ENTRO

Eastern Nile Technical Regional Office

NILE BASIN INITIATIVE – NBI

EASTERN NILE TECHNICAL REGIONAL OFFICE – ENTRO

BARO-AKOBO-SOBAT AND WHITE NILE MULTIPURPOSE WATER RESOURCE DEVELOPMENT STUDY PROJECT

PROJECT BASELINE INFORMATION

ENSAP – IDEN – ENTRO

ADDIS ABABA – ETHIOPIA

2008 – 2009

THE EASTERN NILE – EN COUNTRIES

EASTERN NILE SUBSIDERY ACTION PROGRAM – ENSAP

AND

INTEGRATED DEVELOPMENT OF THE EASTERN NILE - IDEN

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GOEGRAPHICAL LOCATION

Fig (1): The Atlas map of the Baro-Akobo-Sobat and White Nile Basin

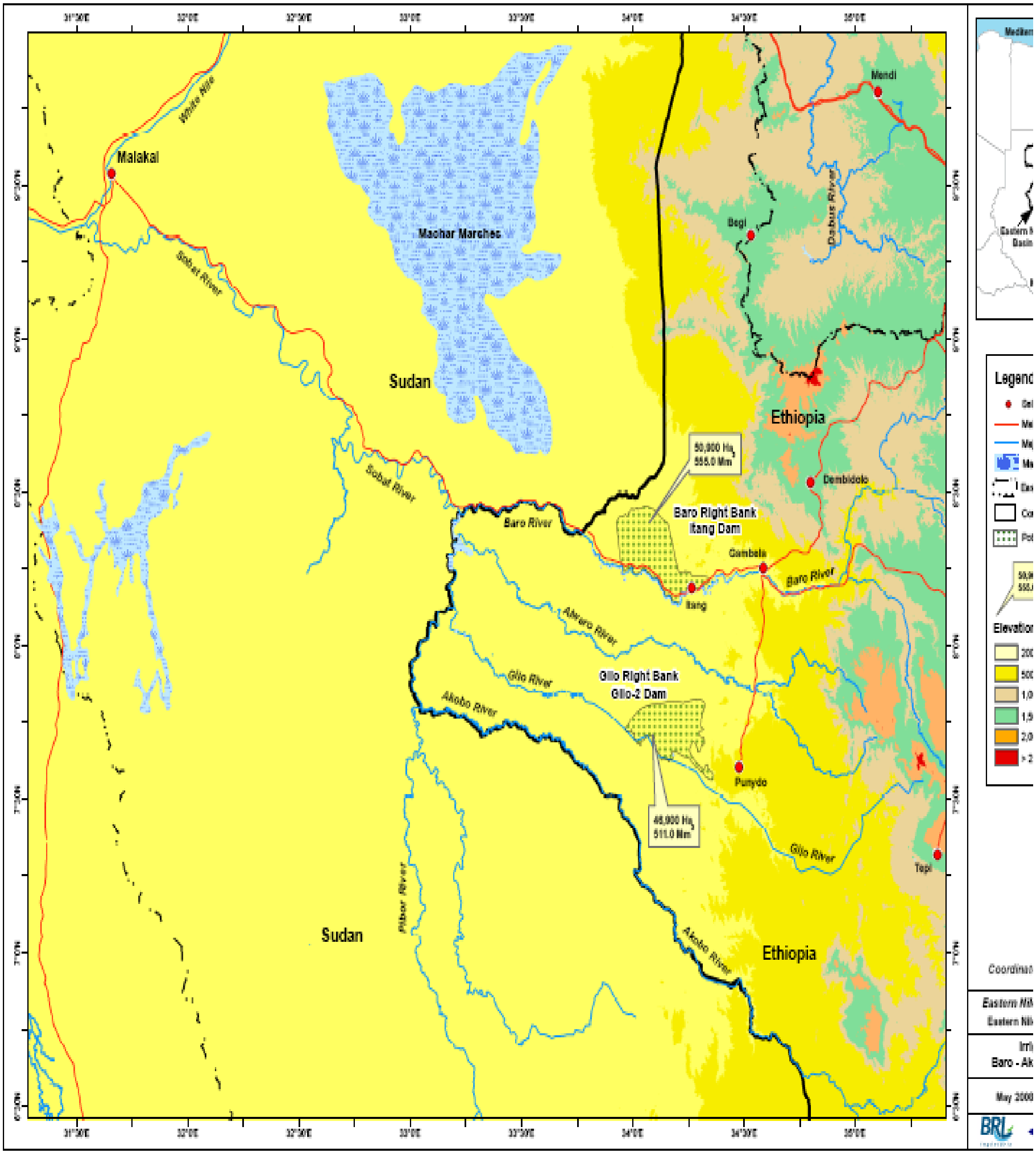

Fig (2): Showing Rivers of the Basin

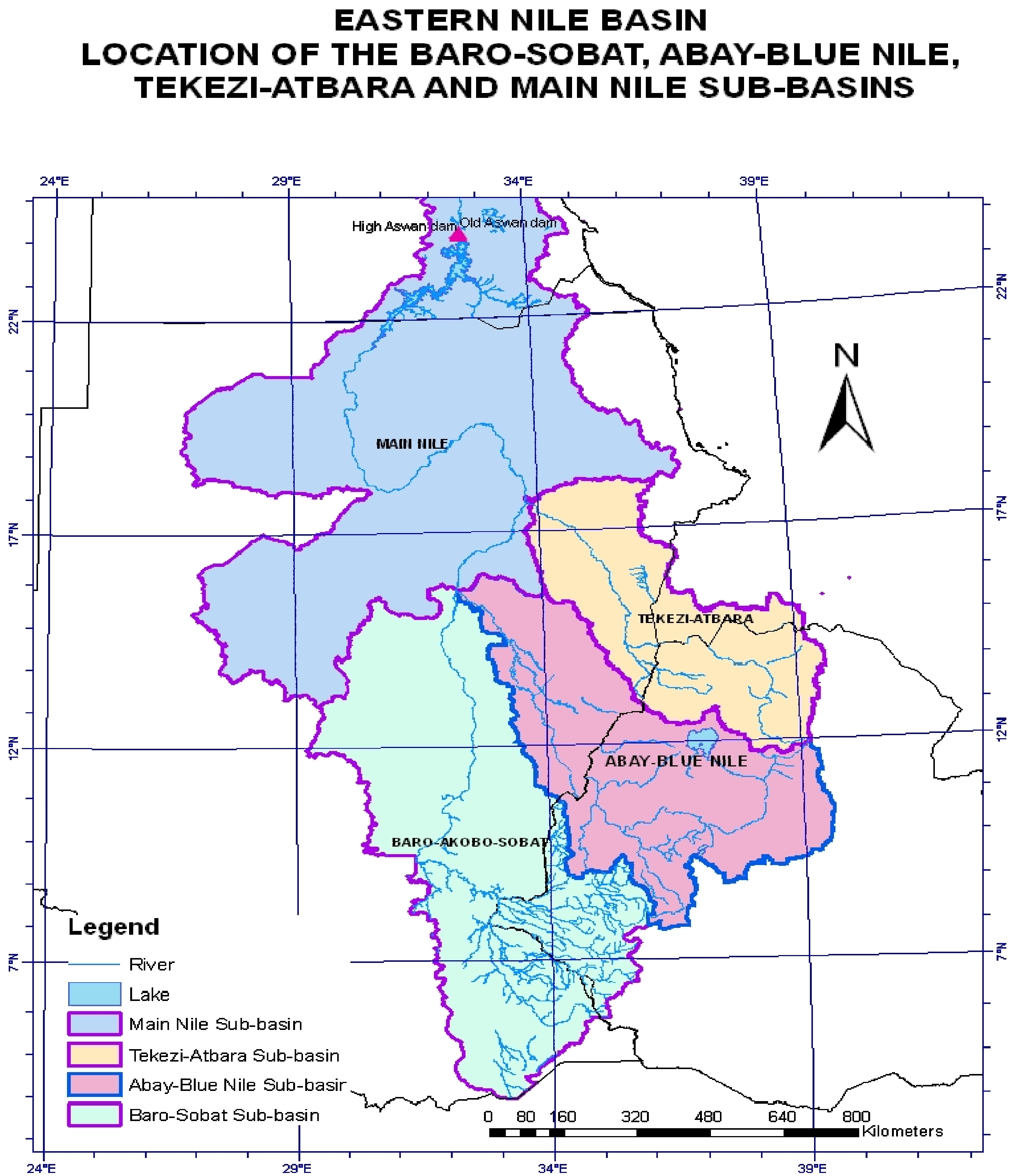

Fig: (3) The Baro-Akobo-Sobat

1. Background

The Nile Basin Initiative (NBI) started this regional cooperation, which is a partnership initiated and led by the riparian states of the Nile River through the Council of Ministers of Water Affairs of the Nile Basin states (Nile Council of Ministers, or NCOM). The NBI seeks to develop the river in a cooperative manner, share substantial socioeconomic benefits, and promote regional peace and security. The Nile Basin is characterized by water scarcity, poverty, a long history of dispute and insecurity, and rapidly growing populations and demand for water is particularly difficult. The NBI started with a participatory process of dialogue among the riparian countries that resulted in their agreeing on a shared vision—to "achieve sustainable socioeconomic development through the equitable utilization of, and benefit from, the common Nile Basin water resources, with the following objectives:

- To develop the Nile Basin water resources in a sustainable and equitable way to ensure
- prosperity, security, and peace for all its peoples
- To ensure efficient water management and the optimal use of the resources
- To ensure cooperation and joint action between the riparian countries, seeking win-win gains
- To target poverty eradication and promote economic integration

Through its Shared Vision concept, the NBI has succeeded in setting the "Strategic Action Program" to provide the means for translating this shared vision into concrete activities through a two-fold, complementary approach of pursuing simultaneously, regional cooperation and cooperative development opportunities to realize physical investments and tangible results through sub-basin activities (Subsidiary Action Programs) in the Eastern Nile - EN and the Nile Equatorial Lakes – NEL regions.

