Water Atlas of

THE BARO-AKOBO-SOBAT AND WHITE NILE SUB-BASIN

NILE BASIN INITIATIVE
Initiative du Bassin du Nil

Table of Content

Introduction

The Eastern Nile Technical Regional Office (ENTRO) is an organization meant to realize ENSAP (Eastern Nile Subsidiary Action Program) in the Eastern Nile Basin countries, namely 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.

Currently, under ENSAP, planning is underway for the multipurpose development of the region. To support its multipurpose development objectives, ENTRO proposes to synthesize information at sub basin level categorized in three themes namely, Water Resources, Environment and Socioeconomy. To implement this objective the base line data compilation at national level has been conducted for the three Eastern Nile countries and compiled a report for each theme at national level. The present assignment is aimed at bringing the national level compiled data in to a sub basin level synthesized data, considering no boundary of the Eastern Nile countries.

The objective of this consultancy work is thus to synthesize essential information on water and related resources at sub basin level. The national level compilations are to be synthesized at sub basin level so that information's on these three themes could be presented at sub basin level, which can be used for proper planning of both resources and further investigation activities on resources in the Eastern Nile Sub-basins under the EN Multipurpose Development Program.

This work includes the preparation of the main report and sub basin level atlas preparations that could be annexed to the main report. This atlas specifically prepared for the Baro-Akobo-Sobat-White Nile sub basin is part of the four annexes that supports the main report This atlas is a summarized version of the main report with a more declarative fashion supported by few explanations and more maps with the objective of providing basic features of each sub basin for decision makers and senior program/project coordinators.

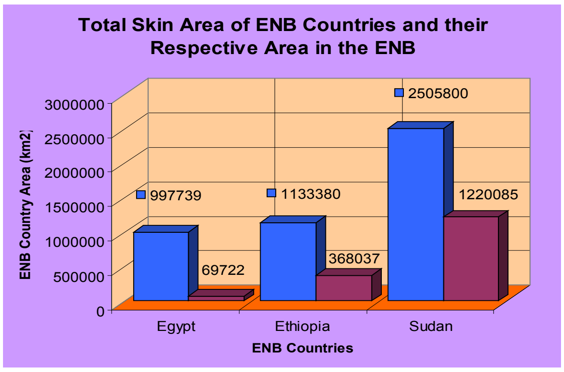
Quick Over View of the eastern Nile Basin

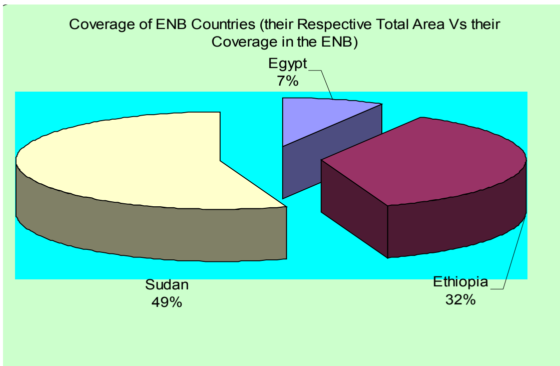
The Eastern Nile Basin is constituted of three riparian countries namely Egypt, Ethiopia and Sudan. A very few portion of Eritrea is also included in the Nile system.

Egypt, with an estimated total area coverage of 997,739km2 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. It 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 1,105km stretching from north to south, with a maximum width at its south border, stretching east-west for some 1130km. Less than 10% of its area is identified to be cultivable, the bulk of its skin coverage (more than 90%) being desert where life could hardly survive. With a total area of 69722km2 the Nile watershed in Egypt accounts only 7% of the country and 4% of the Eastern Nile Basin.

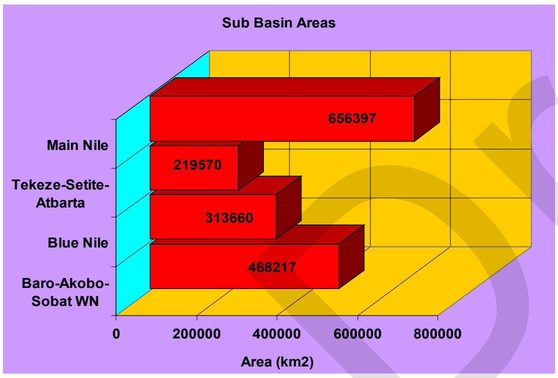
Ethiopia,is located in the horn of Africa, bounded on the northeast by Eritrea and Djibouti, on the east & south east by Somalia, on the south west by Kenya and on the west and northwest by Sudan. With total skin coverage of 1,133,380km2.The highland plateau of the country (above 1800masl) is identified to be the heart of the country covering some 60% of its skin area. The Great Rift Valley splits the Ethiopian highland plateaus diagonally in northeastern and southeastern directions. The northeastern half largely drained by the Nile system. The plateaus are characterized with deep valleys and canyons cut by numerous rivers and streams drained by 12 major river basins, Abbay (the Blue Nile) being one of them taking the lion share both in terms of skin area coverage (18% of the country) and water resources potential (more than 50%). 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 water. Including the upper courses of Tekeze, Abbay & Baro-Akobo sub basins; the Nile watershed in Ethiopia accounts about 32% of the skin area of the country and 22% of the Eastern Nile Basin.

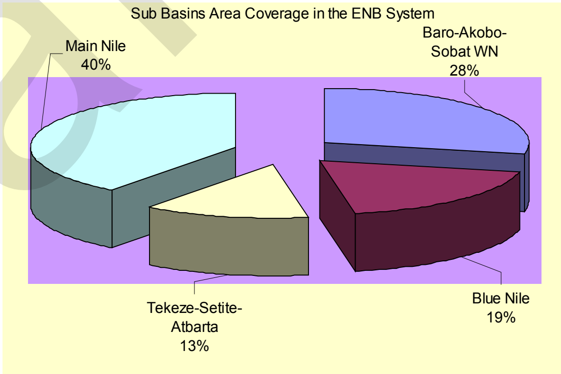
Sudan, located in the northeastern Africa and the largest land state (2,505,800km2) in the continent, is bounded on the north by Egypt, on the east by the Red Sea, Eritrea, and Ethiopia; on the south by Kenya, Uganda, & Democratic Republic of the Congo, and on the west by the Central Africa Republic, Chad, and Libya. The maximum stretch in Sudan is from North to South with a diameter of 2250km, along with its east-west extreme stretch width of 1730km. About 50% of Sudan is included in the Nile watershed. 74% of the Eastern Nile Basin is located within Sudan,





The Eastern Nile Basin is constituted with four major contributing sub basins; the Baro-Akobo-Sobat-White Nile sub basin (with mean annual inflow of 26bm3, that contributes 30% of the inflow at Aswan) from its southern tip, the Blue Nile (at 51bm3 contributes 60% of the inflow at Aswan) located in its middle-east direction, the Tekeze-Setite-Atbara sub basin (contributing 12bm3 per year & accounts 12% of the Nile inflow at Aswan) in its northeastern portion and the Main Nile in its lower course downstream of the Khartoum junction, at its northern tip.

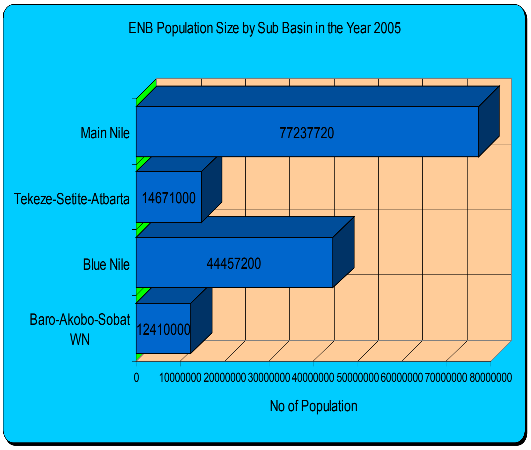


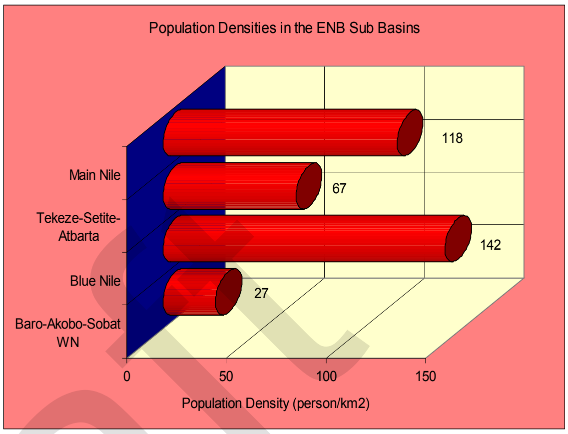


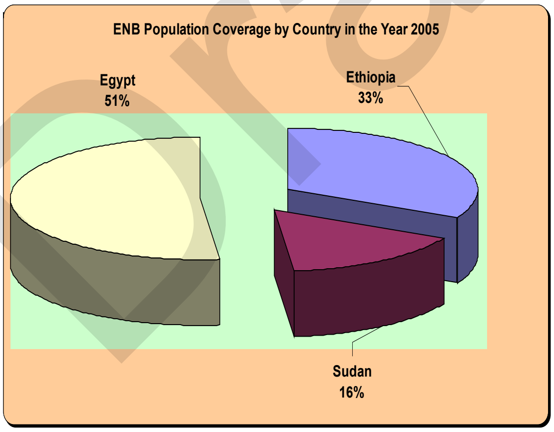
According to the OSI socioeconomic report the total population residing in the Eastern Nile Basin is estimated at 148,775,920 (projected to 2005). In the same report it is however, reported as 160million.

Egypt with a total population of 77million in the Eastern Nile Basin (1105person/km2 one of the worlds highest density) watershed accounts 52% of the population in the Eastern Nile Basin. Ethiopia, with its total Eastern Nile Basin population (population in the upper courses of the three Eastern Nile Basin sub basins) of 48,400,000 (135 persons/km2) , being the second largest populous state in the Eastern Nile Basin, accounts 33% of the ENB population. Sudan, with a total Eastern Nile Basin population of 23,375,920 (20person/km2) accounts 16% of the Eastern Nile Basin population and is the least populous country in the Eastern Nile Basin.

The Baro-Akobo-Sobat-White Nile sub basin (12,410,000) covers 8% of the Eastern Nile Basin population. The Blue Nile, the Tekeze-Setite-Atbara and the Main Nile sub basins with a total population of 44,457,200; 14671000; and 77,237,720 covers 30%, 10% and 52% of the ENB population respectively. Crude population densities (ppkm2) in the four sub basins: Baro-Akobo-Sobat and White Nile, Blue Nile, Tekeze-Setitite-Atbara and Main Nile, is estimated at 27, 142, 67 and 118 respectively.







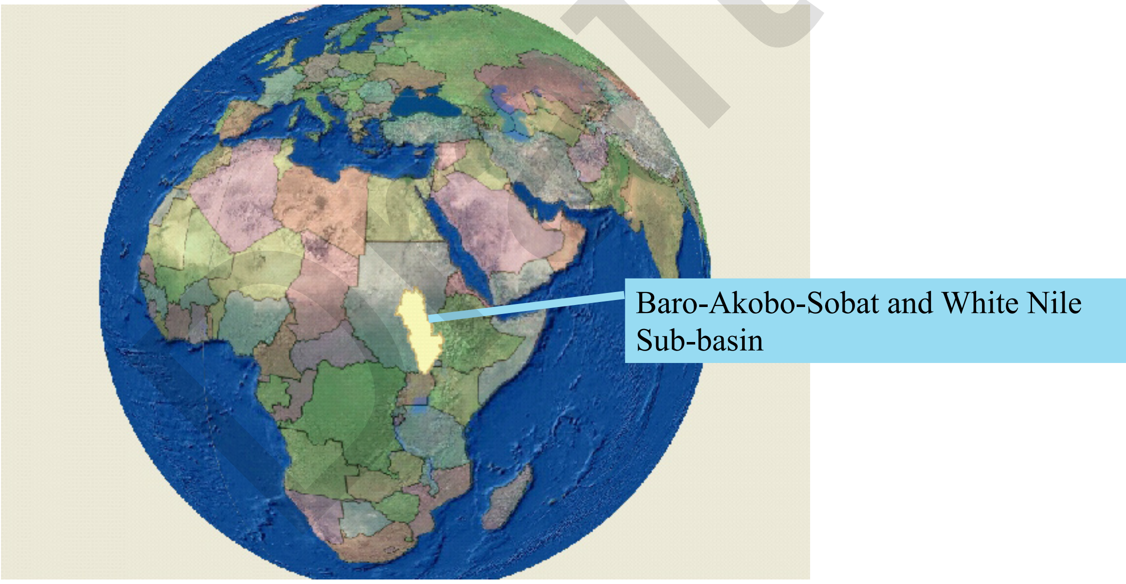
Currently irrigated agriculture is practiced in the lower course of both the Blue Nile, WN and in the Delta, at the mouth of the Nile. In Sudan current irrigation development is estimated at 1.5million hectares (Water Watch, Aug, 2006) and in Egypt it is about 3.25million hectares (Egypt Water Component OSI Report, Jan 2006). In Ethiopia, current irrigated agriculture practice is virtually none existence.

