Livelihood patterns: Crop production and livestock herding are the two most dominant economic activities along the basin, along with fishing, although crop farming is more important as a source of livelihood than pastoral production. However, a greater proportion of the population living in South and East Tigray are engaged in cattle herding and this supports the view of the relative nomadic character of the population living there. 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. Overall, with the exception of the Sudanese portion of the Tekeze-Atbara areas where there are a good number of industrial activities especially in Nahr Elnil state where the famous Portland Cement Factory in Atbara town and the Shendi and Norab Textile Factories are located, the basin population has very limited access to employment in the service and industrial sectors.

Unemployment rates: In Ethiopia, the two basin states of Amhara and Tigray have a lower unemployment rate (7.7% and 6.1%, respectively) than the Sudanese side of the basin appears (ranging from 10.5 in Nahr Elnil state to 23.9 % in Kassala state).

2.5 AGRICULTURE AND PEOPLE

The proportion of farmers in the whole basin is low, but small-scale mixed farming accounts for more than 97% of farm households in the upper portion of the TSA sub-basin, while in the lowlands of the northwest of the basin, there are farmers who own cattle and goats in large numbers and who depend totally on livestock production.

Main Agricultural land Use Systems: The main agricultural land use systems in the TSA sub-basin are relatively distinct, except along the international border where the ago-environment in one case and cultural affinities in another have given rise to very similar systems. Three broad systems can be identified: (i) rainfed cropping, (ii) irrigated cropping and (iii) extensive livestock production (with minor cropping). Differences in the scale of operations, tenure type and to a lesser extent cropping patterns give rise to a number of recognizable sub-categories (Table 2.1).

Table 2.1: Main Agricultural Systems in the Tekeze-Atbara Sub-basin

Main Category	Scale of operations	Tenure type	Main Components	Location
RAINFED CROPPING	Small-scale traditional; sedentary	State land: Individual and Communal use rights	Cropping (Cereals, pulses, oil seeds) Small Livestock holdings (Communal grazing, crop residues)	Ethiopia: Highlands
	Small-scale traditional; shifting – bush fallowing	State land: Individual and Communal use rights	Cropping (cereals, pulses): Small livestock holdings (Communal grazing, crop residues)	Ethiopia & Sudan: Lowlands

Main Category	Scale of operations	Tenure type	Main Components	Location
	Small-scale traditional: Run-off cropping/water harvesting	State land: Individual and Communal Use Rights	Sorghum, Millet (Oennisetum typhoides), okra, karkadeh, water melonlubia, seseme.	Sudan: Kassala, eastern "Border" area.
	Large-scale: Semi-mechanized	State land: Medium-term Leases	Cropping (Sorghum, cotton, sesame)	Ethiopia & Sudan: Lowlands
IRRIGATED CROPPING	Small schemes Small-scale operations (< 1.0ha) Gravity:	State Land: Individual use rights: additional to rainfed land	Cropping (cereals, vegetables)	Ethiopian Highlands
	Small-Moderate Schemes: Small-scale operations:	State Land: Individual use rights: Individual leases and some sub-leases	Geroof recession cropping+ supplementary gravity irrigation: Groundwater from matara: Date Palm	Lower Atbara, Sudan
	Large scheme: small-scale operations (<40 feddans) Gravity	State land: Individual long-term leases. Some freehold	Cropping: Cotton, Sorghum, wheat Small-livestock holdings	Sudan: New Halfa and Gash Schemes
	Large scheme: large-scale operations	State land	Cropping: Sugar	Sudan: New Halfa Sugar Scheme
LIVESTOCK REARING	Small-scale: Extensive Pastoral Transhumant	State land: Communal use (grazing, water) rights	Cattle, small-ruminants	Sudan
	Small-scale: Extensive Agro-pastoral Transhumant-sedentary	State land: Communal use (grazing, water) rights	Cattle, small-ruminants Small-scale cropping	Sudan

2.6 LIVESTOCK REARING

The extensive livestock production systems are distinguished (i) by the inclusion or not of some rainfed or residual moisture crop production, and (ii) the preponderance of cattle or of camels. Over the past two decades many households have and are still making the transition from pastoralism to agro-pastoralism to sedentarized crop cultivation and vice versa as household and external conditions change. With the restoration of exports to Middle East livestock production makes a significant contribution to the agricultural GDP.

The mainly camel extensive livestock systems are largely in the arid and semi-arid northern parts of the sub-basin although they move their herds southwards as far as the Butana Plains.

2.7 FORESTRY AND AGRO-FORESTRY

Forestry Contribution to the Economy: In Sudan, around 80 per cent of the total energy consumption comes from wood fuel and charcoal, and an unknown quantity of charcoal is

exported from the central parts of the sub-basin to Khartoum. The situation in Ethiopia is similar to that in Sudan and around 65% of domestic energy consumption comes from using fuelwood and charcoal as fuel.

Fuel wood: The National Capital State and the Gezeira State in the sub basin are the highest fuel wood consuming areas in the Sudan, and farmers in the highland parts of the sub basin report a shortage of forest product. The existing wood supply comes from trees around homestead and farmland, natural woodland and bush lands.

Industrial wood: The basin has an acute shortage of industrial wood, which is being imported from other parts of the country. There is no industrial plantation.

Non-timber forest products: Incense, gum and honey and are the important non-timber forest produce in the sub-basin.

- Incense and gum: The Tekeze Basin in Ethiopia is one among the potential areas and has a long tradition of exploiting natural gum and incense, although the central part of the basin is virtually cleared of vegetation cover.
- Beekeeping: Apiculture or beekeeping is one of the sustainable agricultural sub-sectors which many rural farming communities practice and from which they derive food security and income. But the basin has lost most of its bee keeping potential due to natural and human factors.

2.8 MINING

In the Tekeze Sub-basin, placer gold is being recovered from numerous small panning sites. It is estimated that several hundred kilograms of gold are recovered annually using this labour intensive method. Resources of gold, which could be exploited by mechanized mining very probably, exist; exploration is needed to indicate which of the known gold occurrences could be profitably mined. Marble and limestone are being quarried from localities south of Adwa and north of Mekele. There are project proposals for exploration activities to be undertaken in the north east of the basin near Hawzen. Similar activities are currently being undertaken in the northwest prospecting area.

2.9 FISHING

In the highland areas of the Tekeze Basin, river fishery is not well developed due to the rugged landscape together with the seasonal flow of many streams, although some rivers and streams in the lowlands flow all year round. Most people living along the river courses fish at some time during the year, but the catches are small and are either consumed or sold fresh. Preservation methods used are sun drying and some times salting. Important commercial fish species in Tekeze River Basin are: Oreochromis niloticus, African catfish, Clarias gariepinus, Barbus, barbus intermedius, other Barbus species, and Bagrus docmac. Other species found in the basin presently have no economic value. The fish catch in the lowlands is higher than in the highlands, but is still insignificant due to the primitive nature of the fishing gear.

2.10 TOURISM

The main international tourist attraction in Ethiopia is in the Tekeze sub basin, including Lake Tana and Gonder (Just outside the basin), Lalibela, Mekele and Axum, and the Simian Mountain National Park.

2.11 POVERTY PROFILE

Research in Ethiopia suggest that the incidence of destitution has dramatically increased in Wollo in the 1990s, while the number of households who were 'doing well' has decreased on the contrary. The people living in the area are identified as those who often suffer from sever food insecurity as ecological vulnerability continues to depress crop and livestock production. Available data show that there is a strong link between poverty and gender and age. Further, these households are held to be poor mainly due to insufficient labour to engage in productive activities. Poverty is also indicated by malnutrition-linked deformity in children and the fact that 30% of households in Tigray are dependent on food aid.

Poverty lines: The basis for determining the poverty lines in Ethiopia and Sudan are different and thus can not be compared with each other. The poverty line in Sudan is US$1 per capita per day, while in Ethiopia it is based on a basket of food and essential non-food goods worth EBirr 1,070 per capita per year (approximately US$ 0.34 per capita per day) in 1995/96 prices.

Poverty estimates: In Sudan, poverty rates are estimated to be 40 – 70% in general. Interestingly, The Red Sea State has the highest rates of poverty and lowest rates of facility provision; Nahr el-Neil State has the lowest poverty rates and highest rates of facility provision; and Gaderef and Kassala States in–between. The poverty rates in Tigray are much higher than in Amhara.

3. NATURAL RESOURCES AND ENVIRONMENTAL ISSUES

3.1 GEOLOGY

The geology of Tekeze-Atbara Sub-basin can be summarized as follows: the southern portion is composed of basic to ultrabasic rocks, mainly basalts, while the northern portion is composed of various layers of sedimentary rocks (including sandstones, shales and limestones), as well as metamorphic rocks, such as gneisses and marble. The lowlands include older Basement Complex rocks, the Nubian Sandstones, Tertiary unconsolidated sediments and Recent superficial wind blown sands. The Nubian Sandstones are located in the northwest corner and uncomfortably overlie the Basement Complex rocks and comprise mainly sandstones, siltstones and conglomerates. Given the incised nature of the Tekeze drainage network in the highlands of Ethiopia, the sedimentary and metamorphic rocks are often exposed below the basalts.

3.2 SOILS

Leptosols (28% of the area) are developed cover most of the Ethiopian highlands whilst Luvisols (26% of the area) are found on the shallower footslopes of the Highlands and the flat slopes of the lower Atbara valley towards the Main Nile. Cambisols are ranked third in terms of area (17%) and are mainly found in the middle Atbara valley with isolated pockets in the Ethiopian Highlands. Vertisols are found on the flat interfluves between the Setit and Atbara Rivers in Sudan. These are black heavy cracking clays. Fluvisols are found along the floodplains of the Atbara River. Arenosols with derived from on cover sands are found in the lower parts of the Atbara Valley together with shallow Regosols.

3.3 LAND USE LAND COVER

Cultivated lands are well distributed over the upstream region of Tekeze-Atbara Sub-basin. A higher percentage is observed in the north and the high plateau that reaches to Lake Tana. Woodlands are mainly located in the south-west part of the lowlands.

The northern region is generally characterized by desert or semi-desert conditions, with little or no vegetation except along wadis with a high water table. Between the 75 and about 250 mm isohyets semi-desert scrub is the most prevalent vegetation type, while south-eastwards, from the 250 mm to the 360 mm isohyet, the vegetation is semi-desert grassland. Much of this vegetation is now covered by the Gezira and Managil Irrigation Schemes. Between the 360 mm and 570 mm isohyets on the heavy clays grassland merges into *A. mellifera* thornland. Above 570 mm to the border with Ethiopia there is increasing dominance by *A. seyal* in association with *Balanites aegyptiaca*. *A. senegal* is retained for gum arabic harvesting whilst *A. seyal* is used for charcoal production. *B. aegyptiaca* becomes increasing prevalent because it is fire resistant. The lowlands located in Ethiopia are mainly covered by shrublands, as are the dissected highlands around the upper head of Tekeze River in the south-east. Grasses are mainly annuals in Sudan as heavy grazing and low rainfall ensures that there is insufficient dry matter for annual fires. Barelands (rock and bare soil) are scattered in the highlands, with a higher concentration within the gorge of Tekeze River, as well as within the central mountainous ridge. Forests and afro-alpine vegetation represent less than 1 % of Tekeze Basin.Below the Kashm el Girba dam is the New Halfa irrigation scheme totalling some 190,000 ha (447,000 feddans). Above the dam are extensive areas of semi-mechanized farms.

3.4 VEGETATION

Woodlands: Woodlands characterize the dominant vegetation cover of the basin and bush lands which occur mainly in the agro-pastoral zones along the northern and western part of the upper course of the sub basin. They have been heavily used as a source of gum and

incense and as sources of fuel wood and fodder for livestock. In the Atbara-Setit Sub-basin in the Sudan, the woodland savannah on the dark cracking clay alternating with grass areas subdivision is mostly under cultivation.

Grassland: In the same sub basin, the semi-desert grassland on clay is the Butana plain, but it is currently threatened by over grazing as large numbers of livestock visit the area during the rainy season. Fire is also a continuous hazard. The northern and central parts of the Butana plain lie in the semi-desert belt and are subject to droughts because of the scanty and erratic rainfall.

Wet Lands: The sub-basin has no significant wetland in its system.

3.5 WILD LIFE

Among the numerous wildlife in the upper part of the Eastern Nile Sub-basin, the Walia Ibex, "Key Kebero" (Ethiopian wolf), and the Gelada Baboon, Menelik's Bush Buck and the Mountain Nyala, are the major ones in the Simien National Park of Ethiopia, in the upper course of the Tekeze-Setite-Atbara Sub-basin. But increased population pressure and an resultant increase in demand for agricultural land, grazing areas and hunting areas, as well as clearing for road construction and irrigation encroach and destroy wildlife habitats. The Walia Ibex that is endemic to Ethiopia is an endangered species, with very few numbers available in the park.

3.6 LIVESTOCK

The Tekeze River Basin cattle are predominantly of zebu type. Five breeds have been identified: Barka (locally called Begait); Arado; Fogera; The Raya-Azebo (locally called Harmo); and Abyssinian short horned zebu. There are also cross-breeds of Holstein-Friesian and locals used for milk production in urban areas. Cattle densities of cattle are high in the Ethiopian Highlands and low in the Lowlands. In Sudan densities are relatively high along the upper Gash and Atbara as far as the New Halfa and Gash irrigation Schemes, where many irrigating households have substantial livestock holdings. Densities are also relatively higher in the northwest in the Butana Plains. Sheep are well distributed across the whole Sub-basin, and are well represented even in the north where cattle and goats are absent. Overall densities of sheep are nearly everywhere higher than goats. In Sudan they are the preferred animal for export to the Middle Eastern countries.

3.7 MAJOR ENVIRONMENTAL ISSUES

Water Quality: Except for its high sediment load, water quality, especially away from urban centres is suitable for most uses. Mekelle already has a water quality problem due to the chemical composition of the aquifer rocks, while Lalibela has severe water shortage with daily water cuts.

Industrial and agricultural input 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.

Soil Erosion & Land Degradation: 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 human and natural factors.

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. In the Tekeze Basin, food production, livestock feed and fuel requirements put competing demands on scarce and vegetation resources. 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. The Tekeze Basin has been a process of gradual degradation of land and vegetation under population pressure and inadequate management of natural resources.

Sheet, rill and gully erosion: This is the most intensive and widespread form of land degradation and also recognized as one of 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 within the watershed depletes riverine forest and bushes that protect the river banks and thus enhances stream bank erosion in the watershed.

Pests and Weeds: Regular crop yield loss caused by various pests such as weeds, diseases, insects, rodents and birds are common, as farmers do not use herbicides and 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.

4. HYDROLOGY AND WATER INFRASTRUCTURE

4.1 SURFACE HYDROLOGY

River System: The Tekeze-Setite-Atbara Sub-basin has three major rivers originating from the central north and north western highland plateaus of Ethiopia: (1) the river called Tekeze in Ethiopia and Setite in Sudan, (2) the river Angereb, and (3) the river called Goang in Ethiopia and Atbara in Sudan. From its source, a spring near Lake Ashange around Lalibela in North Wollo region in Ethiopia, the Tekeze River traverses a distance of about 750 km to the Ethio-Sudan border. In Sudan the river extends another 575 kilometres in a north-westerly direction. The sub basin contributes an estimated 6.5% of the Nile River flow and the chemical quality of surface water is excellent, both for drinking and irrigation. The major tributaries of Tekeze that originates from the north-western highlands of Ethiopia are the Zarima, Tserare, Gheba, Wori and Mena. In the highland portions of the watershed, the river bed slope is higher (>1.5%), which gradually decreases to 0.3% in the lowlands of Ethiopia and further reduces to less than 0.1% in the Sudan lowlands.

Angereb River starts in the Wegera (north Gondar) highland plateau that rises at an altitude of above 2,500 masl as part of the north-western highlands of Ethiopia and flows down to 700 masl at the Ethio-Sudan border, which further descends down to less than 500 masl at its 162 mouth in the Sudan. At the Ethio-Sudan border it covers an area of 13,300 square kilometres. It starts in the Wegera highland plateau in North Gonder that lies at an altitude of above 2,500 masl and traverses to the west for 220 km at the border at an altitude of about 500 masl. The river bed runs at an average slope of 1.3%. The Kaza River is the major tributary joining Angereb close to the border. The watershed area of Goang River at the border is reported to be 6,700 square kilometres. It starts in the north-western highland plateaus of Ethiopia near Chilga that rises at an altitude of above 2000 masl and flows to the west for about 130 km at the border. In the Sudan it is named as Atbara.

Watershed physiology: The Tekeze-Setite watershed starts in the central north highland plateaus of Ethiopia at an altitude of above 3,000 masl and descending down to Humera less than an altitude of 800 masl at the Ethio-Sudan border, which also goes down to less than 500 masl at its mouth in the Sudan. At Ethio-Sudan border, this watershed covers an area of 63,375 square kilometres of which 4,214 square kilometres are in Eritrea. The Tekeze River has the Ras Dashen mountain chain (4,620 masl) in its watershed. About 70% of the area in Ethiopia lies in the highland (above 1,500 masl) and some 40% of its watershed is reported to have an altitude of above 2,000 masl. The lowland (30% of the watershed) is flat in slope with uniform topography, and the highlands are vested with undulating, irregular and none uniform topography.

Catchments: 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 sub-basin can be sub-divided into nine 3^{rd} order and 69 6^{th} order watersheds using the Pfafstetter system based on the topology of the drainage network and the drainage area.

4.2 RUNOFF

Tekeze at Embamadre: This watershed covers the highland portion of the Tekeze Watershed (70%) at Humera/border. The mean annual flow at this node averages 5.40 bm^3, and accounts for 45% of the sub-basin flow at Atbara. Hydrologic variability for the

wet period is 50% and for the dry period it exceeds 100%, while it is 36% for the annual series (Figure 4.1). This highly pronounced hydrologic variability (compared to the Blue Nile sub-basin) has a considerable impact on water investment downstream. Also, rainfall variability in this area of the sub-basin is quite high with the annual series being greater than 35% and being more than 70% in the sowing season.

Tekeze at Humera, Setit & Khasm-el-Girba Stations: The mean annual flow for eleven years averages 5.12 bm^3, at 28% hydrologic variability of the annual series. Hydrologic variability for seasonal flow is considerably high, averaging 66% in the wet season (June-September) and more than 100% in the dry season.

Tekeze/Atbara at Atbara: At Atbara the main Nile meets the Tekeze-Setite-Atbara coming from the northern Ethiopian highlands. Long-term mean annual flow (1903-1982) at Atbara averages 11.66 bm^3 (or 12 bm^3 as in most reports) while the annual series averages 32%. Seasonal hydrologic variability is 43% in the wet season (July-Oct) and more than 100% in the dry period.

4.3 INDICATIVE WATER BALANCE OF THE TEKEZE-SETIT-ATBARA SUB-BASIN

Mean annual inflows: The main stem of the sub-basin at El-Girba station (about 15,6000 square kilometres) is has a mean annual inflow of 11.45 bcm (1980-2000). Mean annual inflow at Atbara is estimated at 11.66 bcm (1903-82, Said 1993) considering the periods from 1912 to 82, mean annual inflow at Atbara is estimated at 10.6 bcm. Shahin (1985) using the period from 1912 to 1973 has estimated the inflow to be 12 bcm.

Evaporation losses and abstraction: Mean annual reservoir evaporation is estimated at 0.202 bcm and abstraction at 1.765 bcm. There is no abstraction from the upstream reaches in the Ethiopian part of the sub-basin as there is no irrigated agriculture.

4.4 GROUNDWATER

Groundwater depth: Given the extreme dissection of the terrain in the highlands, groundwater resources are shallow and confined to fractured basement complex rocks, sandstones and basalts. Groundwater depth varies directly in accordance with landscape units, rainfall regions, seasons and geological basement. In general, the groundwater water table is located between 2 and 6 meters in valley bottoms, along main streams. This depth rapidly increases as landscape becomes mountainous or in the northern region, when rainfall conditions are more arid. The most common depth in the north eastern part of the basins is about 12 meters, while water depths in the plateau plains from Adwa to Endaslasie to Gondar are at about 4 meters.

Storage capacity: Water yields in these basins range from 0.1 to 10 l/s, with mean values of about 2.6 l/s. Extensive good aquifers do not exist in the basins of the Tekeze, Angereb and Goang Rivers and exploitable groundwater is limited to isolated areas of faulted and fractured zones in the rocks and weathered rocks.

Water Point Inventory: An extensive Water Point Inventory (WPI) has been carried out in the basin, during which discharge –draw down data have been collected. Based on of this inventory, it can be stated that the basin has aquifers/formations with very low productivities except high and medium productive areas concentrated around Mekele and Hagere Selam (Agula Shale, Antalo Limestone and Tertiary Dolerite formation).

Ground water quality: The quality of ground water is usually better than surface water. Exceptions are the limestones near Mekele, which have a well-developed system of fissures (dissolved pathways). The quality of this water is not very good.

4.5 WATER INFRASTRUCTURE

Existing Dams and Reservoirs: The Khasm-el-Girba located downstream of the Angereb-Goang-Tekeze confluence in Sudan is the only existing reservoir in the Tekeze-Setite-Atbara system. The dam was built in 1966 in the Atbara main stem at initial storage capacity of 1,300 mcm, and meant for irrigation and hydropower purposes. The New Halfa scheme (146,138 ha) and New Halfa sugar scheme (22,569 ha) are the two large scale irrigation projects in the sub-basin both fed from the El-Girba reservoir in Sudan. Current irrigation practice in the upstream reach of the system is almost non-existent.

Identified Potential Water Resources Infrastructure: The upper course of the TSA sub-basin has considerable hydropower potential, as rivers are quite steep and some have deep gorges, which make ideal dam sites. Eleven hydropower sites have been identified, located in the main stem (eight) and three major tributaries , namely Tserare, Angereb and Goang Sub-watersheds. Out of these identified projects three dams, TK-04A, TK-04B and TK-05 (under construction currently) are designed for installed capacities of 168 MW, 85 MW and 203 MW respectively. TK-05 is to be commissioned by 2009. In addition, three large-scale irrigation, three projects have been proposed: (1) Humera, with a gross (net) irrigable area of 50,500 (42,965) ha; (2) Angereb, with a gross (net) irrigable area of 13,592 (11,561) ha and (3) Metema, with a gross (net) irrigable area of 19,276 (16,385) ha

4.6 HYDROPOWER GENERATION AND TRANSMISSION

Installed capacity: Currently only Girba Dam in Sudan has hydropower plant in the system with installed capacity of 12.5 MW. There is no hydropower plant in the upper course.

SUMMARY: BARO-AKOBO-SOBAT SUB-BASIN

THIS SUMMARY contains information on the Baro-Akobo-Sobat-White Nile Sub basin and is part of the summary report of the One System Inventory prepared by ENTRO.

Figure 1.1: Baro-Sobat-White Nile sub-basin: Location Map

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

1. GENERAL

1.1 LOCATION OF THE SUB-BASIN

The Baro-Akobo-Sobat-White Nile (BASWN) Sub-basin is one of the four major sub-basins in the Eastern Nile Basin, and is located in the southernmost portion of the Eastern Nile Basin (see Figure 1.1). Geographically, the sub-basin extends from 150 47' 40" to the north down to 30 25' 52" in the south, and from 290 24' 43" to the west up to 360 18' 27" to the east and covers some 468,215 km^2.

Most of the sub-basin area (84%) is in Sudan and only a small proportion (16%) is in Ethiopia. The sub-basin area in the Sudan is spread across ten states while that in Ethiopia cuts across four regional states.

1.2 TOPOGRAPHY

Altitude: The Ethiopian part of the sub-basin comprises high plateaux elevations ranging from 1500 to 2000 m and mountains with peaks exceeding 2,500 meters The elevation decreases towards the Sudan reaching as low as 250m. The upper course of the sub basin (largely the watershed east of the Ethio-Sudan border) ranges from above 3,000 masl (south western highland plateaus of Ethiopia around Bedele & Jimma) to below 500 masl as it descends down to the Gambella low-land flood plain. Upstream of the Gambella town, the highland plateau first drops in to an altitude of 1,000 masl where hilly and steeply dissected land topography starts dominating which separates the south-western highland plateaus of Ethiopia with the Gambella low-lying flood plain. In the further west direction towards the border the elevation drops to below 600 masl and in between the rivers in the watershed entered in to a vast low-lying savannah area. Approaching the border between Ethippia and Sudan the elevation of the watershed drops to below 500 masl, where the rivers in the watershed cross flat seasonally flooded area. At Khartoum, the mouth of the sub basin, altitude drops to below 400 masl.

Slope: More than 88% of the sub basin has a slope of less than 5% comprising the low-lying area of the Gambella flood plain in Ethiopia, the Machar flood plain, the low-lying seasonally flood plains at the mouth of the Gillo, Akobo and Pibor watersheds including the major portion of the Sobat and White Nile watersheds in the further downstream reaches of the sub basin. About 6% of the sub basin has a gentle slope of 5 - 10%, while less than 2% of the area (in the highlands) has a land slope of more than 20%.

Land forms: Plain areas with land slope of less than 3% covers nearly 60% of the sub basin. Dunes (8%) and Hills & major Scarps (about 6%) are the next major land forms in the sub basin. The flood plains and Piedmont Plains cover 5.2% and 4% respectively. Mountains and major scarps largely located in the eastern portion of the sub basin covers only 2.4%. Other land forms in the sub basin include plateaus, valleys, Deltas, dunes, water bodies and etc.

Relief: In Ethiopia the Baro-Akobo Sub-basin can be divided into two major landscape units of roughly equal size, the western lowlands and the eastern highlands, separated by an escarpment and areas of severely dissected highlands. The Gambela catchments in the Ethiopian portion gently slope to almost flat plains that continue into the Sudan crossing the border. The plains are abruptly terminated in the east by a well defined, north-south escarpment. North of the salient the foot of the escarpment is less precise and forms a belt of lower altitude broken highlands in BeneShangul-Gumuz Revenue State. A similar area of broken highland terrain is found in the western part of SNNPR around Mizan Teferi

and reaching out to Gurafarda, a highland outlier. Steep slopes clearly mirror the high relief, with the escarpment at the edge of the Ethiopian Highlands, the Imatong Mountains and associated hills and the Nuba Hills standing out. Less clear are the steep slopes of the hills on the Boma Plateau.

The main relief features in the south of the Pibor-Sobat Sub-basin are a series of steep hills and mountains of basement complex rocks stretching north-eastwards along the Sudan-Uganda-Kenya border reaching up to 3,187 masl on Mount Kinyeti in the Imatong Mountains.

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

1.3 CLIMATE

General: The Baro, Gillo and large part of the Akobo watershed areas, located in the south-western highland plateaus of Ethiopia, have a dominantly tropical climate with distinct dry winter. The mean temperature of the coldest month is >18oC and the mean annual rainfall in the range of 680-1200 mm and the dry months are in winter. Some portion of this area (some 10%) is identified to have tropical monsoon rainy climate with short dry season and some other parts (>5%) are identified to have warm temperate rainy climate with distinct dry season. The Pibor watershed starts in semi-arid south-eastern area of the Sudan land characterized with dry tropical type of climate. Alike the Sobat area, the WN watershed of the BASWN sub basin is also characterized with arid type of tropical climate.

The entire sub basin has distinct dry and wet seasons. In the summer, warm moist winds cover the entire sub basin, bringing the wet season to the entire upper course of the sub basin from April/May to October/November. The Baro and Gillo watersheds have relatively high moisture and longer wet periods. In the downstream reaches of these watersheds, moisture is scarce with relatively shorter wet periods, with arid tropical climate dominating towards its mouth around Khartoum.

Rainfall: The sub-basin is in a particularly well-watered region of Ethiopia, but there is considerable spatial variation of the mean annual rainfall due to the great range of difference in elevation across the basin. Average annual precipitation is as low as 600 mm in the lowlands (less than 500 masl), while it reaches as high as 3,000 mm over the highlands (over 2,000 masl). High altitude regions in the Baro and Gillo watersheds are characterized with relatively high moisture and longer wet periods. The rainy period is generally from May to October when 85% of the annual precipitation occurs with a single peak in July. Average rainfall is greater than 200 mm in June, July, August and September. On average, November, December, January and February are dry months.

Within Sudan the highest rainfall is found in the southwest and southeast of the Sub-basin where the mean annual rainfall exceeds 1,000 mm/yr. Over much of the Pibor-Sobat Sub-basin it varies between 750 and 1,000 mm/year. In the White Nile Sub-basin rainfall decreases northwards from 750 to 250 mm near the junction of the White and Blue Niles.

Rainfall exhibits both seasonal and year-on-year variability. Variability increases form south to north.

Temperature: The temperature range in the Baro–Akobo basin is from about 27.5°C below 500 meters elevation on the flood plain to about 17.5°C at 2,500 meters in the highlands. Temperature is maximum in April and minimum in December. Maximum temperatures in the highlands rarely exceed 25°C, whereas in the lowlands they generally exceed 36°C

during the hotter months of January to April. In the Pibor watershed it ranges from 24.5oC to 26.5oC. In the Sobat and Malakal areas where altitude is below 500 masl, temperature ranges from 26.5oC, reaching to a range of 30.5oC at the mouth of the sub basin around Khartoum. In the White Nile valley temperatures are generally 25-27°C along the river but decrease with altitude in the Nuba mountains and towards the Ethiopian highlands.

Evaporation: Mean annual evaporation within the BASWN sub-basin varies from below 1000 mm in the highland plateaus of Ethiopia, to 6815 mm at Khartoum. Evaporation in the upper course of the Baro-Gillo watersheds ranges from 783 mm to 1200 mm. In the low-lying areas (<1000 masl) mean annual evaporation is in the range of 1200 mm to 2000 mm. In the upper course of Pibor and Akobo rivers (low lying areas in the land of Sudan) it ranges from 2000 mm to 3200 mm. At Khartoum, the mouth of White Nile, it ranges from 6500 mm to 7500 mm.

1.4 HUMIDITY

About 50% of the area has a mean annual relative humidity exceeding 55%. Nearly 35% of the sub basin has a mean annual relative humidity ranging from 40% to 55%, while less than 20% of the sub basin has a relative humidity of less than 40%.

2. SOCIO-ECONOMIC CHARACTERISTICS

2.1 DEMOGRAPHIC CHARACTERISTICS

Population: The Baro-Akobo-Sobat-White Nile basin has an estimated population of 12.4 million (7.3 in Ethiopia and 5.11 in Sudan).

Population density: Population density in the BASWM sub-basin varies from 3 persons per km^2 in the Gambella region to 127 per km^2 in the SNNPRS region in Ethiopia, and from 974 persons per km^2 in Khartoum state to only 5 persons per km^2 in Jongli state. The central part of the Ethiopian plateau has the highest density exceeding 122 people per km^2 in some parts. The densities in the deep valleys and the escarpment are very low. In Sudan the highest population densities are in Khartoum, El Gezira, White Nile States and along the main roads in Senner and North Kordofan States. Areas of medium population density include the Nuba Mountains in South Kordofan State, along the White Nile and along the Khor Machar in Upper Nile State, and along the main road from Kenya to Juba in the southern part of East Equatoria State. Elsewhere population densities are very low.

Population growth: This population is expected to grow in the immediate future but is likely to experience a gradual slow down, mainly on the Ethiopian side of the basin, by the year 2015. The urban population growth rates are substantially larger than rural rates in all states, but those in Sudan are generally higher than in Ethiopia.

Birth and death rates: The crude birth rates are around three times the crude death rates in all the states of the sub-basin, and are fairly similar across the states of Sudan and Ethiopia with the exception of Gambella, which has the lowest crude birth rates.

Rural-urban divide: The overwhelming majority of the population is rural, 90.6 % of the population in Ethiopia and 79.1 % in Sudan.

Sex ratios: There is a striking excess of males over females in Khartoum, Equatoria and Blue Nile in the Sudan, while there is an excess of females over males in North and South Kordofan and the White Nile states in North Sudan.