In the Eastern Nile – EN region (Egypt, Ethiopia and Sudan), the Eastern Nile Subsidiary Action Program (ENSAP) was established to undertake the Integrated Development of the Easter Nile (IDEN) and has been prepared in conformity with the objectives and guiding principle of ENSAP. The purpose of the proposed IDEN project is to initiate a regional, integrated, multipurpose development program through a first set of investments, which confer tangible, win-win gains and demonstrate joint action between the Eastern Nile Countries. This resulted into preparation of seven fast track projects of:

1. EN Planning Model Project
2. Baro-Akobo-Sobat Multipurpose project
3. Flood Preparedness and Early Warning
4. Irrigation and Drainage

5. EN Power Trade Program Study
6. Ethiopia-Sudan Transmission Interconnection
7. Watershed Management

The Baro-Akobo-Sobat Multipurpose Water Resources Development Study Project is one of the seven sub-projects identified in Integrated Development of the Eastern Nile (IDEN) and the first project identified by Eastern Nile Subsidiary Action Program (ENSAP) operating within the frame work of the Nile Basin Initiative (NBI), catering the Eastern Nile countries. The Baro-Akobo-Sobat project is also one of the five sub-projects that the African Development Bank (AfDB) indicated its willingness to support during the ICCON meeting in 2001.

The Baro-Akobo-Sobat sub-basin covers about 468,216 km^2 [Ethiopia = 76,742km^2 and Sudan = 391,474km^2] to the mouth of Jonglei canal, south of Malakal town. River Sobat tributaries of Baro, Gila and Akobo rise from the Ethiopian plateau and drains westwards into the Sudan. The Pibor, which originates on the southeastern clay plains of Eastern Equatoria state in the Sudan acts as a collector channel to a number of streams in this clay flat plain, which flow northwest words through the states of Eastern Equatoria and Jonglei. The basin has an altitude of 3,000masl, just around Jimma to 500masl at Gambella [Ethiopian site]. It is most probable that the Sudanese site of the basin may read slightly lesser altitude to those at Gambella.

Below the Pibor-Baro confluence the Sobat forms a defined channel flowing through grassy floodplain with numerous back swamps, joining the White Nile south of Malakal town. While the upper part of this sub-basin consist of hilly upland areas of Ethiopia and higher hills in Eastern Equatoria to a flat plain in Jonglei, Upper Nile, White Nile and Khartoum states in the Sudan. The lowlands of the basin exhibit a low and uniform landform made up of poorly drained savannah grass and woodlands which renders it prone to inundation and water logging during the wet season, forming two floodplains of Gambella (9,000km^2) in Ethiopia and the *Machar marshes* (20,000km^2) in the Sudan.

2. Hydrology

This basin is relatively well watered, characterized by one rainy season that starts around May or June and ends around October. The dry season is long (November/December - April). Effective average rainfall is about 750mm to 1,250mm per annum in the low lands and the higher lands respectively. With mean annual temperature ranging from 17.5^oC – 27.5^oC on the higher lands and the low lands respectively.

Average annual precipitation is as low as 600 mm in the lowlands (less than 500 meters above the sea level), while it reaches as high as 3,000 mm over the highlands (over 2,000 meters above the sea level). Most of the upper basin in Ethiopia has an annual total of more than 1,800 mm while Gore has an average annual total of over 2,200 mm.

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

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

2.1 Sub-Basins Hydrology

The White Nile emerges from the Sudd swamps at Lake No and is joined by the Sobat just below Malakal as a sub-basin of Baro-Akobo-Sobat. Then it flows north in a shallow valley characterized by a flat plain topography joining the Blue Nile flowing from the east at Khartoum.

The other sub-basin is the Baro and Akobo Rivers rise from the Ethiopian highlands, the highlands are covered with dense forests although these are rapidly being cleared for small and large-scale agriculture and settlement. The rivers pass through deep zone valleys before it came onto the Gambella lowlands, passing through grassy and swamp plains before it reaches the Pibor River forming the Sobat River.

The Pibor River joins the Akobo and Baro along the Sudan-Ethiopian border as another sub-basin with characteristically flat plain rising from the highlands in Eastern Equatoria State 2,750 meters above the sea level.

From the Pibor-Baro junction the river becomes the Sobat River, this sub-basin rises in the far southeast at the Pibor and Baro rivers confluent. Just before joining the Sobat another sub-basin is formed from Baro flood spillway to Khor Machar, which flows through the *Machar Marshes.* The water from the *Machar Marshes* forms the Khor Adar River, which joins the White Nile north of Melut town in Upper Nile State.

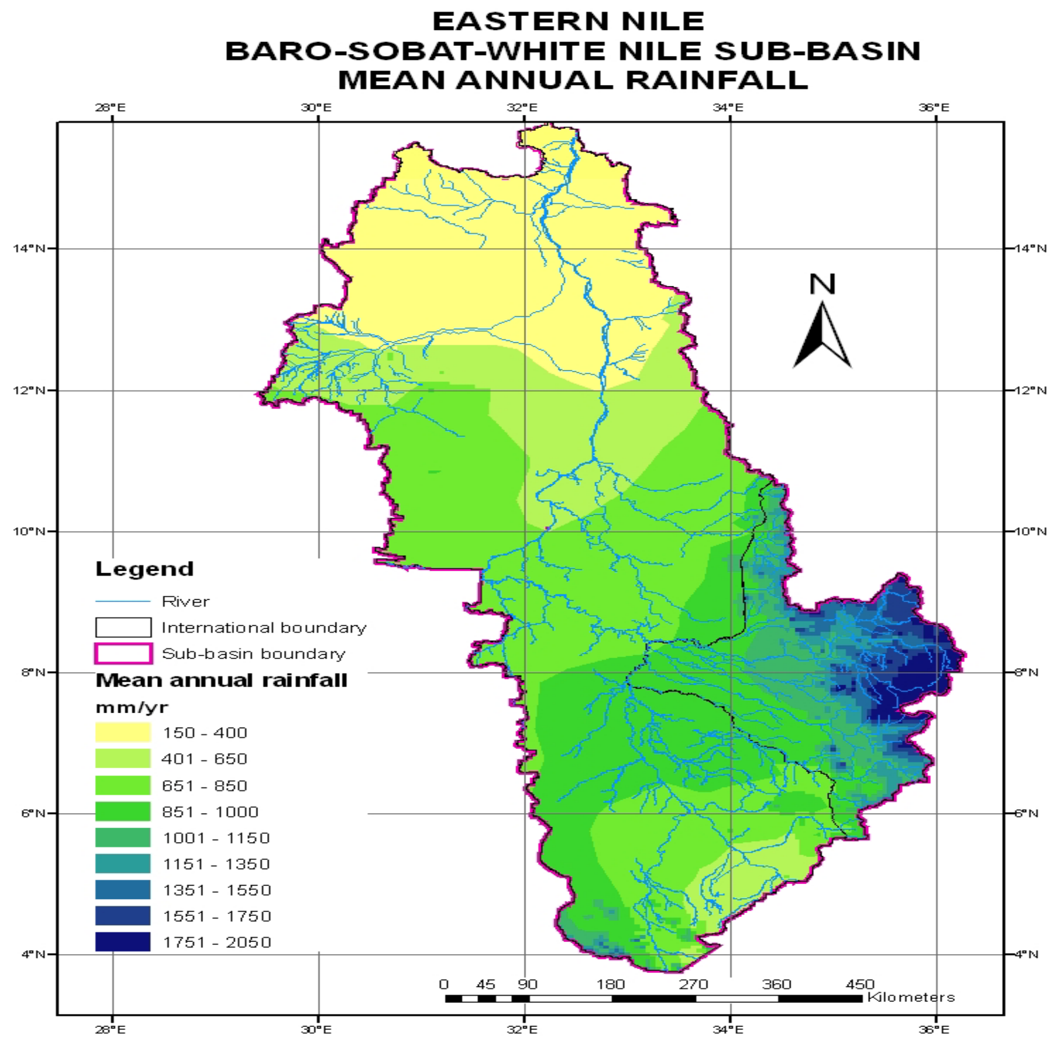

Fig (4): Baro-Akobo- Sobat and White Nile: Mean Annual Rainfall (mm/yr)

Source: ENTRO GIS Database

Table (2): Summary of sub-basins surface hydrology or drainage

Sub-basin:	Surface area:	Mean annual runoff:
Baro river	38,400km^2	9.500km^3/yr
Akobo river	85,900km^2	--
Pibor river	85,900km^2	3.100km^3/yr
Sobat river	--	--

Tunga River	--	--
Khor Adar river	--	--
White Nile river	--	--

(--) no data yet attained
Source: Feasibility Study on Baro-Akobo Volume 1.

2.2 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 highland (Fig 5). Mean monthly maximum temperatures range from below 22°C, in the highlands around Kombolcha (Wollega) to about 40°C, in the lowlands of Gambella around Akobo.

Maximum temperatures in the highlands rarely exceed 25°C, whereas in the lowlands they generally exceed 36°C during the hotter months of January to April. Mean maximum temperatures greater than 30°C occur from February to April in the lowlands, with mean minimum ranges of 14 – 15.4°C. While July and August have the mean maximum temperature values less than 25°C in the higher lands, with mean minimum range of 14 – 16°C during November - February. In the Pibor-Sobat Sub-basin mean annual temperatures range from about 17°C in the southern mountains to 26°C at the Sobat-White Nile junction. In the White Nile valley temperatures are generally 16 - 30°C along the river and decrease with altitude.

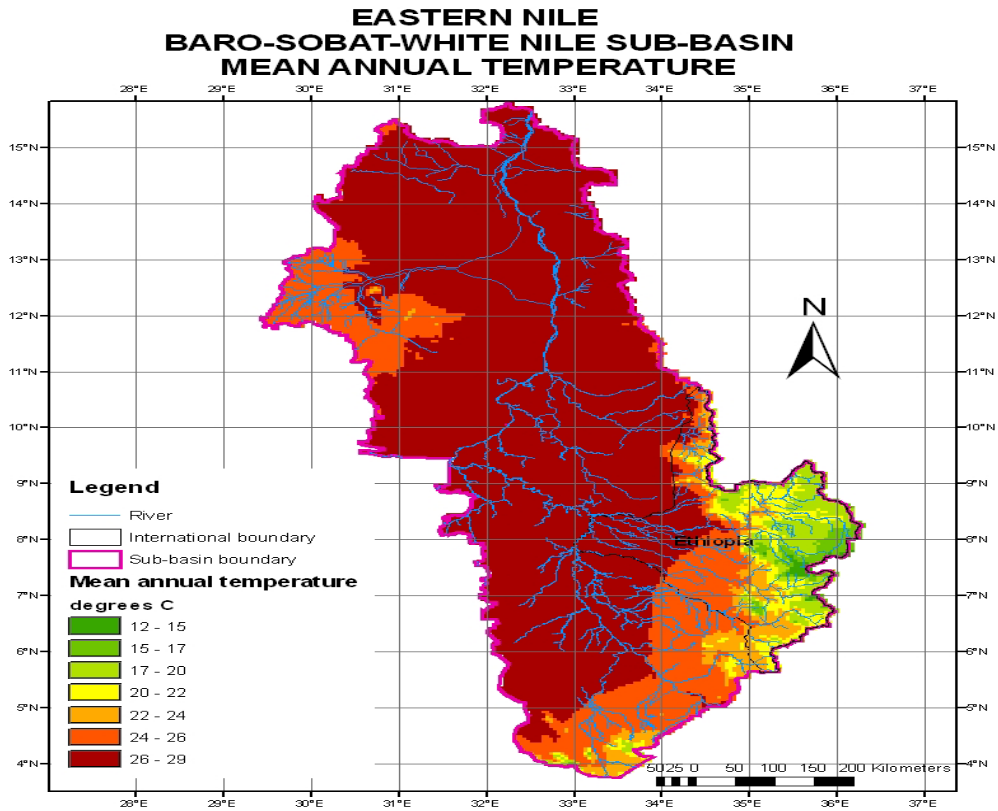

Fig (5): Baro-Akobo-Sobat and White Nile basin: Mean Annual Temperature
Source: ENTRO GIS Database