1. Generals

1.1 Location of Baro-Akobo-Sobat and White Nile Sub-Basin

The Baro-Akobo-Sobat-White Nile sub-basin is one of the four major sub-basins in the Easten Nile Portion of the Nile basin.It is located in the southernmost portion of the Eastern Nile Basin contributing about 26 Billion m^3 of water every year to the Nile system at Khartoum. Geographically ,it extends from 15^0 47' 40" to the north downto 3^0 25' 52" on the south.Similarlity it goes from 29^0 24' 43" to the west upto 36^0 18' 27" to the east covering a toatl area of 468,216 km^2.

It is the sub basin with relatively less environmental degradation and high both rain fed and irrigated agriculture potential. Altitude ranges from above 3000masl in its eastern tip to 400masl at Khartoum, its mouth. More than 65% of the sub basin falls below 500masl and some 25% falls at an altitude that ranges from 500masl to 1000masl. More than 88% of the sub basin land is identified to have land slope of less than 5% indicating its tremendous potential for irrigated agriculture. The predominantly prevailing black clay soil is a possible challenge in the development of irrigated agriculture in this low-lying area of the sub basin.

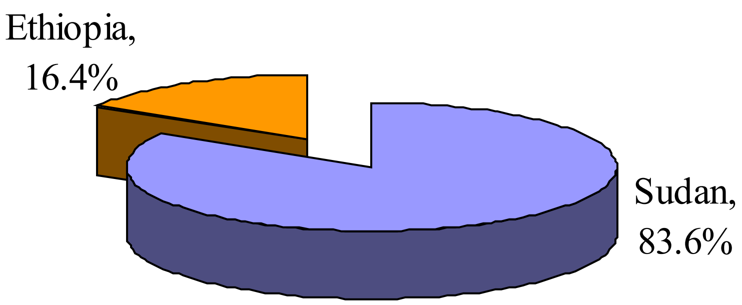


Location of the Baro-Akobo-Sobat and White Nile

Data/Information Source :One System Inverntory Synthesis Report 2007

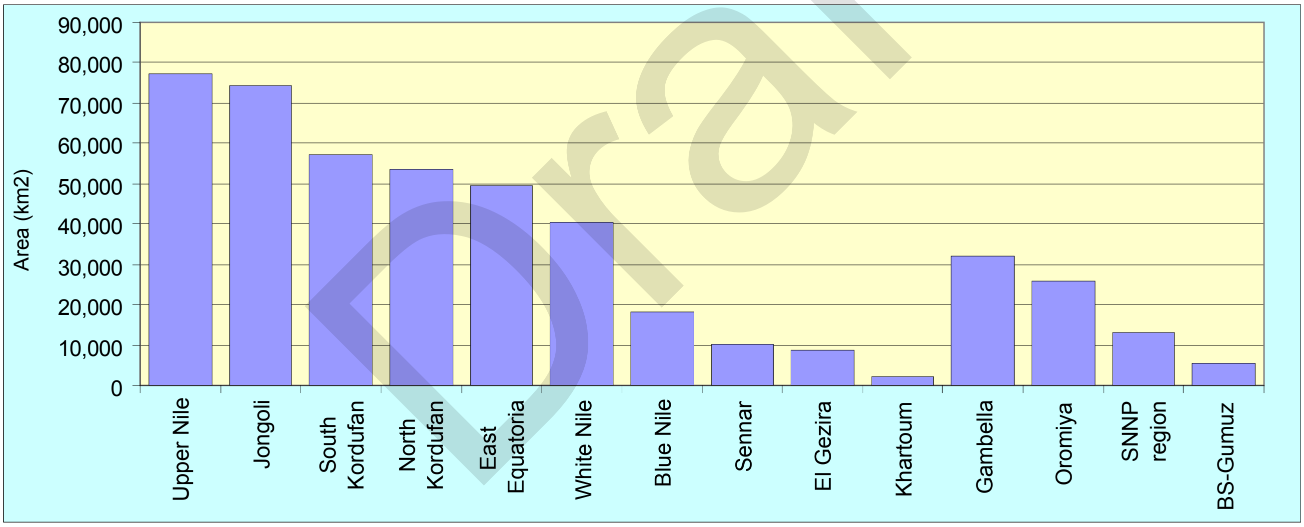
Map - 1.1 : Location Map of Baro-Akobo-Sobat and White Nile Sub-Basin

1.2 Administrative Units



Baro-Akobo-Sobat and White Nile Sub-Basin area coverage (%) between Ethiopia and Sudan

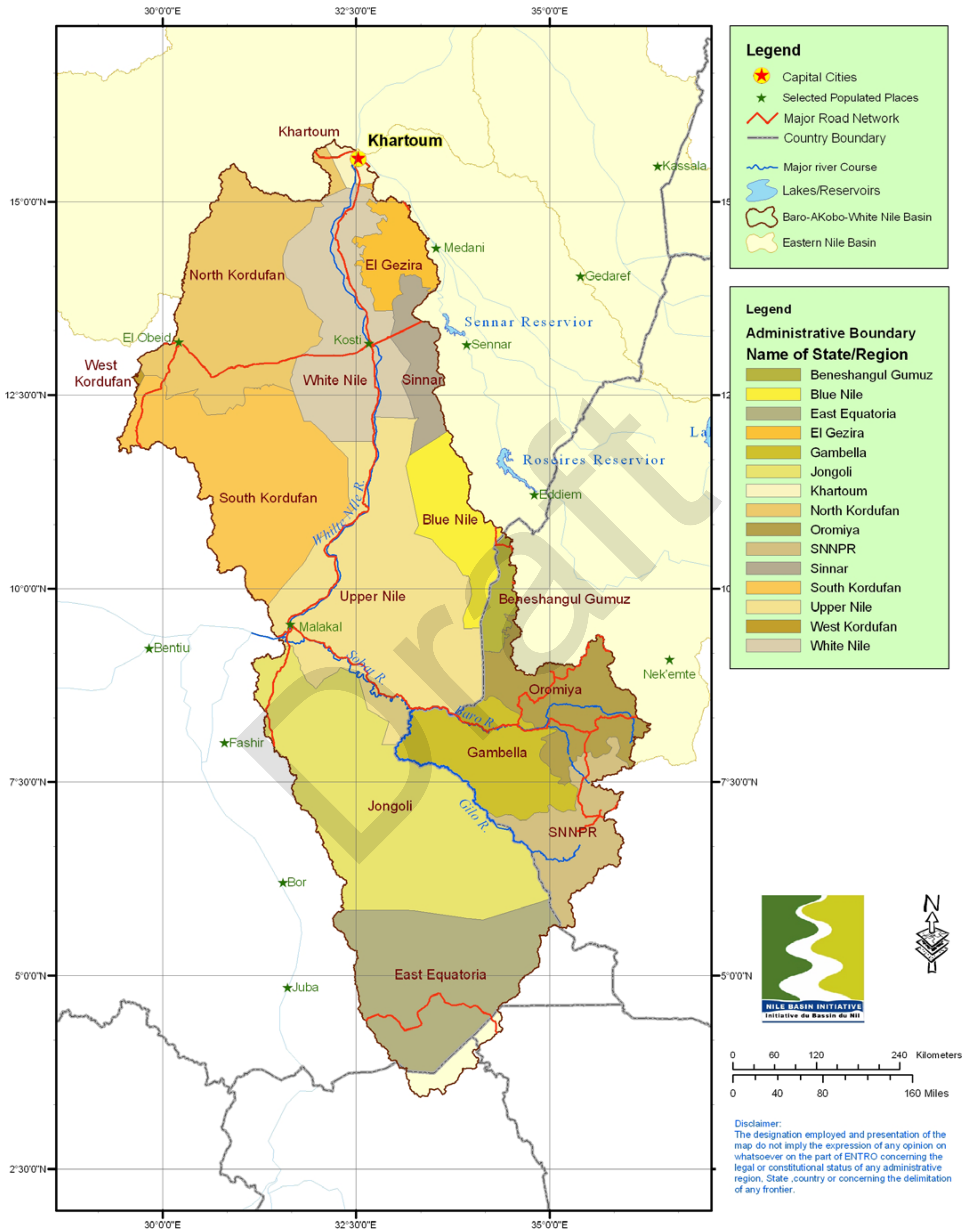
The sub basin is constituted by ten states in Sudan:Upper Nile (77,339 km2), Jongoli (74,207km2), South Kordufan (57,110km2), North Kordufan (53,417km2), East Equatoria (49,517km2), White Nile (40,438km2), Blue Nile (18191km2), Sennar (10,339km2), El-Gezira (8,708km2), &Khartoum (2,206km2); with sub total area of 354,235km2, and four regional states in Ethiopia: Gambella (3,2235km2), Oromiya (25,996km2), SNNP Region (13,045km2) and Beni-Shangul Gumuz (5,466km2); with a total drainage area of 468,216 km^2.



Area of Adminsitrative Units with in the Baro-Akobo-Sobat and White Nile Sub Basin

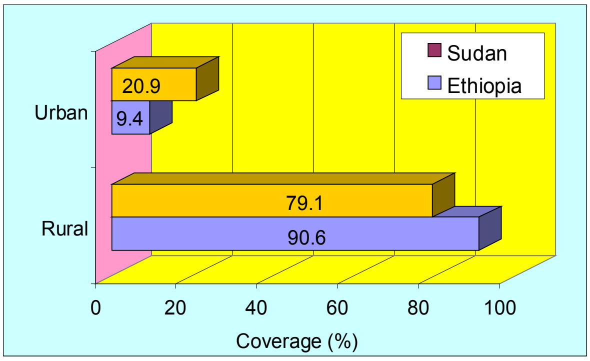
Data/Information Source :One System Inverntory Synthesis Report 2007

Map - 1.2 : Administrative Divisions



1.3 Demography

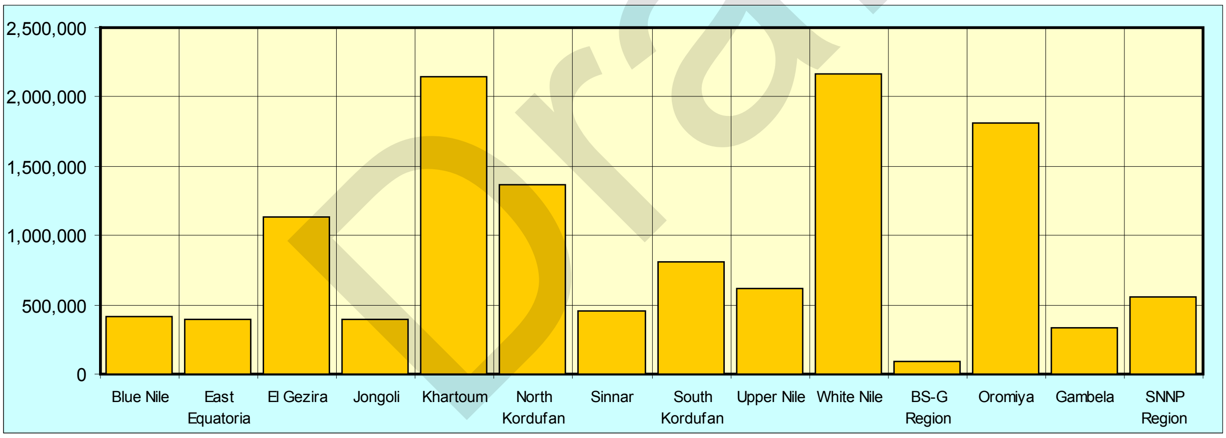
The Baro-Akobo-Sobat-White Nile basin has an estimated population of 12.4 million (7.3 in Ethiopia and 5.11 in Sudan). This population is expected to grow in the immediate future but is gradually likely to experience a slow down (mainly on the Ethiopian side of the basin) by the year 2015. A good proportion of the basin population is in the younger age group – 14 or less years of age – resulting in child dependency ratio of around 85 . On the whole, average life expectancy for the basin population ranges from 46 to 55 years for both males and females.