Population age group: Around 40-45% of the population in all the states in the sub-basin is below the age of 15, while only a small proportion of around 4-5% are above 60. The proportion of elderly (above 60) is strikingly low in South Sudan (2.9% for the state) and in Gambella state.

Infant Mortality: Infant mortality rates are higher on the Sudanese side than on the Ethiopian side in general, while the rate in the South and North Sudan states are considerably higher than the rates in both the Beni-Shangul-Gumuze and SNPP regions. There are, however, regional variations.

Life Expectancy at Birth: Average life expectancy for the basin population ranges from 46 to 55 years for both males and females.

Ethnic groups: Within the Sudan a substantial proportion of the population in the Blue Nile Sub-basin live and work on the large irrigation schemes and semi-mechanized farms or in service and processing industries related to these developments. Many in the past followed pastoralist and agro-pastoralist livelihoods, but who for one reason or another lost their livestock and became sedentary. Within Ethiopia, the Amhara are predominant in the Amhara region, as the Oromo are in the Oromiya region. In the Beni-Shangul-Gumuz region, however, the Jebelaw, Koma, Mao and Gumuz together make up over half the population.

2.2 SOCIAL INFRASTRUCTURE

Literacy and education: In the Ethiopian side of the basin, more than half of the primary school age population (7 to 12 years) do not attend school[3] while secondary school enrolment[4] level is even lower Over three-fourth of the population eligible for secondary education do not enrol, and are engaged in other livelihood activities instead, partly due to poverty, which prevents parents from sending their children to school. Interestingly in Ethiopia the highest rates of enrolment are in relative remote Beneshangul-Gumuz Regional State. In Sudan high enrolment rates are clearly related to the high rates of urbanization in Khartoum and El Gezira States.

Water Supply: There is a wide variation in the nature of access to drinking water within the sub-basin. Urban Khartoum has the largest proportion of population using piped water, followed by El Gezira, Sinnar and the White Nile. This proportion is lowest in South Kordofan and the four Ethiopian states where the proportion of population using taps ranges from 28% (Beni-Shangul-Gumuze) to 19% (SNNP). The proportion of population using rivers, lakes and ponds is also highest in the Ethiopian states.

Sanitation: The majority of states in Sudan reported around 40-45% of population without access to sanitation facilities, while the proportion was higher in North Kordofan, Beni-Shangul-Gumuze and Gambela. In Ethiopia, only 7% of the population is estimated to have access to sanitary latrines is estimated to be 7% of the population.

Health: There are few health centers and hospitals in the Baro-Akobo Basin: with only 2 hospitals and 11 health centers in Beni-Shangul-Gumuze region for a population size of 424,432. There are no data for Sudan.

2.3 TRANSPORT AND COMMUNICATIONS

Roads: There are no major road linkages between Ethiopia and Sudan within the BASWN sub-basin. A dry weather track crosses the border at one point, Kurmuk, and there are two secondary roads: one in Sudan from Malakal and one in Ethiopia from Gambela town come very close and may meet at Jikauo on the north bank of the Baro River, which at this point forms the border. Secondary roads in Ethiopia touch or come very close to the border at Akobo and Dioma. More than half of the sub-basin population does not have access to all-weather roads. This is especially true of Gambela region which is remote and isolated as most of the river and its tributaries flow through here. The absence/lack of all-weather roads is a major obstacle to efforts to promote basin-based development such as fishing and irrigation.

Railways: There is only one railway from Sennar to El Obeid.

River Transport: In Sudan, river transport between Kosti-Alkali-Juba is now functioning and the number of barges increasing.

Air transport: Within Ethiopia, there are six operational airports in the Baro-Akobo basin connected to Addis Ababa by schedule air services. Gambela is the largest and the only

[3]The net enrolment rate in primary education is defined as the number of pupils of primary school (age 7-12 years) who are currently attending primary school divided by the total number of children in the age group 7-12 years

[4]The net enrolment ratio at secondary school level is defined as the proportion of children aged 13-18 years and is attending secondary school (grade7-12) divided by the total number of children in age group13-18 years

airport with paved runway and navigation aids. It handles about 5,000 passengers (arrivals and departures) per year, while the other five handle 15,000 between them.

2.4 ECONOMIC ACTIVITIES

Activity rates: Activity rate is defined as the proportion of the total economically active (employed plus unemployed) population to the total working age population. In Ethiopia, the sub-basin states have the following activity rates: SNNPRS (77%), Oromiyo (70%), Beni-shangul-Gumuze (70%), and Gambella (63%).

Unemployment: Data on unemployment rates is not available for the Sudan and only available for the four states in the Ethiopian side of the sub-basin, which range from 5–6% in Oromiya, Beni-Shangul-Gumuze and SNNPRS to 12.5% in Gambella.

Cultivation: Rain fed crop cultivation is the principal activity in most of the basin where adequate rainfall is available. The economy is largely subsistence, largely based on traditional methods of plough cultivation and supplemented by the hoe in the lowlands, and based on growing crops (e.g. maize & sorghum) for local consumption. The lowland population practices some kind of shifting cultivation (for sorghum). In semi-arid to arid conditions, pastoral livestock becomes predominant, e.g., in the Sudanese side of the basin where there is a high concentration of cattle, sheep, and goats. Farm employment (combining crop and livestock production) constitutes the primary source of occupation for the population. The communities in the basin seem to have very limited experience in accessing cash income because of the remoteness and inaccessibility of the sub basin region from regional market centres.

Farm employment: Farm employment (combining crop and livestock production) constitutes the primary source of occupation for the population.

Irrigated agriculture: There is very little irrigated agriculture (except some traditional methods of water diversion).

Fishing: Fishing is indispensable to the economy of the Baro-Akobo River, on the Ethiopian side. There is a rich diversity of fish fauna in these rivers, and so far 106 distinct types of species have been identified. During the wet season, flooding creates a large area perennial and temporary water bodies and swamps, where intensive fishing is done in the dry season. Currently, however, fishing in the sub-basin is mainly for subsistence.

2.5 AGRICULTURE AND PEOPLE

Major ethnic groups and their livelihoods: There are a number of groups of people who retain their original way of life, although now somewhat altered. These 10 major ethnic groups are (1) the Rufa'a al-Hoi, an Arab speaking Muslim nomadic peoples with sheep, cattle and camels; (2) the Fulani, a mixture of many ethnic groups from West Africa who have long horned cattle that are fast walkers but poor milkers; (3) the Nuba, who live in the Nuba Mountains but who also cultivate crops on the plains and also also raise animals, hunt and forage; (4) the Baggara, an Arab speaking pastoral people, from the west of the White Nile in and below the Nuba Mountains, who use the mountains, the clay plains west of the White Nile and cross over in the dry season and also graze to the north of the Machar Swamps; (5) the Nilotes people, who are a group of Nilotes peoples from further south, some of whom (the Nuer, Dinka and Murle) are agro-pastoralists whilst others (the Shilluk and Anuak) are mainly sedentary cultivators; (6) The Dinka who occupy the area just to the east of the White Nile within the Sobat-White Nile sub-basin and comprise four "tribes" (the Ngok, the Dunjol, the Paloich and the Abialongto); (7) the Shilluk, sedentary

cultivators (of sorghum, maize, groundnuts, beans and tobacco) and fishermen, who occupy a narrow strip along the banks of the White Nile between the Sobat-White Nile confluence northwards to Kodok; (8) the Anuak, who are also cultivators (of sorghum and maize) and fishermen, but have no cattle or small stock, and found in Ethiopia and just to the south of the Gambella salient; (9) the Murle, who are divided into two groups (the plains Murle (Lotilla) who are essentially agro-pastoralists, and the Hills Murle (Ngalan) who occupy the Boma Plateau and are essentially agriculturalists with some cattle; and (10) the Toposa, who live in Kapoeta Locality of Eastern Equatoria, and are mainly pastoralists keeping cattle, camels, goats and sheep, but also cultivate some maize and sorghum.

Main Agricultural Land Use Systems: The main agricultural land use systems in the Baro-Akobo-Sobat-White Nile Sub-basin in Sudan and Ethiopia are relatively distinct except along the international border where the cultural affinities have given rise to very similar systems. Nevertheless, three broad systems can be identified: (i) rainfed cropping, (ii) irrigated cropping and (iii) extensive livestock production (with minor cropping). Differences in the scale of operations, tenure type and to a lesser extent cropping patterns give rise to a number of recognizable sub-categories (Table 2.1).

In both the highland and lowland systems use of improved inputs (chemical fertilizer and seeds) is low. Conversely, the large-scale semi-mechanized systems are under state lease-hold tenure (25 years leases) and a number of cultural operations (ploughing, harrowing and seeding) are mechanized. Nevertheless, the use of improved inputs (fertilizer, seed) is minimal.

Table 2.1: Main Agricultural Systems in the Baro-Akobo-Sobat-White Nile Sub-basin

Main Category	Scale of operations	Tenure type	Main Components	Location
RAINFED CROPPING	Small-scale traditional; sedentary	State land: Individual and Communal use rights	Cropping (Cereals, pulses, oil seeds) Cropping (Enset, roots, cereals, pulses) Small Livestock holdings (Communal grazing, crop residues)	Ethiopia: Highlands
	Small-scale traditional; shifting	State land: Individual and Communal use rights	Cropping (cereals, pulses): No livestock holdings (Tsetse infestation)	Ethiopia & Sudan: Lowlands
	Small-scale: traditional: flood retreat	State land: Individual and Communal use rights	Cropping (cereals, pulses) Small Livestock holdings (Communal grazing	Ethiopia & Sudan: (Anuak, Shilluk)
	Large-scale: Semi-mechanized	State land: Medium-term Leases	Cropping (Sorghum, cotton, sesame)	Sudan: Lowlands
IRRIGATED CROPPING	Small schemes in valley bottoms: Small-scale operations (< 1.0 ha) Gravity: Controlled	State Land: Individual use rights: additional to rainfed land	Cropping (cereals, vegetables)	Ethiopian Highlands

Main Category	Scale of operations	Tenure type	Main Components	Location
	water-tables			
	Small-scale:(<20 ha) Pump	Individual Freehold State land: Lease	Cropping: Sorghum, wheat, Alfalfa	White Nile
	Large scheme: small-scale operations (<40 feddans) Gravity	State land: Individual long-term leases	Cropping: Cotton, Sorghum, wheat Small-livestock holdings	Sudan: Gezira and Rahad Schemes
	Large scheme: large-scale operations	State land: Long lease	Cropping: Sugar	Sudan: Kenana Schemes
LIVESTOCK	Small-scale: Extensive Pastoral Transhumant	Communal use (grazing, water) rights	Cattle, small-ruminants	Sudan (Toposa)
	Small-scale: Extensive Agro-pastoral Transhumant-sedentary	State land: Communal use (grazing, water) rights	Cattle, small-ruminants Small-scale cropping	Sudan (Nuer, Shilluk, Murle)

2.6 FORESTRY AND AGRO-FORESTRY

Forestry Contribution to the Economy: In Sudan, around 80 per cent of the total energy consumption comes from wood fuel and charcoal, and an unknown quantity of charcoal is exported from the central parts of the sub-basin to Khartoum. The situation in Ethiopia is similar to that in Sudan and around 65% of domestic energy consumption comes from using fuelwood and charcoal as fuel.

Non-timber forest products: In Sudan woodlands provide all building materials in rural areas, a third of the livestock feed (browse), a number of non-timber forest products (the most important of which is Gum Arabic), and a number of services which have no direct monetary values such as environmental protection, increase in crop production, conservation of soil fertility, biodiversity, protection of cultural heritage, forming habitat for wildlife and eco-tourism attraction.

In Ethiopia, agro-forestry takes the form of coffee growing under shade, some on-farm Eucalyptus planting (in the Kaficho-Shakiso Zone) while considerable numbers of indigenous trees remain in and around cropland in other Highland areas. Browse is of little importance in the Ethiopian Highland livestock systems. The official figures for timber production do not include timber and poles produced and used outside the official marketing structures, in particular, for domestic use in rural areas.

2.7 FISHING

Fishing occurs on the Baro, Sor, Weber, Yobi, Dibo and Uka rivers, and many of the floodplain lakes, but is purely on a subsistence basis using traditional methods. Virtually, every family that lives near water fishes to supplement its diet. Active fishing is carried out by men using spears, or modifications thereof, cones, various hook and line devices, traps made of reed, etc. In addition to subsistence fishermen, there are three fishing co-operatives.

Around 75 fish species have been identified in the lower Baro-Akobo basin and Nile perch (Lates niloticus) Nile tilapia (Oreochromis niloticus), Catsish (Clarias sp), Bargrus, barbus and Labeo species were important both in ecological and commercial terms. But no formal

studies have been carried out in the upper basin region, where there is little fishing. 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 size, 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.

There have been some attempts to increase fish production by the fisheries department of the Ministry of Agriculture, which 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.

2.8 POVERTY PROFILE

Studies undertaken in the western part of the basin have shown that there is a wide spread poverty and vulnerability situation. For example, the Gumuz, one of the groups inhabiting the basin, are very poor, living a "hand to mouth" existence, and are "below the threshold" of peasants' subsistence economy (Fekadu, 1988). In describing this widespread nature of poverty distribution, Dessalegn (1988) used an expression that "If there is equality in Begga [Gumuz] society, it is equality in destitution. The poverty situation may be worse among agro-pastoral communities of the basin whose livelihood depends on raising cattle and small-scale farming. Overall, there is a paucity of socio-economic data on the welfare and poverty of the local population in the sub-basin.

One indicator of the poverty situation of the basin population is the level of food aid dependency in the region. Estimates suggest 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.

Poverty lines: The basis for determining the poverty lines in Ethiopia and Sudan are different and thus can not be compared with each other. The poverty line in Sudan is US$1 per capita per day, while in Ethiopia it is based on a basket of food and essential non-food goods worth EBirr 1,070 per capita per year (approximately US$ 0.34 per capita per day) in 1995/96 prices.

Estimates of poverty: The scale of poverty ranges from 70% to 20% in the sub basin. High poverty rates are most prevalent in Southern Sudan and North Kordufan State. In the North Kordufan state it ranges from 61% to 70%. In the Khartoum state economic growth is observed to be better with an average poverty scale ranging from 21% to 40%. In Ethiopia, poverty ranges from 55 per cent in SNNP Region and Oromiya to 62 per cent in Gambela.

3. NATURAL RESOURCES AND ENVIRONMENTAL ISSUES

3.1 GEOLOGY

The Baro-Akobo watersheds consist primarily of a high mountainous zone (2400 masl to 3000 masl) of tertiary basalt caped in places with quaternary volcanic rocks, in the general eastern uplands, the high plateaus sectors (1300 to 2400 masl) covered with basalts and granites, the strip of lowlands (800 masl to 1400 masl) staffed with crystalline basement complex rocks and the low-lying are (largely less than 500masl) formed and underlain by unconsolidated and undifferentiated Plio-Quaternary material (such as the Gambella alluvium) that grades westwards at less than 500 masl.

3.2 SOILS

Nearly 60% of the sub basin is covered with black colored vertisols. The low-lying area of Gambella, the entire watershed of the Sobat river and majority of the White Nile watershed downstream of Malakal are almost covered with black cracking vertisols, which poses considerable challenges in agricultural operations. Arenosols covers 10% of the sub basin. Nitosols, Luvosols, fluvisols etc with few proportions for each soil unit, covers the remaining part of the sub basin. The predominant soils in the highlands are the Nitisols, which usually are deep with smaller areas of Leptosols. Unconsolidated Sediments that cover all of the Lowlands in Ethiopia and Sudan are overlain by very extensive areas of Vertisols – deep black cracking clays (56 per cent of the area). Arenosols derived from wind blown sands are extensive in the north-western part of the sub-basin (10 per cent of the area). Locally Fluvisols occur on coarser textured recent alluvial sediments. A range of soil types occur over the southern Mountains and hills, including Lixisols, Nitisols and Leptosols. On their footslopes and across to the Boma Plateau in the south-east are Cambisols and Solonetz soils. Deeper Luvisols and shallower Leptosols occur in the Nuba Mountains. Very coarse textured Arenosols overlay the Cover Sands that merge into Phaeozems and Leptosols over the Nubia Sandstones.

3.3 LAND USE LAND COVER

The land cover is dominated by grassland and open woodland and shrubland. Grassland, open shrub lands and open wood land with coverage of 30%, 23% and 17% respectively are the dominant land cover units in the sub basin. The grass land predominantly covers the low-lying area of the sub basin. In the low-lying area of the Gambella seasonally flooded area and around the border is a considerably large savannah. Semi-mechanized farms are fourth in terms of area coverage, followed by seasonal swamps and wetlands (most importantly, the permanent Machar wetland) and Montane and Lowland High Forests.

3.4 VEGETATION

Vegetative Types: The major vegetations in the sub basin are the forest type vegetations (which includes seven types of forest units (Aninegeria forest, Olea forest, Evergreen forest, Lowland Baphia forest, Tropical rain forest, Podocarpus forest & Riparian forests, *Afro-Alpine and Sub-Alpine Forests* the Highland and lowland bamboos, woodland type vegetations, seasonally river and rain flooded grass lands, the swamp vegetations and cultivated lands.

Forest Types: The forest types are detailed below

- Aningeria Forests lie between 1600 and 2000 m in the Ethiopian Highlands where the annual rainfall is about 1600-2400 mm, and has a diverse species composition (Syzygium guineense, Ficus spp, Olea welwitschll, Prunus africana, Albizzia gummifera, Polyscias fulva, Morus mesozygia, Ekbergia capensis, Celtus gomphophylla, Cordia Africana, and Croton machrostachyus) due to its wide range of suitable climate conditions.
- Olea Forests lie between 1,500 and 2,000 masl in both the Ethiopian Highlands and in the Imatong Mountains, and their preference for gentle slopes exposes them to disturbance and exploitation. They comprise a wide range of commercially desirable species: Olea welwitschii, Bosqueie phoberos, Apodytes dimidiate, Polysicias ferruginea, Olea hochstetteri, Cordia abysinnica and Syzygium guineense.
- Evergreen Forests occur throughout the highland plateau. Remnants of the forests which once clothed Ethiopia's uplands, they are now made up of islands of trees whose under-storey has been removed to provide space for coffee; there is no forest regeneration. Nonetheless, the trees continue to provide a low intensity of habitat for birds and other life as well as some slight hydrological benefit.
- Lowland Baphia Forests are an open Lowland forest type that often merges with riparian forests, and are found in the Gambela Lowlands. It contains such species as Zizyphus pubescens, Diospyrus mesipiliforms, Alstonia boonei, Celtis integrifolia, and Chlorophora excelsa. Woodland species, Albizzia schimeriana, Croton macrostachyus, and Combretum molle, also occur. Baphia forests are under threat from burning and fuel wood collection.
- Tropical rain forests are confined to a few small and scattered localities in the south-western part of the Pibor Catchment, including the base of the Imatong Mountains. In these forests, four stories can be distinguished in the vegetation: the canopy trees, which are 30–50 meters high with long, straight trunks, often buttressed at the base; the second-storey trees, from 15 to 30 meters high, usually not so straight, more copiously branched and with less tendency to form buttresses; the shrub layer, 4–6 meters high, often very dense, with numerous creepers and lianas, and the ground layer of herbs and grasses, usually sparse and often absent. A number of valuable timber trees are found, including Khaya grandifoliola, Chlorophora excelsa, Entrandrophragma angolense and others.
- Podopcarpus Forest of the Imatong Mountains are found between 1,500 and 2,600 masl, the climax vegetation being closed evergreen forest with Podocarpus milanjianus, Olea hochstetteri and Syzygium spp. dominant over a shrubby understorey. Much of the ground is wet or swampy because of the combination of high rainfall and low potential evapo-transpiration. Above 3,000 masl, ferns, Erica arborea and Myrica salicifolia are dominant and many species of herbs occur.
- Riparian Forests extend throughout the plateau drainage pattern, dropping down to the flood plains. Like woodlands of the savannah and upland basin, riparian forests are under enormous pressure from local and refugee populations. Important species include Celtis kraussiana, Ficus sycamorus, Mimusops aethiopum, Tamarindus indica, Maytenus senegalensis, Kigelia aethiopum, Syzgium guinenses and Acacia spp.
- Afro-Alpine and Sub-Alpine Forests lie above 3200 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.

Bamboos: Highland bamboo thicket (Arundaria alpine) occurs on gentle slopes above 2,400 masl in the high rainfall areas of both the Ethiopian Highlands and the Imatong Mountains.

Lowland bamboo (Oxytenanthera abyssinicus) are found within the Baro-Akobo catchment in the Assossa Zone of BS-G Region and extends into Sudan.

Woodlands: The three main types of woodlands are the following:

- Mixed Deciduous Woodlands extend along the south-western and north-western edges of the plateau at about 1200 m altitude. Their species include Albizzia schimperiana, Croton macrostachyus, Euphorbia abyssinica, E. candelabrum, Grewia bicolour, Bersama abyssinica, and Acacia spp, among others.
- Acacia Seyal-Balanites Savanna are found **a**bove 570 mm to about 1,500 masl there is increasing dominance by A. seyal in association with Balanites aegyptiaca. A. senegal is retained for gum arabic harvesting whilst A. seyal is used for charcoal production. B. aegyptiaca is becoming increasing prevalent because it is fire resistant, does not produce good charcoal and is hard to cut.
- Acacia Thornland alternating with Grassland on Clays are present between the 360 mm and 570 mm isohyets on the heavy clays on either side of the White Nile grassland merges into A. mellifera thornland.

Grasslands: The seven main types of grasslands are the following:

- Acacia senegal Savanna and Combretum cordofanum Savanna on Sands are found between the 360 mm and 570 mm isohyets on the western side of the White Nile on the sandy Arenosols of the cover sands and stabilized sand dunes there occurs Acacia senegal Savanna. This area comprises the sandy Gum Arabic belt. The grass cover is represented by the genera Cenchris and Aristida. Occasionally the valuable the perennial grass Andropogun gayanus is found. These grasses become largely unpalatable to livestock during the dry season. There is abundant material for annual fires.
- Seasonally River-flooded Grasslands are flooded annually to varying depths and periods and form the toich, which yields dry season grazing essential to the Nuer and Dinka agro-pastoralists.
- Oryza longistaminata Dominant Grassland where the dominant species constitutes 80-90 per cent of the standing crop. These grasslands are burnt each year early in the dry season. Although a perennial it can produce abundant seed and provide high quality grazing for much of the year even into the dry season.
- Echinochloa pyramidalis Dominant Grasslands are further away from the river and are thus flooded less frequently (although a tall variant grows close to the river). The species produces growth even during the dry season and is thus a year-round pasture.
- Echinochloa haploclada Grasslands are found between the river-flooded and the rain-flooded grasslands where there is often a strip of land with light textured soils and slightly elevated, which is used for settlement and cultivation. As livestock are concentrated here for long periods this grassland is heavily grazed. Nutritionally the grassland is of very high quality during the wet season but quality falls off during the dry season.
- Sprobolus pyramidalis Grassland, a tussock-forming species, is not widespread, and is characteristic of heavily grazed areas. It makes no growth during the dry season, is low in protein and during the dry season nutrient levels fall below those needed for maintenance. It is used to make string used in house construction.
- Hyperrhenia Rufa Grasslands occupy level ground out of reach of river-flooding but are inundated by rain for varying periods. Almost all (90%) of the biomass is stem and contains little of value to livestock. A high proportion of these grasslands are burnt each year. They are generally used at the beginning of the wet season and at the

beginning of the dry season after burning. The grass provides a major source of thatching material.

Swamp vegetation: In addition there are specific vegetation types in the swamps:

- Cyperus Papyrus Swamps: These swamps form a fringe along water courses, pools and other water with deep and constant depth. The plants form a floating mat upon which other species – mainly climbers are found.
- Typha Domingensis Swamps: These are most extensive away from the river channels. The vegetation is not floating but rooted into the substrate covered by very shallow water. There are few other plant species. This is probably the extensive swamp type in the Machar Marshes
- Vossia Cuspidata Swamps: This vegetation is found next to flowing water. It has creeping, submerged or floating stolons. It is often associated with water hyacinth.

Wetlands: Six of the 43 surveyed wetlands of Ethiopia are in this sub-basin (Table 3.1).

Table 3.1: Profiles of Wetlands in Baro-Akobo Basin

Name	Size (ha)	Type	Physical features	Uses	Threats	Ownership	Management Measures
Alwero Reservoir	2,210	Man Made	No rainfall and temperature data No Limnology Data	Water Supply Fishing Grazing Forest area	Deforestation Malaria and Fascioliasis are Common	State-Owned	No known conservation measures but found in good status
GININA	Not delineated	Seasonal Flood Plain	Belongs to the wet Kolla agro-ecological Zones near Gambela Town	Dry season Grazing Fire- wood collection Settlement	Mimosa Pigra, an invasive plant becoming a problem by preventing fishing, grazing and farming	State-Owned	No known conservation measures
Tata /Thata	185	Fresh water Lake	No temperature and rainfall data	Fishing Water supply Grazing Canoe transport Farming	Current Water hyacinth Siltation Potential Introduction of Alien species Malaria and Fascioliasis	Annuak People	Traditional management but facing pressure of refugees
Cheffie Gebo	Not delineated	Wooded Wetland	No Limnology Data No rainfall and temperature data	Forestry Pasture Religious functions Water supply Farming	Current Farming, Overgrazing and Siltation Potential Introduction of Alien species, expansion of drainage farming	Private Farmers Mechara and Sigsega Farmer Associations	Management measures to protect trees
Abol	Not delineated	Seasonal Flood Plain	No Limnology Data No rainfall and temperature	Fishing (seasonal) Grazing	Current No threat Potential Introduction of alien species	Farmers of Abol Kebele farmers	No management measures The site is naturally conserved

Name	Size (ha)	Type	Physical features	Uses	Threats	Ownership	Management Measures
			data		Malaria and Fascioliasis and tse-tse flies		

3.5 WILD LIFE

The Gambella national Park in the upper course of the sub basin the area is an important habitat for 100 mammal species and 400 avifaunal species. Despite receiving legal protection since 1974 and the region was at one time considered as one of the most important wildlife areas in Ethiopia, its present status hardly warrants designations as protected area of any kind. Large area of the original park has been cleared and is being used for cultivation and/or grazing. This portion of the sub basin was once identified as the place for abundant wildlife (at least 27 species of large mammals were recorded 25 years ago), but 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 Gambella National Park by a state farm and Abobo Dam, part of whose upper reservoir also extends in to the Abobo Gog protected area. Most famously the wetlands-flooded grasslands are home to the White-eared Kob (*Kobus kob subspp. leucotis*) and to the Nile Lechwe (*Kobus megaceros*), both of which are listed by IUCN as threatened species.

3.6 LIVESTOCK

The Baro-Akobo basin contains about 1.2 million cattle, 0.4 million Sheep, 0.24 million goats, 0.09 million equines and 1.1 million chickens. Cattle are of primary importance, representing about 90% of the total livestock unit. They are used for draught, milk, capital reserve, a source of cash, and for cultural purposes (status, bride price, etc.). In the lower basin, livestock are managed on a migratory system in response to the availability of grazing and water in the plain but the seasonal distribution of feed is a constraint, as is the case in the upper basin of Baro-Akobo.

Cattle densities are high in the Ethiopian Highlands, the Nuba Mountains and in the area just to the north of the Machar marshes, moderately high in the central area across the White Nile catchment, and relatively low in the southern areas, in particular the area of intermittent drainage across the Pibor catchment. Overall densities of sheep are nearly everywhere higher than goats. Highest sheep densities are located in the Ethiopian Highlands, the Nuba Mountains and in and around the Gezira-Managil Irrigation Scheme.

3.7 BIODIVERSITY

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

National Park Areas: There are two national parks in the sub-basin, the Gambela National Park in Ethiopia and the Boma National Park in Sudan. In addition there is the Kidepo Game Reserve, which adjoins the Kidepo National Park in Uganda.

The Gambella National Park: The Baro-Akobo Sub-basin contains only one of Ethiopia's nine National/Regional Parks and three of the 17 Controlled Hunting Areas. The Gambella Regional Park is 506,100 ha in extent and is located between the Akobo and Ghilo rivers,

east of the road between Gambella and Gog. The Park encompasses a wide range of habitats including wetlands, seasonally flooded grasslands and savanna grasslands and woodlands. It has not been gazetted and conservation resources in terms of staff and facilities are extremely meagre. Following the change of government in 1991 control of the Park passed to the Gambela Regional Administration. The area is visited by the White Eared Kob and elephant have visited the area in the past.

The Boma National Park encompasses an area of some 2.28 million ha of the clay plains and a mosaic of wetlands, seasonally flooded grasslands and open wooded savanna grassland in the north-western part. It was declared a National, Park in 1977 but has not been gazetted. Oil has been discovered in the Park in commercial quantities. The area is extremely inaccessible, most particularly during the wet season. The main routes have been mined and minor routes un-maintained.

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

3.8 MAJOR ENVIRONMENTAL ISSUES

Soil erosion, deforestation in the Ethiopian Highlands, lack of sustainable management of wetlands and low-lying flood plains, and wild life preservation and management are the key environmental issues related to water resources development in the sub basin. Water quality in the Baro-Akobo-Sobat-White Nile sub basin is not threatened.

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

Soil Degradation: 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. In the Baro-Akobo sub basin, soil loss due to runoff, loss of forest cover, etc., are increasing and the risk and consequences of soil erosion have expanded. The total soil eroded in the Baro-Akobo Catchment is estimated to be 43.7 million tons per annum and that from cultivated land 21.5 million tons per annum. This is a much higher proportion than in either the Tekeze or Abay Sub-basins, a reflection of the much higher vegetative cover in the communal lands of this high rainfall area. The impact on crop production of the annual loss due to soil erosion is currently 0.5 per cent of total crop production in the sub-basin, but is estimated to rise to 5 per cent after 10 years, and to 13% after 25 years.

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

the Nuba and the Imatong Mountains and where the forest and woodland cover has been cleared for agriculture sheet erosion is likely to be taking place in these locations.

Gully erosion: Little work has been done in Ethiopia on gully densities and erosion rates. In the Baro-Akobo gully erosion is local and mainly confined to inappropriately located culverts. In this high rainfall area natural vegetation quickly invades and helps stabilize gullies. The Ethiopian highlands of the Sub-basin are relatively free of gulley erosion given the good vegetative cover in this high rainfall environment. Locally some gully erosion can be observed, almost invariably due to the poor location of a road culvert, and along cattle tracks between villages and water sources. In Sudan gully erosion in the Nuba Mountains is more likely given the long period of settlement and the low vegetative cover.

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

Suspended Sediment in the river system: Sediment yields, annual mean suspended sediment load and sediment deliver ratios are considerably lower than those of the Tekeze and Abay Sub-basins, reflecting the greater ground cover in this forested high rainfall regions. There is no significant difference between the sediment yields of small and large catchments, suggesting that, most (81%) of soil eroded remains within the landscape and that the river system is relatively efficient in delivering and removing eroded sediment. This in turn implies that interventions to reduce in-field erosion will affect sediment loading in the river system relatively quickly.

Dam and Reservoir Siltation: The most important off-site negative impacts of soil erosion are sedimentation of streams and water storage infrastructures. High sediment loads in streams pollute water supplies, and cause siltation of dams, reservoirs, water-harvesting structures and irrigation canals, reducing their effective capacities, shortening their service lives, and incurring high maintenance cost, at national, community and individual levels. The only dam in the Baro-Akobo catchment is the Alwero Dam, with a catchment of approximately 2,738 km^2 most of which is heavily forested with little cultivation. The proposed Baro 1 dam, however, will lose 24% of live storage due to suspended sediment after 50 years.