2.3 Evaporation

The temporal pattern of the average monthly evaporation of the Baro–Akobo-Sobat and White Nile basin (Fig, 6) correlates well with the monthly mean maximum temperature distribution over the basin. The average monthly maximum evaporation occurs from February to May and the minimum from June to September. As may be expected, potential evapotranspiration is lowest over the highlands and increases progressively towards the lowlands. For example, Gore (2,130 masl) has a total evapotranspiration of 1,263 mm/yr while Jikawo (410 masl) has a total evapotranspiration of 1,545 mm/yr.

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

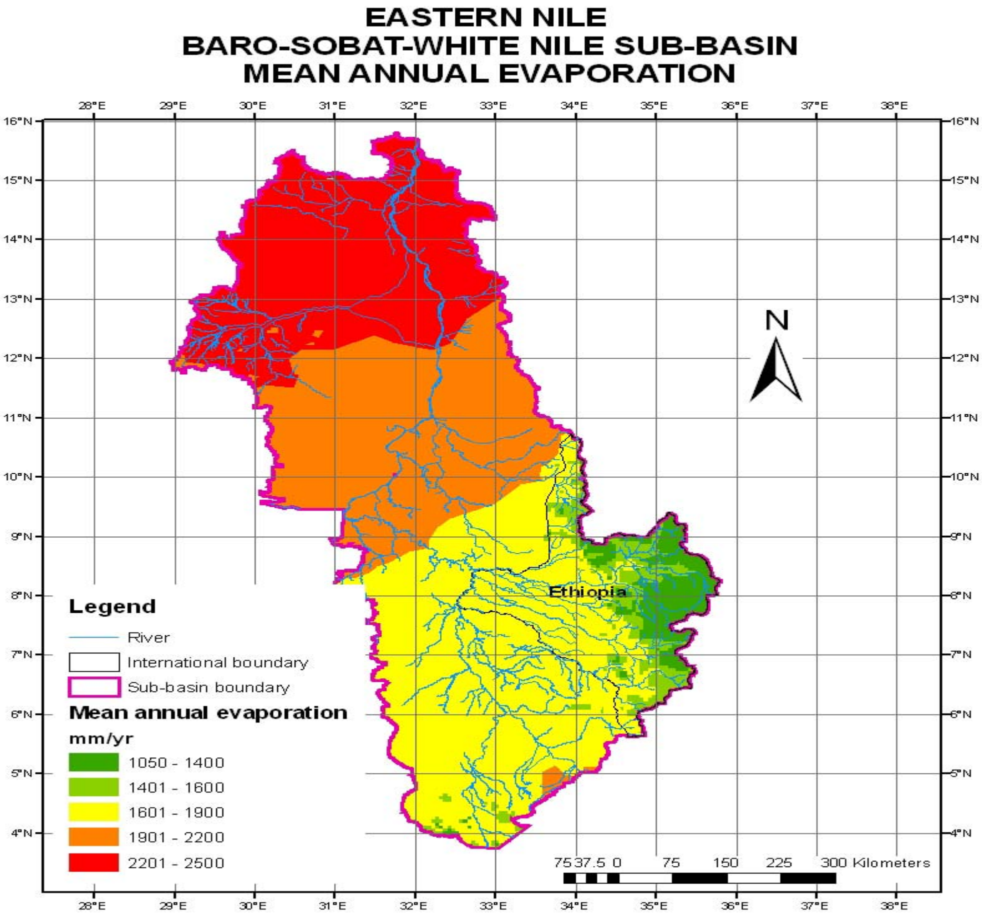

Fig (6): Annual evaporation

2.4 Catchments:

2.4.1 The Baro-Akobo

The major rivers within the Baro-Akobo basin are Baro and its tributaries of Birbir, Geba and Sor. The Alwero and Gilo, with their tributaries of Gecheb, Bitun and Beg; then the Akobo with its tributary as Kashu. The general direction of the rivers is from the east, highland of about 2,000 – 3,500 masl where rainfall is high with steep gradients, to the western lowland plains lesser than 500 masl, that have relatively low rainfall and moderate to low river gradients, which ultimately join Sobat river.

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

The Akobo appears to spill across to the Pibor through an extensive area of wetland at its junction with the Akula River. Just above Jakawu there is a bifurcated into the Baro to the north and the Adura to the south, they rejoin below the junction with the Khor Machar into the *Machar Marshes*.

There is a knowledge gap on this area, because there is a river which probably might have arise from the *Machar Marshes* or from the Bahar el Ghazal river draining through the town of Tunga with immense biodiversity joining the White Nile just about 6km south of Malakal administrative town or 9km north of Sobat White Nile confluent at the Jonglei canal mouth.

2.4.2 Pibor Catchment's

Four patterns of streams have been recognized in the Pibor Catchment's that occur successively northwards in approximately west-east zones (Jonglei Investigation Team, 1954). The first zone is the area of rapid runoff where stream debouch off the Basement Complex Hills and Mountains from Eastern Equatoria State. Flows are seasonal and highly variable, sediment loads are high and gradients very steep. Below these streams on the foot-slopes gradients rapidly decrease and coarse sediment is deposited forming well-defined valley floodplains of Pibor River. It is in this Zone that there is an area of wetlands even more extensive than those of the Machar Marshes, where a spill appears to occur between the Akobo and the Pibor Rivers to the northeast of Pibor Post.

The three main collector streams of: Viveno, Lotila and Kengen joining at Pibor Post to form the Pibor River. Downstream the Pibor is joined on the west by the Geni and Akobo from the Ethiopian highlands, further downstream the Pibor is joined successively by the Gilo, Mokai and Baro. At Baro-Pibor confluence the river becomes the Sobat. During high flows just below the Akobo confluence the Pibor spills westwards to the Twalor (Nyanding) a south bank tributary of the Sobat.

2.4.3 The Sobat System

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

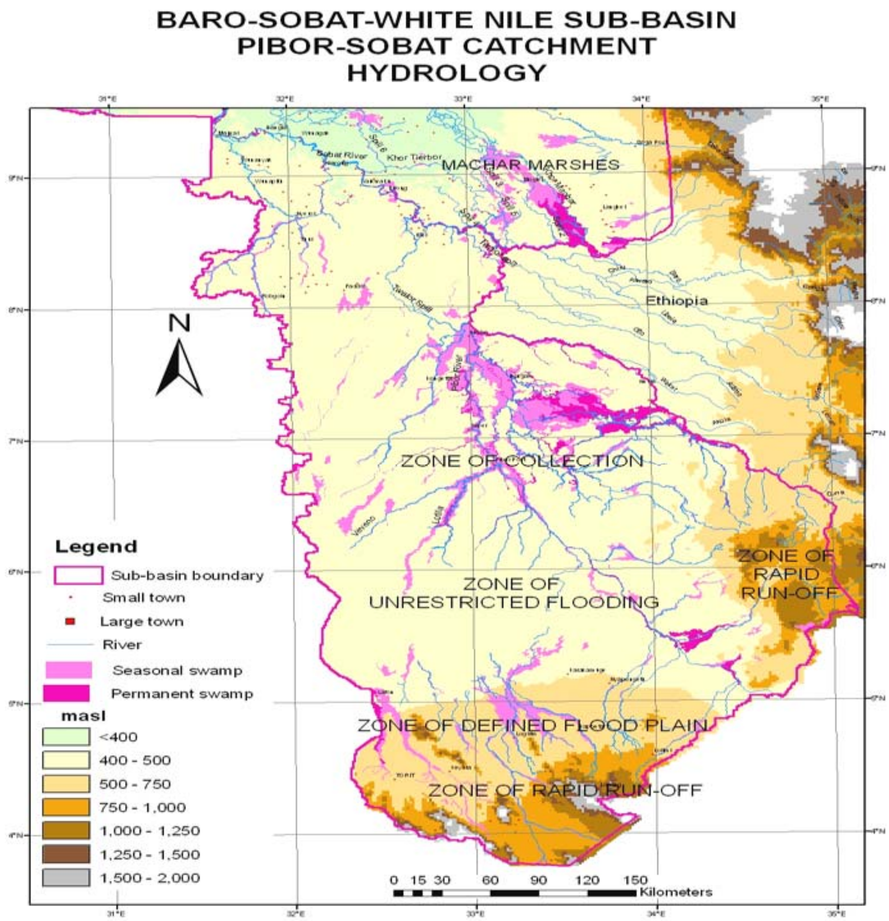

Fig (7): Sudan, Pibor-Sobat Sub-basin - Hydrology
Source: Landsat TM 36-05 & Howell et al (1983); Sutcliffe & Parks, 1999).

2.4.4 The Sudd – White Nile System

Information to be obtained

2.4.5 The Khor Adar Catchment

Information to be obtained

2.4.6 Tunga River Catchment

Information to be obtained

2.4.7 White Nile Catchment

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

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

3. The Machar Marshes

3.1 Permanent and Seasonal Swamp:

The Machar Marshes are the least known of the southern Sudan wetlands. There is neither direct ground evidence for the distribution of permanent and seasonal swamp nor direct evidence of the swamp and grassland vegetation types. The JIT study estimated an annually flooded area (swamp and grassland) of between 6,000 and 20,000 km^2. The area was mapped by El-Hemry and Eagleson (1980) using Landsat imagery. They estimated the area of permanent swamp as 8,700 km^2 (of which 60 percent was grass and forest). The area has also been mapped by the FAO Africover Project. Their survey mapped 967 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. It is possible that part of these grasslands could also be seasonally flooded.