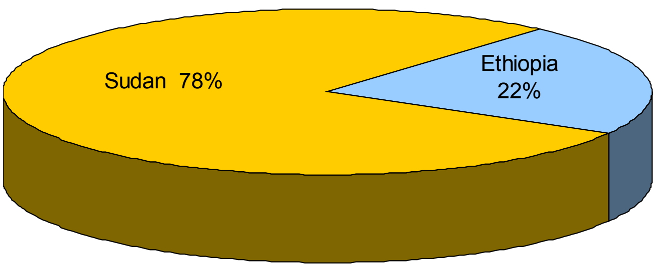
Settelment Patern in Baro-Akobo-Sobat WN Sub Basin

Population density – defined as the total number of people per km^2 – varies from 3 persons/km^2 in Gambella region to more than 200 persons/km^2 in Khartoum state in Sudana . In terms of patterns of settlement, the overwhelming majority of the population is rural,with 90.6 % of the rual population in Ethiopia and 79.1 % in Sudan.

The predominance of the rural over the urban in part shows the lack of development opportunities for the population residing in the Sub-basin.

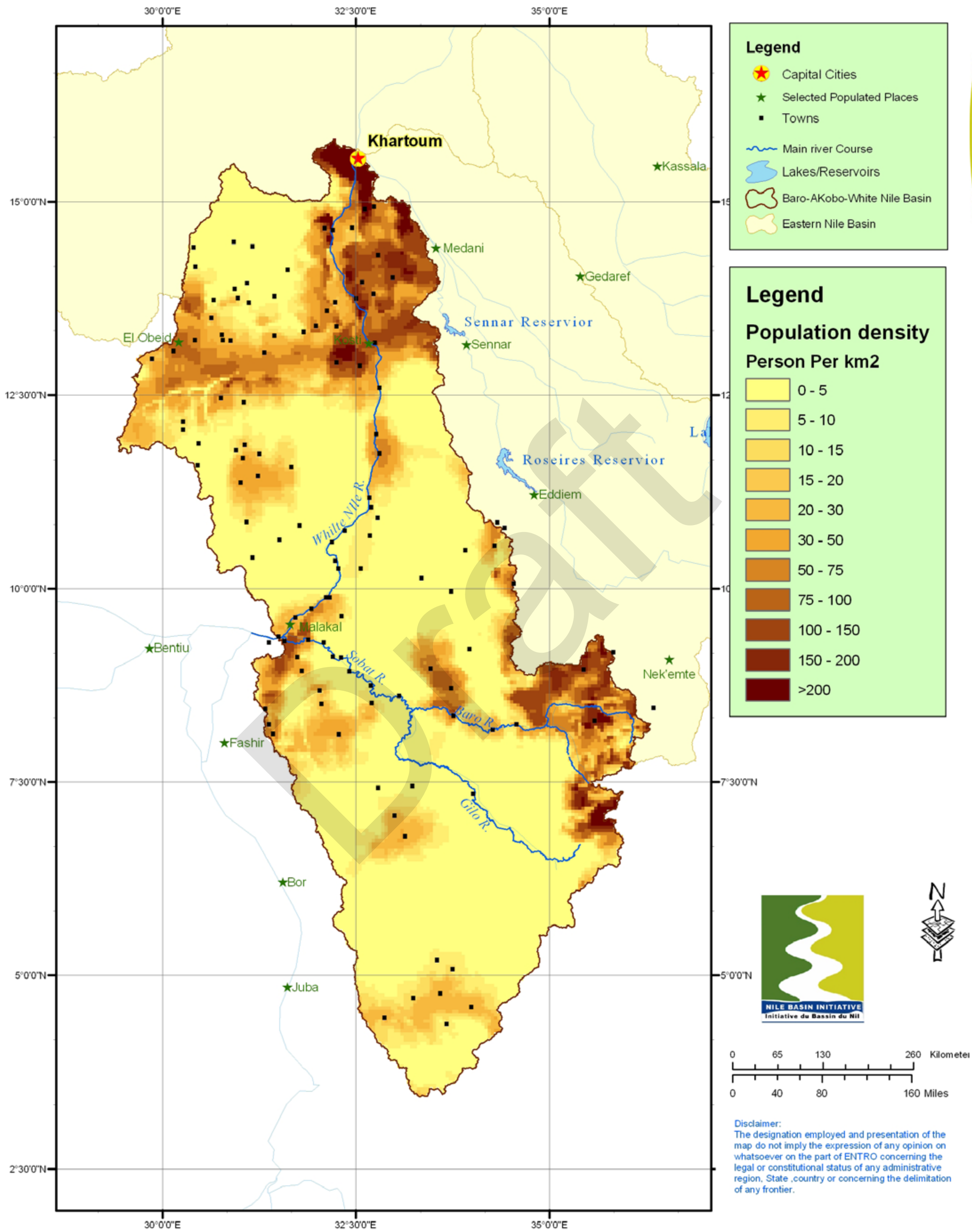


Baro-Akobo-Sobat- and White Nile Sub-Basin Total Population Distribution by Regional States



Data/Information Source :One System Inverntory Synthesis Report 2007
:The LandScan 2002 Global Population Database
:Cooperative regional assessment for watershed management Transboundary analysis

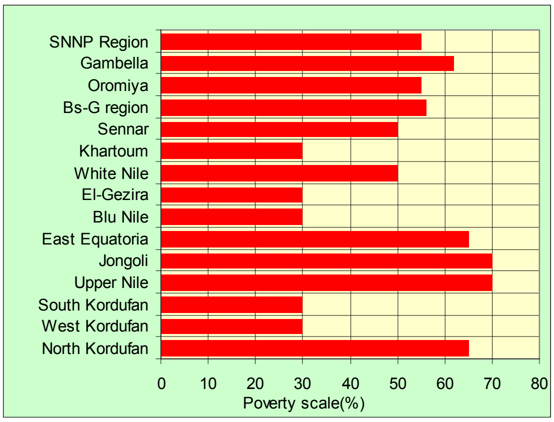
Map - 1.3 : Population within the Baro-Akobo-Sobat and white Nile Sub-Basin



1.4 Economy of Baro-Akobo-Sobat and white Nile Sub- Basin

Rain fed crop cultivation is the principal activity in most of the basin where adequate rainfall is available. The economy, largely based on traditional methods of plough cultivation and supplemented by the hoe in the lowlands, is subsistence oriented. Production is dominated by growing of crops (e.g. maize & sorghum) for local consumption. 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 (see the consultant's report). Generally, it seems that combining crop and livestock production followed by 'crop only' farming and 'livestock only' production are main livelihood strategies undertaken by the basin population in that order.

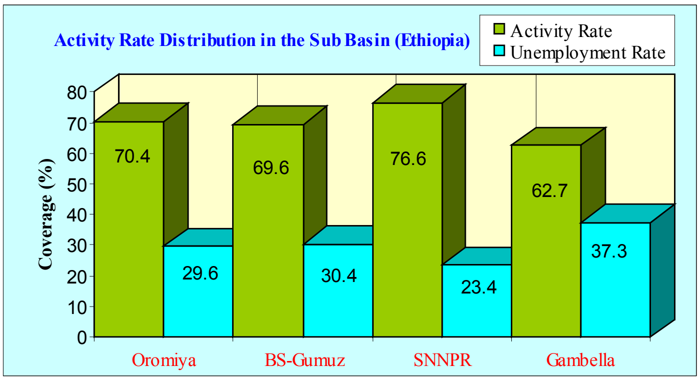
Poverty Scale Indicater in the BASWN Sub Basin



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 centers and hence employment is concentrated in the production of primary commodities. There is very little use of the basin and its tributaries for irrigation activities (except some traditional methods of water diversion).

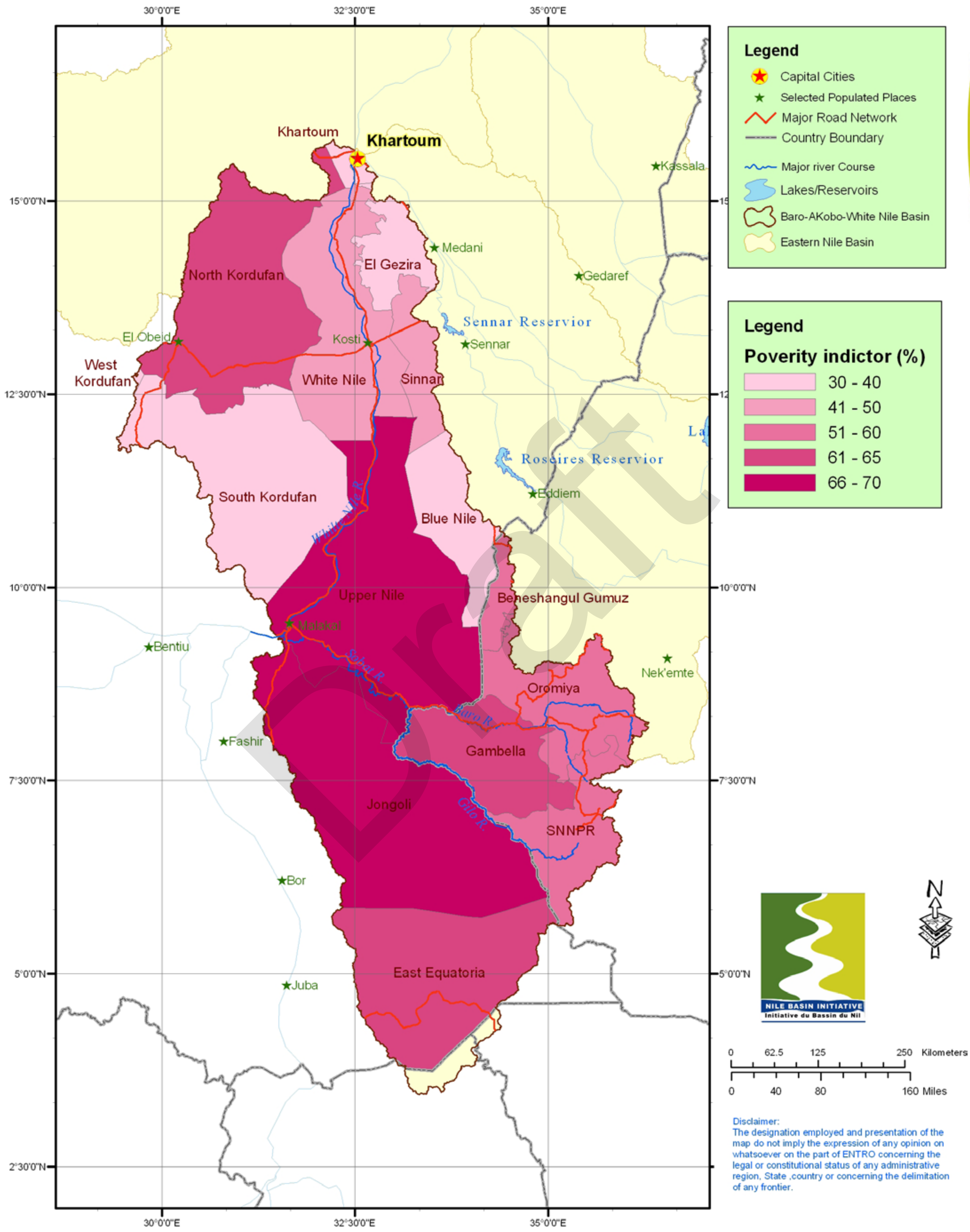
Regarding activity rate (an activity rate is defined as the proportion of the total economically active (employed plus unemployed) population to the total working age population .data) from the Sudanese part is not available and from Ethiopian side of the sub basin some data is available and accordingly, the population in each of the four basin-states (Oromiya, Beni-Shangul-Gumuze, SNNPRS and Gambella) has an activity rate of 70.4%, 69.6%, 76.6% and 62.7 % respectively, while the unemployment rate is estimated to be 6.1%, 5.2%, 5.5%, and 12.5%.