Deforestation and Loss of Vegetative Cover: Upper Baro-Akobo: The dominant environmental change in the Baro-Akobo sub-basin is the loss of forest cover which is most marked in the southern and eastern part of the upper sub-basin where the main areas of forest remain. The main cause of forest loss is agricultural clearance, driven by (1) the decline in yields on cultivated land with the subsequent abandonment of that land from cultivation, and (2) rural population growth. The conversion of forest land to crop land and then grazing land can moderate stream flow, especially the storage of water from the rainy season into the dry season, which can cause higher floods and lower dry season flows. There is some evidence of this already occurring in the sub-basin, with the Sor hydro-power plant (near Metu) becoming more seasonal in its power generation and the Baro River at Gambela having more frequent high floods which are affecting long-established villages and low flows which allow the river to be forded in the dry season. Further, as forest in the upper sub-basin is replaced by farm land sediment loads are reported to be increasing with their implications for dam development in the upper sub-basin and for river bed levels and channel overflow in the lower sub-basin.

Vegetation Loss: Lowlands of the Baro-Akobo Catchment: In the high forest areas of Dima, Godere, Gog, Akobo and Gambela weredas in Ethiopia, the rates of deforestation

caused by expanding population and its need for agricultural crop land, is likely to increase exponentially. The impact of forest loss is likely to be much less serious for soil erosion than in the escarpment zone due to the lower gradients. Nonetheless, there are serious biodiversity implications of the loss of this forest and the habitat it provides for wildlife. The main threats to the lowland woodlands come from clearing for large scale irrigated agriculture, state farms and resettlement schemes, fuel wood collection around the large refugees camps, fuelwood collection for the towns, and the burning activities associated with hunting by the Anuak and Majangir.

Deforestation & Desertification in the Khor Abu Habel: The Khor Abu Habel tributary of the White Nile drains the Nuba Mountains (Southern Kordofan) and parts of Northern Kordofan and White Nile States into the White Nile downstream of Tendelti town. Throughout these States, the continued large increase in rural and urban populations is causing exploitation of woodland resources and hence to increase in soil erosion, sand dune encroachment and desertification (due to the rapidly growing demand for charcoal and fuel wood among urban populations). The impact of drought together with steadily increasing population pressure on arable land, has led subsistence farmers to move out of marginal or depleted lands to extend cultivation into forested areas, with a resultant loss of biodiversity and an increase in soil erosion – and increasing their vulnerability to future droughts.

Deforestation & Loss of Vegetative Cover: Upper Pibor Catchment: The montane Podocarpus forest in the Imatong Mountains and nearby hill masses, within the Pibor Catchment, are unique in Sudan and are important for bio-diversity and could be a significant attraction to expand eco-tourism. But there is no information currently.

Wetland Loss in the Highlands: There has been extensive and, in some areas, complete, loss of wetlands in the southwest highlands of Ethiopia. The impacts of the loss of wetlands or their transformation for farming are considerable and are also distributed in different ways across the communities. Women and the poor are especially seriously affected when wetland cultivation leads to the loss of safe spring water for domestic use and the loss of plant materials for craft and domestic use. The main driving forces for upland wetland drainage cultivation are (1) seasonal food shortages; (2) market production driven by urban demand; (3) land tenure changes, and in particular the need for farmers to cultivate in order to show land use and thus retain access (to redistributed land); (4) resettlement after the 1984 famine, and encouragement of settlers to cultivate wetlands for an early maize harvest; and (5) and NGO eco-programme which sought to reduce the pressure for forest clearance by developing rural livelihoods in areas outside the forest; and (6) the Wetland Task Force, which has set communities targets for additional wetland drainage and cultivation and regularly visits communities to ensure these are achieved.

Loss of Biodiversity: Gambela Regional Park & Boma National Park: Gambela Regional Park is not legally gazetted, no Management plan has been prepared, there are no visitor facilities, no vehicles or stores, a critical problem of illegal hunting (with a large number of arms made available because of the Sudanese Civil War), and a Refugee Camp adjacent to the Park. The Boma National Park has been neglected as indeed has the area generally, partly due to its remoteness and in part to the fact that during the Civil War the area was contested between the government and the SPLA. With the exception of population estimates for Reedbuck, Ostrich and Eland populations, there has been a massive decline in nearly all animal species, especially the White-eared Kob and the Mongalla Gazelle, and the big increase in hunting has caused the migratory routes of White-eared Kob and Elephant to change over 20 years. However, tree densities seem to have increased recently, indicating habitat improvement and stability.

Potential negative impacts on natural resources

- Agricultural land for returning migrants: Much of the area has been affected by the 20 years of Civil War (on both sides of the international border) and its attendant destruction of physical and social infrastructure, and the breakdown in socio-cultural networks and relations. Considerable movements of people have taken place and now many of the displaced people are beginning to return. They will need to clear land for farming, which will involve considerable cutting and burning of trees.
- Proposed investments in water infrastructure**:** There are long-standing plans to change the hydrology of the Bahr el Jebel and the Sobat Sub-basins, including the proposed Jonglei Canal and a diversion canal to collect spill from the Sobat that currently sustains the Machar Marshes and transmit this directly to the White Nile. These will have important implications and impacts on the livelihood systems of the sub-basin.
- Dams in the Baro-Akobo catchment: A number of dams have been proposed in the Baro-Akobo catchment, including those designated Baro 1 and Baro 2, which could reduce flooding and thus affect valuable dry season grazing for pastoralist groups that use the area during the dry season. Dams would also affect high peak flood flows and thus the seasonal and permanent swamps, with serious ecological impacts (e.g., migratory routes of the vast herds of white-eared kob, and the population of Nile Lechew) and thus the livelihoods of the Murle people who use this area for grazing.
- Machar Marshes scheme: This proposed canal to increase the flow of the White Nile and provide "new water" for downstream users could effectively dry out the Machar Marshes, cause some localized flooding from rainfall and cut across livestock trekking routes between dry and wet season pastures.
- Oil extraction**:** Both exploration (cutting of seismic traces, test drilling, access road construction) and drilling and extraction (road construction, new towns, pipelines, oil wells) have already had severe environmental and social impacts. In addition, the separation of the oil from the water will produce contaminated water which must be treated before disposal to prevent severe pollution problems, affecting water supplies, fishing and thus the livelihoods of the local inhabitants. Another potential problem is the construction of all-weather roads without effective drainage and adequate culverts, which could cause serious upstream flooding, lack of water on the downstream side, and have serious impacts on the distribution of the important "toich" grazing areas.
- Water hyacinth infestation: Water hyacinth (*Eichhornia crassipes*) in the White Nile, the Sudd and in the Baro and Sobat systems has a number of serious negative impacts, including increased loss of water from evapotranspiration, reduced areas of open water available for fishing (an important livelihood strategy for the people of the Sub-basin) and impedance to river navigation along the White Nile (with considerable economic consequences). Although current reports indicate that the problem is not as serious now as it was in the 1970s and 1980s, ecological and climatological changes might trigger a second, even more severe, episode of infestation.

4. HYDROLOGY AND WATER INFRASTRUCTURE

4.1 SURFACE HYDROLOGY

River System: The Baro and Gilo rivers start in the south-western highlands of Ethiopia fed by considerable number of small watersheds at an altitude of well above 2500 masl. The Metu & Jimma head in a general south-west direction and terminate at the confluence point at an altitude of less than 500 masl. The Akobo starts in the low-lying areas of the Ethiopian south-western highlands, bordering Ethiopia & Sudan in the north-west direction and forms a confluence with Pibor river before it joins the Baro and Gilo, to finally form the Sobat river. The Pibor River starts in the Sudan low land areas heading north-west before it joins the Akobo. The Machar swamp, fed by the flood spilled from the Baro river, is located at its lower course. The Machar is also fed by local streams sharing the same watershed divide with the Baro river in the north. The sub-basin is estimated to contribute about 26 billion m^3 of water every year to the Nile system at Khartoum.

Watershed physiology: The White Nile emerges from the Sudd swamps at Lake No and is joined by the Sobat just above Malakal. Then it flows north in a shallow valley between the Juba Mountains to the west and the Ethiopian Highlands and then the White Nile-Blue Nile divide to the east. The Baro and Akobo Rivers rise in the Ethiopian Highlands between altitudes of 1,500 to 3,100 masl. The rivers pass through an escarpment zone in deep incised valleys before they debouch onto the Gambela Lowlands. Here they pass through wide grassy and swamp plains before reaching the Pibor River and becoming the Sobat River. The Sobat River rises in the far southeast as the Pibor River on the highlands actually inside Uganda on Mount Moruogole (2,750 masl) although the water from these headstreams only reaches the Pibor in years of very high rainfall. The Pibor joins the Akobo and Baro along the Sudan-Ethiopian border. From the Pibor-Baro junction the river becomes the Sobat. Just before joining the Sobat the Baro has a flood spillway (the Khor Machar) into the Machar Marshes. The water from the Machar Marshes, together with that from khors coming off the Ethiopian Highlands, occasionally reaches the White Nile via the Khor Adar.

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

4.2 RUNOFF

The Baro river: The Baro watershed is largely drained by Geba, Sor, Gumaro, Birber, Ofa in its northern portion and the upper Baro river in its southern portion. All these rivers form a confluence upstream of the Gambella town then after to form the Baro River which flows in the general west direction in to the Sudanese land to Sobat River to form the White Nile watershed system. The mean annual runoff is estimated to be 12.412 bcm with an effective runoff of 415 mm that indicates a runoff coefficient of 30%. The hydrologic variability for the annual series is 12.8%. The hydrologic variability for seasonal series ranges from 46% (May) to 12% (August). Mean seasonal variability for the wet period (May to November) is computed to be 24% and for the dry season it is estimated to be 26%. Annual runoff for years from 1979 to 1988 is below average and thereafter, for most of the events, it is above average.

The Gillo river: The Gillo River is the second largest contributor of the Sobat watershed system. The Gillo River is the second largest contributor of the Sobat watershed system. Its watershed at the Ethio-Sudan border is estimated as 12,815km^2. Mean annual effective runoff is estimated at 315 mm indicating a runoff coefficient of 25% with mean weighted annual rainfall of 1300 mm over the watershed. The mean annual runoff at the gauging station near Pugnido is recorded as 3.2 billion cubic meters, out of which about 80% falls in the wet (May to November) season. The hydrologic variability for the annual series is estimated to be 22%, which is more than the watershed in the Baro River. The hydrologic variability for seasonal series is also much more pronounced in this watershed and is estimated to be around 50% (April) to 21% (August). The mean hydrologic variability in the wet season is 31% and for the dry season it is 85%. The annual runoff from 1980 to 1990 is below average, but is higher than average thereafter. This is similar to the situation in the Baro watershed where the period from 1980 to 1990 was drier than average.

The Akobo river: The river has two major watersheds, the upper Akobo (draining the Ethiopian land, with estimated watershed area of 6036 km^2) and the lower Akobo (largely draining the Sudanese land with estimated watershed area of 7,209 km^2). The mean annual runoff from this watershed is estimated to be 3.9 bcm, and overall, this watershed yields mean annual effective rainfall of 295 mm.

The Pibor river: The Pibor river has an estimated total watershed area of 1435km^2 and after the confluence, the flow of the Pibor disappears into a swamp about 5^{o}N. The mean annual runoff from this watershed is estimated to be 0.224 billion cubic meters.

The Sobat river: The Sobat watershed is drained by four major tributaries, Baro, Gillo, Akobo and Pibor, and other three small watersheds, namely, Alewero, Serkole, and Tirmatid. Together with the Sude, it is one of the major constituents of the White Nile system. The mean annual runoff is estimated to be 23.24 billion cubic meters, while the mean annual runoff from Alewero, Serkole & Tirmatid rivers at the Ethio-Sudan border is estimated to be 1.375, 1.32 and 0.419 billion cubic meters, respectively. At its mouth, the mean annual inflow is estimated to be 13.5 billion cubic meters, and hence its contribution to the White Nile system is almost 50%. The mean annual inflow from the Sude outflow is 16 billion cubic metres, and the estimated watershed area for the Sobat at its mouth is of 186,275 km^2. As a result of the routing effect of the Sude wetland, the Sude inflow to the White Nile system is observed to be regulated, and hence said to contribute nearly all of the base flow for the White Nile system. The seasonal element in the White Nile system is therefore deduced to be contributed by the Sobat river, which it turn, acquires it from the hydrologic variability and seasonality of the inflows from the Ethiopian highlands.

Machar Marshes: The Machar Marshes are the least known of the southern Sudan wetlands. The Machar wetland is hydraulically connected to the Baro river during high stage flows (spillage through the banks of the Baro river) from its south and to the ephemeral torrents originating in the foothills of the western highlands of Ethiopia from its east side. It is also hydraulically connected to the White Nile system through an extended grass field channel known as Khor Adar.

The area has been mapped (by the FAO Africover Project) to be 967 km^2 of permanently flooded swamp and 1,947 km^2 of seasonally flooded swamp – a total of 2,913 km^2 of flooded land. They also map 5,392 km^2 of grassland with no trees or shrubs. But given the variability of the spilling and seasonality of rainfall the area of seasonally flooded land can vary widely from year-to-year. Thus, the Machar Marshes are very different from those of the Sudd in terms of the small area of permanent swamp and the extremely variable area of seasonal swamp.

The general drainage pattern within the area is that water passes through the swamps by three main routes: (1) water from the eastern Baro passes through the Khor Machar and other spills that join to form the Khor Adar, which eventually joins the White Nile; (2) water from the eastern torrents (the Tombak, Yabus, Daga and other small streams) link up on the Khor Daga that in turn links up with the Khor Adar; (3) a tributary of the Khor Machar that flows parallel to the Sobat becoming the Khor Tiebor that in turn becomes the Khor Wol – which eventually joins the White Nile at Kodok.

There are four components of the water balance of the marshes: (i) northward spills from the Baro, (ii) the eastern khors from the Ethiopian escarpment, (iii) rainfall over the marshes, and (iv) evaporation/evapotranspiration.

Based on the mean annual rainfall and a gauged runoff coefficient of 15 per cent, total mean annual runoff was estimated to be 1.744 km^3.

The White Nile river: The White Nile system starting from the Malakal station is formed from the Sobat river, flowing from the general east and south-east directions (Baro, Gillo & Pibor being major constituents) and the outflow of the Sude flowing from the general south direction and the latter being hydraulically connected to the great East African Lakes through the Bahr El Jebel basin in its further south upper course and to the Bahr El Ghazal basin in the western direction

The mean annual runoff entering the White Nile system at Malakal is recorded to be 30.214 bcm (1980-2000) and the mean annual outflow (1980 – 2000) at Jebel Aulia at the mouth of the White Nile System is recorded to be 26.0 bcm.

Runoff in the sub-basin: The highest runoff rates occur over the Ethiopian Highlands and the western escarpment. Very low runoff rates are recorded from the southern clay plains, the north-eastern clay plains and the cover sands of North Kordofan State. Available data suggests a major loss of runoff in the sub basin, largely through evaporation losses in the flood plain, and partly through seepage, as the soil is mostly of high clay content, and partly through reduction in rainfall along the low-lying flood plain (about 88%) of the sub basin. The weighted mean annual runoff in the upper course of the sub basin (eastern watersheds in the Ethiopian Highlands) is estimated to be 750 mm with a weighted runoff coefficient of more than 40%, but descending down to the Gambella low-lying flood plain (for instance at Gambella), the weighted mean annual runoff reduces to 415 mm with a runoff coefficient of 30%. Further, at the Ethio-Sudan border the effective rainfall is reduced to 300 mm and at Malakal, the weighted mean annual effective rainfall is even below 75 mm, with a runoff coefficient of 7% at weighted mean annual rainfall of 1057 mm.

4.3 WATER BALANCE OF THE SUB-BASIN

The mean annual runoff for the different catchments in the sub-basin is in Table 4.1.

Table 4.1: Summary of surface water resources

Name of basin	Catchment area (km^2)	Mean annual runoff (MAR) km^3/yr
Baro Masha	1,653	1.792
Baro 1 site	2,333	2.356
Baro- Kella	4,937	3.473
Baro Gambela	23,461	12.230
Baro: Itang	24,636	10.710
Baro: Jikawo	26,940	11.174
Baro: Border in Ethiopia	30,004	
Baro: Border in Sudan	8,396	

Name of basin	Catchment area (km^2)	Mean annual runoff (MAR) km^3/yr
Baro: Total	**38,400**	**9.500**
Akobo-Pibor: in Ethiopia	45,906	
Akobo-Pibor: in Sudan	39,994	
Akobo-Pibor: Total	**85,900**	**3.100**

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

4.4 GROUNDWATER

Quantitative estimates of groundwater in the Sudan are rather approximate and considerable efforts are needed to arrive at more accurate figures. The Baro-Akobo Catchment has two basic types of aquifers. One is associated with fracture and crush zones in the Basement Complex rocks and the other in the Pliocene to Quaternary alluvium, an unconsolidated sedimentary porous medium. The alluvium constituting the aquifers in the Baro and Pibor Plains is usually fine sand to silt. Water yields from wells constructed in these aquifers range from about 0.01 – 1.01 litres per second, while static water levels of wells in these aquifers vary up to about 7.0 meters below ground surface.

In areas of the Unconsolidated Sediments that stretch from the Sobat Basin and then down the Main Nile and across to the Blue Nile the hydro-geological system comprises two aquifers: (1) an upper aquifer that includes mainly the Upper Gezira Formation and the upper part of the Lower Gezira formation in the area between the Blue and White Nile, and (2) a lower aquifer, developed mainly in the deeper Nubian Sandstones. Water storage in the lower aquifer is some eight times that of the upper aquifer. Except for a few isolated areas water quality is free from impurities for drinking requirements.

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

4.5 WATER INFRASTRUCTURE

Existing Dams and Reservoirs: Alewero reservoir in the upper course of the Baro watershed in Ethiopia, and the Jebel Aulia reservoir at the mouth of the White Nile in the Sudan are the two dams/reservoirs existing in the sub basin.

Alewero Reservoir: Located in the upper course of the Baro watershed, at Alewero River, in Ethiopia, the reservoir was initially built for irrigation and is currently used for both irrigation and hydropower. Initially planned to command 10,400 hectares of agricultural area, there is no data regarding the current level of irrigated agriculture development from this reservoir. According to available estimates, the mean annual sediment yield is in the range of 35 t/km^2 per year, which is equivalent to a mean annual loss of 3 mm depth of soil from the agricultural land in the upper course of the sub basin. At 60% project efficiency the hydro-module is estimated at 13,106 cubic metres per hectare per year, posing a considerable threat to reservoir life and agricultural production.

Jebel Aulia Reservoir: This reservoir is located at the mouth of the White Nile and was built with a storage capacity of 3.5 billion cubic metres. The reservoir is used for both irrigation and hydropower. The Assalaya and Kenana sugar schemes with a total command

area of 80,144 ha are the two state owned large scale irrigated farms in the system, along with 300 hectares of small scale level irrigated farms. Mean annual evaporation from the reservoir is 2.12 bcm on average. No seasonal distribution is available. After nearly 70 years, reservoir sedimentation is not yet a threat for the Jebel Aulia reservoir and it still maintains its original designed storage capacity, largely because the flat land in the lower courses of the Baro river (Gambella low-lying plain) and the Pibor tributaries (Akobo, Gillo & Alewero), the entire watershed of the Sobat river & the Machar wet land in the eastern portion of the sub basin and the presence of the Sude in the south portion, are filtering the sediment load from the highlands of the sub basin. At 60% project efficiency, the hydro-module is estimated at 10,125 cubic metres per year per year with mean annual abstraction of about 820 million cubic metres, including abstractions for small scale projects. The evaporation loss is 2.12 billion cubic metres per year on average.

Potential Water Infrastructure: Both dams and irrigation projects have been identified:

Dams and reservoirs: 14 dams and reservoirs, five for irrigated agriculture development, one for multi-purpose development and eight for hydropower development purposes, have been identified in the upper course of the sub basin by the Integrated Master Plan Studies conducted in 1997 by the Ethiopian Government for the Baro-Akobo basin.

Irrigation Projects: Six irrigation projects have been planned in the upper course of the sub basin in Ethiopia, with a total gross command area of 631,000 ha, and a net command area of 480,000 ha. In Sudan, the current irrigated area of 346,000 ha is to be expanded to 582,000 ha by 2015 and to 750,000 ha by 2025. All this will raise the current abstraction of Sudan in the Nile system, from 20bcm to 40 bcm.

4.6 HYDROPOWER AND TRANSMISSION

Installed Capacity: In the upper course of the sub basin, eight large projects (2375 MW), six medium projects (395 MW) and three small projects (55 MW) were identified as feasible for the first screening stage.

Proposed Interconnections and Transmission Lines: (1) Interconnections with the Ethiopian ICS: In the Baro-Akobo master plan studies large and medium scale hydropower plants are to be connected to the existing national grid system; (2) Interconnection with the Sudan: These have been justified on the basis that there will be periodic surplus of energy by the time the envisaged hydropower plants are commissioned of exchange of surplus energy between the two systems.

4.7 WATER SUPPLY PROJECTS

According to the Baro-Akobo Master Plan studies in Ethiopia, four levels of development plans are proposed: (1) immediate (1997 – 2000), (2) Short term (2001 – 2015); (3) Medium term (2016 – 2030) and (4) long term (2031 - 2035) to serve main towns, small towns and rural populations. This assumes that by the end of the master plan period all the population in main and small towns and 59% of the rural populations in the basin states will have access to safe water supply facilities. Information regarding the Sudanese part of the sub basin is not available.

SUMMARY: MAIN NILE SUB-BASIN

THIS SUMMARY contains information on the Main Nile sub basin and is part of the summary report of the One System Inventory prepared by ENTRO.

Figure 1.1: Main Nile sub-basin: Location Map

***Source*:** Sudan: ENTRO GIS data base

1. GENERAL

1.1. LOCATION OF THE SUB-BASIN

The Main Nile Sub-basin is one of the four major sub-basins in the eastern portion of the Nile Basin and is located in the northernmost portion of the Eastern Nile Basin. The Main Nile Sub-basin starts at Khartoum downstream of the white Nile-Blue Nile confluence and extends up to Mediterranean Sea. Geographically, it extends from 300 30' 35'' to the north down to 130 7' 20'' on the south, and from 260 46' 24'' to the west up to 360 27' 42'' to the east, covering a total area of 789,660 km^2. It is the largest sub-basin of the four sub-basins identified in the Eastern Nile, 89% of which lies in Egypt and 11% in the Sudan. In Sudan the Main Nile Sub-basin encompasses 8 Administrative Regions and three Governorates in Egypt.

1.2. TOPOGRAPHY

Altitude: Large proportion of the sub-basin area (69%) is confined in an altitude that ranges from 200 masl to 500 masl and it occupies the central area of the sub-basin extending from Khartoum to the Delta in Egypt, evenly distributed on both banks of the Nile. About 22% of the sub-basin has an altitude from 500 masl to 1,000 masl. Nearly 1% of the sub-basin has an altitude less than 20 masl and this area is largely confined in the delta around the mouth of the sub-basin. Some 3% of the sub-basin has an altitude ranging from 20 masl to 100 masl and the remaining 4.5% has an altitude between 100 masl and 200 masl. Less than 0.1% of the sub-basin is above an altitude of 1,000 masl.

Slope: Most of the Main Nile sub-basin (96%) has a mild land of slope less than 5%. Land slope ranging from 5% to 10% covers nearly 3% of the sub-basin and the remaining area (less than 1%) is identified to have land slope greater than 10%.

1.3. CLIMATE

General: Owing to its altitude, this portion of the Nile is known for its arid climate where moisture is almost non-existent. The presence of Nile has enabled to support life along its narrow banks of the downstream of Khartoum and the High Aswan Dam (HAD) and into the large delta downstream of the Delta barrages. The delta, where life including green area in the system is confined, accounts for less than 5% of the area of Egypt. The Main Nile sub basin in both Sudan and Egypt has arid-desert to semi-desert climate, characterised by a long hot rainless summer and short rainy mild winter with scarce rainfall.

Rainfall: More than 65% of the sub-basin has mean annual rainfall of less than 50 mm and only 17% of the sub-basin has mean annual rainfall of above 100 mm. Mean annual rainfall at Khartoum is below 200 mm, which reduces to less than 20 mm at Atbara, and to less than 5 mm at Dongola and the High Aswan Dam. At Cairo it is 25 mm and increases to 200 mm in Alexandria in the coastal line of the Mediterranean Sea. Average runoff over the entire area of the delta in Egypt is estimated at 1 bcm, accounting only for 3% of the runoff reaching the Delta through the Nile system.

Temperature: Temperature in this sub-basin is very hot, due to the desert climate, with mean annual daily temperature varying from above 30ºC (around Dongola and HAD) to 18ºC in the coastal areas (Alexandria)The maximum air temperature increases generally from north to south. The difference between the maximum temperatures from north to south reaches 15°C in May and June, and 5°C in January. The hottest month in the north is

during June, while August is the hottest month in the northern coast. The minimum air temperature in the Egyptian part of the sub basin is during January.

Evaporation: Evaporation is considerably high with lake evaporation at HAD estimated at 2.6 meter per year. Potential evapo-transpiration in the sub-basin is estimated at 6.8 metres at Khartoum, 7.8 metres at Dongola, 5.8 metres at HAD and 1.8 metres at Alexandria on the coast of the Mediterranean Sea.

1.4. HUMIDITY

Nearly 85% of the sub-basin is dry with mean annual relative humidity of less than 40%. Only 5% of the sub-basin has mean annual relative humidity of above 50%.The highest relative humidity is over the northern coast of the Egypt, being above 70% during summer, decreasing inwards to reach 20% far to the south with appreciable gradient at the north and weak gradient at the south. Moreover, a steep relative humidity gradient is evident near the Red Sea coast, which weakens westwards.

2. SOCIO-ECONOMIC CHARACTERISTICS

2.1. DEMOGRAPHIC CHARACTERISTICS

Population: The Main Nile Basin has a total population of 78,425,160, accounting for nearly 50% of the total population of the four sub-basins, and is thus the most populous sub-basin in the Eastern Nile system. The area in Sudan from Khartoum to the Egyptian border is called the Northern region, and had a population of 1,035,185 in 2004, which is projected to be 1,425,160 in 2005.

Population Growth: The population in the Egypt Main Nile was estimated at 52.5 million in 1990. Annual population growth rate at the time was 2.6 per cent, which dropped to 2.4 per cent by 2005. Projections indicated that Egypt's population would be 79 million in 2006, with the expectation that it would continue to grow to a figure of 127 million by the middle of the 21st century. By 2005, the projection indicates that the Egypt main Nile population was 77 million and 79 million in 2006, with the expectation that it would continue to grow to a figure of 127 million by the middle of the twenty-first century.

Population Density: In the northern region of Sudan population density is sparse with an average value less than a person per square kilometres. Egypt's overall population density in 1990 was only about fifty-four people per square kilometres. However, close to 99 per cent of all Egyptians live along the banks of the Nile River in nearly 4 per cent of the country's total area. The average population density in the Nile Valley exceeds 1,500 per square kilometres, one of the world's highest densities.

Birth and Death Rates: The crude birth rate was 26 births per 1000 population and is projected to decrease to 17 by 2025. The crude death rate, however, is projected to stay at the 2000 level of 6 deaths per 1000 population even in 2025.

Infant Mortality: The infant mortality rate was put at 33 deaths per 1,000 live births down from 94 deaths in the late 1980's.

Life Expectancy at Birth: In 2005, average life expectancy in Egypt at birth was estimated at 71 years, up from fifty-nine years for men and sixty years for women in 1989.

Major Ethnic Groups: There is considerable socio-cultural diversity among the population of the Main Nile Sub-basin, mainly on the Sudan portion of the Sub-basin. The main groups are Nubians, Danagla, Bedirya and Rekabia. Along both banks of the Nile itself are the Gaa'lian people, the Shaigia, Kawahla, Kababish and Hassaniya peoples, mainly pastoralists but who also cultivate sorghum along the wadis. Living mainly along the Wadi Muqadam and more recently along the Nile below Korti are the Hawaweer people.

On the Egyptian portion of the sub-basin, there are only two main ethnic groups who live in the eastern part of the Lake sub-basin: the Ababda who comprise some two thirds of the population and the Bishari who make up the other third.

2.2. SOCIAL INFRASTRUCTURE

Literacy and Education: In the Egyptian part of the Main Nile basin, by the academic year 1985-86, about 84% of the primary-school-age population (more than 6 million of the 7.2 million children between the ages of seven and twelve) were enrolled in primary school. Less than 30% of eligible youth, however, attended intermediate and secondary schools. The literacy rate however continued to lag behind despite the increase in school enrolment and in 1990 only 45% of the population could read and write. There are significant regional differences in the primary-school enrolment rate. In urban areas, nearly 90% of the school-age children attended, whereas in some rural areas of Upper

Egypt, only 50% percent did. Overall, only half of the students enrolled in primary school completed sixth grade. The enrolment rate for girls continued to be significantly lower than for boys. The shortage of teachers is a chronic problem, especially in rural primary schools.

In Sudan, where complete data on education is lacking, there are very clear differences in literacy and primary school enrolment rates between Northern and Nile States and Red Sea and North Kordofan States, with the former considerably above the Northern Sudan average. Female rates are below those of males, with Red Sea State well below the average for the Northern States.

Water Supply: The River Nile is the main source of water for Egypt, providing almost all the fresh water used by more than 75 million Egyptians living along its banks. In 1990, approximately 25% of the total population, including 36% of all villagers, in the Main Nile area of Egypt did not have access to safe water for drinking. Use of unhygienic water was the major cause of diarrhoea. In addition, more than 50% of all families lived in homes that did not have inside plumbing. Egypt has 217 cities that are 100% covered by potable water network, but only 43% of the 4,617 villages are covered by potable water network. Because of limited water resources and high population density, water share per person in Egypt is less than 1,000 cubic meters per year per person, which is relatively low compared to internationally accepted standard.

Sanitation: The current situation for sanitation is far from satisfactory with the sanitation network covering only 38% of Egyptian cities, while only 11% of the 4,617 villages is covered by the sanitation network.

Health Facilities: The average ratio of hospitals in the Egyptian part of the sub-basin in 2003 was 1.8. Disaggregated by state, the ratio was 4.9 (Northern State), 0.8 (Khartoum State). The specialist ratio for the Basin averaged 3.9 per 100,000 people in 2003. The share of the ratio for each state in the region was 3.3 (Northern State), 12.5 (Khartoum State).In the Egyptian part, however, the situation is relatively better. The Ministry of Health has provided free, basic health care at hundreds of public medical facilities. General health centres offered routine medical care, maternal and child care, family planning services, and screening for hospital admittance. These clinics were usually associated with the 1,300 social service units or the 5,000 social care cooperatives that served both urban and rural areas. In addition, in 1990, the Ministry of Health maintained 344 general hospitals, 280 specialized health care units for the treatment of endemic diseases, respiratory ailments, cancer and other diseases, and dental centres. There were about 45,000 beds in all government hospitals, plus an additional 40,000 beds available in private health institutes. The number of trained medical personnel was high relative to most middle-income countries. In 1990, there were more than 73,300 doctors in the country, approximately 1 physician per 715 inhabitants. There were also about 70,000 certified nurses. Medical personnel tended to be concentrated in the cities, and most preferred private practice to employment in public facilities. Fewer than 30% of all doctors and scarcely 10% of nurses served in villages. Although public health clinics were distributed relatively evenly throughout the country, their services were generally inadequate because of the shortage of doctors and nurses and the lack of modern equipment. In both cities and villages, patients using the free or low-cost government facilities expected a lengthy journey and a long wait to see a physician; service was usually impersonal and perfunctory. Dissatisfaction with public clinics forced even low-income patients to patronize the expensive private clinics. In rural areas, village midwives assisted between 50% and 80% of all births. Even when women used the maternal care available, prenatal care was minimal, and most births occurred before trained personnel arrived.

2.3. TRANSPORT AND COMMUNICATIONS

Roads: By 1996, the total length of roads was about 64,000 kilometres, of which 50,000 were paved and 14,000 unpaved. The highway system is concentrated in the Nile Valley north of Aswan and throughout the Delta; paved roads also extended along the Mediterranean coast from the Libyan border in the west to the border with Israel. In the east, a surfaced road ran south from Suez along the Red Sea, and another connected areas along the southern coast of Sinai from Suez to the Israeli town of Elat. A well maintained route circled through several western oases and tied into the main Nile corridor of highways at Cairo in the north and Asyut in the south. However, large areas of the Western Desert, the mountainous areas near the Red Sea, and the interior of the Sinai Peninsula remained without any permanent-surface roads.