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

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

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

3.2 Drainage through the Machar Marshes

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

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

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

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

3.3 Water balance of the Machar Marshes:

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

Evapotranspiration. The Waterwatch Study focused only on the balance between rainfall and evaporation and used a different method to estimate the loss by evaporation of the two inflow components.

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

The "Eastern Torrents"[1] originate on the Ethiopia escarpment and drain an area of approximately 10,300 km^2. The two main Khors are the Yabus and Daga. Based on the mean annual rainfall and a gauged runoff coefficient of 15 percent, total mean annual runoff was estimated by the JIT to be 1.744 km^3. The MIT study estimated total runoff from the Eastern Torrents 4.2 km^3 and a further runoff from the clay plains of 1.41 km^3. Sutcliffe and Parks consider these to be severely over-estimated and used the JIT estimate.

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

Losses from the area include (i) drainage to the White Nile, and (ii) Evaporation. Drainage to the White Nile is through Khors Adar and Wol. Mean annual loss through the Adar was estimated to be 0.150km^3 and that through the Wol at 0.100 km^3.

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

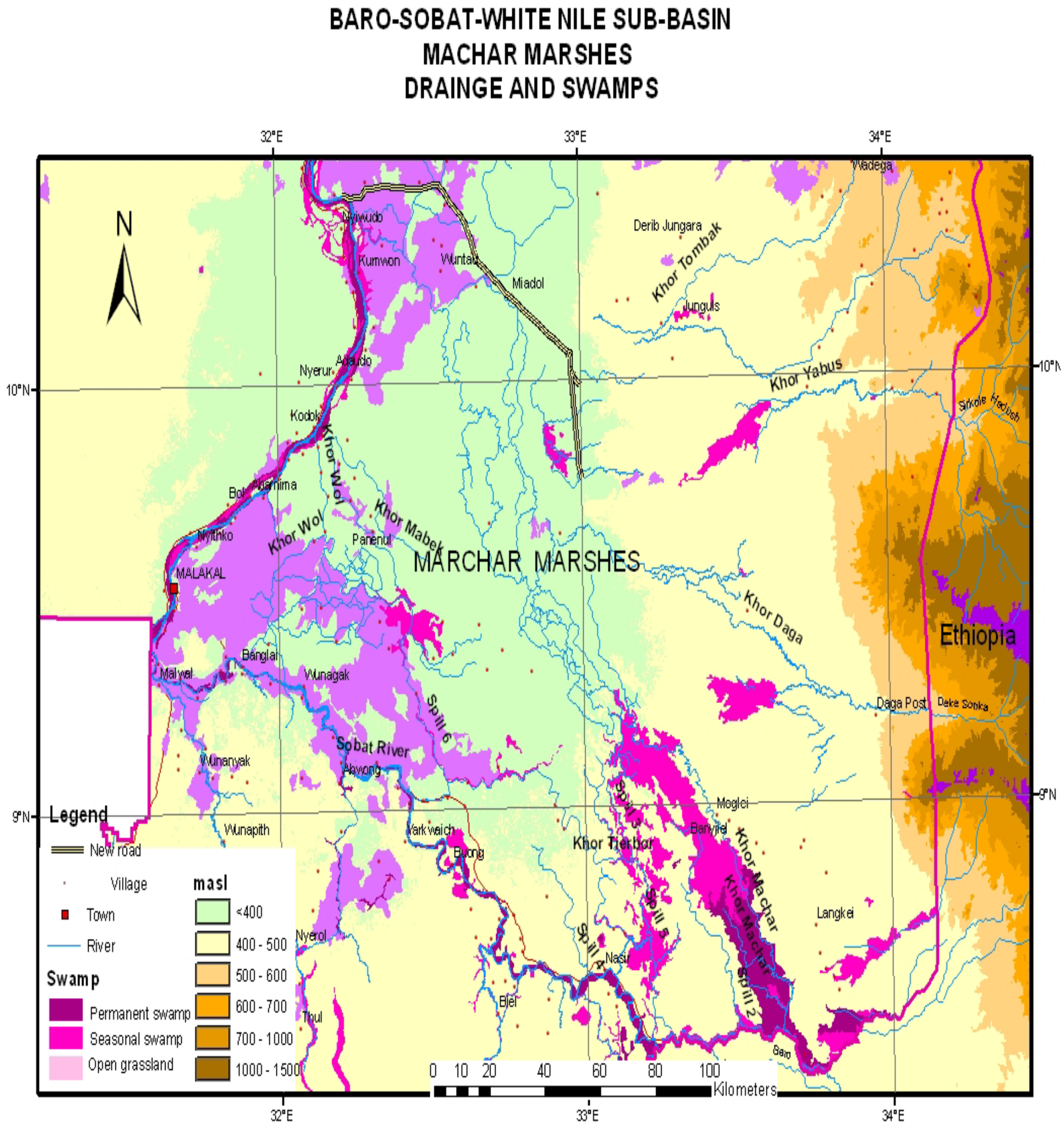

Fig (8): Sobat - Machar Marshes Catchments; Drainage and Swamps
Source: Africover & CRA Interpretation

3.4 Groundwater

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

The Baro-Akobo Catchment has two basic types of aquifer (MWR: Baro-Akobo Master Plan, 2001).

One is associated with fracture and crush zones in the Basement Complex rocks and the other in the Pliocene to Quaternary alluvium, an unconsolidated sedimentary porous medium. Basement Complex aquifers characteristics vary with the degree of fracturing and area continuity that exists in otherwise impermeable bodies of metamorphic and /or igneous rock. Rock type and mode of emplacement usually have little relationship to Basement Complex permeability. The available information indicates production rates to be generally less than one liter per second (1 L/S).

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

In areas of the Unconsolidated Sediments that stretch from the Sobat Basin and then down the Main Nile and across to the Blue Nile the hydro-geological system comprises two aquifers: an upper and a lower (Farah *et al*., 1997). The upper aquifer includes mainly the Upper Gezira Formation and the upper part of the Lower Gezira formation in the area between the Blue and White Nile. The lower aquifer is developed mainly in the deeper Nubian Sandstones. The water storage in the lower aquifer is some eight times that of the upper aquifer. Except for a few isolated localities water quality is free from impurities for drinking and irrigation requirements.

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

4 Soils and Vegetation cover

Information on soil such as a) Physical texture (e.g. moisture/dry content, permeability/porosity, depth etc), b) Chemical tests (e.g. alkalinity, salinity, pH etc) and c) Biological characteristics (nutrients or organic matter) are generally are sparse and under development in the in the basin.

The predominant soils in the highlands of Ethiopia are the Nitisols, which are deep with smaller areas of Leptosols. Unconsolidated Sediments that cover all of the Lowlands in Ethiopia to the Sudanese boarder are overlain by very extensive areas of Vertisols – deep black cracking clays soil. Arenosols derived from wind blown sands are extensive in the north-western part of the Sub-basin. However, a range of soil types occur over the southern mountains and hills in Ethiopia, across to the Boma Plateau in the south-eastern Sudan where Cambisols and Solonetz soils are found. Both deep Luvisols and shallow Leptosols soil types are found in the Nuba Mountains in the Sudanese site of the basin.

4.1 Vegetation

Some considerable works had been done on the vegetation cover of the Baro-Akobo-Sobat and White Nile sub-basin, such as the Jonglei Investigation Team's study (JIT, 1954), the Southern Development Investigation Team (SDIT, 1955), Mann (1977), Obeid Mubarak et al., (1982), Mefit-Babtie (1983), Howell et al., (1988), Howell and Lock (1993), FAO (2005), and Bussmann (2006) in the Sudan. For Ethiopia sources of information included Chaffey (1979), Friis (1993), WBISPP-MARD (2002), Wood and Abbott (2001) and EWLNRS-Bird Life International (1996); that the basin vegetation cover generally ranges from tropical woodland, temperate zones of savannah woodland and savannah grassland to the semi arid zone down stream of the basin.

5. Flood in the Basin System

5.1 Gambella - Ethiopia

Gambella is a provincial Capital city of 30,000 people living on the bank of the Baro River in southwest Ethiopia. Damages incurred in a flood on 1% AEP are estimated to be US$7.10M, comprising $4.3M direct damage and $2.8M indirect damages. Total damages incurred in a flood of 5% AEP are estimated to be US$1.13M. Based on these figures, AAD in urban Gambella is estimated to be US$330,000.

Benefits derived from a single measure recommended for structural flood protection works separating the city from the Baro River and it tributary the Jejebe. The estimate cost of this measure in FPEW Phase 2 at 2006 prices is $2.259M, and its PV assuming an opportunity cost rate of 10% for capital is $1.737M.

The benefits to accrue from this measure include the value of all damages up to the design standard of the structure. As the incremental depth of flooding between flood of1 in 25 and 1 in100 annual probability is not great, and the damage escalate rapidly beyond AEP 5%, it's assumed that the structure should be designed to a 1% AEP standard. If damages up to 1% are considered the estimate benefits is $0.295M per annum on average. Over 30years at an opportunity cost rate of capital of 10%, the PV of these benefits would be $2.777M.

The flood information at Gambella however are not adequate enough, some preliminary investigation should include tophagraphical survey, revised preliminary design and cost estimation, collation of more accurate property and flood damage data, review of environmental and social issues, and hydrological analysis.

5.2 Jonglei – Sudan (Flood Control)

At the Sudanese site of the basin flood is causing a considerable damage and destruction on to properties, agricultural inputs, livestock wealth and settlements; however data on the details and the monitory values of those damages are yet to be obtained as the floodable areas are vast and the capacity to cover the areas is inadequate. The authorities in the Sudan especially at Jonglei State, under GTZ IS USAID funded project (2004 - 2005) had embarked on Dykes construction as mitigation measure to control flood and flooding in the area. The impact of this projects' intervention for continuity in the sub-basin are to be obtained.

Table (3): Summary of Flood Information in the Baro-Akobo-Sobat and White Nile Basin

Sub – Basin:	Flood prone area Km^2	Flood Intensity	Damage at 1% AEP
Baro	--	--	--
Akobo	--	--	--
Pibor	--	--	--
Sobat	--	--	--
Tunga river	--	--	--
Khor Adar	--	--	--
Sudd-White Nile	--	--	--
White Nile	--	--	--

6. Irrigation and Drainage in the Baro-Akobo-Sobat and White Nile Basin

Most of the complete studies on the potential of irrigation in the basin are those by ARDCO-GEOSERV (1995) at the upper part of the basin in Ethiopia and the Selkhozproexport (1990) covering the lower part of the basin in Ethiopia, all were complied in an Integrated Development Master Plan Study of the Baro-Akobo river basin in Ethiopian site.