In the sub basin the scale of poverty ranges from 70% to 20%. In the North Kordufan state of the Sudanese land 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 is observed to be higher in Gambella (62%). The other three states have poverty scale ranging from 55% to 56%.



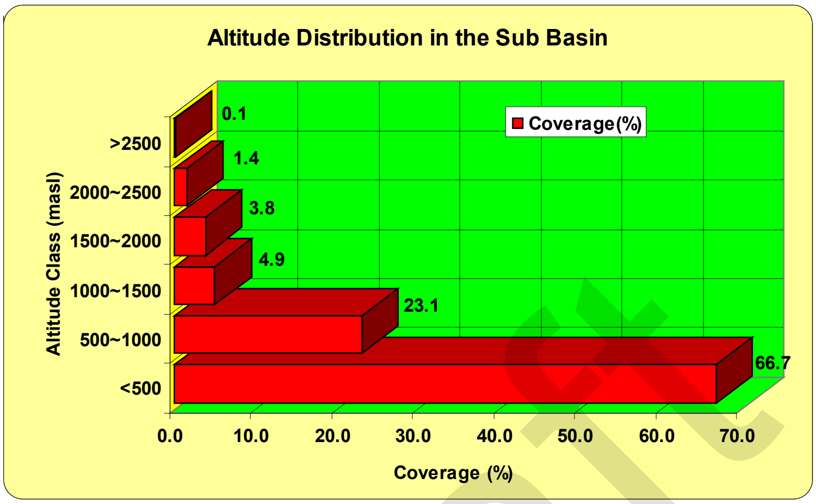
Data/Information Source :One System Inverntory Synthesis Report 2007

Map - 1.4 : Poverity ScaleMap of Baro-Akobo-Sobat and white Nile Sub-Basin

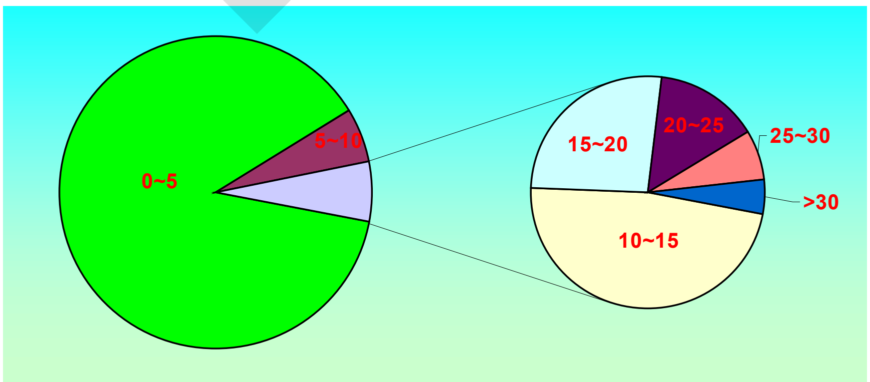


2.1 Topography in Baro-Akobo-Sobat and White Nile Sub basin

Altitude ranges from above 3000masl in its eastern tip to 400masl at Khartoum, its mouth. More than 65% of the sub basin falls below 500masl and some 25% falls at an altitude that ranges from 500masl to 1000masl. More than 88% of the sub basin land is identified to have land slope of less than 5% indicating its tremendous potential for irrigated agriculture. The predominantly prevailing black clay soil is a possible challenge in the development of irrigated agriculture in this low-lying area of the sub basin.

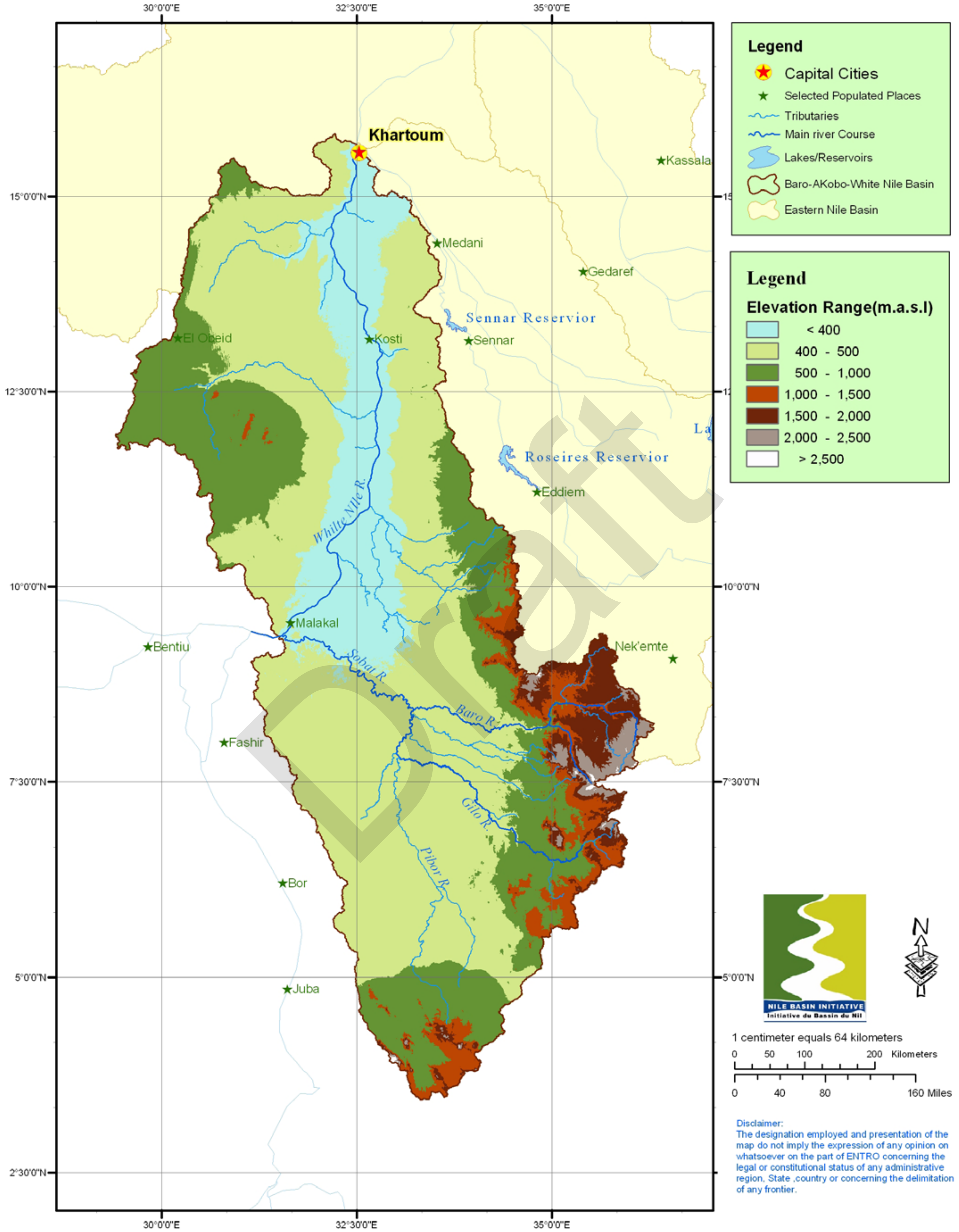


More than 88% of the sub basin is characterized as plain area with land slope less than 5%. This portion of the sub basin constitutes the low-lying area of the Gambella flood plain in Ethiopia, the Machar flood plain , the low-lying seasonally flood plains at the mouth of the Gillo, Akobo and Pibor watersheds including the major portion of the Sobat and White Nile watersheds in the further d/s reach of the sub basin. The altitude of these seasonal flood plains is below 500masl. Nearly 6% of the sub basin is identified as having gentle slope with land slope not exceeding 10%. Portion of the sub basin in the highlands with land slope exceeding 20% is estimated to be less than 2%.



Data/Information Source :One System Inverntory Synthesis Report 2007

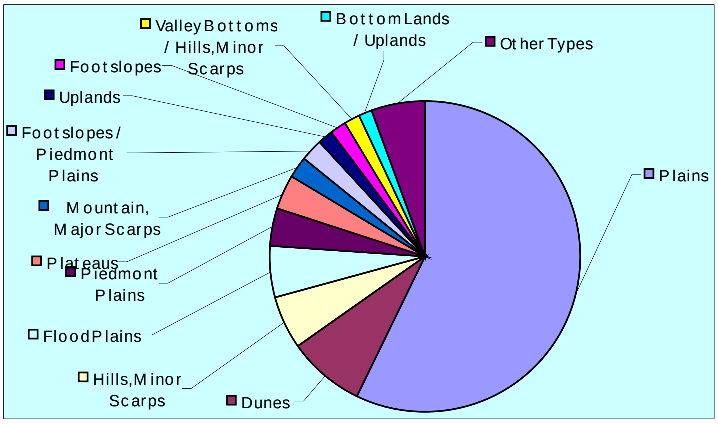
Map - 2.1 : Elevation Model of the Baro-Akobo-Sobat and White Nile basins



2.2 Landforms and Terrain of Baro-Akobo-Sobat and White Nile Basin

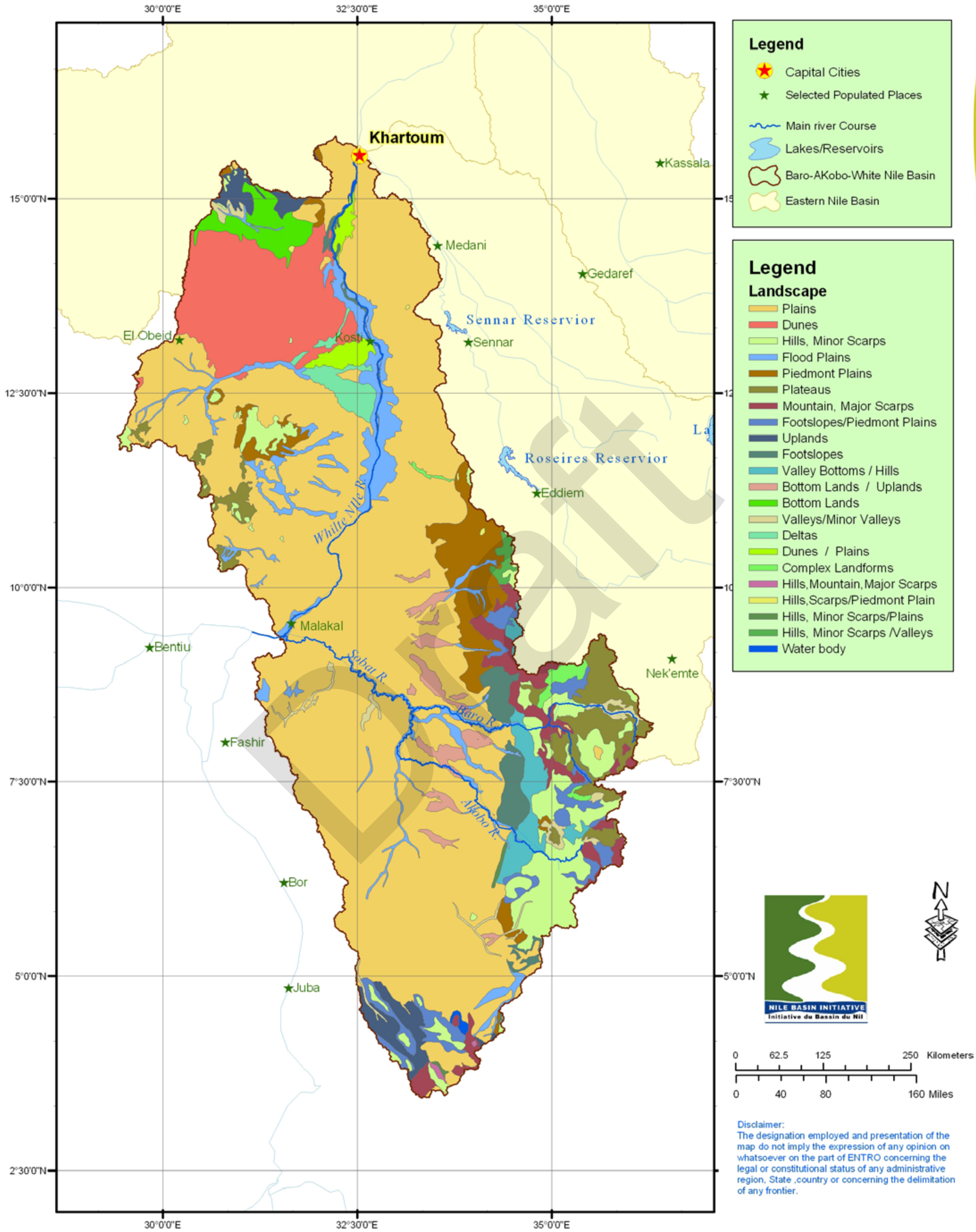
Plain areas with land slope of less than 3% covers nearly 60% of the sub basin. Dunes (8%) and Hills & major Scarps (about 6%) are the next major land forms in the sub basin. The flood plains and Piedmont Plains cover 5.2% and 4% respectively. Mountains and major scarps largely located in the eastern portion of the sub basin covers only 2.4%. Other land forms in the sub basin include, Plateaus (3.5%), valleys, Deltas, Dunes/plains, water bodies and etc.