Railways: The state-owned Egyptian Railways had more than 4,800 kilometres of track running through the populated areas of the Nile Valley and the coastal regions. Most of the track was 1.435-meter standard gauge, although 347 kilometres were 0.750-meter narrow gauge. Portions of the main route connecting Luxor with Cairo and Alexandria were double tracked and a commuter line linking Cairo with the suburb of Helwan was electrified. Built primarily to transport people, the passenger service along the Nile was heavily used.

River Transport: Egypt had about 3,500 kilometres of inland waterways. The Nile constituted about half of this system, and the rest was canals. Several canals in the Delta accommodate ocean-going vessels, and a canal from the Nile just north of Cairo to the Suez Canal at Ismailia (Al Ismailiyah) permitted ships to pass from the Nile to the Red Sea without entering the Mediterranean Sea. Extensive boat and ferry service on Lake Nasser moved cargo and passengers between Aswan and Sudan. The Suez Canal was Egypt's most important waterway and one of the world's strategic links, being the shortest maritime route between Europe and the Middle East, South Asia, and the Orient. The canal extends 160 kilometres from Port Said on the Mediterranean to a point just south of Suez on the Red Sea. It can handle ships with up to sixteen meters draught; transit times through the length of the canal averaged fifteen hours. It was estimated that before the 1967 Arab-Israeli War, 15 percent of the world's total sea traffic passed through the canal.

Air Transport: Although Egypt had sixty-six airfields with paved runways, only the airports at Cairo and Alexandria handled international traffic. Egypt Air, the principal government airline, maintained an extensive international network and had domestic flights from Cairo and Alexandria to Luxor, Aswan, Abu Simbel (Abu Sunbul), and Al Ghardaqah on the Red Sea. In 1983, Egypt Air carried 1.6 million passengers. A smaller, state-owned airline, Air Sinai, provided service from Cairo to points in the Sinai Peninsula. Zas Passenger Service, the newest airline and the only one that was privately owned, had daily flights from Cairo to Aswan, Luxor, Al Ghardaqah, and points in Sinai.

2.4. ECONOMIC ACTIVITIES

Activity Rates: An activity rate is defined as the proportion of the total economically active (employed plus unemployed) population to the total working age population. In the Northern State of Sudan, downstream of Khartoum and part of the main Nile Sub-basin, 35% of the population was reported to be economically active. The refined activity rates for males and females were 69% and 6% respectively.

Unemployment Rates: In Egypt, the official unemployment rate in 2001-2002 was 9.2% although unofficial estimates suggest that it had reached almost 12%. The unemployment rate and duration of unemployment is highest among 15-30 year olds. In the northern region of Sudan, the unemployment rate among the economically active population is 9%, being 7% for males and 23% for females.

Agriculture: In Egypt the agricultural sector, fishing included, contributed 16 percent of the GDP in 2003. The most important crops include cotton, cereal grains, fruits and vegetables, and animal fodder. 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, and almost every piece of land growing at least two crops a year.

Industry: Industry, including manufacturing, mining, and construction, contributed 34 per cent of Egypt's GDP in 2003. The main manufactured goods are textiles, chemicals, metals, and petroleum products. More liberal economic policies have led to the establishment of a number of private companies involved in automobile assembly, electronics, consumer durable goods such as refrigerators and other appliances, and pharmaceuticals. The majority of factories are concentrated around the two major cities of Cairo and Alexandria and in industrial zones along the Suez Canal. Petroleum is Egypt's most important mineral product and a major source of export earnings. In the 1980s the government developed the production of natural gas for domestic energy needs. It began exporting natural gas in the 1990's. The main oil and gas fields are located along the Red Sea coast and in the Libyan Desert. Other minerals produced in Egypt include phosphate rock (a source of fertilizer), iron ore, and salt. The sector contributed 50 percent of the GDP in 2003. Important services include government social services such as health and education, financial services, and personal services.

Tourism: In Egypt, tourism is one of the most important economic sectors, attracting as many as 5.7 million tourists into the country in 2003 and providing US$4.6 billion in revenues. The tourism industry is made up entirely of privately owned businesses.

Fishery: Fishing is a significant industry in Egypt, given the large quantities of fish in the Nile, the Mediterranean Sea, and the Red Sea. It accounts for about 20 percent of both GDP and total exports, and about 34 percent of total employment.

2.5. AGRICULTURAL AND PEOPLE

Major Livelihood Activities of Ethnic Groups: The livelihoods of the Sudanese living in the main Nile sub-basin were devastated by the 1983/84 drought but many have returned and rebuilt their livelihoods. In the Egyptian side, there is little difference between the livelihoods of the two major ethnic groups in Egypt, being based on (i) charcoal production, (ii) sheep herding, (iii) camel herding, (iv) collecting medicinal plants and (v) residual moisture cultivation. There are seasonal differences: with charcoal production and sheep herding taking place between December and April, cultivation between May and September, and camel herding and medicinal plant collection throughout the year. In the hill areas to the east winter rains are common and people migrate there for sheep herding and charcoal production. Sacks are transported to Allaqi by camel and then either sold to truck drivers of a local quarry, AHDLA or WFP, or are taken on such lorries for sale.

Lake-shore cultivation: In 1989 the World Food Program (WFP) launched a joint program with the High Dam Lake Development Authority whereby WFP would provide food for work to reclaim land along the lake-shore for agriculture as well as for the eventual construction of 33,000 houses. By the mid-1990s 10,000 feddans had been reclaimed in three upper reservoir areas that Nubians had first attempted to pioneer in the late 1970s. Nubians, however, are only one of the people involved; others included non-Nubian fisher/farmers from Upper Egypt as well as Beja pastoralists from the eastern desert and the Red Sea coast who have begun to graze and water their stock around the edges of the reservoir.

Agricultural Development around Lake Nasser: There are two main strategies: (1) agricultural development above the high water level by pumping water; and (2) development of land below the full supply level using residual soil moisture and

supplementary irrigation (mobile pumps or temporary wells). The estimates of suitable land above the high water level vary from 0.103 million to 3.82 million feddans. Currently the first phase development is envisaged to be 50,000 feddans in four designated areas. Below the full storage level it is estimated that there is the potential to develop 200,000 feddans. Given the seasonal and year-on-year fluctuations in the Lake level and as a consequence the lateral area available for cultivation this figure is not fixed.

Agricultural development of the Tushka Project: The Tushka Project aims to develop some 500,000 feddans of land using water from the Sheik Fayed canal and from local groundwater resources. Much of this development will be large-scale and thus the numbers of people is likely to smaller than if this was a resettlement scheme for small farmers.

2.6. FORESTRY AND AGRO-FORESTRY

Most of the man-made forests (i.e., plantations) in Egypt are irrigated with treated sewage water, resulting in the production of trees with high quality timber. Some timber forests have been planted, and there are plans to cultivate 80 thousand feddans of forest-trees, adjacent to sewage water treatment plants in the desert. In addition, Egypt has developed, and is currently implementing, a strategy for combating desertification. This includes the establishment of nurseries for the afforestation of new roads, the improvement of existing plantings along roads, and the stabilization of sand dunes through tree planting.

2.7. POVERTY PROFILE

There are considerable regional disparities in the accessibility of social services in Egypt. The main features of access to social services are: the appropriation and concentration of most of the services in Cairo with the other urban governorates of Alexandria, Port Said and Suez combined running a distant second. Rural areas are mostly deprived of services, be it cultural, religious, health or entertainment.

Vulnerability is high, particularly for women, with domestic violence (beating, marital rape, and female genital mutilation) being a serious social problem in Egypt. In the business world, women are guaranteed pay equal to that of men, but there are strong societal pressures against women being employed. Many laws favour males, particularly inheritance laws, and men receive lighter sentences than women for similar crimes. Many governments-mandated labour laws are not enforced, such as minimum wages and maximum hours. Child labour was a serious problem in Egypt, but there has been marked improvement recently, although children, along with the elderly, prison inmates, AIDS patients, and minorities are among the most vulnerable groups in Egypt.

3. NATURAL RESOURCES AND ENVIRONMENTAL ISSUES

3.1. GEOLOGY

The main underlying geological formations within the Main Nile Sub-basin include the older Basement Complex rocks, the Nubian Sandstones, Tertiary unconsolidated sediments and recent superficial wind blown sands. The Basement Complex comprises gneisses, schists, marbles and intrusive granites and basic rocks. The Nubian Sandstones overlay Basement Complex rocks and comprises mainly sandstones, siltstones and conglomerates. This formation forms the main groundwater basins in Sudan and Egypt. Recent deposits include the Nile alluvium, sand dunes and the black clays of the flood plains.

3.2. SOILS

The Nile Delta and Valley soils are classified into three main orders namely: Entisols, Aridisols and vertisols. In the northeast on the hills and ridges of the Basement Complex rocks are shallow, stony, light-textured, low fertility and highly erodible Regosols, Leptosols and Phaeozems. Across the northern part of the sub-basin Arenosols are widespread and are derived from unconsolidated sediments. Their textures are very sandy. soils are deep but excessively well drained, and extremely susceptible to wind erosion. Where rock are near the surface these grade into shallow and stony Leptosols. Along the Nile River is a narrow band of Vertisols and Fluvisols.

The dominant soil types around Lake Nasser are Leptosols on rock and Arenosols derived from the cover sands. Locally Calcisols are found derived from crystalline limestones. In valley bottoms Fluvisols are very important as they comprise the main soils for irrigation around the Lake shore and in the Wadi Allaqi.

3.3. LAND COVER AND LAND USE

On nearly on 95% of the sub basin, a general desert or semi-desert conditions with little or no vegetation except along the wadis with high water table prevails as it falls below the 100 mm isohyets. Semi desert scrub exists in those areas of the sub basin that falls above the 100 mm isohyets and accounts only 5% of the sub basin. The Nile Delta area covers about 10,000 km^2 and extends for 175 kilometres from south to north and 220 kilometres from east to west along its base at the north. Most of the southern part is now cultivated, while a part of the northern delta is being occupied by extensive shallow lakes and marshes and in part consists of low-lying salty ground which is under reclamation.

3.4. VEGETATION

Vegetative Types

- **Desert:** North of the 75 mm isohyet generally desert or semi-desert conditions prevail with little or vegetation except along wadis with a high water table. Occasional years of very good rainfall can transform areas of desert into valuable grazing areas known as “gizzu”.

- **Semi-Desert Scrub:** Between the 75 and about 250 mm isohyets “Semi-desert Scrub” is the most prevalent vegetation type, and comprises a varying mixture of grasses and herbs, generally with a variable scatter of shrubs up to 4 meters high interspersed with bare earth. There is a zoning of vegetation around the Lake Nasser/Nubia from the water's edge. Normally, this stretches only tens to hundreds of meters from the Lake

shore but along the Wadi Allaqi this zoning has been stretched over some 30 kilometres from the lowest water mark recorded to the highest (177.5 masl). Annuals characterize the zone closest to the water's edge typically dominated by Glinus blitoides, together with Portulaca oleracea, Helianthemum spinum, Amaranthus blitoides and the grasses Erogrostis aegyptica, Fimbrystilis bis-umbellata and Crypsis schoenoides. In the middle zone Tamarix nilotica is dominant. In the central section the stands are mono-specific, and individual plants may be large, exceeding 5 meters. The highest zone is characterized by a vegetative type dominated by the composite shrub Pulicaria crispa that replaces T. nilotica. It appears to mark the highest levels attained by Lake Nasser. Associated with P. crispa are Acacia ahrenbergiana, A. raddiana, Cassia senna and Citrillus colocynthis.

3.5. WETLANDS

Egyptian wetlands are classified into two broad categories: coastal and inland wetlands. Depressions of western desert or other areas along the Nile valley can be further classified as either natural wetlands (Wadi el Natrun depression) or manmade wetlands (Siwa oasis).

3.6. LAKES

The River Nile has two main branches, and many man-made distribution canals and drains that collect drainage water from irrigated lands. These drains dump their water into four ancient depressions, forming lakes along the delta coast. These four lakes, Manzala (1160 km^2), Burullus(475 km^2), Edku (115 km^2), Qarun Lake (230 km^2), Wadi Al-Rayan (180 km^2) and Mariut (62.5 km^2), represent a vital economic resource in Egypt, due to their shallow depths and huge quantities of nutrient-rich water disposed from agriculture drainage.

Lake Manzala: 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.

Lake Burullus: The 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. Burullus Lake 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.

Edku Lake: It is the smallest northern delta lakes, with an area of about 27,470 feddans, and located about 30 kilometres to the northeast of Alexandria. Edku lake is the third most productive fishery among delta lakes, 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.

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.

3.7. WILDLIFE

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.

3.8. MAJOR ENVIRONMENTAL ISSUES RELATED TO WATER

Water quality: Due to intensive agricultural and industrial uses pollution is significantly higher and is important economic problem in the sub-basin. 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.

Water-related diseases: Routine testing has detected the following pathogens in Egyptian waters and sewage: salmonella, shigella, vibrio cholera, parasites, hepatitis A and E, viral gastroenteritis and poliomyelitis virus.

Soil Degradation and Contamination: The use of inefficient traditional irrigation techniques and the inadequacy of drainage systems have led to the increase in water logging and salinization. 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. Pollutants carried by irrigation water are also a major source of soil pollution and an estimated 50% 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.

Potential environmental impact of proposed agricultural development around Lake Nasser: There are a number of potential impacts that such a substantial development could have on the environmental with the Lake Nasser/Nubia catchments. The use of fertilizers and agro-chemicals and their leakages in drainage water into the Lake is an immediate and obvious concern. Currently, experience from the Wadi Allaqi indicates that the regular inundation of the Lake and the nutrients it brings with the sediment is sufficient to keep soils fertile, in particular in terms of nitrogen and phosphorous. But the use of chemical fertilizers and pesticides for large-scale commercial cultivation, can cause eutrophication in the lake. Large-scale agricultural development will bring with it a number of additional impacts. There will be a substantial rise in the population: some temporary such as the winter cultivators who come from the middle Nile Valley each year to grow vegetables on the residual moisture, but others permanent such as the labourers and support staff for the large-scale developments. These people will require housing and supporting utilities: electricity and water. This will require careful settlement and supporting infrastructure planning as well as adequate waste disposal facilities to prevent pollution of both the Lake and the groundwater resources.

Potential environmental impact of agricultural development of the Tushka Project: The Government has already installed strict regulations on the use of fertilizers and agro-chemicals. Nevertheless, there will need to be a comprehensive system of monitoring install at the outset if severe pollution of groundwater is to be prevented. Similarly, there

is a need for careful planning of settlements and supporting infrastructure and waste disposal facilities. The modelling by Jeongkon Kim and Mohamed Sultan (2002) to investigate the long-term hydrological impacts of the proposed large scale irrigation development in the Tushka Depression has indicated the danger to the Nubian aquifer of irrigation drainage water causing flooding and salinization. Again, a comprehensive system of groundwater monitoring should be in place at the outset if these negative impacts are to be avoided.

Threats to biodiversity: 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).

4. HYDROLOGY AND WATER INFRASTRUCTURE

4.1. SURFACE HYDROLOGY

River System: Except for the Sabaloka gorge about 80 kilometres north of Khartoum the main Nile flows through an arid plain with the occasional rocky outcrops. To the eastern edge of the sub-basin are the Red Sea Hills that rise in parts to 1,800 masl. On the western edge reaches up to a broad plateau in Northern Darfur and Northern Kordofan at about 1,500 masl. A large wadi, the Wadi el Milk, intermittently drains this area but fails to reach the Nile. The main feature is large loop made by the Nile River when it suddenly turns southwest-wards as far as Abu Dom before resuming its northerly course. The river profile shows a gentle gradient to the 5th Cataract, followed by a steep segment between the 5th and 4th cataracts. Again a more gentle gradient between cataracts 4 and 3, followed by a steep reach between cataracts 3 and 2 just above Wadi Halfa. The gradient is extremely variable: ranging between a minimum of 3.2 m per 10,000 and a maximum of 1 meter per 1,000. Average channel width is about 600 metres. Its only tributary along the way is the Tekeze-Atbara River at Atbara. Except in years of exceptional rainfall (e.g. August 1988) there is no other inflow. Between Khartoum and the AHD there are no dams except for on-going construction of the Meroe Dam at the Fourth Cataract.

Watershed Physiography: The main Nile starts its flow at Khartoum where the Blue Nile from the general east direction and the White Nile from a general south direction converge. Khartoum has an average altitude of 400 masl. Downstream of Khartoum, the Nile flows in a general north direction to the Mediterranean Sea through the Sabaloka gorge in the Sudan to meet its last tributary, the Tekeze-Setite-Atbara Sub-basin, at Atbara after traversing 325 kilometres. Downstream of Atbara it flows in a series of wide loops through an arid area of successive small waterfall and flatter river bed slopes.

The Nile enters Egypt through Dongola station, the last gauging station in the Sudan, then through the Nubian Lake, an extension of the Aswan/Lake Nasser in Sudan. The Aswan has an average altitude of 100 masl. The Nile has a total length of about 1532 kilometer inside Egypt, starting from Egypt-Sudan border in the south and ending at the Mediterranean Sea in the North with an altitude of 0 masl. The construction of Aswan High Dam has created Lake Nasser with a length of 500 kilometres (350 kilometres in Egypt and 150 kilometres in Sudan usually known as Lake Nubian). The lake has an average width of 12 kilometres and surface area of 6,000 square kilometres at the highest water level.

Downstream of the Aswan High Dam (HAD), to its mouth in the Mediterranean Sea has a total length of 1428 Kilometres sub divided into three major parts. The first part is located between the HAD and the Delta Barrage having a length of 946 kilometres. This upstream part is again sub-divided into four reaches separated by the historic barrages, namely Isna, Nag Hammadi, and Asyut barrages. At the apex of the delta, the Nile bifurcated into two branches, Damietta-the east branch and Rosetta the west branch. The length of Damietta branch is 246 kilometres and that of the Rosetta branch is 236 kilometres.

The width of the Nile differs from Aswan to Delta Barrages. Wherever Nile has one channel, its width varies between 300 meter and 650 meter, but it varies between 1200 and 1500 meter or more, along reaches, where the river flows in two or more channels, with central islands. In plan, the Nile is relatively straight with some sinuous reaches over short distances which are related to a steeper valley slope. The increase in sinuosity appears to occur with a valley slope in excess of 7 -10 centimetres per square kilometres.

There are about 356 islands in the Nile channel between Aswan and Cairo with an average of one island every 3 kilometres. This number includes all types of islands, permanent ones (defined as having permanent vegetation and are distinct from sand bars), the

submerged islands which appear only in low stage flow seasons, sand bar islands, and weed islands. Many islands are attached to the main bank of the river and the secondary channels are blocked in many parts of the river.

4.2. RUNOFF

The Nile at Khartoum: The flow passing the Khartoum node and entering to the main Nile is contributed from two major sub-basins, the Blue Nile that constitutes 66% of its flow enters the main Nile from the general east directions; and the White Nile constituting 34% of its flow enters from a general south direction. Mean annual flow contributed from the south sub-basins through the White Nile is averaged at 25 bcm and the inflow entering from the east sub watersheds through the Blue Nile is averaged at 48.7 bcm (long-term average taken as 50 bcm). This makes the mean annual inflow to the main Nile at the Khartoum to be 74.7 bcm.

The Nile at Atbara and Dongola Stations: The Nile receives a mean annual inflow of 12 bcm at Atbara from the Tekeze-Setite-Atbara Sub-basin that drains the northern highland plateaus of Ethiopia. At this node the mean annual inflow through the Main Nile is increased to 86.70 bcm. Between Atbara and Dongola stations, there is an abstraction of 1.2 bcm for the purpose of irrigated agriculture in Sudan, making the mean annual flow passing the Dongola station 85.6 bcm.

The base flow of Nile at Khartoum is of the same magnitude as the inflow coming from the general south direction indicating its base flow is largely coming from the White Nile. Similarly, the peak runoff at this junction is also with similar magnitude to the inflow coming from the general east direction indicating almost all of the peak runoff component is coming from the central and western highland plateaus of Ethiopia through the Blue Nile with some runoff elements added from the south western highland plateaus of Ethiopia through the Baro-Akobo Sub watershed. This data is also helpful to fairly conclude that the base flow in the Nile accounts nearly 40% and the peak runoff 60%. At Dongola station the gap between the peak runoff at the Nile and Blue Nile is wide indicating the contribution of the Atbara inflow to the peak runoff of the Nile inflow. The base flow component does not show much difference as the inflow coming from the northern highland plateaus of Ethiopia through the Tekeze-Setite-Atbara Sub-basin is more importantly a flushing runoff type with almost none and/or little base flow component.

The Nile Between the HAD and its Mouth: The water resources system downstream of the HAD abstracts mean annual flow of 55.5 bcm from the Nasser reservoir/Lake. Including the delta barrage, four barrages are constructed along the reach of the Nile downstream of the HAD to its mouth for the purpose of regulation and to facilitate abstractions in the system. Esna barrage is the first barrage located some 150 kilometres downstream of the HAD. At this node two canals, Asfoun in the left bank and Kelabia in the right bank, have been constructed and abstract water equivalent to 3 bcm, which makes the total mean annual abstraction at this node about 5 bcm. The mean annual inflow passing the Esna barrage is then deduced to be 5 bcm. The Naga Hammadi Barrage is the second barrage located some 400 km downstream of the HAD. Two canals, the east Naga Hammadi in the right bank and West Naga Hammadi in the left bank, are constructed to abstract mean annual inflow of 1 bcm and 2.8 bcm respectively. Mean annual inflow passing this node is thus deduced to be 46 bcm. The Asyut barrage is the third barrage in the system some 600 kilometres downstream of the HAD. Ibrahimia canal is the major abstraction located in the left bank with mean annual abstraction of 9.6 bcm, and along with pump abstraction with mean annual flow of 0.5 bcm, total mean abstraction at this node is 10 bcm. Mean annual inflow passing this node is thus 36 bcm. This inflow is equivalent to the inflow passing Cairo and entering the Delta Barrage.

The Delta barrages are located some 1,000 kilometres downstream of the HAD. The Lower Nile is bifurcated in to branches, the Rosetta branch in the left bank and the Damietta

branch in the right bank. These branches are usually known as the west and east branches respectively. In the east branch two barrages, Zifta and Farascour are located and Edfina barrage is located at the mouth of the west branch. Upstream of the Delta barrages, abstraction which is equivalent to mean annual inflow of 17.4 bcm is made both in the right and left banks of the system. Mean annual flow of 5.1 bcm is abstracted using the central canals located between the west and east branches. The west branch abstracts 3 bcm and the east branch abstracts 10 bcm which makes the total abstraction at the node 36 bcm.

4.4. INDICATIVE WATER BALANCE OF THE MAIN NILE SUB-BASIN

Mean annual inflow reaching the Aswan reservoir is estimated / recorded to be 84 bcm.The Blue Nile with mean annual inflow of 50 bcm contributes 60% of the inflow entering the Aswan reservoir. The White Nile with mean annual inflow of 26 bcm and Tekeze-Setit-Atbara with mean annual inflow of 12 bcm contributes 25% and 15% of the inflow entering the Aswan reservoir respectively. Mean annual evaporation from the Nasser Lake is averaged at 10 bcm, while at Aswan station it is 5.85 bcm, implying that water available for abstraction downstream of the HAD is 74 bcm. However, since mean annual abstraction for the water resources system in Egypt is averaged at 55.5 bcm, there is an imbalance in the system to the tune of 12 – 19 bcm.

4.5. GROUNDWATER

Three categories of ground water basins have been recognized based on the geological formations:

(1) Nubian Sandstone Basins; The Nubian sedimentary formation forms the most extensive and largest ground water basin in Sudan and Egypt. Although recharge from rainfall is very limited a substantial annual amount is received from the Nile River system. The quality is good to excellent with salinity values rarely exceeding 600 mg per litre.

(2) Dentrital Quaternary-Tertiary Basins: The Quaternary-Tertiary aquifers are located in a steep sided rifted basin in the Blue Nile Rift in Sennar State. The total annual recharge is estimated at 160 million cubic meters. Water quality is variable with local highly salinized zones.

(3) Recent Alluvium Basins: The alluvial basins are located along most seasonal streams and are recharged from rainfall and season flows. Water quality is generally good. Along the Gash and other streams shallow hand dug wells are used to irrigate small plots of vegetables.

In the Wadi Allaqi groundwater is from two sources: (1) deep percolating water from the Red Sea Hills, which is normally 30 meters below the surface and of poor quality; (2) from the Lake, usually available about 2 to 3 meters below the surface, of good quality and extremely sensitive with changes in Lake level (a 1-meter change in lake level causes a 1-km change in inundation of the Wadi).

4.6. WATER RESOURCES INFRASTRUCTURE

Existing Dam and Reservoirs: More than 95% of the Egypt water supply comes from the Nile sources. Currently major abstraction in the Nile system is made at four points using the historic barrages. The Aswan High Dam is the major water conservation dam in operation in the Main Nile Sub-Basin. It was constructed to meet the demand for high capacity storage of Nile waters for use downstream in Egypt. There is also the old Aswan

Dam, downstream of the HAD, built in 1902 which had been raised twice, the last one being in 1934 and with a final reservoir capacity of 5.1 bcm.

Potential water resource infrastructure: The Merowe Dam upstream of the Dongola station, in the Sudan, is under construction

4.7. HYDROPOWER GENERATION AND TRANSMISSION

Installed capacity: Both the HAD and the old Aswan Dam are used for the generation of hydroelectric power, which is connected to Cairo through the ultra-HV of 500 KV transmission line and the upper Egypt HV 220 & 132KVs. Historic barrages like Isna and Nag Hammadi are also used for production of hydropower energy. The major proportion of the hydropower energy production comes from HAD and the old Aswan Dam, but hydropower generation from the Nile system accounts only 20% with a total production of 14,425.61 GWH in Egypt.

APPENDIX 1: COMMENTS FROM COUNTRY ENSAP TEAMS

This appendix presents the comments received from the country ENSAP teams. Comments from Egypt are first presented, followed by comments from Ethiopia.

ARAB REPUBLIC OF EGYPT
Ministry of Water Resources
and Irrigation

EGYPT'S COMMENTS

on

THE ONE SYSTEM INVENTORY (OSI) DOCUMENT EASTERN NILE JOINT MULTIPURPOSE PROGRAM

Prepared by
THE NATIONAL REFERENCE GROUP

National NBI Office, EGYPT

May 2009

EGYPT'S COMMENTS

on

THE ONE SYSTEM INVENTORY (OSI) DOCUMENT
EASTERN NILE JOINT MULTIPURPOSE PROGRAM

Prepared by

THE NATIONAL REFERENCE GROUP

May 2009

1. INTRODUCTION

The Eastern Nile Joint-Multipurpose Program (JMP) seeks to promote the development of multi-country joint projects that benefits all riparian countries. The main objective of the One System Inventory (*OSI*) is to prepare a regional knowledge base which initially focuses on three primary themes (technical issues of water resources, socio-economic issues, and environmental issues) agreed upon by the three countries. The *OSI* includes full information that serves water resources management and development in the major four subbasins in the Eastern Nile (Baro-Akobo-Sobat and White Nile, Tekeze-Setit- Atbara, Blue Nile and the Main Nile).

The first draft of the *OSI* was prepared in 2007. It was then discussed in a regional consultation workshop in Addis Ababa, Ethiopia. A second modified version was prepared, presented and discussed in national consultative workshops organized by the three countries (Egypt, Ethiopia, and Sudan) in May 2009. The target of these three consultations was to improve the contents of the *OSI* including: information, data, graphs, tables, format and compilation, and the interactive CD tool kit. The National Consultation Meeting of Egypt was held during the period (5-6) May, 2009. During that meeting a large number of comments were raised on the detailed contents of the *OSI*. The JMP's National Reference Group (NRG) reported their written comments shortly after the meeting. Then, the National NBI Office consolidated all comments in this official report.

2. PURPOSE

The main use of the *OSI* is to serve the projects preparation of Nile Basin Initiative together with planning tools. Chief among these are the NBI's Decision Support System (DSS), Nile Information System (Nile IS), and the Eastern Nile

Planning Model (EN-PM). The *OSI* is expected to be a useful reference guide for all users in the Eastern Nile Countries as it provides those users with the required information, data, maps, graphs, and statistics.

This "*Report*" is prepared after profound review and discussion of the Draft *OSI* (presented in four sets of reports including annexes) by the JMP's National Reference Group (NRG) in May 2009. The purpose of this "Comment Report" is to enable ENTRO as well as the OSI's international consultant who was assigned to carry out the essential modifications and adjustments before 30 June 2009; which is the date determined by the financial agency to conclude this phase of financing the *OSI*. Furthermore, the outcome of the review "*the Comments Report*" could work as reference guide for ENTRO and the JMP consultants in all future updating, revision of the OSI. A second version of the *OSI (phase 2)* will be financed by the Eastern Nile's Planning Model Project starting July 1st , 2009, this will be revised before the end of this year to ensure that ENTRO will take into consideration all comments and recommendations included in the "*Comments Report of Egypt*".

3. GENERAL COMMENTS

The NRG was divided into three sub-groups in order to review the *OSI* from three different perspectives (water resources' technical issues, Environment issues, and Socio-economic issues). The sub-groups gave their own opinion on the reports, CD tool kit including the quality and clarity of information. The NRG agreed on the following general comments:

- There are several typing errors. Spelling of Egyptian cities needs to be reviewed and corrected (for example, Assuit).
- Fonts need to be bigger to become clear.
- Political borders, of Egypt are not accurate in all maps. Correct map of Egypt can be found at the web site (http://www.eip.gov.eg/AboutEgypt/EgyptMaps/egypt.gif). Alternatively political borders could be removed for the purpose of the *OSI*.
- Updating governorates data. As for Egypt, two new governorates: 6 October and Helwan are formulated (Need a new Map for Egypt's Governorates).
- There are a lot of missing data especially for Tekeze-Setit-Atbara Sub-Basin, Blue Nile Sub Basin, and Baro-Akobo-Sobat & White Sub-Basin. These data could be completed –for example- from the web site of the World Bank.
- Technical data regarding the rain fall, sedimentation and erosion, evaporation, etc... Need to be reviewed and referenced.

- Under institution in each sub basin, the document refers to Egypt only in every sub basin, nothing is mentioned about other countries.
- Under subtitle “Scientific Research Institution” there is no mention about the National Water Research Center (NWRC) or the National Research Center of Egypt. Instead the document included irrelevant institutes addresses (e.g., a Fashion Institute). Whereas, NWRC of Egypt is listed under water management.
- Location latitude and longitude need to be corrected in some maps.
- Evaporation rates cannot be more than 3.0 m/year. Please refer to Hand Book of Applied Hydrology by Van Te Chow.
- For some important technical data, especially in Ethiopia, can be found in IWMI working paper #131 and #132.
- There are differences concerning the intensity and level of details in the data reported among the three countries.
- There is no homogeneity among the three reports w.r.t formats, titles and subtitles.
- Data is not coherent and many gaps are found, throughout the report.
- Some analysis needs to be more specific and/or in-depth. Annual rainfall, for instance, is given at few locations and not on a monthly basis. The same applies for "river flow" which needs to be given in more detail (e.g. spatial and temporal variability).
- Data is presented only for the period from 1980 to 2000. Data prior to 1980 and until 2008, if available, should be added.
- The final version of the *OSI* should include the following additional data:
    - All published data in the Nile Basin covering the three countries.
    - Raw and processed data based on monthly time series at sufficient key locations in the three countries for:
        - Rainfall.
        - Rate of flow.
        - Water and bed levels.
        - Sediment transport.
    - At all existing dam sites and major hydraulic structures, time series data on monthly basis is to be furnished considering:
        - Water inflow and outflow.
        - Surface water and bed levels (upstream and downstream) all existing dam sites.
        - Sediment deposition rate at the upstream (reservoirs).