The potential of irrigatable area lies at the Gambella plain, under these study the gross potential area available amount to 600,000hacters from which 480,000hacters could be developed for irrigation. From this study 14 irrigation projects were identified and prioritized into:

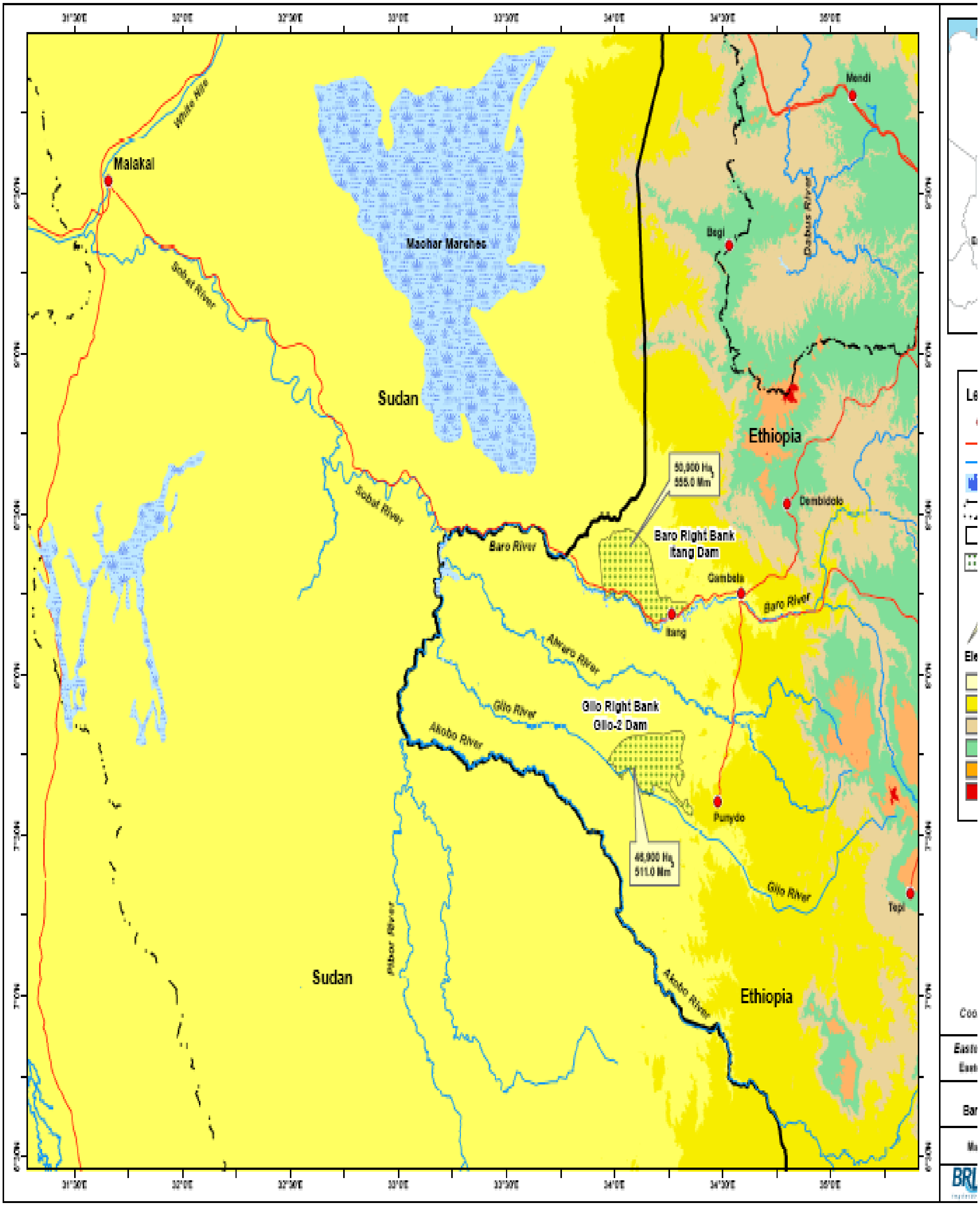

Fig (9): Showing irrigation schemes in Ethiopia

Table (4): Summary of Irrigation and Drainage in Baro-Akobo-Sobat basin

SN	Sub-basins in Ethiopia	Area (ha)	Economic benefit per annum
1	Baro river, right bank, gravity fed from Itang dam	50,900	--
2	Alwero project, fed by gravity from Abobo Dam	10,400	--
3	Upstream Alwero project, fed by gravity from Dumbong Dam	15,000	--
4	Gilo river, right bank, fed by gravity from Gilo-2 Dam	47,000	--
5	Itang irrigation	53,000	--
6	TAMS Dam	--	--
	Total	**176,300**	
SN	**Sub-basins in Sudan**	**Area (ha)**	**Economic benefit per annum**
1	Pibor-Sobat	**--**	**--**
2	Sobat	**--**	**--**
3	Tunga	**--**	
4	Khor Adar	**--**	**--**
5	Sudd-White Nile	**--**	**--**
6	White Nile	**--**	**--**

(--) No reliable data obtained

Baro river bank irrigation project is located on the right bank, north of the Baro river 430 to 420 meters above the sea level, between coordinates 33°57'E to 34°30'E and 8°10'N to 8°25'N.

Gilo irrigation project is also located within the Baro-Akobo river basin. The potential of irrigation development within this area was estimated to be 61,326hacters gross and 46,900 ha net. The Gilo river has a mean annual run-off estimated at 3,224MCM/year that could irrigate the scheme.

The Itang Dam with a capacity of 100m^3/S with two capacities of 66m^3/S on the right bank and 62m^3/S on the left bank could have an active storage of 157.9 MCM and dead storage of 88.6MCM.

7. Hydropower Potential Development

A number of hydropower development projects had been earmarked in the basin, at the Ethiopian site of the basin pre-feasibility studies had been conducted on dams development for hydropower production and storage of water for irrigation and river flow control.
The Baro-1 and Baro-2 schemes are located along the Baro River between Gore and Bonga, approximately 600km west of Addis Ababa form a hydropower cascade, the Baro-1 create head pond for the cascade. Baro-2 is downstream plant in the hydropower cascade on Baro River, with gross head of 510m, between 1,320 and 810 meters above the sea level.

Studied in the Baro Master Plan, to serve as a diversion to the Baro-2 scheme through a reservoir peak created by the considerable catchment drains of Genji River which is a tributary of Baro River

At Itang some 3 km downstream of Baro-2, Genji dam site had been proposed and the dam is located 25km downstream from Gambella regional capital. The dam and its reservoir would be for river regulation and storage of water for Itang irrigation project of 53,000 hectare.

Table (5): Summary of the proposed dams in the Baro-Akobo-Sobat and White Nile basin

SN	Dams	Catchment area (km^2)	spillway (m^3/S)	reservoir surface area (km^2)	reservoir elevation (masl)	hydropower/Installed capacity (MW)	Economic return analysis
1	Baro – 1	2,210	2,500		1,525		
2	Baro – 2	2,332	2,990		1,325		
3	Genji	1,380	1,130		1,205		
4	Itang	24,420	1,397	--	--		
5	TAMS	20,970	1,365	105.0	--	1,060	
6	Pibor-Akobo confluent	--	--		--		
7	Nasseir downstream	--	--		--		

Itang drainage (1906) 24,636 & 23461km^2 (- -) not reliable data located

8. Navigation

The Baro-Akobo-Sobat and White Nile basin is reported to have a viable potential for navigation; that the distance between Gambella in Ethiopia and Malakal in Sudan had a long history of navigation trade between the two towns and the people living along the Gambella – Sobat – Malakal basin. From Malakal the basin remains navigable northwards through Kosti town (White Nile) – Khartoum then to Egypt, linking trade cooperation and service provision to the basin resource and its people.

Likewise, from Malakal southward through the Sudd region into Juba (Sudd – White Nile sub-basin), the basin remains navigable.

Data on the distances and navigable depths remains sparse, however the presence of water hyacinthine reported in the basin seem to obstruct navigation in some seasons in the year.

Table (6): Summary of navigable sub-basin distances in km

SN	Sub-Basins	Navigable distance (km)
1	Baro-Sobat	--
2	Akobo-Sobat	--
3	Sobat- White Nile	--
4	Khor Adar – White Nile	--
5	Sudd-White Nile	--
6	White Nile-Northwards	--

(--) No reliable data obtained

9.0 Livelihood and Natural Resources

Natural resources is another wide water user sector, the renewable and nonrenewable natural resources sectors influencing livelihoods in this basin include: Agriculture, Fisheries, Forestry, Livestock, Mining and Wildlife. Approach to basin sustainable development is most likely to target communities whose lives almost and entirely depend on exploitation of these resources for their wellbeing, although sustainability and environmental management remains a challenge.

9.1 Crop Production

Crop production (agriculture) is one of the natural resources practices, as means of earning cash and foodstuff for sustaining lives. The main agricultural practices in the Baro-Akobo-Sobat and White Nile basin in Sudan and Ethiopia are relatively distinct, however some similarities exist in the systems of farming across the international border where the cultural affiliation have given rise to these systems. The commonly practiced systems are the rainfed cropping and irrigated cropping. However, different sub-categories of farming systems are embodied within these systems depending on scale and practices.

Rainfed agriculture is the most commonly operated traditional system of farming on small-scale subsistent to a large-scale semi-mechanized and mechanized farming.

Rainfed Agriculture, Upper Nile

Mixed cropping and back yards livestock production are other common practices along with shifting cultivation.
In both the highland and lowland given the varied methods of cultivation the use of agricultural input such as fertilizers is still minimal.

9.1.1 Traditional Small-scale Rainfed Agriculture

In the highlands traditional rainfed systems can be divided into cereal and enset-root based crop production. The enset-root based system is common with the Mocha (Sheka) people, living mainly in the highest parts of the Ethiopian highlands, cultivating enset as a co-staple crop with cereals and tubers, similar practices do exist also in the Sudanese higher land and rainy forest. The common crops produced here include enset, root crops, yam, taro and sweet potato, pulses, vegetables, spices, teff, rice, cassava, maize, sorghum, cowpeas, groundnuts and sesame in Sudan at the Nuba and Imatong Mountains and below 2,000 meters above the sea level coffee is produced in Ethiopia. Coffee, teff, maize, sorghum, cotton and root crops are the important cash crops in either country.