Lanscape	Percentage area
Plains	57.25%
Dunes	7.94%
Hills, Minor Scarps	5.64%
Flood Plains	5.18%
Piedmont Plains	4.05%
Plateaus	3.50%
Mountain, Major Scarps	2.39%
Footslopes / Piedmont Plains	2.07%
Uplands	1.73%
Footslopes	1.66%
Valley Bottoms / Hills, Minor Scarps	1.63%
Bottom Lands / Uplands	1.53%
Bottom Lands	1.47%
Valleys/Minor Valleys	0.99%
Deltas	0.96%
Dunes / Plains	0.76%
Complex Landforms	0.44%
Water body	0.33%
Hills, Minor Scarps / Valleys/Minor Valleys	0.27%
Hills, Minor Scarps / Plains	0.09%
Hills, Minor Scarps / Mountain, Major Scarps	0.06%
Hills, Minor Scarps / Piedmont Plains	0.04%



Data/Information Source :One System Inverntory Synthesis Report 2007

Map - 2.2 : Terrain Map of Baro-Akobo-Sobat and White Nile Basin



2.3 Relief of Baro-Akobo-Sobat and White Nile Basin

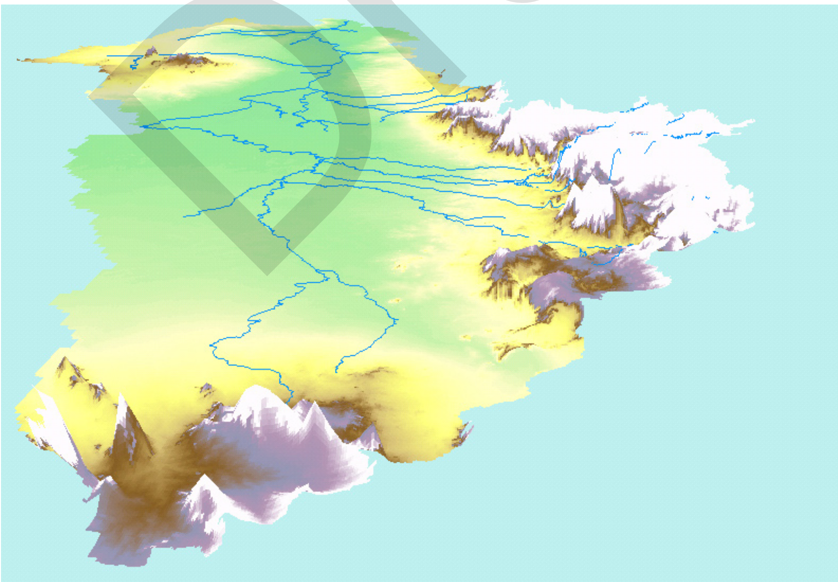
In Ethiopia the Baro-Akobo Sub-basin can be divided into two major landscape units of roughly equal size, the western lowlands and the eastern highlands

The Gambela cathemnts, in ethiopian portion , comprises gently sloping 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 RS. 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.

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.

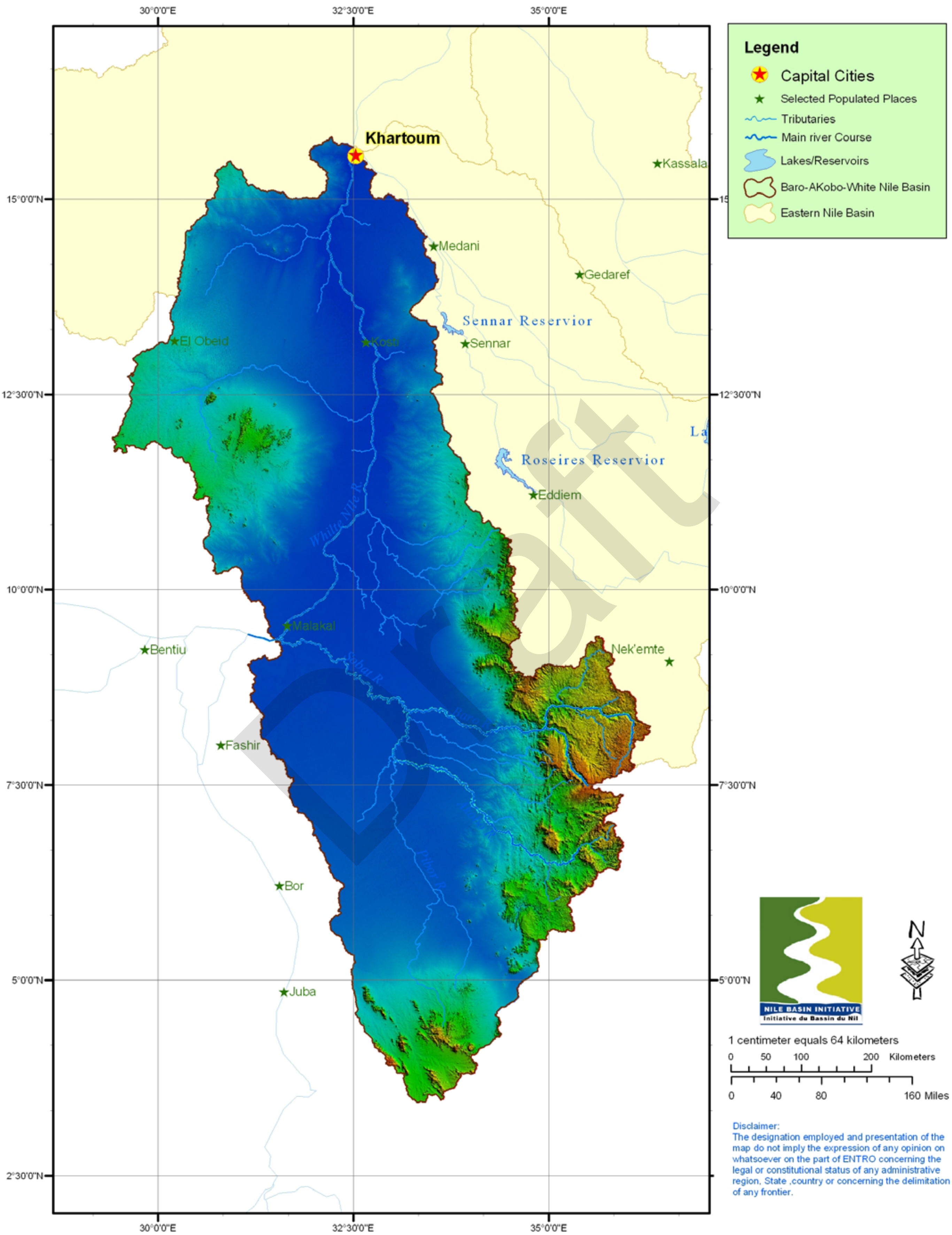
Steep slopes clearly mirror the high relief The escarpment at the edge of the Ethiopian Highlands, the Imatong Mountains and associated hills and the Nuba Hills all stand out. Less clear are the steep slopes of the hills on the Boma Plateau.



Computer Terrain 3d view of the baro-Akobo-Sobat and White Nile

Data/Information Source :One System Inverntory Synthesis Report 2007

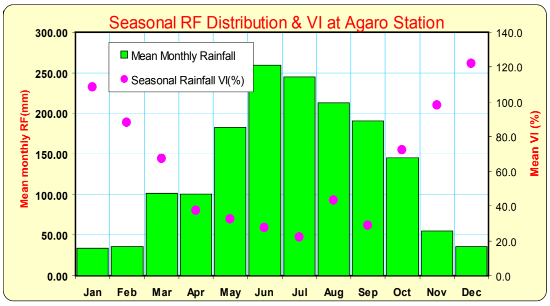
Map - 2.3 : Relief Map of Baro-Akobo-Sobat and White Nile Basin

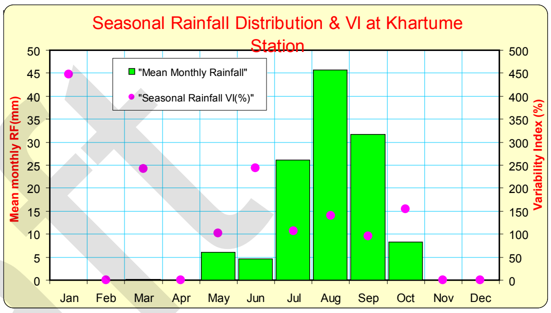


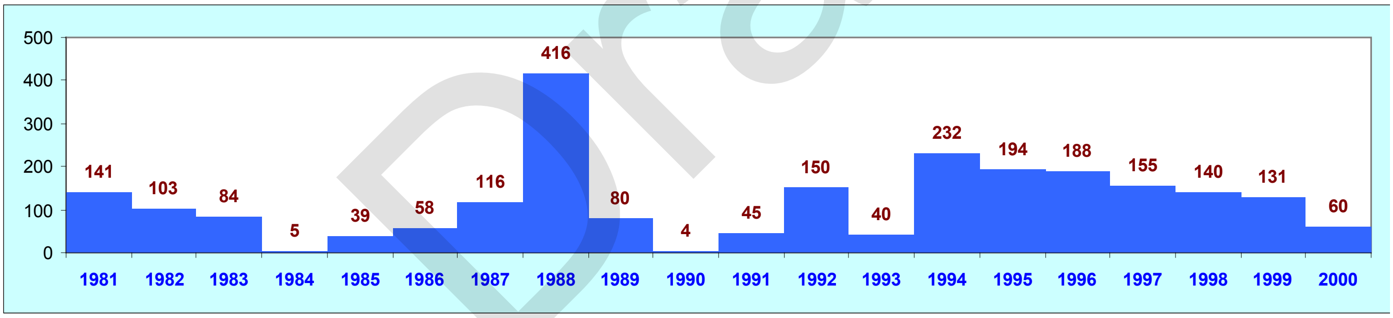
3.1 Climate-Rainfall in the Baro-Akobo-Sobat and White Nile Sub-basin

Mean annual rainfall in Baro-Akobo-Sobat and White Nile sub-basin varies from above 2200mm,eastern most portion, to less than 200mm at Khartoum.