- Sediment transported to the downstream (TSS).

- Illiteracy rate is expressed in terms of number of citizens. Percentages might be a better option.
- The part of ethnic groups should be properly reviewed and edited.
- References should be given for each graph and tables.
- Recent information on sanitation, and access to clean water, could be obtained from the "UN Millennium Development Goals", available on the internet.
- Data is to be presented not only in graphical forms but also in tabular forms. The required tabular form is to be presented such that the user can copy the table and paste it using other software such as Excel.

4. SPECIFIC COMMENTS

4.1 The One System Inventory Annexes Reports

A. HYDROLOGY AND WATER INFRASTRUCTURE

Annex 1 : Baro Akobo Sobat and White Nile Sub-Basin

Page 8: Table 1, ***The Period of the mean annual inflow to be mentioned and it should match with the data in Annex 4.***

Page 12: Table 1.1 Upper Nile is repeated – the country Ethiopia and the four regional states should be mentioned to give area 76,742 km2 and the percentage 16% (***time was limited to check all the tables).***

Page 12: ***It has been noticed the Gilo River gives different name spelling Gila, Gilo, Gillo. It would be better if it is typed always in the same way. Also Jakau or Jokau or Jikawo.***

Page 13: Figure 1.3-Relief Map of Baro-Sobat-White Nile Sub-basin, ***there is no Legend.***

Page 16: Figure 1.4: Seasonal Rainfall Distribution at Masha Station (1980-96, 1998-2000), ***No statistical data are given (Max, Min, CV%, and Mon. Mean), Also for yearly totals (Max, Min, CV %).***

Page 19: Point 1.4.5 Evaporation, ***No Map is given for Evaporation.***

Page 20: Point 1.5 Humidity. ***No Statistical data, no period of records are given.***

Page 68: Table 4.3 shows the area of Baro-Akobo – Sobat. White Nile sub-basin 468,216 km2 ***while in page 8, it is mentioned 425,54 km2.***

Page 70: Although four patterns of streams are given for Pibor-Sobat system, ***the second zone has not been mentioned.***

Page 72: The first line in 4.2.1 is repeated. How far is the Pugindo gauging Station from the Gilo mouth?. There is big difference in the amount of flow (3.2 – 1.12 = 2.1 BCM) (page 71, 73). Is the difference attributed to spelling, abstraction, etc.

Page 72: The Hydrological Variability, ***the figure (4.5) is not presenting the annual runoff, and also for figure (4.4) there is no CV.***

Page 74: Figure 4.6: for the Annual Runoff Series of Gillo River near Pugnido, ***there is no CV***.

Page 75: For Alewero, Serkole and Tirmatid rivers for the Sobat River it ***should be shown on a map and a schematic for the Pibor is needed.***

Page 85: The mean annual runoff of the Pibor is mentioned (0.224 km3/yr), ***it should be checked***.

ANNEX 2: BLUE NILE SUB-BASIN

Page 9: Figure 1.4, Blue Nile Sub-basin: Relief and drainage, ***there is no Legend.***

Page 12: Figure 1.5: Mean Annual Rainfall Spatial Distribution (Isohyets), Blue Nile sub-basin, ***No statistical data are given (Max, Min, CV%, and Mon. Mean, No periods of records)***.

Page 13: Figure 1.7: Spatial Distribution of Temperature (Isolines) in the sub-basin, ***No periods of records are given.***

Page14: Figure 1.8: Spatial Distribution of Evaporation in the subbasi***n,No periods of records are given.***

Page 15: The Figure present the relative humidity has ***No title, No periods of records are given.***

Page 99: Figure 4.12: Seasonal Distribution and annual series of Runoff & Variability of Abbay at Kessie (1980-2000), ***No statistical data are given (Max, Min, CV%, and Mon. Mean).***

Page 100: Figure 4.13: Deddissa & Dabus Rivers at Arjo & Assossa, Seasonal Runoff Distribution & Variability (1980-2000), ***No statistical data are given (Max, Min, CV%, and Mon. Mean).***

Page 101: Figure 4.15: Seasonal Runoff Distribution & Variability, BN at the Border (1960-92, 1999-2003), ***No statistical data are given (Max, Min, CV%, and Mon. Mean).***

Page 102: Figure 4.16: Annual Runoff Series for BN at the Border (1960-92, 1999-2003), ***No statistical data are given (CV %).***

Page 103: Figure 4.17: Seasonal Distribution & Variability of Runoff for BN at Rosaries (1913-2000) and Figure 4.18: BN Annual Series of the Runoff at Rosaries Reservoir…), ***No statistical data are given (Max, Min for monthly Data, CV%, for yearly Data).***

Page 104: Figure 4.19: Rahad & Dindir rivers Seasonal Distribution of Runoff at their Respective mouth (After Sutcliffe & Parks Feb 1999) ***No statistical data are given for annual flows (CV %).***

Page 106: Figure 4.21: Annual Runoff Series BN at Khartoum (1980-2000), ***No statistical data are given for annual flows (CV%).***

Page 107: Point 4.2.8. Runoff in the sub-basin, ***Figure 4.22 that shows the spatial pattern of the mean annual runoff (mm/yr) in relation to the 3rd order catchment is missing.***

ANNEX 3: TEKEZE ATBARA SETIT SUB-BASIN

Page 11: Figure 1.2-Relief Map of Tekeze-Setit-Atbara Sub-basin, ***there is no Legend for the maps.***

Page 12: Table 1.3- Tekeze-Setit-Atbara Sub-basin: Major Catchments, ***it needs a map to show these Sub-basins.***

Page 14: Figure 1.3- Figure 1.4, ***it needs to show variation.***

Page 15: Figure 1.6- Mean Monthly Rainfall, Khashm-el-Girba (1980-2000), ***its n****eed to show Monthly Variation*.

Page 16: Figure1.7- Mean Annual Rainfall Spatial Distribution (Isohyets) map of the sub-basin, ***On the Map, where are Abi-Abi & Lali-Bela stations?.***

Page 17: Figure 1.8- Spatial Variation of PET in the TSA Sub-basin, ***Is this logic to have this jump from 1753 to 5431?.***

Page 18: Figure 1.9- Spatial Variation of temperature in the TSA Subbasin ***On the Map, where are Mekele, Lalibela and Endaselassie?.***

Page 19: Point 1.5 Humidity, ***No title or period of records is shown for the figure.***

Page 55: Table 4.3- Tekeze-Setit-Atbara Sub-basin: Area of third order catchments, ***it needs a map to show these Sub-basins.***

Page 56: Figure 4.1- Annual Runoff Series, Tekeze River at Embamadere Station, ***it needs to present the CV%.***

Page 57: Figure 4.4- Annual Runoff Series for Tekeze River at Humera Station (1980-90), ***it needs to present the CV%.***

Page 58: Figure 4.5- Annual Runoff Series of the TSA Sub-basin to the Main Nile at Atbara Station, ***Need to present the CV%, and a Map to show the location of Embamadera, Humera & Atbara Stations is also needed.***

ANNEX 4: MAIN NILE SUB-BASIN

Page 8: The area of the Main Nile sub-basin ***656,398 Km2 while mentioned in page 3 the area is 654,600 Km2.***

Page 9: Figure 1.5: Main Nile Sub-basin: Relief and drainage, ***there is no Legend for the map.***

Page 11: Figure 1.6: Mean Annual Rainfall Distribution (Isohyets) map for the Main Nile Sun-basin, ***these data are not correct for Cairo & Bani Suef (50-100 mm), these figures are misleading for the Rainfall Data. Correct data can be obtained from NOAA or any other authenticated weather forecast website.***

Page 13: Figure 1.8- Evaporation Iso-Line Map of the Sub-basin***, the figure is not correct at Aswan, Cairo, Port-Said, the corrected data are (Aswan 7.5 mm/day, Cairo 2.3 mm/day, Port Said 2.2 mm/day, Alexandria 2.0 mm/day)- (source: Nile Basin Vol 1)***

Page 54: The main annual inflow to the Nile at Khartoum as ***74.7 BCM is not correct. It should be written at upstream the confluence of Blue Nile and White Nile, it can be written at the gauge discharge station at Tamaniat. Also it should be corrected in table 4.1 page 56.***

Page 56: Table 4.1- Mean Monthly Inflows to the Main Nile between Khartoum & Dongola Stations (After J.V. Sutcliffe & Y.P. Parks, The Hydrology of the Nile, Feb, 1999), ***No statistical data are given (Max, Min, CV %), the comparison is not true because these flows are not natural, it is combination of Measured & Natural flows.***

Page 58: Lake Nasser mean evaporation is 10 BCM/year and the mean annual abstraction downstream of the AHD is 74 BCM. ***This is not correct***, ***as the piche or the pan coefficient is not accurate, that paragraph is to be deleted; also the question mark in Figure 4.6 is to be deleted.***

Page 59: The indicative water balance schematic ***should show clearly all the measuring stations and the abstractions from Khartoum to Aswan***.

Page 59: Figure 4.6- Indicative Water Balance Schematic for the Main Sub-basin, ***This figure did not show the abstractions***

of the river inside Sudan as shown in Egypt; it is misleading and not consistent. Correction should be made or remove the map until other two countries furnish its equivalent data.

B- NATURAL RESOURCES ENVIRONMENTAL ISSUES

ANNEX 1: BARO AKOBO SOBAT AND White Nile SUB-BASIN

Page 47: Figure 3.1, ***no legend for geological classification***.

Page 58: Point 3.9 minerals, ***no text.***

Page 58: Point 3.10.2. Water-quality, neither ***statistical data , nor period of record are given.***

Point 3.10.3. ***No text.***

Point 3.10.4. Water-related diseases, neither ***statistical, nor period of record are given.***

The natural resources part should include information about:

- ✓ Fisheries.
- ✓ Protected areas.

The Data addressed give a general overview and they are very short. There is no analysis done for the water quality, also no any data for industrial and agricultural pollution. No figure is given for the water related diseases. They mention only that malaria is the main disease page 58.

ANNEX 2: ABBAY-BLUE NILE SUB-BASIN

Page 52: Point 3.1.1, ***minerals are repeated in page 76 point 3.9.***

Page 66: Point 3.6.2 Aquatic flora and fauna ***is repeated in page 68 point 3.6.6.***

Point 3.6.3 zooplankton and benthos ***is repeated in page 69 point 3.6.7.***

Point 3.6.4 fish and other aquatic life, ***part of it is repeated in page 69 point 3.6.8.***

Page 68: Point 3.6.5 Endemic species is repeated in page 71 point 3.6.9.

Page 70: The last 4 paragraphs are repeated in the next page 71.

Page 72: Table 3.6 there are two columns named Abbay River?

Page 73: Table 4.7, ***the protected area is missing***.

Point 3.6.12, ***protected and conservation worthy areas are complement for the previous point.***

Page 77: Point 3.10.2. Water-quality, ***no statistical data, no period of record are given.***

Page 78: Point 3.10.3. Water-related diseases, ***no statistical data, no period of record are given.***

Page 83: Point 3.10.7. Development options for blue Nile, ***there is no relation to point 3.10 unless these projects have effects on the environment.(It is not described)***

Page 89: Point 3.11, ***Should be added to point 3.1.***

The data sets about for the aquatic flora and fauna in Mondays zooplankton are very poor, the indication of the presence of flue green and green algae which have negative effect on health - page (66-68). The water quality date present that the only analysis done is the turbidity, as using polymer has caused serious health risk to the consumers. This health risk needs recording (page 78).

ANNEX 3: TEKEZI ATBARA NILE SUB-BASIN

Page 49: Figure 3.4 and figure 3.5 ***are missing.***

Point 3.9. Fisheries, ***no statistical data, and no reference***.

Page 51: Point 3.11.1. Water-quality***, no statistical, and no period of record are given.***

Point 3.13.3. Water-related diseases, ***no statistical, and no period of record are given.***

Point 3.11.4. ***No map for soil degradation and no reference are given***.

The natural resources part should include information about:

- ✓ Aquatic flora and fauna.
- ✓ Protected areas.

The data of the major Environmental issues are weak, as the overview of Tekeze Atbara Setit sub-Basin are not including data for water quality, industrial and agricultural input pollution, water borne diseases, % cover of the populations using drinking water and sanitation system (Page 51).

ANNEX 4: MAIN NILE SUB-BASIN

Page 27: Point 3.2- Geology: ***There is no reference to the geological information.***

Point 3.2-Soil: ***there is no map for the soil classification. There is no reference for the soil information and there is no relation between the paragraphs.***

Page 29: Table 3.1: ***Not clear and no reference for it in the text. There is no reference for source of information and date of information.***

Point 3.3(land cover): ***There should be a map for the Land Cover, There is no reference for source of information for the land cover information.***

Point 3.4 (Vegetation): ***There is no reference for source of information of the vegetation, There is only point 3.4.1, The paragraphs need to be more organized and separated by titles, In the last paragraph what are the recent study??.***

Point 3.5(Wetland): ***There is no reference for the wetland information (the original reference should be mentioned), There is only point 3.4.1., The paragraphs need to be more organized and separated by sub-titles, What are the recent number of area because it changes from year to year.***

Page 32: Table 3.2: ***there is no reference for the table (the original reference should be mentioned).***

Page 33: Point 3.6.1 overview: ***The overview should include the efforts of protection of the River Nile from pollution.***

Page 34: ***The information in Tables 3.2 and 3.3 should be checked, All information in tables 3.4-3.5 are from the Ministry of State for Environmental Affairs since 1992.***

Page 36: Point 3.6.2 water related diseases; ***there is no reference for the information.*** The year of information in not mentioned.

<u>Data to be updated:</u>

Page 37: Point 3.7.Water quality, ***it is repeated in page 34 point 3.6.2.***

Point 3.7.3, ***no reference of source of this information is given.***

Point 3.7.4 1st paragraph***, Assessment of the results of the monitoring trip, who do this trip and what is the source of the results. Data to be updated***

Page 39: Point 3.7.5 (Soil Erosion), ***this effect in desert land but Delta and Wadi are not significantly affected by soil erosion.***

The number of water treatment plants 36 is not correct and there is no reference in page 38 also the number of the compact water treatment (308)is not correct.

Page 40: Point 3.8 (water Related Disease), ***the 1st paragraph is repeated on page 35, the second paragraph till end of this point is repeated in page 36.***

Point 3.9 (Industrial Pollution), it ***is repeated on page 34.***

Page 41: Point 3.9.1, according ***to environmental law no 4/1994 it is not allowed to drain on the Nile until downstream the treatment plant and it can be drain in the sewage network system***

Point 3.9.4, ***Table 3.6 the sources of information from Environmental work plan yr. 1992.***

Page 42: Tables 3.7, 3.8, and ***3.9, it is repeated in page 35***.

Page 43: Table 3.10, ***it doesn't mention the reference and date of information.***

Page 45: ***No reference is given for data established in this page. Figures (2, 3) is not found in the report.***

Page 47: Herbicides….***where is table (11)??***

For Table 3.10***, it doesn't mention the unit of the chemical fertilizer and the source of information.***

Table 3.11, ***it doesn't mention the source of information.***

Pesticides Residues in the River Nile….***where is table (16)??.***

Page 48: Drains and irrigation canals …from 2nd paragraph (as the study of drains…)***, what is the source of this study??.***

Page 49: Table 3.13, ***the reference and date of information are not mentioned.***

Coastal lakes, ***where is table (16)??***.

In last paragraph, the survey should be more updated than 1997

Page 50: Table 3.14, ***the reference and date of information are not mentioned.***

Page 51: Water logging/ salinity /sodicity….***where is figure (11)??***.

The natural resources part should include information about the following:

- ✓ Wild life.
- ✓ Fisheries.
- ✓ Mineral resource.
- ✓ Protected areas.
- ✓ Aquatic flora and fauna.

The natural part should include information about:

- ✓ Soil degradation.

C- SOCIO-ECONOMIC ISSUES

- Balance of data presentation in the report is to be maintained throughout the report.
- Very poor information is provided about the socio-economic issues in Sudan and Ethiopia although there are several authenticated sources available even on the web (www).
- No clear data is given about the socio economics characteristics.
- The information and data are old and need to be updated.
- The poverty measures in Egypt were presented in the reports without mentioning the socio-economic development indicators.
- There is no methodology mentioned for data exchange and sharing.
- The report should include socio-economic records of the present conditions and projection of future situations.
- Recent data of 2007 for economic features can be found at world bank website: http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/0,,menuPK:476823~pagePK:64165236~piPK:64165141~theSitePK:4 69372,00.html.

- The authenticated global reports were not used nor even mentioned (such as Human Resources Development Report – Sustainable Development Millennium Goals Report - …)
- The report needs to include the cited references for all mentioned numbers/record/graph/table/map/….

4.2 The One System Inventory CD Tool Kit Interface

The CD Kit Home Page:

- There is no BACK button on each page.
- Better to include maps without political borders (one system).
- Screens of the CD Tool Kit are crowded with text; it should be simple and user friendly to present all data information about the three countries.
- The first page is crowded with text. A simple table to compare the three introductory paragraphs is proposed as shown below:

	Egypt	**Ethiopia**	**Sudan**
Location	Upper North of Nile	Horn of Africa	North Eastern Africa
Boundaries	Mediterranean, Red Sea, Libya, Sudan	Eritrea, Djibouti, Somalia, Kenya, Sudan	Egypt, red sea, Eritrea, Ethiopia, Kenya, Uganda, DRC, CAR, Chad, Libya
Area (km2)	1,001,449 (997,739)	1,133,380	2,505,800
Topography	10% cultivable, 90 % desert, max length and width 1,105 and 1130 km	60% high land plateau > 1,800 amsl, split diagonally (Nile – north west) , drained by 12 major rivers	Max length and width 2,250 and 1,730 km
Area of Nile basin (km2)	96,772	-	50% of its total area, 74% of EN basin
Sub-basins	Main Nile, Abbay-Blue Nile, Takeze-Setit-Atbara, Baro-Akobo-Sobat-White Nile		

- The introductory map is not clear due to its extended size to cover areas out of interest. The text should be brief as the objective is to introduce more graphics – less text.

- When you hit the "***About***" button, you can hardly read the content due to dense text and choice of grey colors.

- You can't go back to the previous slide, you can only go home.

- The feature/tool that supposed to show the "Meta-Data–what type of information is where" is missing.

- The associated text throughout most of the Interface needs to be improved. In some parts it refers to tables and figures with misleading numbering sequence. This could be due to the copy/paste process from the original reports without reviewing or processing.

- In most of the text sections, there is no reference to the source or location in the detailed reports, in which user can go back for more detailed information.

- No "Glossary" is given to describe abbreviations used in displaying graphics such as CV and VI.

- The paragraph of water policies section under Institutional / Environment and water policies was just duplicated improperly under all other equivalent sub-basins.

- Moreover, the Academic Institutes information is improperly copied and repeated under all Sub-basins.

- In spite of presented rainfall data under Tekeze-Setit Atbara Sub-Basin, Water data are not found.

- The ***"About"*** key presents very detailed and repeated information. Moreover the readability of such text is weak.

- The data provided in the CD cannot be used elsewhere or processed in any digital form. It is read only.

- The data can be useful if it is extracted to be utilized in other calculations or introduced into other systems

- Some data furnished in the CD- Kit lacks of accuracy (names of sites, not up to date, missing units, …,)

- For example evapo-transpiration of Lake Nasser and Egypt's map that does not contain Halayeb and Shalateen.

- Stations at which data are visualized in tabular and graphical formats are very few although there are several other stations in Sudan and Ethiopia but are not included in the CD Kit.

The Social Characteristics

- When you hit 'more details' some graphs are not readable, even after enlargement.
- Sources of information are not mentioned.
- Main Nile Basin: ethnic groups map has no legend.
- The same column of three pictures appears on the left hand side of all basins in '***more details***'.
- Baro-Akobo-* basin: the ethnic/tribal tab has the map of poverty instead, and has no data under access to electricity.
- Blue Nile sub basin has no information under ethnic/tribal and no data under poverty, access to electricity, access to health services and Malaria.
- Tekeze-Setit-* sub-basin has no data under access to electricity.
- There should be a tool that allows comparison among the sub basins w.r.t. criteria in 'more details' in a form of table or map.
- There should be a view facility that allows the text size to be enlarged if the user wants to read the contents with ease.

Environment and Resource Based

- For Main Nile sub basin, Terrain column graph have extra decimal places of the y-axis values. Erosion and sedimentation do not show a map but a block diagram of sediment budget. Historical and cultural data are not found, and for wetlands/parks there is no map are given.
- Tekeze-Setit: flows, schematic, flood risk, historical and cultural, wetlands/parks have no data.
- Blue Nile sub basin: erosion and sedimentation and historical/cultural have no data.
- Baro-Akobo: flows, schematic, flood risk, historical/cultural have not data.

Economic Features

- Main Nile sub-basin: GDP, cultivated areas/crops have no data, crop water is mis-spelled.
- Tekeze-Setit sub-basin: GDP, towns and cities, hydropower/transmission, irrigation, crop water requirements, cultivated areas/crops have no data.
- Blue Nile sub-basin: GDP, agriculture (3 items) have no data.
- Baro-Akobo sub-basin: GDP, towns and cities, hydropower/transmission have no data.

Institutional Issues

- Main Nile sub-basin: development institutions have no data.
- Tekeze-Setit sub-basin: data are copied from the Main Nile sub-basin.
- Blue Nile sub-basin: with the exception of administrative and NGOs, data are copied from the Main Nile sub-basin.
- Baro-Akobo sub-basin: all data is copied from the Main Nile sub-basin.

5. DATA QUALITY AND CONSISTENCY

- It should be recognized that some data will be used for modeling and accuracy of output will depend on the quality of input data used.
- Sources of data and information should be mentioned.
- Global data basis created by international agencies could be used to expand and improve the OSI.
- The different studies developed under NBI (e.g. DSS and FAO reports) can improve the OSI through agreed procedures, mechanism and framework for data exchange.
- Quality of information could be improved while completing this ***OSI*** (phase 2) under Eastern Nile Planning Model; and different products for different purposes. Compatibility for integration with NEL region for NBI-DSS should be considered. Information should be communicated with others involved – the aim is to make an overall "Nile Basin One System Inventory".
- Same level of details should be maintained and balanced among the three countries in all issues.

- It should be announced in a transparent way who is falling behind in providing the required information.

6. RECCOMENDATIONS FOR FUTURE UPDATES

6.1 Recommendations for Updating Information and Data in Phase Two

- All data and information in the OSI Reports and Kit should be updated annually (presently information up to 2008/2009 is the target).
- Due to differences in time intervals covered by the data provided by each country, statistical parameters should be used for aggregation with note about the period covered.
- Data tables should present the time series, time periods, all statistical data.
- All maps should be with legends, presenting all the information shown.
- Sources of data should be mentioned.
- Get the missing data and information about Sudan.

6.2 Recommendations for Presenting the Data Parameters

6.2.1 Data presentation in the report

Monthly Data if any:

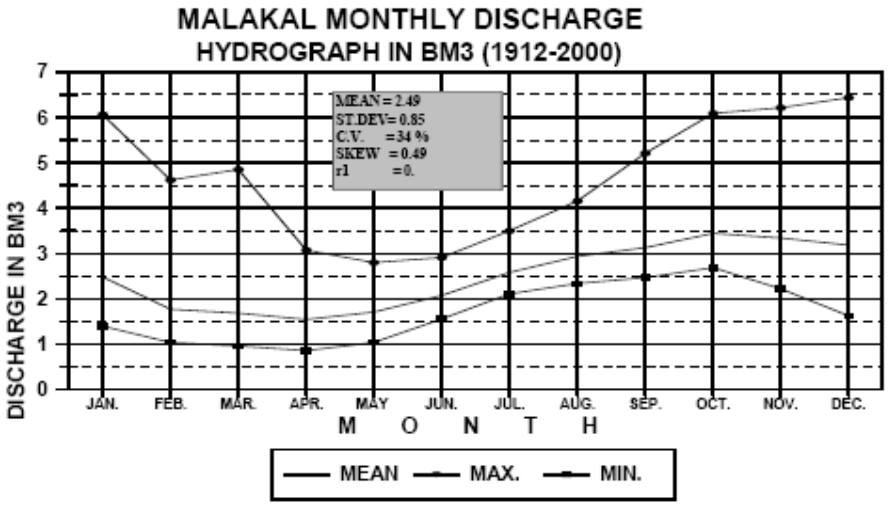
A table listed: station name in the title with units and parameter name, location, selected time span.

Year	Jan	Feb	Mar	…..	Nov	Dec	Average	Total	Remarks
Average									
St. Dev.									
C.V.									
Max.									
Min.									

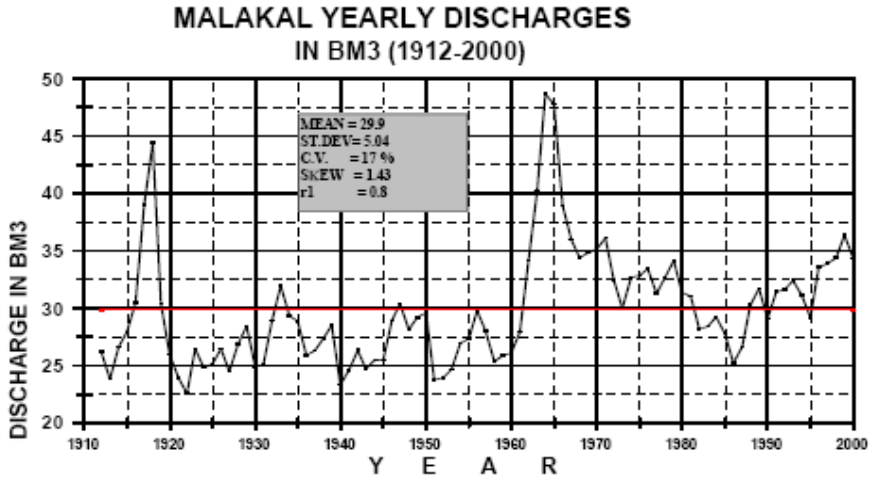
Different Parameters should be explained in ACRNM with their equation if any

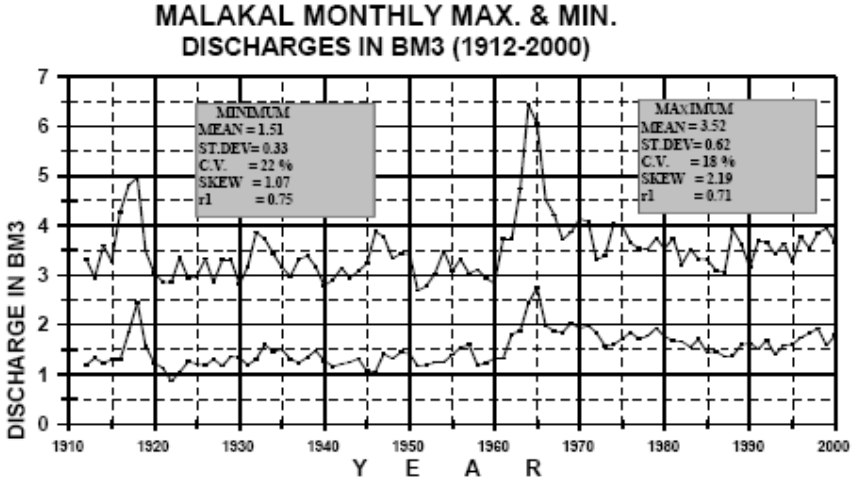
6.2.2 Graphs presentation in the report

Monthly Data if any: Location of Map, Yearly time series, Monthly Hydrograph (Mean, Max, Min) as shown below:



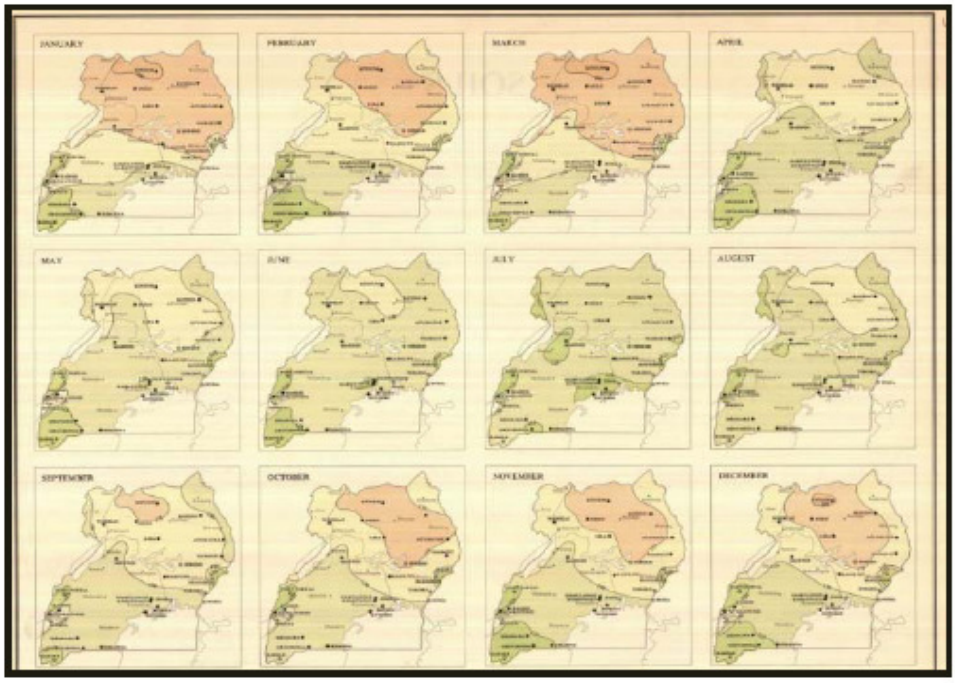
Yearly Data (only available): Location of Map, Yearly time series, Monthly Hydrograph (Mean, Max, Min) as shown below:

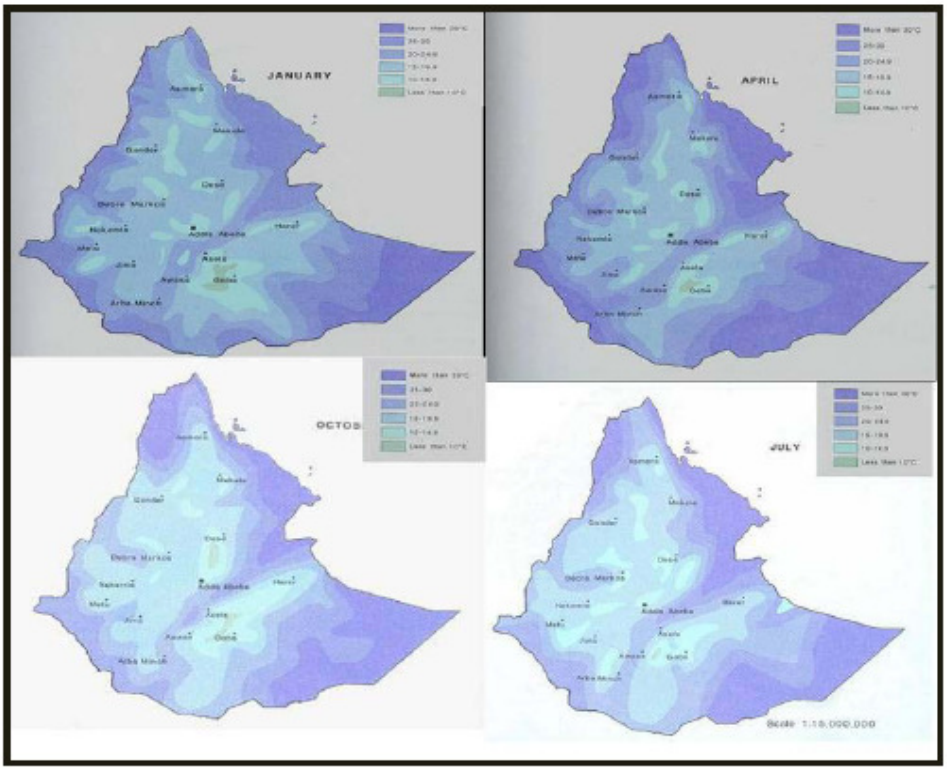




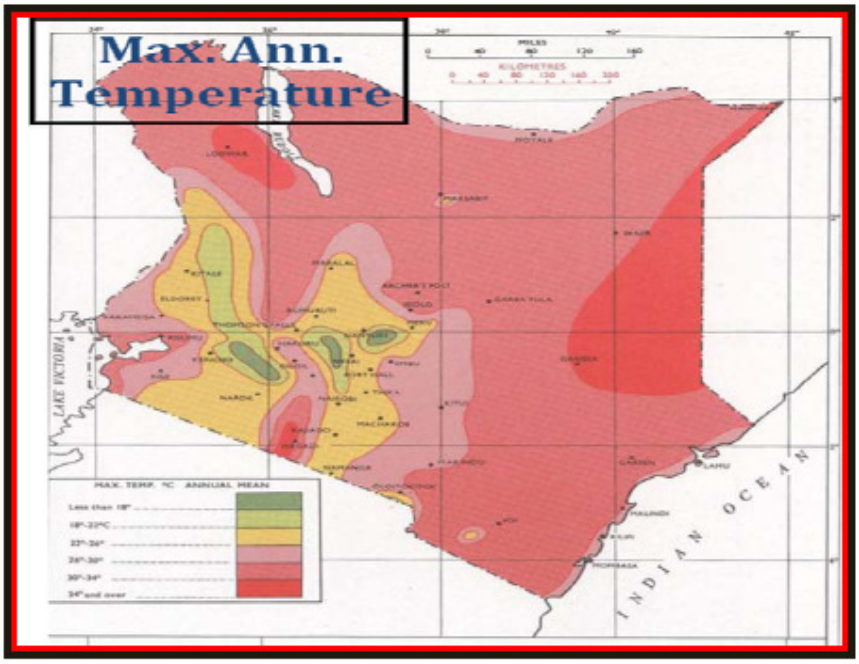
6.2.3 Maps presentation in the report

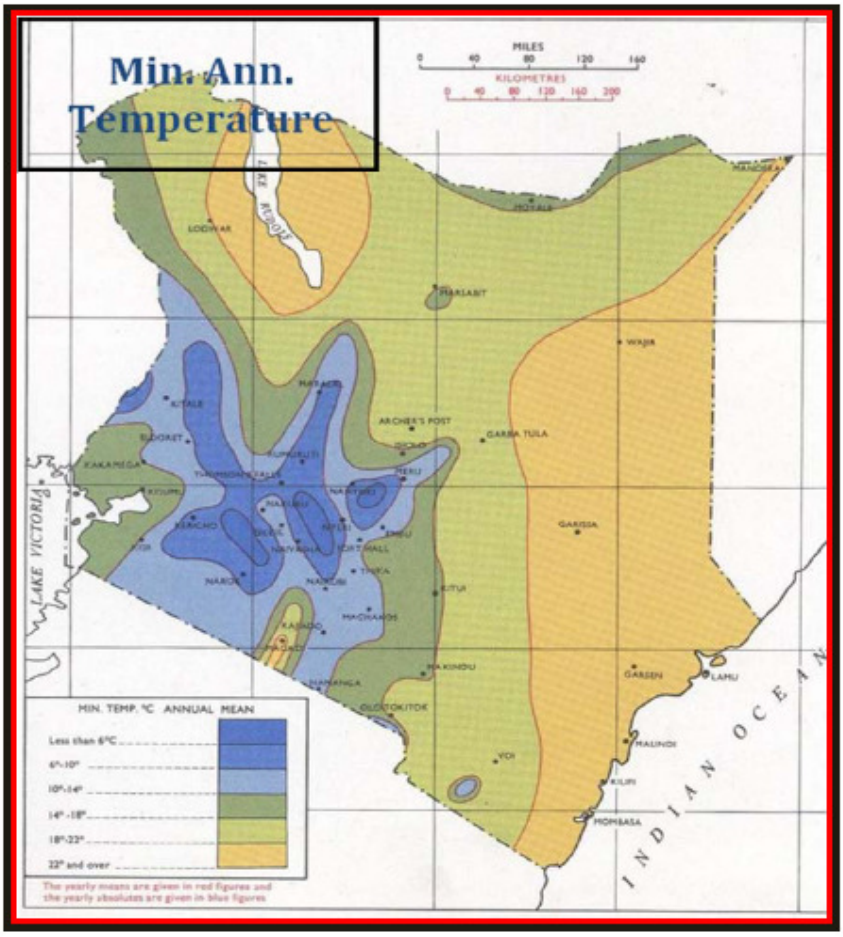
For Monthly Data for Meteorological data: monthly or group of months Maps to be shown as contours according the degree of variation of the parameters as below





Yearly Data for Meteorological data(only available): three Maps for (Max, Min, Mean) as contour maps as below:





6.3 Recommendations on the Natural Resources and Environmental Issues

- Cover the available environmental information and data of the three countries including (air, soil, water, and biodiversity).
- Environmental aspects of the River Nile in the three countries, including monitoring programs and stations along the Sub basins is needed.
- Environmental data need consistency and continuity over time in the three countries and mechanism of continuous updating of the data.
- OSI needs to be presented in a way to equally reflect the comparable resources and environmental issues and data in the Nile Basin.
- Develop indicators for quick assessment to be used by the OSI users, for a cost effective and sustainable system.

6.4 Recommendations on Socio-Economic Issues:

- The parameters under the "***Social Characteristics***" and "***Economic Features***" main headings of the OSI should not be in contradiction with those mentioned in the relevant credible national reports namely.
- The "***National Human Development Report***" produced annually by the Institute of National Planning (INP) and the UNDP. This report gives socio-economic parameters on the national as well as the governorate levels. A local Human Development report, produced by INP, gives those parameters at lower levels.
- The "***National Millennium Development Goals (MDGs) Report***" produced biannually by the Ministry of Economic Development and the UNDP. A recent edition was produced last year.
- "***A National Poverty Report***", produced also last year by UNDP and the Ministry of Economic Development.

7. NEXT STEPS

7.1 Updating the OSI

- Countries to provide information: to update and correct the information already in the ***OSI*** as lively document.

- New information sets need to differentiate between sources: countries, authenticated regional and international websites; or reports on studies by JMP.

- Using the new studies carried out (and will be carried out) within the scope of JMP (after countries endorsement) as additional source of data and information.

7.2 Sharing Information

- Facilitating discussions within NBI, ENTRO, Nile IS, DSS and WRPM to assure ***OSI*** as an integrated one shared system of information. This will furnish a good arena for optimum utilization of the ***OSI*** under all NBI activities.

ETHIOPIA

Multipurpose Development of the Eastern Nile

Comments on: Water Resources Related Data and Information Reports

Water Group

May 2009

General Comments

1. Collected datasets are limited to 20 years (1980-2000). A meaningful (hydro-met) analysis requires data beyond the specified time range.

2. Number of hydro-met stations considered in the country reports should cover all applicable stations in the sub-basins.

3. There is no uniformity in the country water reports. Say for example, information on exiting projects is detailed in some and not properly covered in others. Further consideration should be given for all identified projects.

4. Some facts and figures presented require verification and cross-checking.

5. Maps and tabular figures taken from existing sources should have proper citation and referencing.

6. Standard referencing and citation need to be used in all cases. Horizontal referencing b/n reports need to be avoided.

7. There are editorial errors to be checked.

8. Synthesis reports cover beyond the country water reports produced by the respective country consultants. In the background or introduction, the methodologies, procedures and sources used need to be indicated.

9. Data and figures say for example in irrigation mostly refer the master plan studies. Currently, the situation and assumptions (say for example on slope) on the ground is different and there is a need to account for this as it is a basis for the JMP. Updating is required.

10. Access to the time series data both for the specified period of 20 years and beyond is vitally important .

11. Redundancy of facts, figures and write-ups need to be avoided, particularly from synthesis and summary reports.

12. Important project reports need to be availed by all parties, similar to the availability of the master plan reports for Ethiopia.

13. The write-up of the sub-basin reports lack uniformity. Example tabular figures on land use are presented on Baro-Akobo-Sobat ,while it is lacking in the Main Nile sub-basin.

14. Data inconsistency is a concern. For the JMP relying on country availed data might be important. Yet to be validated if there are inconsistencies.

15. The presentation of the report based on Sub-basin approach visa-vi thematic need to considered.

16. Concepts like drought and precipitation anomalies need to be supported by proper analysis and statistical figures.

Specific Comments

1. Ethiopian part of the Nile basin comprises four river basins. However, the country water report neglects Mereb Basin.

2. On page 2, Fig. 1 shows the river basins of Ethiopia. On this map there are two fundamental errors:

    - The South-Western part of the Abbay basin and the Northern part of the Baro-Akobo basin are mixed up.

    - The basin named as Danakil-Aysha is only applicable for Danakil basin. Aysha basin is found in the eastern lower notch of the Awash Basin.

3. On page 42 it is mentioned that the Tekeze Basin has a catchment area of 59,067 km2.. This figure underestimates the size of the basin which is actually 82,350 km2.

4. On page 4 under section basin physical characteristics there is a statement that states "the consultant has concerns on the quality of these maps……" It links the case as if the state of the art for collection of such kind of data is new in Ethiopia. The fact on the ground is that the master plan studies are conducted by international consultants (BECOM, TAMS and ULG, and NEDECO) for which they used EMA standard geo-referencing that is applicable for Ethiopia

5. Annotated references mainly refers to the respective master plan studies. It is vitally important to include important documents like: Water Sector Development Program, Ethiopian Water Resources Management Policy and other national policy and strategy documents etc,

6. GIS maps on synthesis reports need to use standard color coding, for example the representation of temprature and ET maps is not proper.

7. Representation of features like sediment and actual evaporation by a rating curve is not technically valid, example on Baro sub-basin report.

8. On Page 10 and 11: Table 2 and Table 3 are titled "……..Data Quality and Availability". There is no quality related information on the tables. What is on the remark column is more of a data gap rather than quality. Quality is more to do on type of measurement, device used, and system of analysis and recoding.

9. Longitudinal river profiles need to be presented for all main rivers.

10. Page 37, Major issues in water resources development and management in Ethiopia: In this section points like food shortage and recurrent drought and alarming population growth have been mentioned as a reason for implementing the potential irrigable areas identified by the master plan studies. The erratic nature and spatial variability of rainfall and its impact on rainfed agriculture and the fact that rainfed agriculture alone can no longer guarantee food security and economic growth in Ethiopia should be mentioned.

11. On water report of Egypt captions of maps, figures and tables require sequential numbering, even some are without.

12. Maps presented on the same report are very general. No map is presented on the part of the Nile Basin that is applicable to it.

13. On the detailed report annexes there is inconsistency, say for example some of the reports cover existing programs and projects while the others not.

14. The accuracy and level of detail of the sub-basin reports need to be checked. Example the Baro-Akobo-Sobat Baisn (Water balance Model).

15. Data need to be availed on inter basin water transfer on country water reports

Summary Report on Sub-Basin

1. Installed capacity given for Fincha, Tis Abbay I and II are wrong.

2. It is stated that "the Alwero reservoir is currently used for both irrigation and hydropower". This basically wrong.

Meta Data Report

1. This document includes list of datasets and some of the referenced reports, which are within the premises of ENTRO library. However, to meet the purpose of a complete metadata, it should at least provide information on data quality, access procedures and who has such information.

2. There are quite a good number of references, which are cited by the authors of One-system Inventory country reports. Means of access to such documents and the inclusion of these to the list in the metadata document will be of a great help to the JMP.

Comments on Data collection and compilation of Environmental Reports for Easter Nile Subsidiary Action Program, Joint Multipurpose Program (JMP)

General Comments

- The Document required editing works (formatting, spelling, etc.)
- Most of the tables in the document do not have titles and sources, please check it.
- Under Legislation, Guideline and standards exhaustive review of other sectoral policies and guidelines is required. E.g. public health proclamation, solid waste management proclamation, water resource management proclamation, proclamation of Rural Land administration and land use, and etc.
- As Per the TOR the consultant is required to identify gaps and list the possible recommendation to fill the gap. However, in these report the document was failed to have such by- laws and illustrate weak gap identification in some section of the reports. Therefore please identify data gaps and bestow strong recommendations to fill the gap.
- Again as per the TOR, during this inventory works the consultant was required to depict a strong recommendation for the impacts presented, but he was failed to do so.
- The reports are prepared on 2006 and 2007. And hence they need updating.
- In view of realizing the concept of JMP 1 on the ground SEA guideline framework containing the following aspects among others is crucial.
    - The proposed set of criteria (i.e. Environmental, Social and Economic parameters).
    - Setting in place of threshold of acceptable limits of the water/environment quality.
    - Appropriate methodologies that would be followed to undertake SSEA.

The above preconditions would have importance in specifically determining the specific components projects which will be included in JMP 1 in the next level study and proceed to the preparation of these projects.

- It is recommended that the above set of preconditions to be either prepared by the consulting firms or Nile Eastern Trans-boundary Action Program (NETAP).
- The importance of presenting resettlement and the conflict emerging is not well cleared.
- The writer stick mostly on limited resources (MoWR of Ethiopia), but he is expected to see other relevant documents from EPA, Road Authority, ENTRO (CRA), EEPCo.

Specific Comments

Summary report by sub basin, January 2008

- From the overall reading of the reports of sub-basin it is observed that they contain insufficient data for some of the essential components of the study.
- If at all some of the data are somehow been lightly briefed in one sub-basin in others they have not been discussed at all. And hence they need further scrutiny.
- Key gaps in data and information that the consultant is required to fill and address in all sub-basins in a uniform manner with in the given schedule are the following among others.
    - Supporting the qualitative description of biophysical environment such as soil and water quality information with quantifiable data
    - Cultural and Historic environment (e.g. Monuments, Statues, Religious significant areas).
    - General health status of the population based on health indicators such as prevalence and incidence of major disease of concern (refer data from Ministry of Health).
    - Major health problem that may arise as the result of the development (e.g. Water and Vector borne disease).
    - Updating demographic indices based on population census data which has been undertaken recently.

- Population growth rate projection in all sub-basin based on appropriate technology.
- Loss of soil and Seismic data.
- Invasive alien species and their impacts on biodiversity, hydropower generation and other intervention areas.
- Water balance of all sub-basins.
- The ten top disease of concern in each sub –basin.

- *Accusation of the above quantifiable baseline information (i.e., both environment and social aspects) would have importance in objectively undertaking SSEA during the next phase study, i.e. identification stage.*

Synthesis of Environmental Assessment of Eastern Nile Sub- Basins, 2007

- It would have been better that this section is extended and making review analysis in the context of the project.
  - Accelerated poverty reduction program and Millennium Development Goal (MDG) master plan, land use plan, water policy, health policy, public health proclamation among others are required to be reviewed.
  - International Environmental treaties and conventions such as international plant protection convention.

- Some of the constraints that may contribute the JMP not to be translated on the ground are absence of:
  - Appropriate mechanism as to ensuring adequate and useful public involvement throughout the project cycle.
  - Scientific methods (e.g. environmental accounting, GIS, SEA, etc.)
  - Inadequate component managerial and technical resources.
- *In order to overcome the above constraints therefore, establishing ground work in terms of building the capacity of the basin is crucial. In this respect hence it is highly recommended that the Nile trans-boundary Environment Action Program(NTEAP) takes immediate action and develop certain instruments of application such as SEA,CEA, etc. at least at generic levels.*

- The level of environmental degradation (deforestation, soil loss) and the current protection efforts were not addressed, e.g. Tekeze sub- basin.

Data Collection and Compilation for the Environment Theme of ENSB in Ethiopia, 2006

- Page 15, first paragraph, it is possible to include the foreign investment as additional mandate for FEPA to undertake EIA.
- Page 20 first paragraph, what about the SNNPR, because this region had a department that is responsible for the environmental issue under the Regional agricultural bureau.
- Page 20: Naming of institution should be corrected.
- Page 20: write the scientific name in an standard way.
- Page 35: Table, No table name, and event it is difficult to understand why these areas were become sensitive and no clear information were placed. Therefore, it is better if there is some discussion on the text to clearly provide information about their sensitive nature.
- Page 36: the consultant tried to present critical information gap, so what, there should be some recommendation or opinion to avert the problem
  and to fill the gap. Not only this, it is also expected that the consultant to show his endeavor to review all the available information in the nation before providing such recommendation.
- Page 42, first line: please indicate other types of important mineral and place where they are found. This can be obtained from other recent study documents that have been undertaken in the Abbay basin and it is also possible to consult the Ethiopian ministry of Mine.
- Page 43 and 44: No table Title. The number and lists were not exhaustive, even please check whether this data was published or not. It is a rapid assessment data that was used for an official use; this should be checked and corrected.
- Page 45: 4.16, this section was wrote for the sake of completing the format and it was addressed carelessly and in a very low standard. Therefore, please rewrite the text under this section.
- Page 46: No table title and number. No source year and spelling error.

- Page 47: negative impact described under this table is not clear, please discuss sound impacts. Generally this table was not exhaustive and presented in a very less quality. Therefore, since the document is an inventory, you can have a lot of information from the various study documents.
- Page 55, 5.12: Here also the consultant made a general discussion, therefore please rewrite or supplement some information specific to the basin.
- Page 55 and 57, regarding irrigation of the basin it was treated at two different section, please check it and if possible merge together.
- Page 59: avoid repeated numbering: 5.17, 5.17.
- Page 61: no mitigation measures were proposed or listed for the indicated impacts, please check it and write the potential mitigation measures that help to reverse the situation in an environmental sound manner.

Comments on Socio-economic Characteristics of OSI and Synthesis Report

I. One System Inventory

Generally speaking, information, figures and data presented here are not accompanied with their respective sources (except very few).

1. Abbay- Blue Nile Sub-basin

1.1 Two conflicting area figures are presented on page 2 Table 1.1 and page 4 under the title of "The Location of the Sub-basin" (i.e. 313,657 km^2 and 311,548 km^2 respectively).

1.2. On page 6, under the "Demographic Characteristics", the third line states "Nearly two thirds the population of the sub- basin (30 million) is in Ethiopia, while the remaining 12 million being in Sudan. This requires correction as the sum of the two figures doesn't match with the figure in the other parts of the document (43 million).

1.3. On page 6, under the "Marital Status", the second line expresses "The majority of the ethnic groups in the Ethiopian side are Gumuz". This is wrong and the Gumuz could only become the third after the Amhara and Oromo ethnic groups.

1.4. On page 6, under the "Migration", the statement says "…In the Amhara region, **where people are considered relatively wealthier than other parts,** migration is

very low". This conclusion is not the result of the research findings and is based on Subjective judgment. Therefore, the underlined statement is to be better omitted.

1.5. On page 9, under the " Fishing", the statement says "Fishing is indispensable to the economy of the Baro- Akobo River on the Ethiopian side". This statement and others that follow it are irrelevant as they are talking about the sub-basin different from the Abbay-Blue Nile. Or fishing activities currently undertaken in the Lake Tana of the sub-basin are worth mentioning.

1.6. On page 9, under the "Mining", the second line states "currently, traditional gold mining (by planning) is widespread in Benishangul Gumuz in general, but very limited in the Mandaya Project affected woredas. The Mandaya Project is only on its pre- feasibility study phase and none has been invested so far to judge its adverse impact and the statement therefore lacks reliability.

1.7. On page 10, under the "Trade and Other Services", the statement describes "On the other hand, in Amhara project woredas, markets seem better organized". But if fails to explain which project and how.

1.8 Also check for the population figure of this document against the other documents.

2. Baro-Akobo-Sobat-White Nile Sub-basin

2.1. Page 4, under the "Location", the second line of the second paragraph explains "The sub-basin area in the Sudan is spread across 10 states, while that in Ethiopia cuts across 4 regional states. This is better explained if 10 states of Sudan and 4 regional states of Ethiopia (namely: Benishangul Gumuz, Gambella, Oromia and SNNPR) are mentioned by name.

2.2. On page 7, under the "Socio-economic Characteristics", line 5 explains "with in Ethiopia, the Amhara are predominant in the Amhara region, as the Oromo are in the Oromiya region, in the Benishangul Gumuz region, however, the Jabalaw, Komo, Mao and Gumuz together make up over half of the population". The first point is that the Amhara region is not inside this sub-basin and to be omitted from the list. Second, with the exception of those in Oromiya and Benishangul Gumuz, ethnic groups of the other two regions inside this sub-basin (of Gambella and SNNPR, like, Anuwak, Kafecho, Maji, Meenit Mejenger, Nuwer, Otto, Shekacho, and Surma) weren't mentioned. Third, the statement that says "the Jabalaw, Komo. Mao and Gumuz together make up over half of the population" is not based on the actual population and census data. Thus it requires correction or better to omit if the data is not available.

2.3. On page 9, under the "Access to Social Infrastructure", the statement is to be edited as "In Ethiopia, only 7% of the population is estimated to have access to sanitary latrines".

2.4. On page 9, under the "Health Facilities", the statement describes "There are few health centers and hospitals in the Baro-Akobo sub-basin: with only 2 hospitals and 11 health centers in Benishangul Gumuz region for a population size of 424, 432.

There is no data for other three regions of Ethiopia and the Sudan part of the sub-basin. The above data, therefore, weakly describes the sub-basin.

2.5 Also check for the population figure of this document against the other documents.

2. Tekeze-Setit-Atbara Sub-basin

3.1 On page 4, under the "Location of the Sub-basin", the second statement of paragraph two states that there are 8 states (are they really 8? or 3?) in the Sudan side of the sub-basin and 2 regions in the Ethiopian side. On the other hand, on page 6 of "Demographic Characteristics", the statement reads as"…while the second group lives in the Sudan comprising the three regional states of Nahr El nil, Kassala and El Gadarif". This data need to be corrected. And it would also better to mention the name of those states or regions found in the sub-basin of the two countries.

3.2 On the sixth line of the page 6, the statement explains "Total population of the sub-basin is estimated to be 8.47 million. This makes the sub-basin the third largest populated region of the three sub-basins of the Nile River, after the Main Nile and Abbay-Blue Nile sub-basins". The first point is that the population figure mentioned here is not confirmed with the one mentioned elsewhere. Second, in terms of the population data given in OSI, this sub-basin is the fourth largest populated region of the four sub-basins of the Nile River, after the Main Nile, Abbay-Blue Nile and Baro-Akobo-Sobat sub-basins.

3.3. On the same page, under the "Ethnic Groups", the second statement reads as "…The Ethiopian portion of the basin is predominantly inhabited by the Amharas (89.7%) and the Tigreans (94.8%), although there are also other smaller ethnic groups". This statement is not correct if it is not to mean that in their respective regions. Or if the percentage is to show the sub-basin figure of the Ethiopian side, it requires some modification.

3.4. On page 7, under the "Poverty Estimates", the statement that says "The poverty rates in Tigray are much higher than in Amhara", is incorrect as far as it is not associated with some research findings. Therefore, it is better to omit the statement.

3.5. Under the "Health Facilities", the fourth line sounds more if it is rewritten as " But the health coverage in Tigray is relatively higher than the Amhara region".

3.6 Also check for the population figure of this document against the other documents.

II. Socio-economic Synthesis Report

1. Executive Summary

4.8 On page 5, figures of Max and Min temperatures on Box 1 to be interchanged.

4.9 Population figures on Page 9 of this report and the one on OSI are quite different. This will create some confusion on the reliability of the data. Look at the following table.

Population in million (as presented in the OSI and Synthesis Report)

	Main Nile	Abbay-Blue Nile	Tekeze-Atbara	Baro-Akobo-Sobat	Total
OSI	**78.4**	**43**	**8.47**	**12.4**	**142.27**
Synthesis Report	**76.1**	**44.3**	**16.5**	**15.1**	**152**

1.3 On page 10, besides the ethnic groups mentioned, there are others including Komo, Mao, Maji, Meinet, Mejenger, Otto, Shekacho and Surma (in Gambella and SNNPR Regions). Therefore, advisable also to include them.

1.4 On page 10, the last statement of the last paragraph after the table states "The majority of the people living in the Baro-Akobo River Basin are Ethiopian Orthodox Christian, while a great number of the followers of the Islamic faith and Protestant Christian as well as those of traditional beliefs coexist in the wider region of the river basin". The conclusion is not drawn from the research findings or the population and census data. Therefore, it is preferable rather to put it in the following way: "In the Baro-Akobo river basin of the Ethiopian side significant number of Orthodox and Protestant Christians, Islam Faith as well as traditional beliefs followers co-exist".

1.5 The second paragraph on page 17 contains non relevant information. It says "In Ethiopia, the Gibe hydro power project is another development program underway in the Abbay basin, with a huge impact on the local population". The project is not inside the sub-basin and therefore the statement should be omitted.

1.6 The statement on the last paragraph of page 18 also to be revisited as it mixes some regulation issues not yet dealt with among countries. This one says "The 1959 Nile Water Aggrement permitted the Sudanese Government to utilize additional waters of the Nile Basin".

1.7 There is significant number of development projects currently underway in any of the three countries. In Ethiopia, the list can include the Koga Irrigation Scheme, Tana Beles Multi- purpose development project, Medium level Irrigation Projects of Rib and Megech. Similarly, the consultant is expected to include lists of the Sudan and Egypt.

2. Abbay-Blue-Nile Sub-basin

2.1 On page 35, under "Livelihood Profile", the last statement says "Employment opportunities in the public administration is the least in **Amhara (6.0%), relatively higher in Oromia (4.9%)** and the highest in Benishangul Gumuz (12.3%). This requires some correction.

2.2 On page 39, under "Educational Services", figures are misplaced for the statement says "Accordingly, in the academic year 2004/5, there were **293** teachers in primary school (grades 1 - 8) and **2,631** in secondary school (grades 9 - 12)"

2.3 The sixth line on page 42, under "Major Human Diseases", states "The incidence rates in Oromia and Amhara regions are 2.9% and **%** respectively".

2.4 The last statement on the third paragraph of page 53 is better if re-written as " Despite its economic significance for hydro power generation, the Tiss Abbay II hydro power project is reported to have similarly affected the scenic views of the falls, causing observers and local residents to express concerns about the possible impact on tourism potentials of the area and revenue from the sector". Because the original statement highlights only the negative impacts.

2.5 Similarly, the development projects currently underway, to be included as suggested to the Executive Summary Section of 1.7.

2.6 Points suggested to Executive Summary part (1.5 and 1.6) are also relevant here.

2.7 In Ethiopian part of the sub-basin, Abbay Basin Management Authority is in the process of establishment as the authority of enforcing regulation. It is good to include this statement in the regulatory section.

2.8 Also check for the population figure of this document against the other documents

3. Baro-Akobo-Sobat Sub-basin

3.1 Points suggested to Executive Summary part (1.3 and 1.4) are also relevant here.

3.2 Check the last paragraph of the page 113 against the suggestion given under 2.1, 2.2 and 2.4 of OSI.

3.3 Also check for the population figure of this document against the other documents.

4. Tekeze-Setit-Atbara Sub-baisn

4.1 Check for the population figure (including of pages 134 - 135) against the other documents.

4.2 On the second paragraph of page 140, the figures given to the Sudan States on the one hand and to Ethiopian Regions on the other and the conclusion drawn thereafter contradicts.

4.3 On the same page the statement says "The Ethiopian side of the basin (especially Tigray Regional State) appears to have done better in improving females' access to primary education compared to the Sudanese side of the basin where girls are lagging behind boys in all the three states". However, no female data is attached that could support the justification.

4.4 On page 141, under "Health Services", the statement reads as "Though it is not possible to trace information on the number of health facilities on the **Ethiopian** side of the basin, there are 393 health posts and clinics in Tigray Region while there are 1461 in Amhara. Ethiopia to be changed with Sudan.

4.5 The second paragraph of page 141 states "Only 15 hospitals and 48 health centers are

located in Tigray Region while there are 18 hospitals and 126 health services in **Oromia and** Amhara Regions. Oromia is place probably by mistake as this region is not inside the sub-basin.