The Anuwak, Opo and Komo peoples cultivate the banks and levees of the Baro, Akobo and Sobat rivers rather than the woodlands on the interfluves. The crops obtained are maize, beans and sorghum. The average cropped area for maize is 1-2 hectors with 1 hector of long season sorghum. The first maize and bean crops are grown on the wetter soils where there is residual moisture. The second crop is grown during the rain season on the high and better-drained levee soils with the sorghum and bean crops.

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

9.1.2 Small-scale irrigated cropping

Traditionally the wetlands have been avoided due to the presence of diseases such as typhus fever for humans and liverfluke for cattle. Limited wetland edge cultivation for maize remains the only practiced in the wetland areas. In addition, to the drainage based cultivation of wetlands in the northern and eastern parts of the upper Baro-Akobo sub-basin, there is also long established cultivation of *taro* (*Colocasia esculenta*) in wetlands in Bench Maji Zone around Mizan Teferi, and in Sheka zone around Tepi. Traditionally this does not usually involve any water management, as this crop is tolerant of flooding. However, water management is occurring in some places because farmers have realized that yields can be increased in this manner with flooded areas extended and water availability improved before and after the rains.

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

This is the Kenana Sugar Scheme, which is partly State and part commercially financed. Is irrigated by pumping water directly from the White Nile into the plantations. It has some 146,000 feddans (61.320 ha) of irrigated land (Knott & Hewett, 1994) under sugar cane production. Its Mill has a crushing capacity of 17,000 tons/day over a 218-day cycle. The total contribution of agriculture to the Sudanese GDP in 1990s was reported as 10.8%

9.2 Fisheries

Capture and Aquaculture fisheries sectors are among the renewable natural resources supporting a substantial population whose livelihood depends on direct and indirect exploitation of the fisheries resources of the basin. However, information on the fisheries resources of the basin is sparse. In Sudan White Nile sub-basin 136 fish species belonging to 42 genera of 21 families were recorded, the most taste preference and of commercial important fish species include *Lates nilotica, Gymnarchars nilotica, Tilapia* spp*, Clarias* spp*, Hetrotis nilotica, Labeo* spp*, Distichodus niloticus* and others, Muso (2002).

It supports about 5.3% of the countries total population and its contribution to the total GDP is under compilation, however total potential of annual landing are estimated at 150,000 - 300,000 metric tones per annual on sustainable yield bases in the basin alone.

Fisheries are widely regarded in the basin as an important economic backbone to the inhabitants of the basin, such as the Anuwak, Nuer, Dinka, Bari, Shilluk and the Falata are largely employed in the sector. Information on the Ethiopian site of the basin and the resources contribution to nations GDP are under compilation, aquaculture potential is regarded high in the basin wetland ecosystem.

9.3 Forestry

In Sudan in the Sub-basin approximately 8.8 million m^3 of wood fuel and charcoal (per capita consumption of 1.4 m^3) are consumed forming about 80 percent of the total energy consumption. An unknown quantity of charcoal is exported from the central parts of the Sub-basin to Khartoum. Woodlands provide all building materials in rural areas. They constitute 33 percent of the livestock feed as browse. They also provide a number of non-timber forest products the most important of which is Gum Arabic.

In addition to these products the woodlands give a number of services which have no direct monetary values such as environmental protection, increase in crop production, conservation of soil fertility, biodiversity, protection of cultural heritage, forming habitat for wildlife and eco-tourism attraction and conservation of water catchment areas.

The situation in Ethiopia is not similar to that in Sudan. In Ethiopia in the Baro-Akobo-Sobat sub-basin provide some 7.95 million m^3/yr of fuel wood and charcoal (wood equivalent) are consumed as fuel forming about 65 percent of domestic energy consumption. Browse is of little importance in the Ethiopian highland livestock systems. The official figures for timber production do not include timber and poles produced and used outside the official marketing structures, in particular, for domestic use in rural areas.

9.3.1 Agro-forestry

In Sudan the main components of agro-forestry are the harvesting of Gum Arabic, Gum Acacia and browse for livestock as mentioned above. The Gum Arabic Belt (GAB) in the Baro-Sobat-White Nile Sub-basin comprises the major part of the low rainfall savannah grassland zone extending from the border with Ethiopia through to North Kordufan west of the White Nile sub-basin on the sandy soils. The Gum Acacia belt is the savannah woodland zone extending from Eastern Equatoria through Upper Nile and South Blue Nile States.

There is a distinct difference between the clay and the sand provenances of *Gum Acacia and Gum Arabic* in terms of their water-use efficiency and gum yield (Raddad & Luukkanen, 2006). The clay gum produced in Eastern Equatoria, Upper Nile and South Blue Nile States were distinctly superior to the sand States of White Nile and North Kordufan in all traits studied, especially in their basal diameter and crown width. The Gum Acacia are adapted for fast growth rates and high biomass and gum productivity than the Gum Arabic.

There are a number of direct (production) and indirect (environmental) benefits accruing to gum production (Barbier, 1990).
In terms of direct benefits the trees provides fodder for cattle, sheep, goats and camels. Older trees (i.e. 15 years or more) that no longer produce good quality gum are often cut for fuel wood and for charcoal production. In terms of indirect benefits the deep taproot and its extensive lateral root system means that it assists in reducing soil erosion and water runoff and for stabilizing soils. Because of its leguminous characteristics the tree fixes nitrogen, which encourages grass growth for grazing by livestock. The trees can act as windbreaks and can assist in the stabilization of shifting sand and moving dunes.

Seasonal laborers from other parts of the country migrate to the Gum Belt seeking employment and thus its production system supports and extends livelihood strategies, by this time they too gather for Shear nut and Honey.

Currently, the Gum production is unstable due to climatic factors and marketing policies, in particular the ban on private companies exporting unprocessed Gum. The floor prices paid by the government-owned Gum Corporation as a percent of export prices (f.o.b. Port Sudan) declined from 70 percent in 1994 to only 21 percent 2000/2001 (World Bank (2004). In 1990-1992 the government temporarily waived controls and the percent of export price rocketed to 160 percent! The gum plays an important role as major source of foreign exchange, accounting for 13.6 percent of the annual export income excluding petroleum.

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

9.3.2 Vegetation burning and Wildfires

Information to be obtained

9.4 Livestock

Within the Baro-Akobo-Sobat basin the political boundary between Sudan and Ethiopia is mirrored by socio-cultural and physical affiliations. Many people in the past followed pastoralist and agro-pastoralist livelihoods, keeping of livestock had become rooted into their life style and is now the source of cultural and national identification, others whom for one reason or another lost their livestock and had became sedentary. Although so a number of groups of these people had retain their original way of life style, but with somewhat alterations.

The Rufa'a al-Hoi is an Arab speaking Muslim nomadic peoples keeping sheep, cattle and camels. The south group the Badiya used to move between the Yabus (in the dry season) and the Gezira / Managil schemes (in the wet season), keeping the trails of Butana and Kenana breed cattle. As agro-pastoralist they as well collect Gum Arabic (from *A. seyal* spp.) and cultivate sorghum, cotton, sesame, beans and nuts to supplement their livelihoods.

The Fulani are in fact a mixture of many ethnic groups from West Africa who moved into the Funj in the mid 1940's.They have the West African long horned cattle that are fast walkers but poor milk producers *(Mbororo cattle)*. They are adapted to similar type of wet and dry seasonal migration for water and pasture along the White Nile basin.

West of the White Nile are the Nuba group of peoples who live in the Nuba Mountains, but cultivate in the plains. They mostly keep sheep and goats (*Nubian goats*) and practice a range of productive activities including crop production, as well as other animal husbandry types e.g. back yards poultry keeping.

The Baggara are an Arab speaking pastoral people, a large proportion of whom belong to the Hawazma group of western White Nile basin in and below the Nuba Mountains interacting with the Nilotic Shilluk tribe. They use the Nuba Mountains in the wet season, and the clay plains west of the White Nile and cross to the east over in the dry season and also graze to the north of the Machar swamps.

They rarely enter the southern Funj area in the dry season; they are identified by their White colour cattle, (*Baggara cattle*).

Further south are the Nilotic groups of: Nuer, Dinka, Shilluk, Anuwak, Murle, Mundari and other Bari speaking groups. The Nuer, Dinka and Murle are pastoralists keeping the long horned varied coloured *nilotic cattle*, other groups are more agro-pastoralists such as the Shilluk, Anuwak and Bari groups, the later group keeps the dwarf and compressed *Mangala* type of cattle, known of their resistance to testest fly and are mainly sedentary cultivators.

The Taposa people live in Kapoeta county of Eastern Equatoria, which experiences a lower rainfall in this region, but they depend mostly on the Pibor catchment. They are mainly pastoralist keeping Taposa type of cattle, camels, sheep and goats, but they also cultivate maize, sorghum and collect minerals.

Sudan Uganda Cattle auctioning market

NILOTIC CATTLE

The Shilluk, Nuer and Dinka groups occupying mainly the riverbanks of the basin alternate most of their socio-economic activity with fishing component for their food and economic security.

The Anuwak are also agro-pastoralist, found in both Ethiopia and Sudan adjusting to each other in the Gambella plain. They occupy the high levees along the Sobat River and its eastern tributaries in Ethiopia. They cultivate sorghum and maize on the flood retreat soils below the levee. Fishing is also an important element of their livelihoods.

Within Ethiopia in two of the three regions located within the basin one ethnic group tends to be predominant. Only in the Beneshangul-Gumuz region are the various groups more evenly distributed. There are over 55 ethnic groups represented in the Amhara Region. However, the main groups are Amhara with 91 percent and Agew with 4% of the rural population.

9.5 Geology and Mining

The Baro-Akobo-Sobat and White Nile catchments consist primarily of basement crystalline rocks in the eastern uplands with a covering of tertiary lavas in places and quaternary sediments in the lowlands to the west.

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

Granites and gneisses of the basement complex outcrop in the mountains and hills of the southern part of the Pibor-Sobat sub-basin. Some mining of Gold is going on in this belt in and around Kapoeta County, although it annual and/or per Capita income and contribution to national GDP is going unnoticed, mining for Cement is also reported visible in the belt.

North of these stretching all the way to the Blue and White Nile junction are deep deposits of Quaternary and late tertiary unconsolidated sediments. The Sudanese Block five (Blk-5) of the oil field is located along this belt southeast ward. The exploitation of Oil had change the usual trend of the natural resources influence on livelihood and their contribution to the national GDP, although figures on the oil per Capita income are yet under computing. To the west of the White Nile is the Basement Complex gneisses outcrop into the Nuba Mountains, where various kinds of minerals are possibly reported.