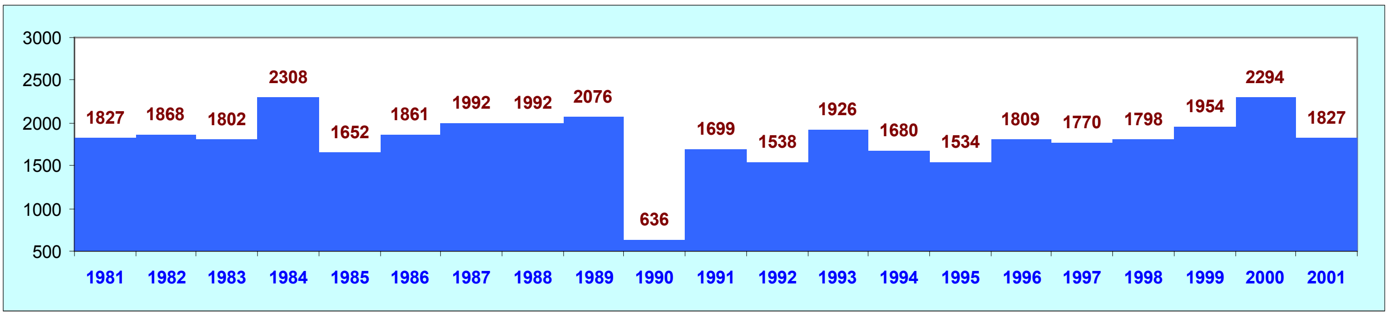
In the Baro and Gillo watersheds, are characterized with relatively high moisture and longer wet periods, that extends from April/May to October/November. In the downstream reaches of these watersheds, where altitude is largely below 1000masl, moisture is scarce with relatively shorter wet period limited to less than four months (May/June to September/October). Further in the downstream reach of the sub basin, beyond the Ethio-Sudan border, where the altitude is well below 500masl the wet period is shortening to less than three months, with arid tropical climate dominating towards its mouth around Khartoum







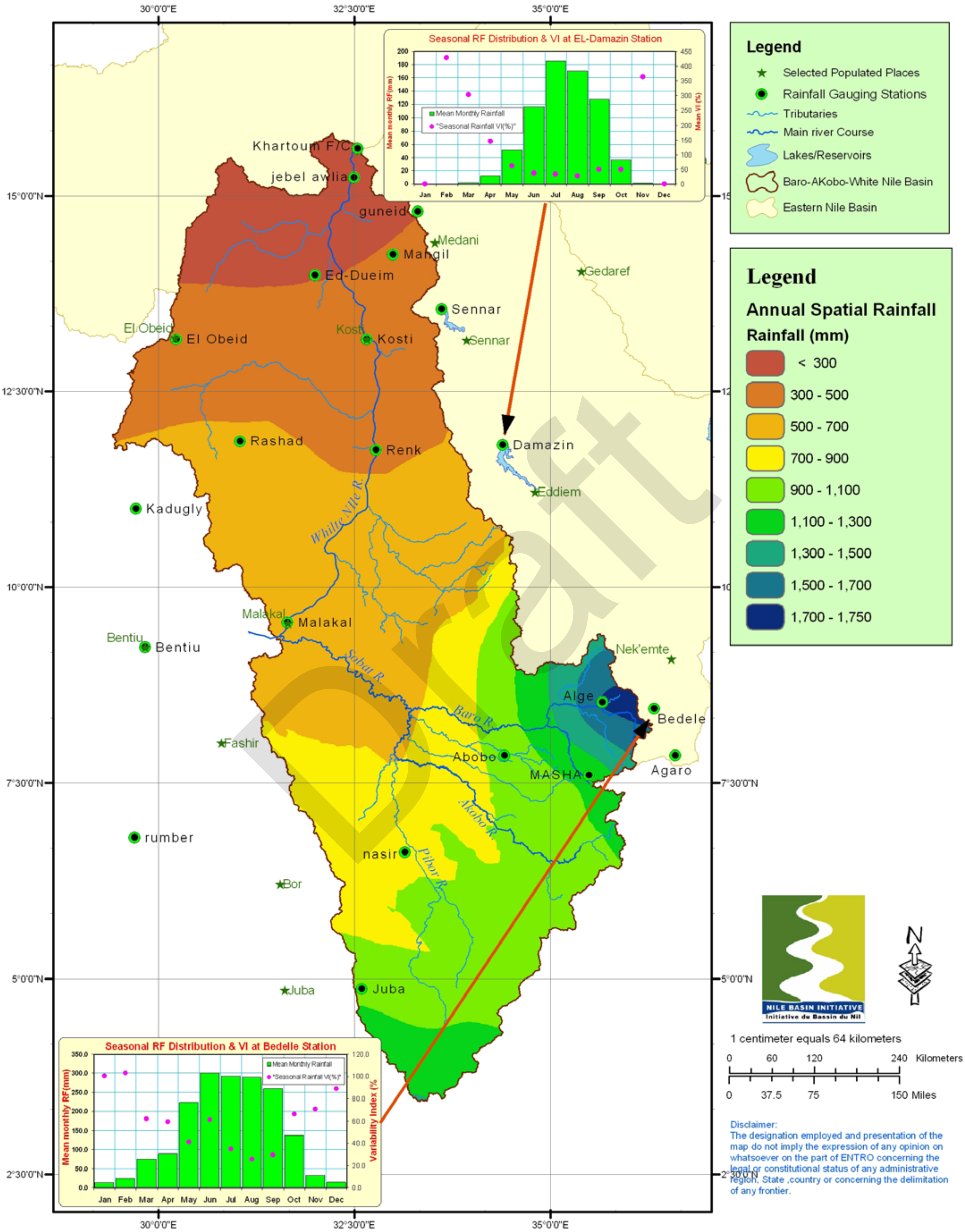
Khartoum Station Annual Rainfall in mm



Bedele Station Annual Rainfall in mm

Data/Information Source :One System Inverntory Synthesis Report 2007

Map - 3.1 : Rainfall Map of Baro-Akobo-Sobat and White Nile Basin



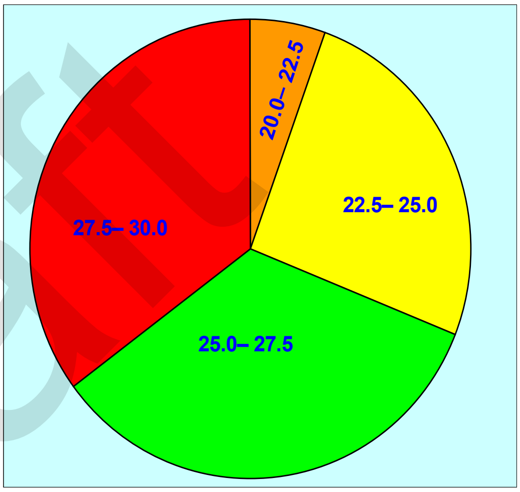
3.2 Climate-Temprature in the Baro-Akobo-Sobat and White Nile Sub-basin

Climate in the eastern portion ,highland plateaus, is identified to be sub tropical with pleasant temperature rarely exceeding 20ºC.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. Mean monthly maximum temperatures range from below 22°C, in the highlands around Kombolcha (Wollega) to about 40°C, in the lowlands of Gambela 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 while July and August have the mean maximum temperature values less than 25°C.

The mean monthly minimum temperatures generally range from 14 – 16°C in the highlands of Illubabor and western Wollega, but they sometimes drop to below 10°C in isolated locations of the highlands during November-February. The mean monthly minimum temperature pattern shows a maximum temperature value in April and a minimum temperature value in December. The mean minimum temperature values greater than 15.5°C occur from January to May while the mean minimum temperature values ranging from 14°C to 15.4°C occur from June to December.

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 25-27°C along the river but decrease with altitude in the Nuba Mountains and towards the Ethiopian highlands.



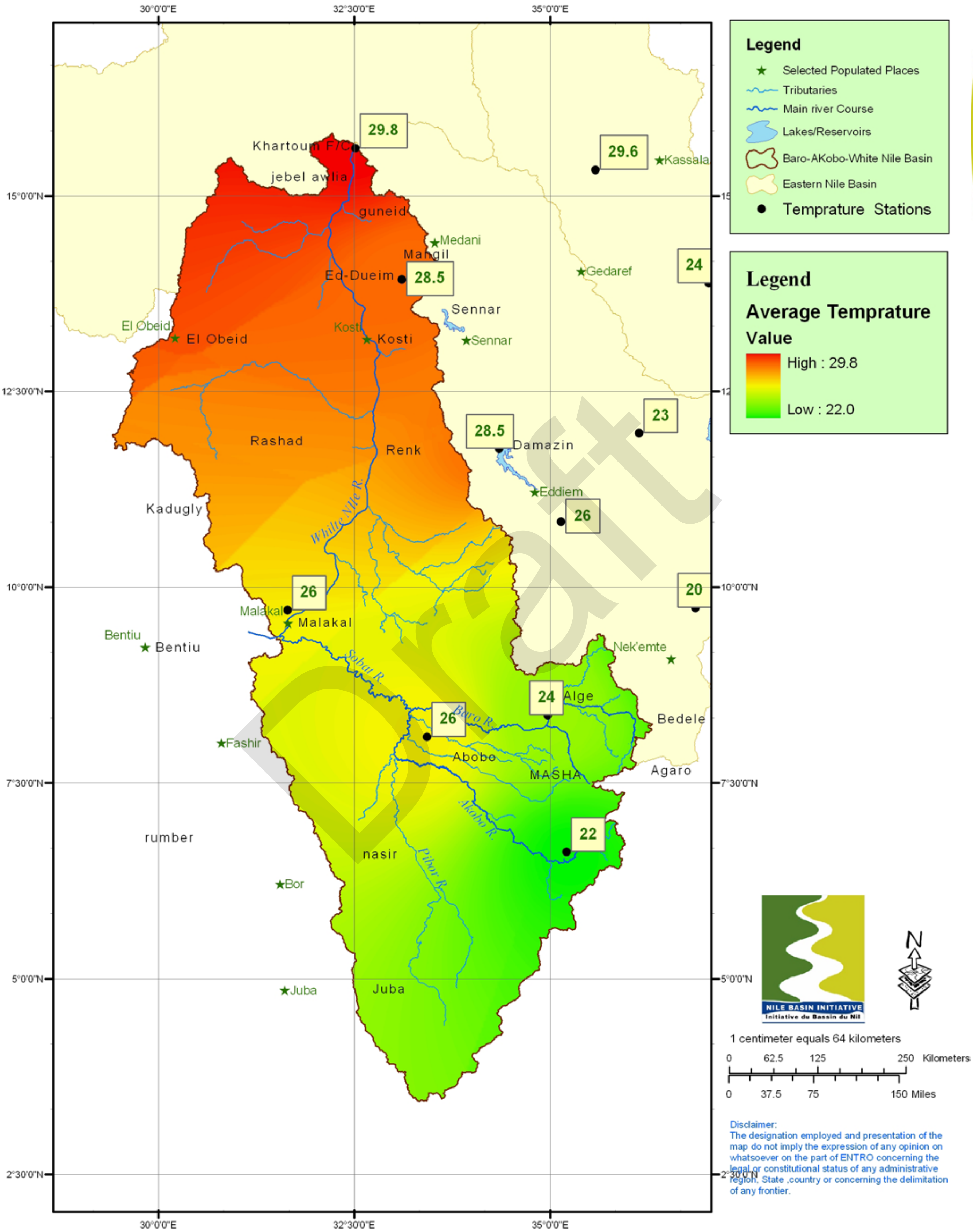
Temperature categories in C

Temperature categories in degree Centigrade	Area coverage
20.0 – 22.5	5.43%
22.5 – 25.0	25.70%
25.0 – 27.5	33.73%
27.5 – 30.0	35.14%
Total	**100.00%**

Area coverage of temperature(C⁰) categories in the Baro-Akobo-Sobat and White Nile sub-basin

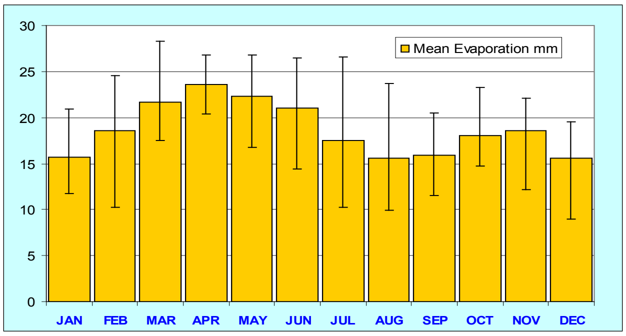
Data/Information Source :One System Inverntory Synthesis Report 2007
:Cooperative regional assessment for wateshed management Transboundary analysis