APPENDIX 2: RESPONSES TO COUNTRY COMMENTS ON OSI ANNEXES AND TOOL KIT

I. ANNEXES and SUMMARIES

Comment	Action
EGYPT: GENERAL COMMENTS	
There are several typing errors. Spelling of Egyptian cities needs to be reviewed and corrected (for example, Assuit).	Check names with Dr. Sharif
Political borders, of Egypt are not accurate in all maps. Correct map of Egypt can be found at the web site (http://www.eip.gov.eg/AboutEgypt/EgyptMaps/egypt.gif). Alternatively political borders could be removed for the purpose of the *OSI*.	
Updating governorates data. As for Egypt, two new governorates: 6 October and Helwan are formulated (Need a new Map for Egypt's Governorates).	Check names with Dr. Sharif
There are a lot of missing data especially for Tekeze-Setit-Atbara Sub-Basin, Blue Nile Sub Basin, and Baro-Akobo-Sobat & White Sub-Basin. These data could be completed –for example- from the web site of the World Bank.	OSI 2
Technical data regarding the rain fall, sedimentation and erosion, evaporation, etc... Need to be reviewed and referenced.	OSI 2
Under institution in each sub basin, the document refers to Egypt only in every sub basin, nothing is mentioned about other countries.	Take from base OSI Reports
Under subtitle “Scientific Research Institution” there is no mention about the National Water Research Center (NWRC) or the National Research Center of Egypt. Instead the document included irrelevant institutes addresses (e.g., a Fashion Institute). Whereas, NWRC of Egypt is listed under water management.	Take from base OSI Reports
Location latitude and longitude need to be corrected in some maps.	
Evaporation rates cannot be more than 3.0 m/year. Please refer to Hand Book of Applied Hydrology by Van Te Chow.	OSI 2
For some important technical data, especially in Ethiopia, can be found in IWMI working paper #131 and #132.	Check
There are differences concerning the intensity and level of details in the data reported among the three countries.	OSI 2
There is no homogeneity among the three reports w.r.t formats, titles and subtitles.	Check
Data is not coherent and many gaps are found, throughout the report.	OSI 2

Comment	Action
Some analysis needs to be more specific and/or in-depth. Annual rainfall, for instance, is given at few locations and not on a monthly basis. The same applies for "river flow" which needs to be given in more detail (e.g. spatial and temporal variability).	OSI 2
Data is presented only for the period from 1980 to 2000. Data prior to 1980 and until 2008, if available, should be added.	OSI 2
The final version of the *OSI* should include the following additional data:	OSI 2
All published data in the Nile Basin covering the three countries.	OSI 2
Raw and processed data based on monthly time series at sufficient key locations in the three countries for rainfall, rate of flow, water and bed levels and sediment transport	OSI 2
At all existing dam sites and major hydraulic structures, time series data on monthly basis is to be furnished considering (1) Water inflow and outflow (2) Surface water and bed levels (upstream and downstream) all existing dam sites; (3) Sediment deposition rate at the upstream (reservoirs); (4) Sediment transported to the downstream (TSS)	OSI 2
Illiteracy rate is expressed in terms of number of citizens. Percentages might be a better option.	Check
The part of ethnic groups should be properly reviewed and edited.	Check
References should be given for each graph and tables.	Check
Recent information on access to sanitation and clean water can be obtained from the "UN Millennium Development Goals", available on the internet.	OSI 2
Data is to be presented not only in graphical forms but also in tabular forms. The required tabular form is to be presented such that the user can copy the table and paste it using other software such as Excel.	Done for all?
EGYPT SPECIFIC COMMENTS ON THE OSI ANNEXES	
A. HYDROLOGY AND WATER INFRASTRUCTURE	
Annex 1 : Baro Akobo Sobat and White Nile Sub-Basin	
Page 8: Table 1, *The Period of the mean annual inflow to be mentioned and it should match with the data in Annex 4.*	Possible?
Page 12: Table 1.1 Upper Nile is repeated – the country Ethiopia and the four regional states should be mentioned to give area 76,742 km2 and the percentage 16% (*time was limited to check all the tables).*	Check
Page 12: *It has been noticed the Gilo River gives different name spelling Gila, Gilo, Gillo. It would be better if it is typed always in the same way. Also Jakau or Jokau or Jikawo.*	Done
Page 13: Figure 1.3-Relief Map of Baro-Sobat-White Nile Sub-basin, *there is no Legend.*	Changed?
Page 16: Figure 1.4: Seasonal Rainfall Distribution at Masha Station (1980-96, 1998-2000), *No statistical data are given (Max, Min, CV%, and Mon. Mean), Also for yearly totals (Max, Min, CV %).*	OSI 2

Comment	Action
Page 19: Point 1.4.5 Evaporation, *No Map is given for Evaporation.*	OSI 2
Page 20: Point 1.5 Humidity. *No Statistical data, no period of records are given.*	OSI 2
Page 68: Table 4.3 shows the area of Baro-Akobo – Sobat. White Nile sub-basin 468,216 km2 *while in page 8, it is mentioned 425,54 km2.*	Done
Page 70: Although four patterns of streams are given for Pibor-Sobat system, *the second zone has not been mentioned.*	No data
Page 72: The first line in 4.2.1 is repeated. How far is the Pugindo gauging Station from the Gilo mouth?. There is big difference in the amount of flow (3.2 – 1.12 = 2.1 BCM) (page 71, 73). Is the difference attributed to spelling, abstraction, etc.	OSI 2
Page 72: The Hydrological Variability, *the figure (4.5) is not presenting the annual runoff, and also for figure (4.4) there is no CV.*	OSI 2
Page 74: Figure 4.6: for the Annual Runoff Series of Gillo River near Pugnido, *there is no CV.*	OSI 2
Page 75: For Alewero, Serkole and Tirmatid rivers for the Sobat River it *should be shown on a map and a schematic for the Pibor is needed.*	OSI 2
Page 85: The mean annual runoff of the Pibor is mentioned (0.224 km3/yr), *it should be checked.*	OSI 2
ANNEX 2: BLUE NILE SUB-BASIN	
Page 9: Figure 1.4, Blue Nile Sub-basin: Relief and drainage, *there is no Legend.*	Changed?
Page 12: Figure 1.5: Mean Annual Rainfall Spatial Distribution (Isohyets), Blue Nile sub-basin, *No statistical data are given (Max, Min, CV%, and Mon. Mean, No periods of records).*	OSI 2
Page 13: Figure 1.7: Spatial Distribution of Temperature (Isolines) in the sub-basin, *No periods of records are given.*	Check OSI Base Report
Page14: Figure 1.8: Spatial Distribution of Evaporation in the subbasi*n,No periods of records are given.*	Check OSI Base Report
Page 15: The Figure present the relative humidity has *No title, No periods of records are given.*	Check OSI Base Report
Page 99: Figure 4.12: Seasonal Distribution and annual series of Runoff & Variability of Abbay at Kessie (1980-2000), *No statistical data are given (Max, Min, CV%, and Mon. Mean).*	OSI 2
Page 100: Figure 4.13: Deddissa & Dabus Rivers at Arjo & Assossa, Seasonal Runoff Distribution & Variability (1980-2000), *No statistical data are given*	OSI 2

Comment	Action
(Max, Min, CV%, and Mon. Mean).	
Page 101: Figure 4.15: Seasonal Runoff Distribution & Variability, BN at the Border (1960-92, 1999-2003), *No statistical data are given (Max, Min, CV%, and Mon. Mean).*	OSI 2
Page 102: Figure 4.16: Annual Runoff Series for BN at the Border (1960-92, 1999-2003), *No statistical data are given (CV %).*	OSI 2
Page 103: Figure 4.17: Seasonal Distribution & Variability of Runoff for BN at Rosaries (1913-2000) and Figure 4.18: BN Annual Series of the Runoff at Rosaries Reservoir…), *No statistical data are given (Max, Min for monthly Data, CV%, for yearly Data).*	OSI 2
Page 104: Figure 4.19: Rahad & Dindir rivers Seasonal Distribution of Runoff at their Respective mouth (After Sutcliffe & Parks Feb 1999) *No statistical data are given for annual flows (CV %).*	OSI 2
Page 106: Figure 4.21: Annual Runoff Series BN at Khartoum (1980-2000), *No statistical data are given for annual flows (CV%).*	OSI 2
Page 107: Point 4.2.8. Runoff in the sub-basin, *Figure 4.22 that shows the spatial pattern of the mean annual runoff (mm/yr) in relation to the 3rd order catchment is missing.*	OSI 2
ANNEX 3: TEKEZE ATBARA SETIT SUB-BASIN	
Page 11: Figure 1.2-Relief Map of Tekeze-Setit-Atbara Sub-basin, *there is no Legend for the maps.*	Changed?
Page 12: Table 1.3- Tekeze-Setit-Atbara Sub-basin: Major Catchments, *it needs a map to show these Sub-basins.*	OSI 2
Page 14: Figure 1.3- Figure 1.4, *it needs to show variation.*	OSI 2
Page 15: Figure 1.6- Mean Monthly Rainfall, Khashm-el-Girba (1980-2000), *its need to show Monthly Variation.*	OSI 2
Page 16: Figure1.7- Mean Annual Rainfall Spatial Distribution (Isohyets) map of the sub-basin, *On the Map, where are Abi-Abi & Lali-Bela stations?.*	OSI 2
Page 17: Figure 1.8- Spatial Variation of PET in the TSA Sub-basin, *Is this logic to have this jump from 1753 to 5431?.*	OSI 2
Page 18: Figure 1.9- Spatial Variation of temperature in the TSA Subbasin *On the Map, where are Mekele, Lalibela and Endaselassie?.*	OSI 2
Page 19: Point 1.5 Humidity, *No title or period of records is shown for the figure.*	Check OSI Base Report
Page 55: Table 4.3- Tekeze-Setit-Atbara Sub-basin: Area of third order catchments, *it needs a map to show these Sub-basins.*	OSI 2
Page 56: Figure 4.1- Annual Runoff Series, Tekeze River at Embamadere Station, *it needs to present the CV%.*	OSI 2
Page 57: Figure 4.4- Annual Runoff Series for Tekeze River at Humera Station (1980-90), *it needs to present the CV%.*	OSI 2
Page 58: Figure 4.5- Annual Runoff Series of the TSA Sub-basin to the Main Nile at Atbara Station, *Need to present the CV%, and a Map to show the location*	OSI 2

Comment	Action
of Embamadera, Humera & Atbara Stations is also needed.	
ANNEX 4: MAIN NILE SUB-BASIN	
Page 8: The area of the Main Nile sub-basin *656,398 Km2 while mentioned in page 3 the area is 654,600 Km2.*	Done
Page 9: Figure 1.5: Main Nile Sub-basin: Relief and drainage, *there is no Legend for the map.*	Changed?
Page 11: Figure 1.6: Mean Annual Rainfall Distribution (Isohyets) map for the Main Nile Sun-basin, *these data are not correct for Cairo & Bani Suef (50-100 mm), these figures are misleading for the Rainfall Data. Correct data can be obtained from NOAA or any other authenticated weather forecast website.*	OSI 2
Page 13: Figure 1.8- Evaporation Iso-Line Map of the Sub-basin, *the figure is not correct at Aswan, Cairo, Port-Said, the corrected data are (Aswan 7.5 mm/day, Cairo 2.3 mm/day, Port Said 2.2 mm/day, Alexandria 2.0 mm/day)- (source: Nile Basin Vol 1)*	OSI 2
Page 54: The main annual inflow to the Nile at Khartoum as *74.7 BCM is not correct. It should be written at upstream the confluence of Blue Nile and White Nile, it can be written at the gauge discharge station at Tamaniat. Also it should be corrected in table 4.1 page 56.*	OSI 2
Page 56: Table 4.1- Mean Monthly Inflows to the Main Nile between Khartoum & Dongola Stations (After J.V. Sutcliffe & Y.P. Parks, The Hydrology of the Nile, Feb, 1999), *No statistical data are given (Max, Min, CV %), the comparison is not true because these flows are not natural, it is combination of Measured & Natural flows.*	OSI 2
Page 58: Lake Nasser mean evaporation is 10 BCM/year and the mean annual abstraction downstream of the AHD is 74 BCM. *This is not correct, as the piche or the pan coefficient is not accurate, that paragraph is to be deleted; also the question mark in Figure 4.6 is to be deleted.*	OSI 2
Page 59: The indicative water balance schematic *should show clearly all the measuring stations and the abstractions from Khartoum to Aswan.*	Re-do in OSI 2
Page 59: Figure 4.6- Indicative Water Balance Schematic for the Main Sub-basin, *This figure did not show the abstractions of the river inside Sudan as shown in Egypt; it is misleading and not consistent. Correction should be made or remove the map until other two countries furnish its equivalent data.*	Re-do in OSI 2
B- NATURAL RESOURCES ENVIRONMENTAL ISSUES	
ANNEX 1: BARO AKOBO SOBAT AND White Nile SUB-BASIN	
Page 47: Figure 3.1, *no legend for geological classification.*	Insert legend
Page 58: Point 3.9 minerals, *no text.*	Check
Page 58: Point 3.10.2. Water-quality, neither *statistical data , nor period of record are given.*	Check OSI base report
Point 3.10.3. *No text.*	Check

Comment	Action
Point 3.10.4.Water-related diseases, neither *statistical, nor period of record are given.*	Check OSI base report
The natural resources part should include information about (1) Fisheries and (2) Protected Areas	OSI 2
The Data addressed give a general overview and they are very short. There is no analysis done for the water quality, also no any data for industrial and agricultural pollution. No figure is given for the water related diseases. They mention only that malaria is the main disease page 58.	OSI 2
ANNEX 2: ABBAY-BLUE NILE SUB-BASIN	
Page 52: Point 3.1.1, *minerals are repeated in page 76 point 3.9.*	Done
Page 66: Point 3.6.2 Aquatic flora and fauna *is repeated in page 68 point 3.6.6.*	Done
Point 3.6.3 zooplankton and benthos *is repeated in page 69 point 3.6.7.*	Done
Point 3.6.4 fish and other aquatic life, *part of it is repeated in page 69 point 3.6.8.*	Done
Page 68: Point 3.6.5 Endemic species is repeated in page 71 point 3.6.9.	Done
Page 70: The last 4 paragraphs are repeated in the next page 71.	Done
Page 72: Table 3.6 there are two columns named Abbay River?	Done
Page 73: Table 4.7, *the protected area is missing.*	Done
Point 3.6.12, *protected and conservation worthy areas are complement for the previous point.*	Done
Page 77: Point 3.10.2. Water-quality, *no statistical data, no period of record are given.*	Check OSI base report
Page 78: Point 3.10.3. Water-related diseases, *no statistical data, no period of record are given.*	Check OSI base report
Page 83: Point 3.10.7. Development options for blue Nile, *there is no relation to point 3.10 unless these projects have effects on the environment.(It is not described)*	Deleted
Page 89: Point 3.11, *Should be added to point 3.1.*	Check
The data sets about for the aquatic flora and fauna in Mondays zooplankton are very poor, the indication of the presence of flue green and green algae which have negative effect on health - page (66-68). The water quality date present that the only analysis done is the turbidity, as using polymer has caused serious health risk to the consumers. This health risk needs recording (page 78).	OSI 2
ANNEX 3: TEKEZI ATBARA NILE SUB-BASIN	

Comment	Action
Page 49: Figure 3.4 and figure 3.5 *are missing.*	Check
Point 3.9. Fisheries, *no statistical data, and no reference.*	Check OSI base report
Page 51: Point 3.11.1. Water-quality*, no statistical, and no period of record are given.*	Check OSI base report
Point 3.13.3. Water-related diseases, *no statistical, and no period of record are given.*	Check OSI base report
Point 3.11.4. *No map for soil degradation and no reference are given.*	Check OSI base report
The natural resources part should include information about (1) Aquatic flora and fauna and (2) Protected areas	OSI 2
The data of the major Environmental issues are weak, as the overview of Tekeze Atbara Setit sub-Basin are not including data for water quality, industrial and agricultural input pollution, water borne diseases, % cover of the populations using drinking water and sanitation system (Page 51).	OSI 2
ANNEX 4: MAIN NILE SUB-BASIN	
Page 27: Point 3.2- Geology: *There is no reference to the geological information.*	Check OSI base report
Point 3.2-Soil: *there is no map for the soil classification. There is no reference for the soil information and there is no relation between the paragraphs.*	Check OSI base report Check text
Page 29: Table 3.1: *Not clear and no reference for it in the text. There is no reference for source of information and date of information.*	Check OSI base report
Point 3.3(land cover): *There should be a map for the Land Cover, There is no reference for source of information for the land cover information.*	Check OSI base report
Point 3.4 (Vegetation): *There is no reference for source of information of the vegetation, There is only point 3.4.1, The paragraphs need to be more organized and separated by titles, In the last paragraph what are the recent study??.*	Check OSI base report Check text
Point 3.5(Wetland): *There is no reference for the wetland information (the original reference should be mentioned), There is only point 3.4.1., The paragraphs need to be more organized and separated by sub-titles, What are the recent number of area because it changes from year to year.*	Check OSI base report Check text

Comment	Action
Page 32: Table 3.2: *there is no reference for the table (the original reference should be mentioned).*	Check OSI base report
Page 33: Point 3.6.1 overview: *The overview should include the efforts of protection of the River Nile from pollution.*	Check
Page 34: *The information in Tables 3.2 and 3.3 should be checked, All information in tables 3.4-3.5 are from the Ministry of State for Environmental Affairs since 1992.*	Check OSI base report
Page 36: Point 3.6.2 water related diseases; *there is no reference for the information.* The year of information in not mentioned.	Check OSI base report
Data to be updated:	
Page 37: Point 3.7.Water quality, *it is repeated in page 34 point 3.6.2.*	Done
Point 3.7.3, *no reference of source of this information is given.*	Check OSI base report
Point 3.7.4 1st paragraph, *Assessment of the results of the monitoring trip, who do this trip and what is the source of the results. Data to be updated*	Check OSI base report
Page 39: Point 3.7.5 (Soil Erosion), *this effect in desert land but Delta and Wadi are not significantly affected by soil erosion.*	Check
The number of water treatment plants 36 is not correct and there is no reference in page 38 also the number of the compact water treatment (308) is not correct.	OSI 2
Page 40: Point 3.8 (water Related Disease), *the 1st paragraph is repeated on page 35, the second paragraph till end of this point is repeated in page 36.*	Done
Point 3.9 (Industrial Pollution), it *is repeated on page 34.*	Done
Page 41: Point 3.9.1, according *to environmental law no 4/1994 it is not allowed to drain on the Nile until downstream the treatment plant and it can be drain in the sewage network system*	Check
Point 3.9.4, *Table 3.6 the sources of information from Environmental work plan yr. 1992.*	Check
Page 42: Tables 3.7, 3.8, and *3.9, it is repeated in page 35.*	Done
Page 43: Table 3.10, *it doesn't mention the reference and date of information.*	Check OSI base report
Page 45: *No reference is given for data established in this page. Figures (2, 3) is not found in the report.*	Check OSI base report
Page 47: Herbicides….*where is table (11)??*	Check OSI

Comment	Action
	base report
For Table 3.10, *it doesn't mention the unit of the chemical fertilizer and the source of information.*	Check OSI base report
Table 3.11, *it doesn't mention the source of information.*	Check OSI base report
Pesticides Residues in the River Nile….*where is table (16)??.*	Check OSI base report
Page 48: Drains and irrigation canals …from 2nd paragraph (as the study of drains…), *what is the source of this study??.*	Check OSI base report
Page 49: Table 3.13, *the reference and date of information are not mentioned.*	Check OSI base report
Coastal lakes, *where is table (16)??.*	Check OSI base report
In last paragraph, the survey should be more updated than 1997	OSI 2
Page 50: Table 3.14, *the reference and date of information are not mentioned.*	Check OSI base report
Page 51: Water logging/ salinity /sodicity….*where is figure (11)??.*	Check OSI base report
The natural resources part should include information about the following: (1) Wild life.; (2) Fisheries; (3) Mineral resource; (4) Protected areas (5) Aquatic flora and fauna; and (6) soil degradation	OSI 2
C- SOCIO-ECONOMIC ISSUES	
Balance of data presentation in the report is to be maintained throughout the report.	Check
Very poor information provided about socio-economic issues in Sudan & Ethiopia though there are several authenticated sources available on the web.	OSI 2
No clear data is given about the socio economics characteristics.	OSI 2
The information and data are old and need to be updated.	OSI 2
The poverty measures in Egypt were presented in the reports without mentioning the socio-economic development indicators.	OSI 2
There is no methodology mentioned for data exchange and sharing.	OSI 2

Comment	Action
The report should include socio-economic records of the present conditions and projection of future situations.	OSI 2
Recent data of 2007 for economic features can be found at world bank website: http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/0,,menuPK:476823~pagePK:64165236~piPK:64165141~theSitePK:469372,00.html.	OSI 2
The authenticated global reports were not used nor even mentioned (such as Human Resources Development Report – Sustainable Development Millennium Goals Report - …)	OSI 2
The report needs to include the cited references for all mentioned numbers/record/graph/table/map/….	Check OSI base reports
ETHIOPIA: GENERAL COMMENTS	
1. Collected datasets are limited to 20 years (1980-2000). A meaningful (hydro-met) analysis requires data beyond the specified time range.	OSI 2
2. Number of hydro-met stations considered in the country reports should cover all applicable stations in the sub-basins.	OSI 2
3. There is no uniformity in the country water reports. Say for example, information on exiting projects is detailed in some and not properly covered in others. Further consideration should be given for all identified projects.	OSI 2
4. Some facts and figures presented require verification and cross-checking.	OSI 2
5. Maps and tabular figures taken from existing sources should have proper citation and referencing.	Check OSI base reports
6. Standard referencing and citation need to be used in all cases. Horizontal referencing b/n reports need to be avoided.	Check OSI base reports
7. There are editorial errors to be checked.	Check
8. Synthesis reports cover beyond the country water reports produced by the respective country consultants. In the background or introduction, the methodologies, procedures and sources used need to be indicated.	Done
9. Data and figures say for example in irrigation mostly refer the master plan studies. Currently, the situation and assumptions (say for example on slope) on the ground is different and there is a need to account for this as it is a basis for the JMP. Updating is required.	OSI 2
10. Access to the time series data both for the specified period of 20 years and beyond is vitally important .	OSI 2
11. Redundancy of facts, figures and write-ups need to be avoided, particularly from synthesis and summary reports.	Check
12. Important project reports need to be availed by all parties, similar to the availability of the master plan reports for Ethiopia.	OSI 2
13. The write-up of the sub-basin reports lack uniformity. Example tabular figures on land use are presented on Baro-Akobo-Sobat ,while it is lacking in the	Check

Comment	Action
Main Nile sub-basin.	
14. Data inconsistency is a concern. For the JMP relying on country availed data might be important. Yet to be validated if there are inconsistencies.	OSI 2
15. The presentation of the report based on Sub-basin approach visa-vi thematic need to considered.	OSI 2
16. Concepts like drought and precipitation anomalies need to be supported by proper analysis and statistical figures	OSI 2
17. Ethiopian part of the Nile basin comprises four river basins. However, the country water report neglects Mereb Basin.	OSI 2
ETHIOPIA: SPECIFIC COMMENTS ON THE OSI ANNEXES AND SUMMARIES	
Water	
1. On page 2, Fig. 1 shows the river basins of Ethiopia. On this map there are two fundamental errors: (1) The South-Western part of the Abbay basin and the Northern part of the Baro-Akobo basin are mixed up; and (2) The basin named as Danakil-Aysha is only applicable for Danakil basin. Aysha basin is found in the eastern lower notch of the Awash Basin	Check
2. On page 42 it is mentioned that the Tekeze Basin has a catchment area of 59,067 km2.. This figure underestimates the size of the basin which is actually 82,350 km2.	Done
3. On page 4 under section basin physical characteristics there is a statement that states "the consultant has concerns on the quality of these maps……" It links the case as if the state of the art for collection of such kind of data is new in Ethiopia. The fact on the ground is that the master plan studies are conducted by international consultants (BECOM, TAMS and ULG, and NEDECO) for which they used EMA standard geo-referencing that is applicable for Ethiopia	Done
4. Annotated references mainly refers to the respective master plan studies. It is vitally important to include important documents like: Water Sector Development Program, Ethiopian Water Resources Management Policy and other national policy and strategy documents etc,	OSI 2
5. GIS maps on synthesis reports need to use standard color coding, for example the representation of temprature and ET maps is not proper.	Check
6. Representation of features like sediment and actual evaporation by a rating curve is not technically valid, example on Baro sub-basin report.	Check
7. On Page 10 and 11: Table 2 and Table 3 are titled "……..Data Quality and Availability". There is no quality related information on the tables. What is on the remark column is more of a data gap rather than quality. Quality is more to do on type of measurement, device used, and system of analysis and recoding.	Check
8. Longitudinal river profiles need to be presented for all main rivers.	OSI 2
9. Page 37, Major issues in water resources development and management in Ethiopia: In this section points like food shortage and recurrent drought and alarming population growth have been mentioned as a reason for implementing the potential irrigable areas identified by the master plan studies. The erratic nature and spatial variability of rainfall and its impact on rainfed agriculture and the fact that rainfed agriculture alone can no longer guarantee food security and economic growth in Ethiopia should be mentioned.	Done
10. On water report of Egypt captions of maps, figures and tables require sequential numbering, even some are without.	Check

Comment	Action
11. Maps presented on the same report are very general. No map is presented on the part of the Nile Basin that is applicable to it.	Check
12. Installed capacity given for Fincha, Tis Abbay I and II are wrong.	Check
13. It is stated that "the Alwero reservoir is currently used for both irrigation and hydropower". This basically wrong.	Check
14. This document includes list of datasets and some of the referenced reports	
15. There are quite a good number of references, which are cited by the authors of One-system Inventory country reports. Means of access to such documents and the inclusion of these to the list in the metadata document will be of a great help to the JMP.	Provide source
Environment: General	
1. The Document required editing works (formatting, spelling, etc.)	Check
2. Most of the tables in the document do not have titles and sources, please check it.	Check
3. Under Legislation, Guideline and standards exhaustive review of other sectoral policies and guidelines is required. E.g. public health proclamation, solid waste management proclamation, water resource management proclamation, proclamation of Rural Land administration and land use, and etc.	Check OSI Base Report
4. As Per the TOR the consultant is required to identify gaps and list the possible recommendation to fill the gap. However, in these report the document was failed to have such by- laws and illustrate weak gap identification in some section of the reports. Therefore please identify data gaps and bestow strong recommendations to fill the gap.	OSI 2
5. Again as per the TOR, during this inventory works the consultant was required to depict a strong recommendation for the impacts presented, but he was failed to do so.	None
6. The reports are prepared on 2006 and 2007. And hence they need updating.	OSI 2
7. In view of realizing the concept of JMP 1 on the ground SEA guideline framework containing the following aspects among others is crucial.	
The proposed set of criteria (i.e. Environmental, Social and Economic parameters).	OSI 2
Setting in place of threshold of acceptable limits of the water/environment quality.	OSI 2
Appropriate methodologies that would be followed to undertake SSEA.	OSI 2
The above preconditions would have importance in specifically determining the specific components projects which will be included in JMP 1 in the next level study and proceed to the preparation of these projects.	
8. It is recommended that the above set of preconditions to be either prepared by the consulting firms or Nile Eastern Trans-boundary Action Program (NETAP).	
9. The importance of presenting resettlement and the conflict emerging is not well cleared.	OSI 2

Comment	Action
10. The writer stick mostly on limited resources (MoWR of Ethiopia), but he is expected to see other relevant documents from EPA, Road Authority, ENTRO (CRA), EEPCo.	OSI 2
Environment: Summary OSI Report of Jan 2008	
From the overall reading of the reports of sub-basin it is observed that they contain insufficient data for some of the essential components of the study.	OSI 2
If at all some of the data are somehow been lightly briefed in one sub-basin in others they have not been discussed at all. And hence they need further scrutiny.	OSI 2
Key gaps in data and information that the consultant is required to fill and address in all sub-basins in a uniform manner with in the given schedule are the following among others.	OSI 2
Supporting the qualitative description of biophysical environment such as soil and water quality information with quantifiable data	OSI 2
Cultural and Historic environment (e.g. Monuments, Statues, Religious significant areas).	None
General health status of the population based on health indicators such as prevalence and incidence of major disease of concern (refer data from Ministry of Health).	OSI 2
Major health problem that may arise as the result of the development (e.g. Water and Vector borne disease).	OSI 2
Updating demographic indices based on population census data which has been undertaken recently.	OSI 2
Population growth rate projection in all sub-basin based on appropriate technology.	OSI 2
Loss of soil and Seismic data.	OSI 2
Invasive alien species and their impacts on biodiversity, hydropower generation and other intervention areas.	OSI 2
Water balance of all sub-basins.	OSI 2
The ten top disease of concern in each sub –basin.	OSI 2
Accusation of the above quantifiable baseline information (i.e., both environment and social aspects) would have importance in objectively undertaking SSEA during the next phase study, i.e. identification stage.	
Synthesis of Environmental Assessment of Eastern Nile Sub- Basins, 2007	
It would have been better that this section is extended and making review analysis in the context of the project.	OSI 2
Accelerated poverty reduction program and Millennium Development Goal (MDG) master plan, land use plan, water policy, health policy, public health proclamation among others are required to be reviewed.	OSI 2
International Environmental treaties and conventions such as international plant protection convention.	OSI 2

Comment	Action
Some of the constraints that may contribute the JMP not to be translated on the ground are absence of:	
Appropriate mechanism as to ensuring adequate and useful public involvement throughout the project cycle.	OSI 2
Scientific methods (e.g. environmental accounting, GIS, SEA, etc.)	OSI 2
Inadequate component managerial and technical resources.	OSI 2
In order to overcome the above constraints therefore, establishing ground work in terms of building the capacity of the basin is crucial. In this respect hence it is highly recommended that the Nile trans-boundary Environment Action Program(NTEAP) takes immediate action and develop certain instruments of application such as SEA,CEA, etc. at least at generic levels.	None
The level of environmental degradation (deforestation, soil loss) and the current protection efforts were not addressed, e.g. Tekeze sub- basin.	OSI 2
It would have been better that this section is extended and making review analysis in the context of the project.	OSI 2
Data Collection and Compilation for the Environment Theme of ENSB in Ethiopia, 2006	*Outdated*
Page 15, first paragraph, it is possible to include the foreign investment as additional mandate for FEPA to undertake EIA.	
Page 20 first paragraph, what about the SNNPR, because this region had a department that is responsible for the environmental issue under the Regional agricultural bureau.	
Page 20: Naming of institution should be corrected.	
Page 20: write the scientific name in an standard way.	
Page 35: Table, No table name, and event it is difficult to understand why these areas were become sensitive and no clear information were placed. Therefore, it is better if there is some discussion on the text to clearly provide information about their sensitive nature.	
Page 36: the consultant tried to present critical information gap, so what, there should be some recommendation or opinion to avert the problem and to fill the gap. Not only this, it is also expected that the consultant to show his endeavor to review all the available information in the nation before providing such recommendation.	
Page 42, first line: please indicate other types of important mineral and place where they are found. This can be obtained from other recent study documents that have been undertaken in the Abbay basin and it is also possible to consult the Ethiopian ministry of Mine.	
Page 43 and 44: No table Title. The number and lists were not exhaustive, even please check whether this data was published or not. It is a rapid assessment data that was used for an official use; this should be checked and corrected.	
Page 45: 4.16, this section was wrote for the sake of completing the format and it was addressed carelessly and in a very low standard. Therefore, please rewrite the text under this section.	
Page 46: No table title and number. No source year and spelling error.	