9.6 Wildlife and Conservation

The basin has an extremely wide range of wildlife species and rich in habitat biodiversity. In habitats two of the most important high and lowland forests of the Ethiopian Highland and the Imatong Mountains in Sudan are the wetland-flooded grassland.

In Ethiopia, the lowland transecting from Gambela plains to the higher parts of the basin contain nearly one wide range of forest from the *Guinea-Congolian* forest through transitional sub-types to the *Afro-Montane*, Friis (1992). The forests are home to *wild coffee* spices of genetic resistance to *coffee berry* disease. Other wildlife spices found here includes *Colobus* and *Vervet Monkeys, Tree Squirrel, Lion, leopard, antelopes, buffalo, Elephant, Porcupine, Aardvark, Wart Hog* and *Forest Pig*, information on the endangered species are yet under compilation.

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

9.6.1 Wetlands-Flooded Grasslands

The plain ecology of the wetlands-flooded grassland located on the clay plains of the Baro and Sobat Catchments has their importance in the livelihood strategies of the agro-pastoral peoples who live on the plains, those wetlands also provide habitat and species biodiversity to a considerable degree. Most famously they are home to the White-eared Kob (*Kobus kob sub-spp. leucotis*) and to the Nile Lechwe (*Kobus megaceros*). The White eared kob, undertake a massive migration of some 1,500km. Both listed by IUCN as threatened species, including the Rhino species. In addition the area is an important habitat for 100 mammalian species and 400 avifaunal species.

9.6.2 Conservation

There are three national parks in this basin, the Gambela National Park in Ethiopia and two Boma National Park and Badingilo National Park in Sudan. In addition there is the Kidepo Game Reserve, which adjoins the Kidepo National Park in Uganda,

The Baro-Akobo-Sobat and White Nile 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 Gilo 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 meager. Following the change of government in 1991 control of the Park passed to the Gambela Regional Administration. The area is being visited by *White eared kob* and endangered Elephants.

The Boma National Park encompasses an area of some 2.28 million ha of the clay plains wetlands, seasonally flooded grasslands and open wooded savanna grassland in the northwestern part. The southeastern part of the Park includes part of the Boma Plateau and the escarpment that separates the plateau from the plains.

It was declared a National, Park in 1977 but has not been gazetted. The area is extremely inaccessible, most particularly during the wet season. The main routes have been disrupted due to the long civil conflict over there. The New Sudan Wildlife Organization (NSWO) and a regional headquarters now manage the Park, and a Training Center has been established at Boma town. The number of Staff had increased considerably, including Senior Staff (Tutors of the training center and researchers) but facilities and equipment are lacking (Morjan et al., 2001). A first study of the Park for nearly two decades was made in 2001 and preliminary in wet season wildlife inventory and human livelihoods survey was made. Informations on Badingilo total area coverage, the dominant species including the endangered once are yet under compilation.

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 yet available on either the status of the reserve or maps of its boundaries (Babiker A. Ibrahim, 2000).

Table (7): Summary of Baro-Akobo-Sobat and White Nile natural resources and Livelihood base

SN	Natural Resource	Per Capita annual Income/ consumption MM^3		Contribution to the national GDP	
		Ethiopia	Sudan	Ethiopia	Sudan
1	Agriculture (crop production)	--	--	--	10.8
2	Fisheries	--	--	--	--
3	Forestry	--	1.4	--	13.6
4	Livestock (animal production)	--	--	--	--
5	Mining	--	--	--	--
6	Wildlife	--	--	--	--

10.0 Social Setup and Institutional Arrangements

10.1 Institutional Arrangement

Within the basin in the Sudan there are ten administrative states and in Ethiopia there are four regional states partially located within the basin. Geographically 84% of the basin area is in the Sudan and 16% in Ethiopia.

Table (8): Baro-Akobo-Sobat and White Nile Administrative areas (km2)

States / Regional States:	Administrative Area (km^2):	Basin coverage in %:
Sudan States:		
1. Upper Nile State	77,339	16.5
2. Jonglei State	74,207	15.8
3. South Kordufan State	57,110	12.2
4. North Kordufan	53,419	11.4
5. Eastern Equatoria State	49,517	10.6
6. White Nile State	40,438	8.6
7. Blue Nile State	18,191	3.9
8. Sinnar State	10,339	2.2
9. El Gezira State	8,708	1.9
10. Khartoum State	2,206	0.5
Sudanese total:	**391,474**	**84%**
Ethiopian States:		
1. Gambella region state	32,235	6.9
2. Oromiya regional state	25,996	5.6
3. SNNP regional state	13,045	2.8
4. Beni-Shangul Gumuz State	05,466	1.2
Ethiopian total:	**76,742**	**16%**

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

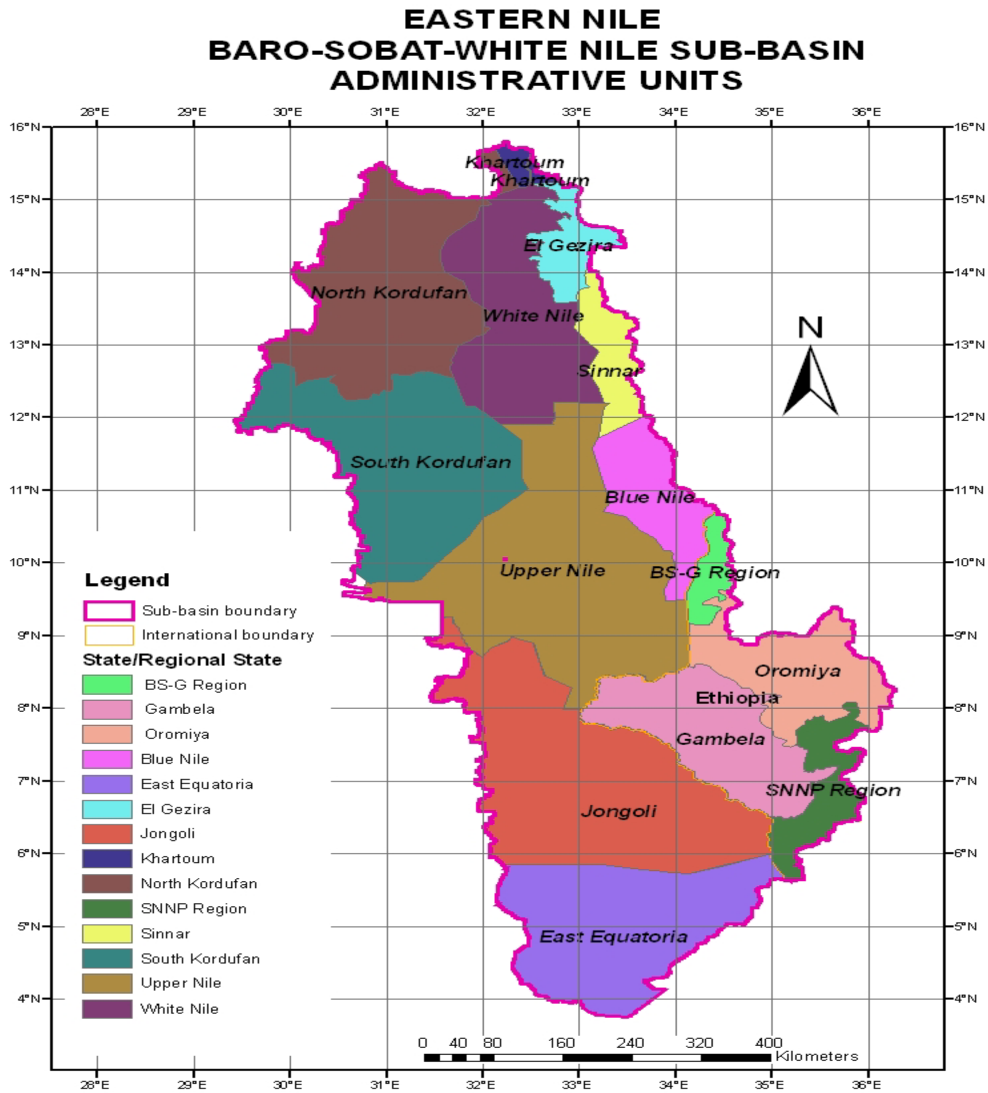

Fig (10): Baro-Akobo-Sobat and White Nile basin Administrative States/Regional States
Source: Sudan: ENTRO GIS data base: Ethiopia WBISPP GIS database.

10.2 Population and Distribution

The LandScan 2002 Global Population Database developed by Oak Ridge National Laboratory (ORNL) of the United States provides, 2002 population estimates on a 1 km^2 grid. This was clipped by the State and Regional State boundaries within the basin to provide population estimates within the basin by State/Regional State[2]. National census estimates of the rural-urban distribution were used to provide estimates of total rural and urban populations. These are shown in table below.

Table (9): Baro-Akobo-Sobat and White Nile basin: Total, rural and urban population estimates by State/Regional State for 2002.

State / Regional State	Total Pop.	Rural Pop.	Urban Pop.	Rural %	Pop. Density pp km^2
1. White Nile State	2,162,050	1,318,851	843,200	61	53
2. Khartoum State	2,148,190	285,709	1,862,481	13	974
3. North Kordufan	1,366,520	941,532	424,988	69	26
4. El Gezira State	1,131,140	877,765	253,375	78	130
5. South Kordufan	811,353	622,308	189,045	77	14
6. Upper Nile State	615,417	482,487	132,930	78	8
7. Sinnar State	451,829	323,961	127,868	72	44
8. Blue Nile Sate	411,895	308,097	103,798	75	23
9. Eastern Equatoria	398,782	294,301	104,481	74	8
10. Jonglei State	392,065	307,397	84,686	78	5
Sub/Totals:	**9,889,241**	**5,762,390**	**4,126,851**		
1. Oromiya R. State	1,816430	1,507,577	308,846	83	70
2. SNNP Region	556,571	502,528	54,044	90	43
3. Gambella R. State	338,233	303,283	34,950	90	10
4. BS-G Region	89,903	74,711	15,192	83	16
Sub/Totals:	**2,801,137**	**2,388,099**	**413,032**		
G/Totals:	**12,690,378**	**8,150,489**	**4,539,883**		

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

Nearly 80% of the population lives in the Sudanese site of the basin. Densities vary from 974 people per km^2 in Khartoum State to only 5 people per km^2 in Jonglei State. Except in Khartoum rural rates are generally high between 61% and 90% in White Nile State in the Sudan. The patterns of population densities are as shown in the below map.