Map - 3.2 : Temprature Map of Baro-Akobo-Sobat and White Nile Basin

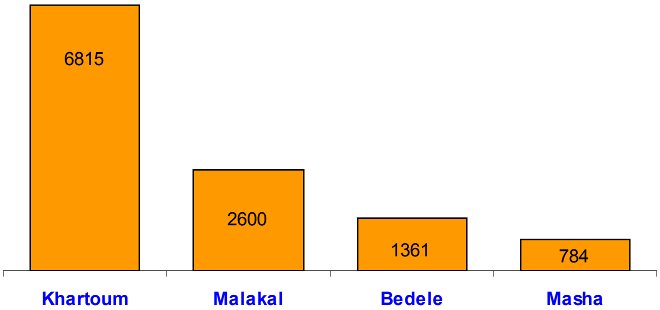


3.3 Evaporation within the Baro-Akobo-Sobat and White Nile Sub-basin

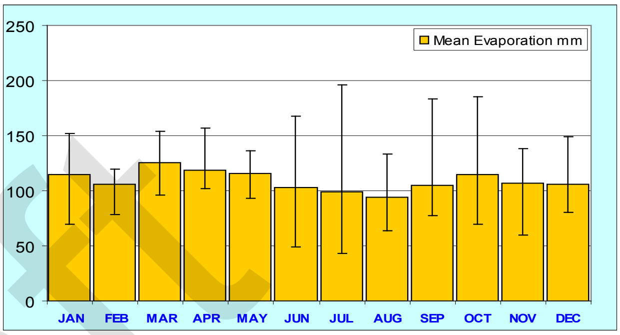
Mean annual evaporation within the Baro-Akobo-Sobat and White Nile Sub-basin is observed to vary from below 1000mm ,in the highland plateaus of Ethiopia, to 6815mm at Khartoum. As a result evaporation loss at Jebel Awlia reservoir with a total storage capacity of 3.5 Billion Meter Cube. is averaged at 2.12 Billion Meter Cube per year.



Monthly Mean Evaporation at Khartoum Station

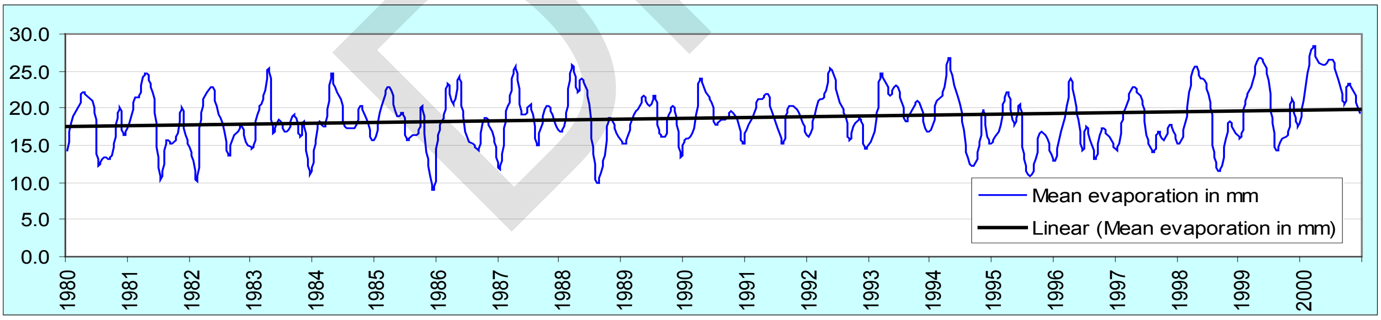


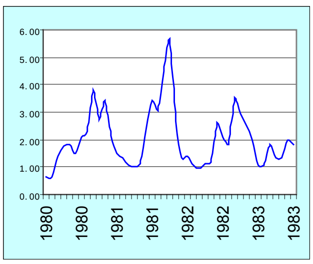
Annual Average Evaporation values from stations in Baro-Akobo-Sobat and White Nile sub-basin.



Monthly Mean Evaporation at Aggaro Station

Khartoum Station monthly mean time series evaporation in mm

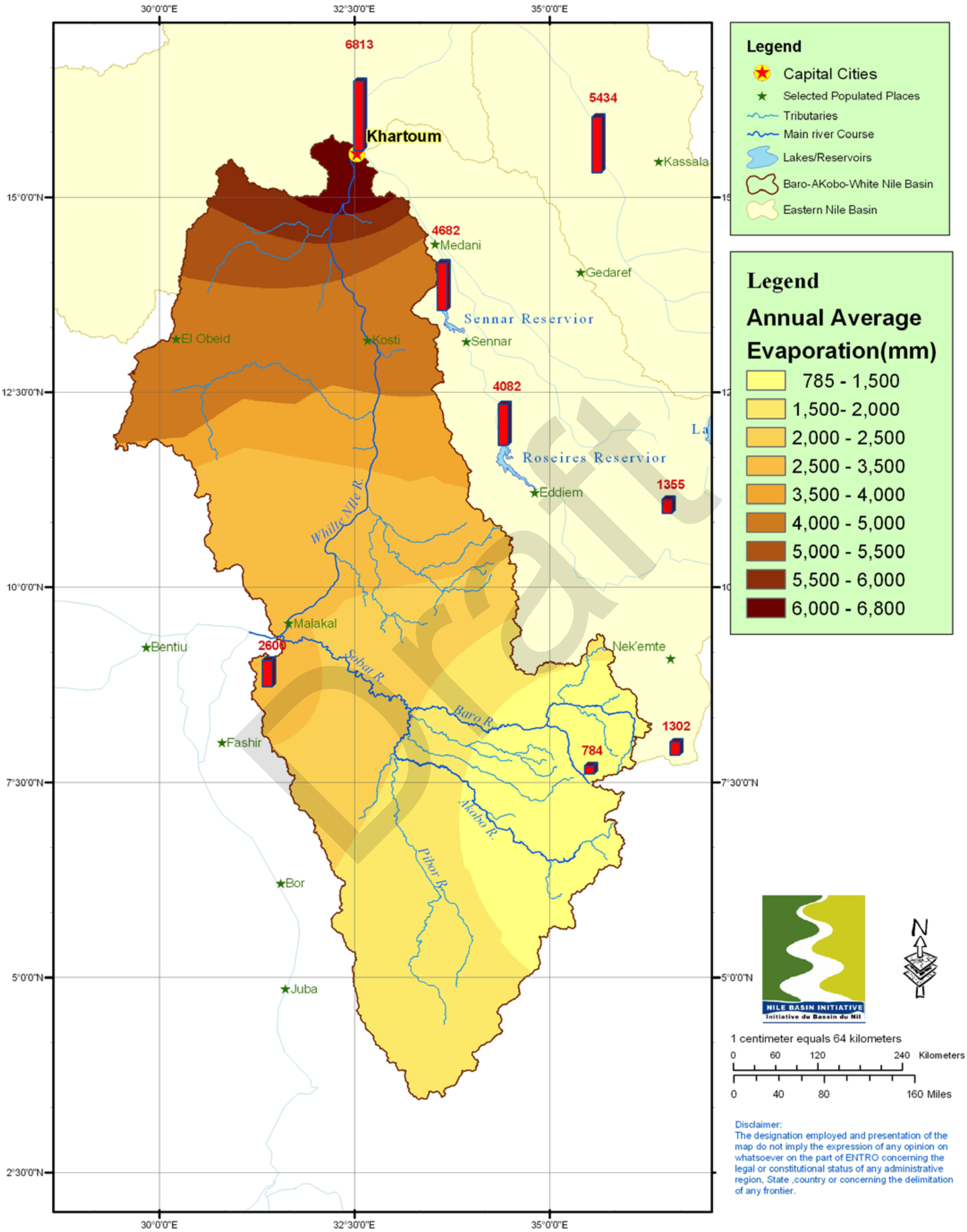




Masha Station monthly mean three years trend series evaporation in mm

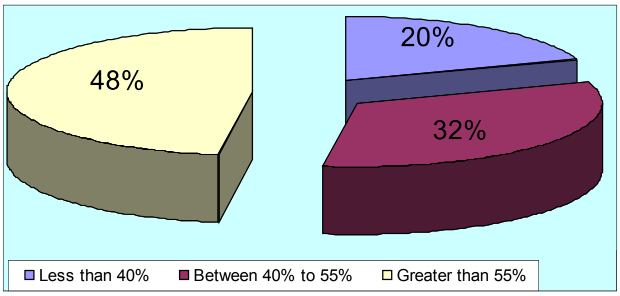
Data/Information Source :One System Inverntory Synthesis Report 2007

Map - 3.3 : Evaporation Map of Baro-Akobo-Sobat and White Nile Sub-basin

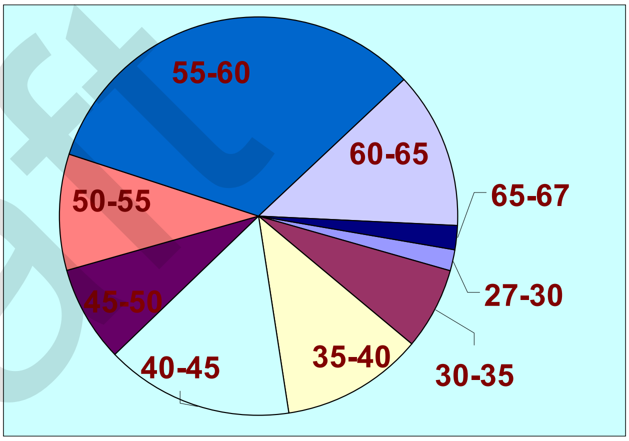


3.4 Climate-Humidity in the Baro-Akobo-Sobat and White Nile Sub-basin

Despite the fact, the low-lying area (less than 500masl) accounts nearly 70% of the sub basin; about 50% of its area is identified to have mean annual relative humidity exceeding 55% indicating much proportion of the sub basin is relatively wet. The presence of good vegetation cover and less environmental degradation might have attributed to such climatic effects. Nearly 35% of the sub basin is identified to have a mean annual relative humidity ranging from 40% to 55%. It is less than 20% of the sub basin with relative humidity of less than 40%.