Comment	Action
Page 47: negative impact described under this table is not clear, please discuss sound impacts. Generally this table was not exhaustive and presented in a very less quality. Therefore, since the document is an inventory, you can have a lot of information from the various study documents.	
Page 55, 5.12: Here also the consultant made a general discussion, therefore please rewrite or supplement some information specific to the basin.	
Page 55 and 57, regarding irrigation of the basin it was treated at two different section, please check it and if possible merge together.	
Page 59: avoid repeated numbering: 5.17, 5.17.	
Page 61: no mitigation measures were proposed or listed for the indicated impacts, please check it and write the potential mitigation measures that help to reverse the situation in an environmental sound manner.	
Socio-economic Characteristics	
1. Abbay- Blue Nile Sub-basin	
1.1 Two conflicting area figures are presented on page 2 Table 1.1 and page 4 under the title of "The Location of the Sub-basin" (i.e. 313,657 km^2 and 311,548 km^2 respectively).	Done
1.2. On page 6, under the "Demographic Characteristics", the third line states "Nearly two thirds the population of the sub- basin (30 million) is in Ethiopia, while the remaining 12 million being in Sudan. This requires correction as the sum of the two figures doesn't match with the figure in the other parts of the document (43 million).	Done
1.3. On page 6, under the "Marital Status", the second line expresses "The majority of the ethnic groups in the Ethiopian side are Gumuz". This is wrong and the Gumuz could only become the third after the Amhara and Oromo ethnic groups	Done
1.4. On page 6, under the "Migration", the statement says "…In the Amhara region, where people are considered relatively wealthier than other parts, migration is very low". This conclusion is not the result of the research findings and is based on Subjective judgment. Therefore, the underlined statement is to be better omitted.	Done
1.5. On page 9, under the " Fishing", the statement says "Fishing is indispensable to the economy of the Baro- Akobo River on the Ethiopian side". This statement and others that follow it are irrelevant as they are talking about the sub-basin different from the Abbay-Blue Nile. Or fishing activities currently undertaken in the Lake Tana of the sub-basin are worth mentioning.	Done
1.6. On page 9, under the "Mining", the second line states "currently, traditional gold mining (by planning) is widespread in Benishangul Gumuz in general, but very limited in the Mandaya Project affected woredas. The Mandaya Project is only on its pre- feasibility study phase and none has been invested so far to judge its adverse impact and the statement therefore lacks reliability.	Done
1.7. On page 10, under the "Trade and Other Services", the statement describes "On the other hand, in Amhara project woredas, markets seem better organized". But if fails to explain which project and how.	Done
1.8 Also check for the population figure of this document against the other documents.	OSI 2

Comment	Action
2. Baro-Akobo-Sobat-White Nile Sub-basin	
2.1. Page 4, under the "Location", the second line of the second paragraph explains "The sub-basin area in the Sudan is spread across 10 states, while that in Ethiopia cuts across 4 regional states. This is better explained if 10 states of Sudan and 4 regional states of Ethiopia (namely: Benishangul Gumuz, Gambella, Oromia and SNNPR) are mentioned by name.	Done
2.2. On page 7, under the "Socio-economic Characteristics", line 5 explains "with in Ethiopia, the Amhara are predominant in the Amhara region, as the Oromo are in the Oromiya region, in the Benishangul Gumuz region, however, the Jabalaw, Komo, Mao and Gumuz together make up over half of the population". The first point is that the Amhara region is not inside this sub-basin and to be omitted from the list. Second, with the exception of those in Oromiya and Benishangul Gumuz, ethnic groups of the other two regions inside this sub-basin (of Gambella and SNNPR, like, Anuwak, Kafecho, Maji, Meenit Mejenger, Nuwer, Otto, Shekacho, and Surma) weren't mentioned. Third, the statement that says "the Jabalaw, Komo. Mao and Gumuz together make up over half of the population" is not based on the actual population and census data. Thus it requires correction or better to omit if the data is not available.	Done
2.3. On page 9, under the "Access to Social Infrastructure", the statement is to be edited as "In Ethiopia, only 7% of the population is estimated to have access to sanitary latrines".	Done
2.4. On page 9, under the "Health Facilities", the statement describes "There are few health centers and hospitals in the Baro-Akobo sub-basin: with only 2 hospitals and 11 health centers in Benishangul Gumuz region for a population size of 424, 432. There is no data for other three regions of Ethiopia and the Sudan part of the sub- basin. The above data, therefore, weakly describes the sub-basin.	Done
2.5 Also check for the population figure of this document against the other documents.	OSI 2
3. Tekeze-Setit-Atbara Sub-basin	
3.1 On page 4, under the "Location of the Sub-basin", the second statement of paragraph two states that there are 8 states (are they really 8? or 3?) in the Sudan side of the sub- basin and 2 regions in the Ethiopian side. On the other hand, on page 6 of "Demographic Characteristics", the statement reads as"…while the second group lives in the Sudan comprising the three regional states of Nahr El nil, Kassala and El Gadarif". This data need to be corrected. And it would also better to mention the name of those states or regions found in the sub-basin of the two countries.	Done
3.2 On the sixth line of the page 6, the statement explains "Total population of the sub-basin is estimated to be 8.47 million. This makes the sub-basin the third largest populated region of the three sub-basins of the Nile River, after the Main Nile and Abbay-Blue Nile sub-basins". The first point is that the population figure mentioned here is not confirmed with the one mentioned elsewhere. Second, in terms of the population data given in OSI, this sub-basin is the fourth largest populated region of the four sub-basins of the Nile River, after the Main Nile, Abbay-Blue Nile and Baro-Akobo-Sobat sub-basins.	Done
3.3. On the same page, under the "Ethnic Groups", the second statement reads as "…The Ethiopian portion of the basin is predominantly inhabited by the Amharas (89.7%) and the Tigreans (94.8%), although there are also other smaller ethnic groups". This statement is not correct if it is not to mean that in their respective regions. Or if the percentage is to show the sub-basin figure of the Ethiopian side, it requires some modification.	Done
3.4. On page 7, under the "Poverty Estimates", the statement that says "The poverty rates in Tigray are much higher than in Amhara", is incorrect as far as it is not associated with some research findings. Therefore, it is better to omit the statement.	Done
3.5. Under the "Health Facilities", the fourth line sounds more if it is rewritten as "But the health coverage in Tigray is relatively higher than the Amhara	Done

<table>
<tr><th>Comment</th><th>Action</th></tr>
<tr><td>region”.</td><td></td></tr>
<tr><td>3.6 Also check for the population figure of this document against the other documents.</td><td>OSI 2</td></tr>
<tr><td>SOCIO-ECONOMIC SYNTHESIS REPORT</td><td></td></tr>
<tr><td>1. Executive Summary</td><td></td></tr>
<tr><td>On page 5, figures of Max and Min temperatures on Box 1 to be interchanged.</td><td>Check</td></tr>
<tr><td>Population figures on Page 9 of this report and the one on OSI are quite different. This will create some confusion on the reliability of the data. Look at the following table.
Population in million (as presented in the OSI and Synthesis Report)
<table>
<tr><td></td><td>Main Nile</td><td>Abbay-Blue Nile</td><td>Tekeze-Atbara</td><td>Baro-Akobo-Sobat</td><td>Total</td></tr>
<tr><td>OSI</td><td>78.4</td><td>43</td><td>8.47</td><td>12.4</td><td>142.27</td></tr>
<tr><td>Synthesis Report</td><td>76.1</td><td>44.3</td><td>16.5</td><td>15.1</td><td>152</td></tr>
</table>
</td><td>Check</td></tr>
<tr><td>1.3 On page 10, besides the ethnic groups mentioned, there are others including Komo, Mao, Maji, Meinet, Mejenger, Otto, Shekacho and Surma (in Gambella and SNNPR Regions). Therefore, advisable also to include them.</td><td>Done</td></tr>
<tr><td>1.4 On page 10, the last statement of the last paragraph after the table states “The majority of the people living in the Baro-Akobo River Basin are Ethiopian Orthodox Christian, while a great number of the followers of the Islamic faith and Protestant Christian as well as those of traditional beliefs coexist in the wider region of the river basin”. The conclusion is not drawn from the research findings or the population and census data. Therefore, it is preferable rather to put it in the following way: “In the Baro-Akobo river basin of the Ethiopian side significant number of Orthodox and Protestant Christians, Islam Faith as well as traditional beliefs followers co-exist”.</td><td>Done</td></tr>
<tr><td>1.5 The second paragraph on page 17 contains non relevant information. It says “In Ethiopia, the Gibe hydro power project is another development program underway in the Abbay basin, with a huge impact on the local population”. The project is not inside the sub-basin and therefore the statement should be omitted.</td><td>Done</td></tr>
<tr><td>1.6 The statement on the last paragraph of page 18 also to be revisited as it mixes some regulation issues not yet dealt with among countries. This one says “The 1959 Nile Water Agreement permitted the Sudanese Government to utilize additional waters of the Nile Basin”.</td><td>Done</td></tr>
<tr><td>1.7 There is significant number of development projects currently underway in any of the three countries. In Ethiopia, the list can include the Koga Irrigation Scheme, Tana Beles Multi- purpose development project, Medium level Irrigation Projects of Rib and Megech. Similarly, the consultant is expected to include lists of the Sudan and Egypt.</td><td>OSI 2</td></tr>
<tr><td>2. Abbay-Blue-Nile Sub-basin</td><td></td></tr>
<tr><td>2.1 On page 35, under “Livelihood Profile”, the last statement says “Employment opportunities in the public administration is the least in Amhara (6.0%),</td><td>Done</td></tr>
</table>

Comment	Action
relatively higher in Oromia (4.9%) and the highest in Benishangul Gumuz (12.3%). This requires some correction.	
2.2 On page 39, under "Educational Services", figures are misplaced for the statement says "Accordingly, in the academic year 2004/5, there were 293 teachers in primary school (grades 1 - 8) and 2,631 in secondary school (grades 9 - 12)"	Done
2.3 The sixth line on page 42, under "Major Human Diseases", states "The incidence rates in Oromia and Amhara regions are 2.9% and % respectively".	Done
2.4 The last statement on the third paragraph of page 53 is better if re-written as "Despite its economic significance for hydro power generation, the Tiss Abbay II hydro power project is reported to have similarly affected the scenic views of the falls, causing observers and local residents to express concerns about the possible impact on tourism potentials of the area and revenue from the sector". Because the original statement highlights only the negative impacts.	Done
2.5 Similarly, the development projects currently underway, to be included as suggested to the Executive Summary Section of 1.7.	OSI 2
2.6 Points suggested to Executive Summary part (1.5 and 1.6) are also relevant here.	OSI 2
2.7 In Ethiopian part of the sub-basin, Abbay Basin Management Authority is in the process of establishment as the authority of enforcing regulation. It is good to include this statement in the regulatory section.	Check
2.8 Also check for the population figure of this document against the other documents	OSI 2
3. Baro-Akobo-Sobat Sub-basin	
3.1 Points suggested to Executive Summary part (1.3 and 1.4) are also relevant here.	OSI 2
3.2 Check the last paragraph of the page 113 against the suggestion given under 2.1, 2.2 and 2.4 of OSI.	OSI 2
3.3 Also check for the population figure of this document against the other documents.	OSI 2
4. Tekeze-Setit-Atbara Sub-basin	
4.1 Check for the population figure (including of pages 134 - 135) against the other documents.	OSI 2
4.2 On the second paragraph of page 140, the figures given to the Sudan States on the one hand and to Ethiopian Regions on the other and the conclusion drawn thereafter contradicts.	Check
4.3 On the same page the statement says "The Ethiopian side of the basin (especially Tigray Regional State) appears to have done better in improving females' access to primary education compared to the Sudanese side of the basin where girls are lagging behind boys in all the three states". However, no female data is attached that could support the justification.	Done
4.4 On page 141, under "Health Services", the statement reads as "Though it is not possible to trace information on the number of health facilities on the Ethiopian side of the basin, there are 393 health posts and clinics in Tigray Region while there are1461 in Amhara. Ethiopia to be changed with Sudan.	Done
4.5 The second paragraph of page 141 states "Only 15 hospitals and 48 health centers are located in Tigray Region while there are 18 hospitals and 126 health services in Oromia and Amhara Regions. Oromia is place probably by mistake as this region is not inside the sub-basin.	Done

II. CD TOOL KIT

<table>
<tr><th>Comment</th><th>Action</th></tr>
<tr><td>EGYPT</td><td></td></tr>
<tr><td>Home Page</td><td></td></tr>
<tr><td>Fonts need to be bigger to become clear</td><td>Increase</td></tr>
<tr><td>There is no BACK button on each page.</td><td>Put in</td></tr>
<tr><td>Better to include maps without political borders (one system).</td><td>Done</td></tr>
<tr><td>Screens of the CD Tool Kit are crowded with text; it should be simple and user friendly to present all data information about the three countries.</td><td>OSI 2</td></tr>
<tr><td>The first page is crowded with text. A simple table to compare the three introductory paragraphs is proposed as shown below:</td><td>OSI 2</td></tr>
<tr><td>
<table>
<tr><th></th><th>Egypt</th><th>Ethiopia</th><th>Sudan</th></tr>
<tr><td>Location</td><td>Upper North of Nile</td><td>Horn of Africa</td><td>North Eastern Africa</td></tr>
<tr><td>Boundaries</td><td>Mediterranean, Red Sea, Libya, Sudan</td><td>Eritrea, Djibouti, Somalia, Kenya, Sudan</td><td>Egypt, red sea, Eritrea, Ethiopia, Kenya, Uganda, DRC, CAR, Chad, Libya</td></tr>
<tr><td>Area (km2)</td><td>1,001,449 (997,739)</td><td>1,133,380</td><td>2,505,800</td></tr>
<tr><td>Topography</td><td>10% cultivable, 90 % desert, max length and width 1,105 and 1130 km</td><td>60% high land plateau > 1,800 amsl, split diagonally (Nile – north west) , drained by 12 major rivers</td><td>Max length and width 2,250 and 1,730 km</td></tr>
<tr><td>Area of Nile basin (km2)</td><td>96,772</td><td>-</td><td>50% of its total area, 74% of EN basin</td></tr>
<tr><td>Sub-basins</td><td colspan="3">Main Nile, Abbay-Blue Nile, Takeze-Setit-Atbara, Baro-Akobo-Sobat-White Nile</td></tr>
</table>
</td><td></td></tr>
<tr><td>The introductory map is not clear due to its extended size to cover areas out of interest. The text should be brief as the objective is to introduce more graphics – less text.</td><td>Done</td></tr>
<tr><td>When you hit the “About” button, you can hardly read the content due to dense text and choice of grey colors.</td><td>Done</td></tr>
</table>

Comment	Action
You can't go back to the previous slide, you can only go home.	Done
The feature/tool that supposed to show the "Meta-Data–what type of information is where" is missing.	Done
The associated text throughout most of the Interface needs to be improved. In some parts it refers to tables and figures with misleading numbering sequence. This could be due to the copy/paste process from the original reports without reviewing or processing	OSI 2
In most of the text sections, there is no reference to the source or location in the detailed reports, in which user can go back for more detailed information.	OSI 2
No "Glossary" is given to describe abbreviations used in displaying graphics such as CV and VI.	OSI 2
The paragraph of water policies section under Institutional / Environment and water policies was just duplicated improperly under all other equivalent sub-basins.	OSI 2
Moreover, the Academic Institutes information is improperly copied and repeated under all Sub-basins.	OSI 2
In spite of presented rainfall data under Tekeze-Setit Atbara Sub-Basin, Water data are not found.	Done
The *"About"* key presents very detailed and repeated information. Moreover the readability of such text is weak.	Done
The data provided in the CD cannot be used elsewhere or processed in any digital form. It is read only.	Done
The data can be useful if it is extracted to be utilized in other calculations or introduced into other systems	Done
Some data furnished in the CD- Kit lacks of accuracy (names of sites, not up to date, missing units, …,)	Done
For example evapo-transpiration of Lake Nasser and Egypt's map that does not contain Halayeb and Shalateen.	OSI 2
Stations at which data are visualized in tabular and graphical formats are very few although there are several other stations in Sudan and Ethiopia but are not included in the CD Kit.	OSI 2
The Social Characteristics	
When you hit 'more details' some graphs are not readable, even after enlargement.	Done
Sources of information are not mentioned.	Done
Main Nile Basin: ethnic groups map has no legend.	Done
The same column of three pictures appears on the left hand side of all basins in '*more details*'.	Done
Baro-Akobo-* basin: the ethnic/tribal tab has the map of poverty instead, and has no data under access to electricity.	Done
Blue Nile sub basin has no information under ethnic/tribal and no data under poverty, access to electricity, access to health services and Malaria.	OSI 2
Tekeze-Setit-* sub-basin has no data under access to electricity.	OSI 2

Comment	Action
There should be a tool that allows comparison among the sub basins w.r.t. criteria in 'more details' in a form of table or map.	OSI 2
There should be a view facility that allows the text size to be enlarged if the user wants to read the contents with ease.	OSI 2
Environment and Resource Based	
For Main Nile sub basin, Terrain column graph have extra decimal places of the y-axis values. Erosion and sedimentation do not show a map but a block diagram of sediment budget. Historical and cultural data are not found, and for wetlands/parks there is no map are given.	OSI 2
Tekeze-Setit: flows, schematic, flood risk, historical and cultural, wetlands/parks have no data.	OSI 2
Blue Nile sub basin: erosion and sedimentation and historical/cultural have no data.	OSI 2
Baro-Akobo: flows, schematic, flood risk, historical/cultural have not data.	OSI 2
Economic Features	
Main Nile sub-basin: GDP, cultivated areas/crops have no data, crop water is mis-spelled.	Done; OSI 2
Tekeze-Setit sub-basin: GDP, towns and cities, hydropower/transmission, irrigation, crop water requirements, cultivated areas/crops have no data.	OSI 2
Blue Nile sub-basin: GDP, agriculture (3 items) have no data.	OSI 2
Baro-Akobo sub-basin: GDP, towns and cities, hydropower/transmission have no data.	OSI 2
Institutional Issues	
Main Nile sub-basin: development institutions have no data.	OSI 2
Tekeze-Setit sub-basin: data are copied from the Main Nile sub-basin.	OSI 2
Blue Nile sub-basin: with the exception of administrative and NGOs, data are copied from the Main Nile sub-basin.	OSI 2
Baro-Akobo sub-basin: all data is copied from the Main Nile sub-basin.	OSI 2

III. GENERAL DATA QUALITY AND CONSISTENCY

Comment	Action
It should be recognized that some data will be used for modeling and accuracy of output will depend on the quality of input data used.	Yes
Sources of data and information should be mentioned.	Check base OSI Reports
Global data basis created by international agencies could be used to expand and improve the OSI.	OSI 2
The different studies developed under NBI (e.g. DSS and FAO reports) can improve the OSI through agreed procedures, mechanism and framework for data exchange.	OSI 2
Quality of information could be improved while completing this *OSI* (phase 2) under Eastern Nile Planning Model; and different products for different purposes. Compatibility for integration with NEL region for NBI-DSS should be considered. Information should be communicated with others involved – the aim is to make an overall "Nile Basin One System Inventory".	OSI 2
Same level of details should be maintained and balanced among the three countries in all issues.	OSI 2
It should be announced in a transparent way who is falling behind in providing the required information.	OSI 2

APPENDIX 3: VARIATIONS IN DATA IN OSI ANNEXES

	Abbay Blue Nile		Baro-Akobo Sobat White Nile		Tekezi-Setit-Atbara		Main Nile
1	GENERAL CHARACTERISTICS		GENERAL CHARACTERISTICS	1	GENERAL CHARACTERISTICS	1	GENERAL CHARACTERISTICS
1.1	**Sub-Basin Location and Area**	**1.1**	**Sub-Basin Location and Area**	**1.1**	**Sub-Basin Location and Area**	**1.1**	**Sub-Basin Location and Area**
	Location		*Location*		*Location*		*Location*
	Area		*Area*		*Area*		*Area*
1.2	**Administrative Units**	**1.2**	**Administrative Units**	**1.2**	**Administrative Units**	**1.2**	**Administrative Units**
1.3	**Topography**	**1.3**	**Topography**	**1.3**	**Topography**	**1.3**	**Topography**
1.3.1	Altitude	1.3.1	Altitude	1.3.1	Altitude	1.3.1	Altitude
1.3.2	Slope	1.3.2	Slope	1.3.2	Slope	1.3.2	Slope
1.3.3	Relief and Major Landforms	1.3.3	Relief and Major Landforms	1.3.3	Relief and Major Landforms	1.3.3	Relief
			Relief (Baro-Akobo, Pibor-Sobat, White Nile)		*Relief (mountainous relief, flat piedmont)*		
			Major landforms		*Major landforms*		
1.4	**Climate**	**1.4**	**Climate**	**1.4**	**Climate**	**1.4**	**Climate**
1.4.1	General	1.4.1	General	1.4.1	General	1.4.1	General
			Climate types		*Climate types*		
					Agro-climatic zones		
1.4.2	Rainfall	1.4.2	Rainfall	1.4.2	Rainfall	1.4.2	Rainfall
			Total and average rainfall				
			Mean annual rainfall		*Mean annual rainfall*		*Mean annual rainfall*
	Seasonal and spatial variation in rainfall		*Seasonal and spatial variation in rainfall*		*Spatial variation in rainfall*		
	Wet and dry seasons		*Rainy period*		*Wet and dry seasons*		

	Abbay Blue Nile		Baro-Akobo Sobat White Nile		Tekezi-Setit-Atbara		Main Nile
			Wet and dry seasons				
			Average rainfall				
			Maximum rainfall				
			Dependable rainfall and growing seasons				
1.4.3	Temperature	1.4.3	Temperature	1.4.3	Temperature	1.4.3	Temperature
			General				*General*
			Maximum and minimum temperature		*Mean annual temperature*		*Maximum and minimum temperatures*
			Mean monthly maximum temperature		*Maximum and minimum monthly temperatures*		*Mean daily temperature*
1.4.4	Evaporation	1.4.4	Evaporation	1.4.4	Evaporation	1.4.4	Evaporation
	Mean annual evaporation		*Mean annual evaporation*				
	Horizontal variation		*Average monthly maximum and minimum*				
	Evaporation losses in reservoirs		*Evaporation losses in reservoirs*				*Evaporation losses in reservoirs*
			Potential evapotranspiration		*Mean annual potential evapo-transpiration*		*Potential evapotranspiration*
	Data sources and calculations						
1.5	**Humidity**	**1.5**	**Humidity**	**1.5**	**Humidity**	**1.5**	**Humidity**
	Mean annual relative humidity		*Mean annual relative humidity*		*Mean annual relative humidity*		*Mean annual relative humidity*
							Variations in relative humidity
2	**SOCIO-ECONOMIC CHARACTERISTICS**	**2**	**SOCIO-ECONOMIC CHARACTERISTICS**	**2**	**SOCIO-ECONOMIC CHARACTERISTICS**	**2**	**SOCIO-ECONOMIC CHARACTERISTICS**
2.1	**Demographic Characteristics**	**2.1**	**Demographic Characteristics**	**2.1**	**Demographic Characteristics**	**2.1**	**Demographic Characteristics**
2.1.1	Population estimates	2.1.1	Population	2.1.1	Population	2.1.1	Population

	Abbay Blue Nile		Baro-Akobo Sobat White Nile		Tekezi-Setit-Atbara		Main Nile
2.1.2	Population growth rates	2.1.2	Population growth rates	2.1.3	Population Growth Rates	2.1.2	Population growth rates
			Population growth		*Past sub-basin growth rates*		
			Urban and rural growth rates		*Urban and rural growth rates*		
					Reasons for high growth rate		
					Future growth rates		
			Sub-basin		*Sub-basin*		
			Ethiopia		*Sudan*		
			Sudan		*Ethiopia*		
2.1.3	Population Density	2.1.5	Population density	2.1.5	Population density	2.1.4	Population Density
2.1.8	Rural-urban divide	2.1.6	Rural-urban divide	2.1.6	Rural-Urban divide		
2.1.9	Sex ratios	2.1.7	Sex Ratios	2.1.7	Sex Ratios		
2.1.10	Population age groups	2.1.8	Population age groups	2.1.8	Population age groups		
2.1.4	Birth rates and death rates	2.1.4	Crude birth and death rates	2.1.4	Crude birth and death rates	2.1.3	Crude Birth and Death Rates
2.1.11	Infant and child mortality	2.1.9	Infant mortality	2.1.9	Infant mortality	2.1.5	Infant Mortality
2.1.12	Life expectancy at birth	2.1.10	Life expectancy at birth	2.1.10	Life expectancy at birth	2.1.6	Life Expectancy at Birth
2.1.2	Ethnic Groups	2.1.2	Ethnic groups	2.1.2	Ethnic Group	2.6.1	Major ethnic groups
2.1.5	Marital Status						
2.1.6	Migration						
2.2	**Social Infrastructure**	**2.3**	**Social Infrastructure**	**2.2**	**Social Infrastructure**	**2.3**	**Social Infrastructure**
2.2.1	Literacy and education	2.3.1	Literacy and education	2.2.1	Literacy and education	2.3.1	Literacy and education
			Sub-basin		*Sub-basin*		*Egypt*
					Enrolment ratios		*Sudan*
					Enrolment ratios in the sub-basin		
					Enrolment in primary		

	Abbay Blue Nile		Baro-Akobo Sobat White Nile		Tekezi-Setit-Atbara		Main Nile
					schools		
					Enrolment in secondary schools		
2.2.2	Water Supply	2.3.2	Water Supply	2.2.2	Water Supply	2.3.2	Water Supply
			Sub-basin		*Access to safe water*		*Egypt*
			Ethiopia		*Access to water in Ethiopian states*		
			Sudan		*Access to water in Sudanese states*		
2.2.3	Sanitation	2.3.3	Sanitation	2.2.3	Sanitation	2.3.3	Sanitation
			Sub-basin		*Access to sanitation in Ethiopian states*		
			Ethiopia		*Access to sanitation in Sudanese states*		
2.2.4	Health	2.3.4	Health	2.2.4	Health	2.3.4	Health
			Government health posts and clinics		*Ethiopian regions: health posts, centres and clinics*		*Sudan*
			Ethiopia		*Ethiopian regions: Hospital beds*		*Egypt*
			Sudan		*Ethiopian regions: Health coverage rates*		*Sub-basin*
					Ethiopian regions: Ratio of population to professionals		
2.6.2	Major Health Problems						
2.2.5	The Burden of Diseases						
2.2.6	Harmful Traditional Practices						
2.2.7	Women's workload						
2.3	**Transport And**	**2.4**	**Transport And**	**2.3**	**Transport and**	**2.4**	**Transport and**

	Abbay Blue Nile		Baro-Akobo Sobat White Nile		Tekezi-Setit-Atbara		Main Nile
	Communications		**Communications**		**communications**		**communications**
2.3.1	Roads	2.4.1	Roads	2.3.1	Roads	2.4.1	Roads
			Number of roads				*Egypt*
			Sub-basin		*Ethiopia*		
			Ethiopia		*Sudan*		
			Sudan		*Ethiopia and Sudan*		
					The sub-basin (has info on other 2 too)		
			Length and density of roads				
			Ethiopia				
			Access to all-weather roads				
			Ethiopia				
			Possible improvements in roads				
			Ethiopia				
2.3.2	Railways	2.4.2	Railways	2.3.2	Railways	2.4.2	Railways
			Sub-basin		*Ethiopia*		*Egypt*
					Sudan		
2.3.3	River Transport	2.4.3	River Transport			2.4.3	River Transport
			Sudan				*Egypt*
2.3.4	Air transport	2.4.4	Air Transport			2.4.4	Air Transport
			Ethiopia				*Egypt*
2.3.5	Telecommunications						
2.3.6	Energy						
2.5	**Economic Activities**	**2.5**	**Economic Activities**	**2.4**	**Economic Activities**	**2.5**	**Economic Activities**
2.5.1	Activity Rates	2.5.1	Activity rates	2.4.1	Activity rates	2.5.1	Activity rates
			Sub-basin				
			Ethiopia				

	Abbay Blue Nile		Baro-Akobo Sobat White Nile		Tekezi-Setit-Atbara		Main Nile
2.5.2	Unemployment and underemployment	2.5.2	Unemployment Rates	2.4.3	Unemployment rates	2.5.2	Unemployment rates
			Sub-basin				
			Ethiopia				
2.7	**Livelihood Patterns**	**2.7**	**Livelihood Patterns**	**2.7**	**Livelihood Patterns**	**2.7**	**Livelihood Patterns**
2.7.1	Main livelihoods	2.5.3	Livelihood patterns	2.4.2	Livelihood patterns	2.5.3	Livelihood patterns (+ emplyt)
2.8.1	Major livelihood activities of ethnic groups	2.6.1	Major livelihood activities of ethnic groups			2.6.1	Major livelihood activities of ethnic groups
				2.6.3	Mining	2.6.5	Tourism
				2.6.4	Industrial and agricultural input production		
2.8	**Agriculture And People**	**2.6**	**Agriculture and People**	**2.5**	**Agriculture and People**	**2.6**	**Agriculture and People**
2.8.2	Main Agricultural Land Use Systems	2.6.2	Main Agricultural Land Use Systems	2.5.1	Main Agricultural Land Use Systems	2.6.2	Main Agricultural Land Use Systems
2.8.3	Rainfed cropping					2.6.3	Agricultural development around Lake Nasser
2.8.4	Semi-mechanised farms					2.6.4	Agricultural development of the Tushka Project
2.8.5	Irrigated cropping					2.7.2	Other cultivators
2.8.6	Livestock						
2.9	**Forestry And Agro-Forestry**	**2.7**	**Forestry and Agro-Forestry**	**2.6**	**Forestry and Agro-forestry**	**2.7**	**Forestry and Agro-Forestry**
2.9.1	Forestry Contribution to the Economy	2.7.1	Forestry Contribution to the Economy	2.6.1	Forestry Contribution to the Economy	2.7.1	Man-Made Forests And Programme Implementation Sites
			Ethiopia				
			Sudan			2.9	On-going forest activities and future plans
2.9.2	Agro-forestry	2.7.2	Agro-forestry	2.6.2	Agro-forestry		

	Abbay Blue Nile		Baro-Akobo Sobat White Nile		Tekezi-Setit-Atbara		Main Nile
			Sudan: Gum Arabic				
			Ethiopia				
		2.7.3	Fishery	2.6.5	Fishery	2.8	Fishery
			Overview		*Overview*		
			Upper basin (fish species, fishing, fisheries development)		*Important commercial fish species*		
			Lower basin (fish species, fishing)		*Fishing livelihoods*		
					Fish catch		
					Fisheries yield potential		
2.10	**Poverty Profile**	**2.2**	**Poverty Profile**	**2.7**	**Poverty profile**	**2.2**	**Poverty Profile**
2.10.1	Estimates of Poverty	2.2.1	Poverty measurements	2.7.1	Poverty measurements	2.2.1	Poverty measurements
2.6	Poverty Profile		*Sub-basin*		*Basin level*	2.2.2	Vulnerability indicators
2.6.1	Overall		*Poverty estimates in Sudan*		*Poverty estimates in Sudan*		
			Poverty estimates in Ethiopia		*Poverty estimates in Ethiopia*		
			Trends in poverty in Ethiopia		*Trends in poverty in Ethiopia*		
			Trends in poverty in Sudan		*Trends in poverty in Sudan*		
		2.2.2	Welfare and poverty	2.7.2	Welfare and poverty		
				2.7.3	Vulnerability indicators		
		2.2.3	Food aid as a proxy indicator of poverty	2.7.4	Food aid as a proxy indicator of poverty		
2.10.2	Poverty and Food Security			2.7.5	Nutritional status of basin population		
2.4	Non-Governmental Institutional Arrangements						

	Abbay Blue Nile		Baro-Akobo Sobat White Nile		Tekezi-Setit-Atbara		Main Nile
2.4.1	Community Based Organizations						
2.4.2	NGOs						
3	NATURAL RESOURCES AND ENVIRONMENTAL ISSUES	3	NATURAL RESOURCES AND ENVIRONMENTAL ISSUES	3	NATURAL RESOURCES AND ENVIRONMENTAL ISSUES	3	NATURAL RESOURCES AND ENVIRONMENTAL ISSUES
3.1	**Geology**						
3.12	LOCAL GEOLOGY AND GEOMORPHOLOGY						
3.12.1	Local Geomorphology						
3.12.2	Local Geological Formations and Petrography						
3.12.3	Granite / Gneissic Granite Formation						
3.12.4	Biotite Schist /Marble Formation						
3.1.1	Construction Materials						
3.1.2	Rock-Fill Material						
3.1.3	Coarse Aggregate						
3.2	**Soils**						
3.3	**Land Use And Land Cover**						
3.3.1	Land Use						
3.3.2	Agro-ecological zones						
3.4	**Vegetation**						
3.4.1	Vegetation Types						
3.4.2	Forests Types						
3.5	**Wetlands**						
3.6	Wildlife						
3.6.1	Fauna						

	Abbay Blue Nile		Baro-Akobo Sobat White Nile		Tekezi-Setit-Atbara		Main Nile
3.6.2	Aquatic flora and fauna						
3.6.3	Zooplankton and benthos						
3.6.4	Fish and other aquatic life						
3.6.5	Endemic Aquatic Species						
3.6.6	Fisheries						
3.7	**Protected And Conservation Worthy Areas**						
3.8	**Livestock**						
3.9	**Biodiversity**						
3.9.1	National Park Area						
3.10	**Mineral Resources**						
3.10.1	Gold and Base Metals						
3.10.2	Marble						
3.11	**Major Environmental Issues Related To Water**						
3.11.1	Overview						
3.11.2	Water Quality						
3.11.3	Water-related diseases						
3.11.4	Soil Erosion						
3.11.5	Soil Degradation and loss of agricultural productivity						
3.11.6	Dam and Reservoir Siltation						
3.11.7	Deforestation and degradation of woody biomass						
3.11.8	Degradation of Herbaceous Biomass						
3.11.9	Extent and Degradation of Wetlands						

	Abbay Blue Nile		Baro-Akobo Sobat White Nile		Tekezi-Setit-Atbara		Main Nile
3.11.10	Soil Degradation with no Watershed Management Programme						
3.11.11	Loss of biodiversity						
4	HYDROLOGY AND WATER INFRASTRUCTURE	4	HYDROLOGY AND WATER INFRASTRUCTURE	4	HYDROLOGY AND WATER INFRASTRUCTURE	4	HYDROLOGY AND WATER INFRASTRUCTURE
4.1	**Surface Hydrology**		River system				
4.1.1	Watershed physiography		*Major rivers & tributaries*				
4.1.2	Catchments		*Contribution to the Nile system*				
4.2	**Runoff**						
4.2.1	The Lake Tana Watershed						
4.2.2	The Deddessa, Dabus and Angar Rivers						
4.2.3	The Beles River						
4.2.4	Blue Nile at the Ethiopia-Sudan Border						
4.2.5	Blue Nile at Roseires						
4.2.6	Blue Nile Down Stream of Sennar Reservoir						
4.2.7	Blue Nile at Khartoum						
4.2.8	Runoff in the sub-basin						
4.2.9	Water balance of the sub-basin						
4.2.10	Groundwater						
4.3	**Dams And Reservoirs**						
4.3.1	Existing Dams and Reservoirs						
4.3.2	Sediment Analysis						
4.3.3	Suspended Sediment in the Blue Nile River System						

	Abbay Blue Nile		Baro-Akobo Sobat White Nile		Tekezi-Setit-Atbara		Main Nile
4.4	**Potential Water Infrastructure**						
4.5	**Hydropower And Transmission**						
4.5.1	Installed Capacity						
4.5.2	Proposed Interconnections and/or Transmission Lines						
5	**ANNOTATED BIBLIOGRAPHY**	**5**	**ANNOTATED BIBLIOGRAPHY**	**5**	**ANNOTATED BIBLIOGRAPHY**	**5**	**ANNOTATED BIBLIOGRAPHY**
5.1	**Customary & Statutory Laws, Institutions and Organizations**						
5.2	**Institutions and Organizations**						
5.3	**Demographic And Socio-Economic Profile**						
5.4	**Livelihood Profile/Employment Characteristics**						
5.5	**Social And Physical Infrastructure**						
5.6	**Conflict And Conflict Management**						
5.7	**Development Projects**						
5.8	**Recent Literature On Nile Basin Cooperation**						