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 the lower basin densities are low and generally confined to the Baro River.

In Sudan the highest population densities are found in Khartoum, El Gezira, and White Nile States and along the main road in Sinner and North Kordufan States. Areas of medium population density include the Nuba Mountains in South Kordufan 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, where population densities are very low.

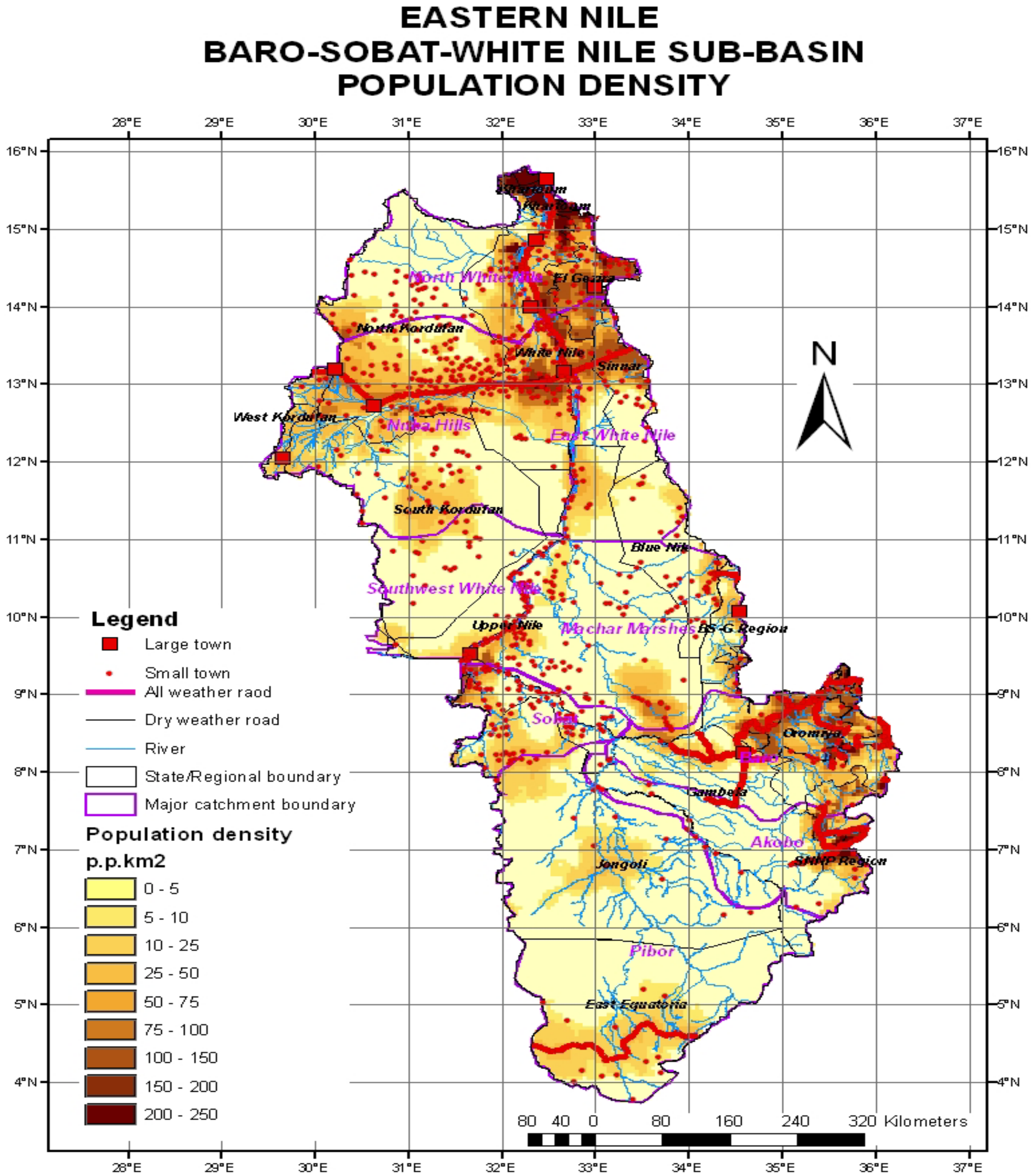

Fig (11): Baro-Akobo-Sobat and White Nile Sub-basin Population densities and distribution.

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

10.3 The Main Economic Activities

It had been noted through out this literature that the inhabitants of this basin are engaged in agriculture (crop production), livestock husbandry, fishing, forestry and wild gathering, Wildlife (hunting) and some mining. However, little is known on which of the above water user sectors predominate their socioeconomic activities and the zones or sub-basins.

Table (10): Showing percentages of socioeconomic activities in the basin

SN	Water user economic sector	Pop. % involved	Per Capita income (annual)
1	Agriculture	--	--
2	Fisheries	--	--
3	Forestry	--	--
4	Livestock	--	--
5	Mining	--	--
6	Wildlife	--	--

(--) information not yet available

10.4 Literacy and Education

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

Table (11): Baro-Sobat-White Nile Sub-basin: States/Regional States – Literacy and Primary School Enrolment Rates

States/Regions	Literacy >15yrs % average	Literacy >15yrs % male	Literacy >15yrs % female	Pop. 6-13yr	Total primary enrolment
Sudanese site:					
1. Khartoum State	73.6	81.1	65.0	795,983	659,028
2. El Gezira State	65.2	75.5	55.8	658,547	538,183
3. Upper Nile State	62.4	75.8	50.3	259,318	48,002
4. White Nile State	54.4	64.5	44.3	335,040	255,152
5. Sinnar State	52.0	64.5	40.0	267,649	146,090
6. Eastern Equatoria State	47.4	60.6	34.3	292,646	42,728
7. South Kordufan State	44.4	56.2	34.4	290,819	100,663
8. Jonglei State	--	--	--	--	--

9. North Kordufan State	39.1	52.0	29.4	364,719	170,023
10. Blue Nile State	31.3	41.8	20.4	143,305	48,914
Ethiopian site:					
1. Gambella Regional State	29.3	38.6	19.5	1,098,511	335,222
2. SNNP Region	24.4	33.9	15.2	609,321	207,169
3. Oromiya Regional State	22.4	29.3	15.6	2,240,471	3,600,777
4. B-G Region	17.7	24.9	10.5	180,971	493,599

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

10.5 Health

Information to be obtained

11. Gender Issues

Information to be obtained

Flood control

Information to be obtained

12. Physical Infrastructure (Roads / Railway / Airstrips)

Information to be obtained

12.1 Housing

Information to be obtained

13. Poverty Level

No information obtained yet

13.1 Cost of Living Index (CLI)

No information obtained yet

14. Environment

14.1 Drinking Water

The percent of the population with access to safe drinking water and sanitation facilities in the basin is as shown in the below tables.

Table (12): Baro-Akobo-Sobat and White Nile basin: States/Regional States, Percent (%) of Population with access to safe drinking water

States	Pipe dwelling	Public tap	Bore halls	Dug wells	River or Canal	Rain Water	Others
Khartoum	59.8	3.5	29.5	2.4	0.2	1.6	2.9
El Gezira	47.2	14.1	16.6	6.6	12	0.2	3.3
Sinnar	30.2	11.3	32.4	0.6	8.1	9.3	7.6
Blue Nile	12.3	2.1	9.3	2.1	33.2	27.9	13
North Kordufan	16.3	5.3	20.5	25.4	2.2	13.2	17.1
South Kordufan	0.9	1.7	76.6	7.1	0.1	4.9	8.6
White Nile	23.1	5.5	10.3	12.4	28.5	7.7	11.8
Upper Nile	--	--	--	--	--	--	--
Jonglei	--	--	--	--	--	--	--
Eastern Equatoria	--	--	--	--	--	--	--

Ethiopian Site							
	Tap	**Protected Well/Spring**	**Unprotected Well/Spring**	**River/Lakes /Ponds**			
BS-G Region	12.5	5.7	0.1	63.1	--	--	--
Oromiya	11.2	11.2	34.2	43.1	--	--	--
Gambella	16.7	9.8	16.5	56.2	--	--	--
SNNP	7.6	11.2	30.5	50.1	--	--	--

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

Khartoum, El Gezira and Sinner States have rates of piped water and deep wells well above those of Blue Nile, and North and South Kordufan State. Data for other South Sudan States are not available. Malakal town has 94% of the total population using rivers, which might reflect the situation to most of the towns in South Sudan.

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

14.2 Sanitation Facilities

Sanitation services in the basin are generally inadequate and inefficient for access of the population. The below table explains the access to sanitation facilities in the basin

Table (13): Sanitation facilities and types used in the Baro-Akobo-Sobat and White Nile basin

States	Flush to sewage	Flush to septic tank	Pit latrine	Soak away pit	Others	Missing info	No facility
Khartoum	1.1	11.2	73.8	0.9	3.1	0.4	9.5
El Gezira	--	4.2	51.7	2.1	1.7	0.2	40.0
Sinnar	--	2.7	46.6	5.3	2.1	0.7	42.7
Blue Nile	--	3.5	56.0	3.2	0.4	0.8	36.0
North Kordufan	--	2.9	31.4	1.9	1.0	0.1	62.6
South Kordufan	--	2.4	48.7	0.3	1.4	0.9	46.4
White Nile	--	4.8	45.7	3.7	2.2	0.5	43.2
Upper Nile	--	--	--	--	--	--	--
Jonglei	--	--	--	--	--	--	--
Eastern Equatoria	--	--	--	--	--	--	--
		Flush	**Flush**	**Private**	**Shared**	**Missing**	**No**

Ethiopian site	Private	Shared	pit	pit		facility
BS-G Region	2.2	3.9	30.3	0.3	1.7	61.6
Oromiya Region	1.8	1.4	33.4	22.4	1.1	39.9
Gambella Region	3.0	3.1	13.1	11.7	2.1	36.0
SNNP Region	1.2	0.9	38.1	22.8	1.2	36.0

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

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

14.3 Pollution

Information's on the basin pollution are yet under compiling; however two main sources of pollution are currently eminent.

i) River basin settlement; which an indirect source of pollution, however such settlements reduces the basin flood plain, giving no chance for silt to settle along their way downstream, biodiversity too are affected. Although this activity may save loss of water through evaporation, yet it saves less with increase human utilization.

ii) Dumpling; a common practice in urban (industrial, sewage) or sub-basin settlements household dumping, greatly affects the quality of water and populations using the water as access to water is mainly the rivers in most

Threatening habitats and Wildlife

of the areas shown in table (12), above.

iii) Agricultural run off is yet uncommon source in the basin.

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