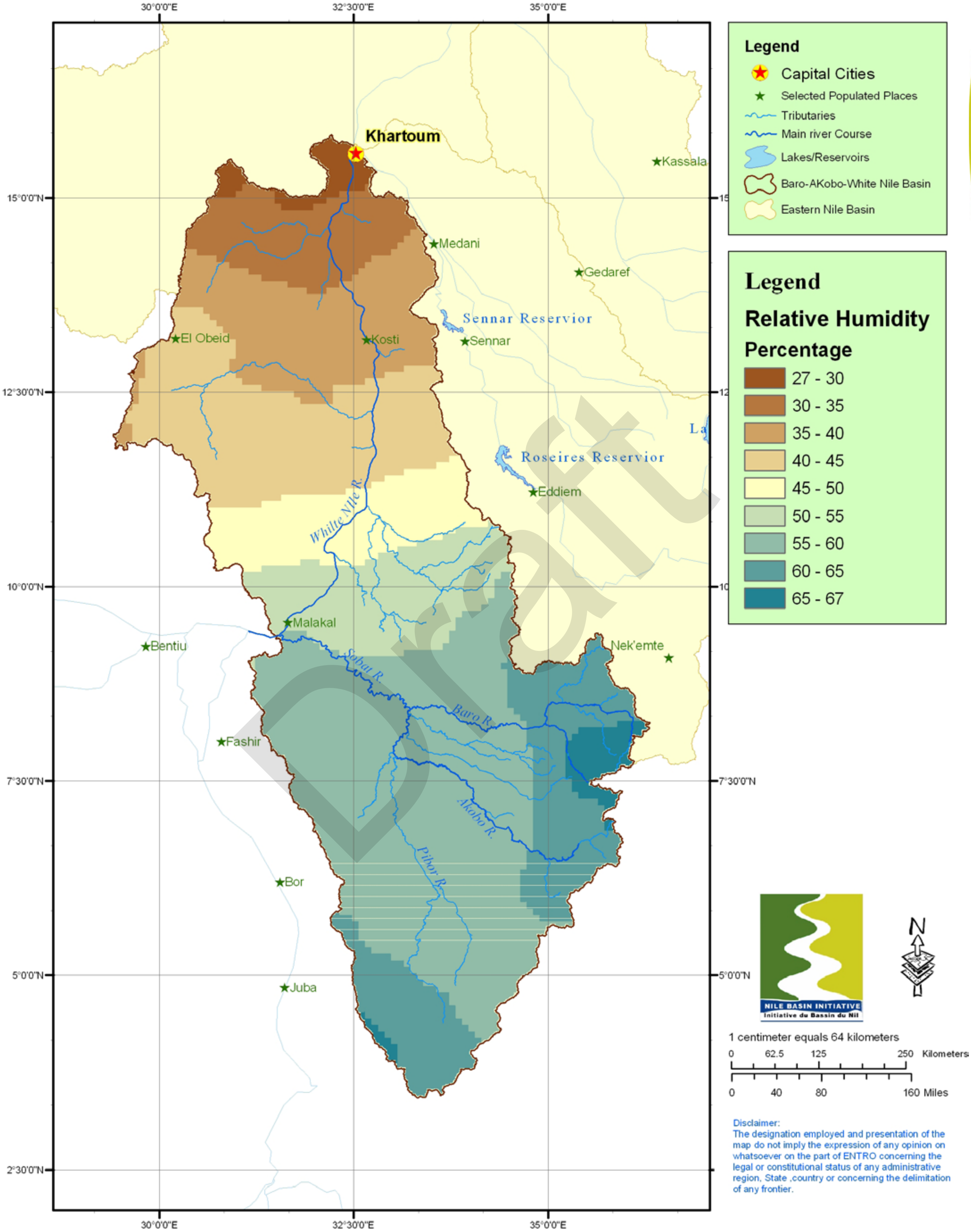
Relative Humidity Distribution within the Eastern Nile basin.



Relative Humidity Distribution within the Baro-akobo-Sobat and White Nile sub-basin

Data/Information Source :One System Inverntory Synthesis Report 2007

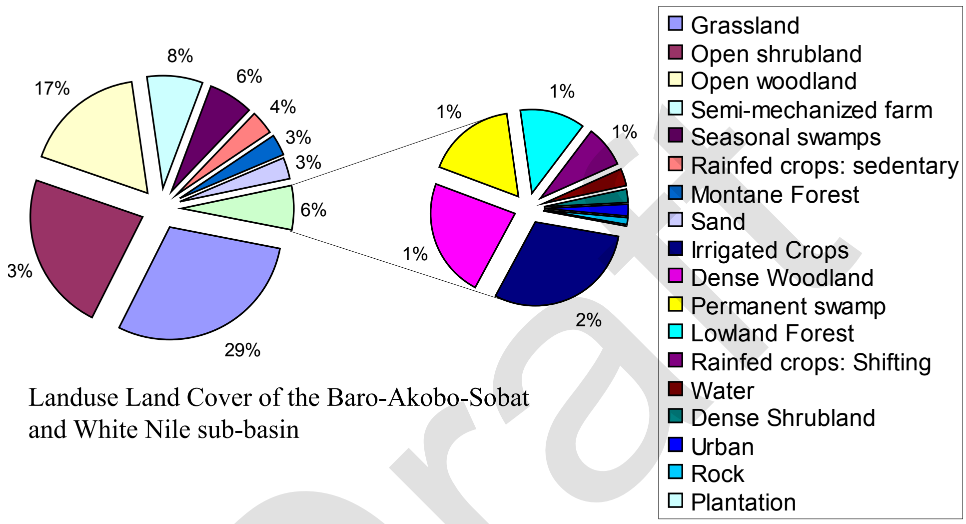
Map - 3.4 : Reletive Humidity Map of Baro-Akobo-Sobat and White Nile Basin



4. Land

4.1 Land use and Land Cover of Baro-Akobo-Sobat and White Nile Sub-basin

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 a savannah of considerably large in size, which is perhaps believed to be the largest food chain in Ethiopia, is available. In this area the grass land and the open wood land unites are intermingled together forming the savannah land in the system.



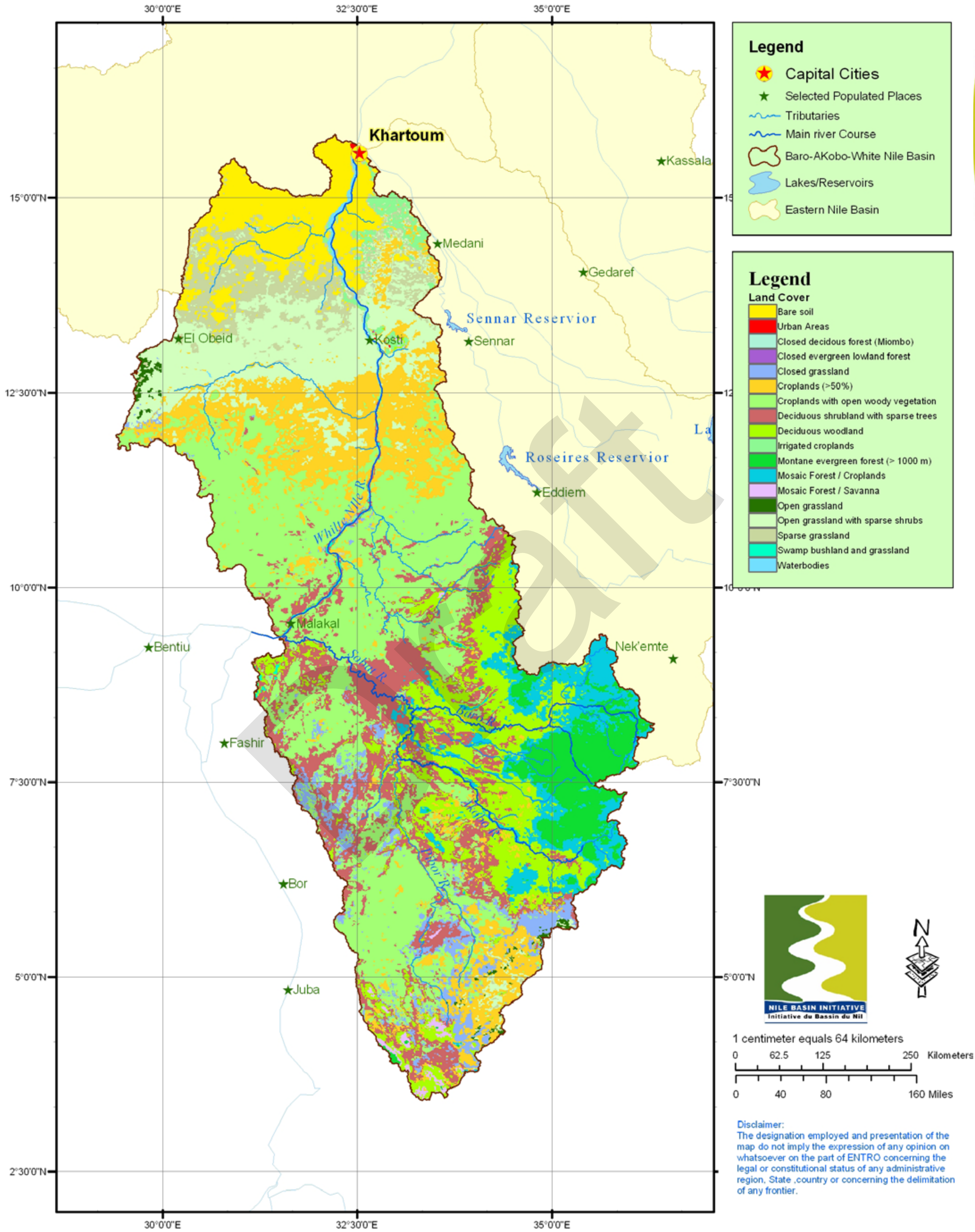
Landuse Land Cover of the Baro-Akobo-Sobat and White Nile sub-basin

The land use land cover map as prepared from Afri-cover indicates that cultivated land in the sub basin covers only 14%, indicating its high potential for future agricultural development works. Seasonal swamp area covers some 6.2% of the sub basin indicating the environmental importance of the extensive flooded lowland areas below 500masl. The Machar wetland, as a permanent wetland covers about 1% of the sub-basin.

Landuse Landcover Type	Area(km2)	Coverage(%)
Grassland	136075	29.1
Open shrubland	108993	23.3
Open woodland	81488	17.4
Semi-mechanized farm	38187	8.2
Seasonal swamps	28974	6.2
Rainfed crops: sedentary	16851	3.6
Montane Forest	14412	3.1
Sand	14131	3.0
Irrigated Crops	8613	1.8
Dense Woodland	6680	1.4
Permanent swamp	5032	1.1
Lowland Forest	3581	0.8
Rainfed crops: Shifting	2400	0.5
Water	905	0.2
Dense Shrubland	865	0.2
Urban	641	0.1
Rock	338	0.1
Plantation	51	0.0

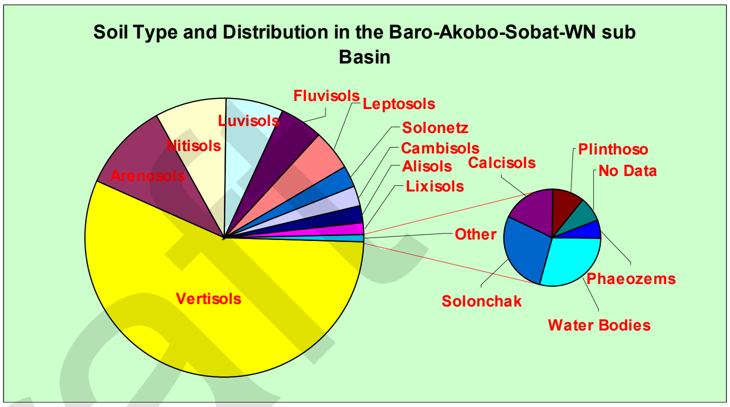
Data/Information Source :One System Inverntory Synthesis Report 2007

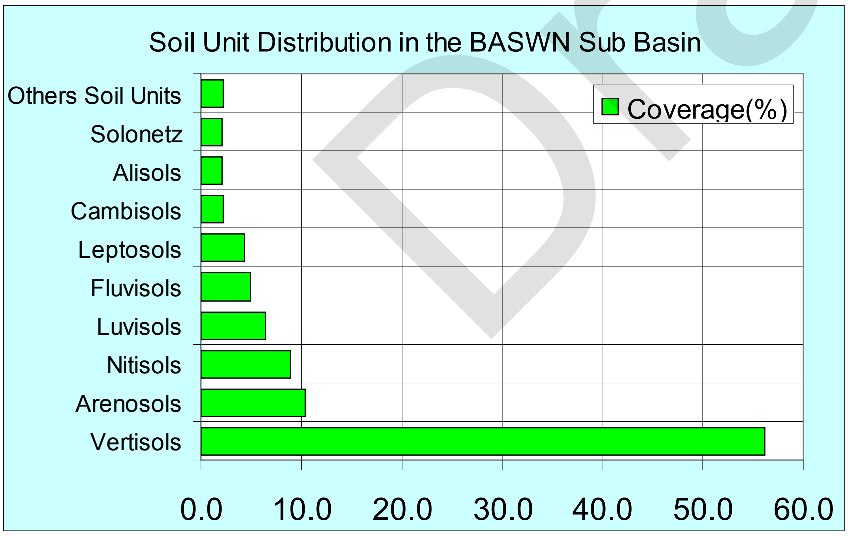
Map - 4.1 : LandCover Map of Baro-Akobo-Sobat and White Nile Basin



4.2 Soil of Baro-Akobo-Sobat and White Nile Sub-basin

Nearly 60% of the sub basin is covered with black colored vertisols. The lowlying area of Gambella, the entire watershed of Sobat river and majority of the white Nile watershed d/s of Malakal are almost covered with vertisols of black and cracking in nature. This soil imposes 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.

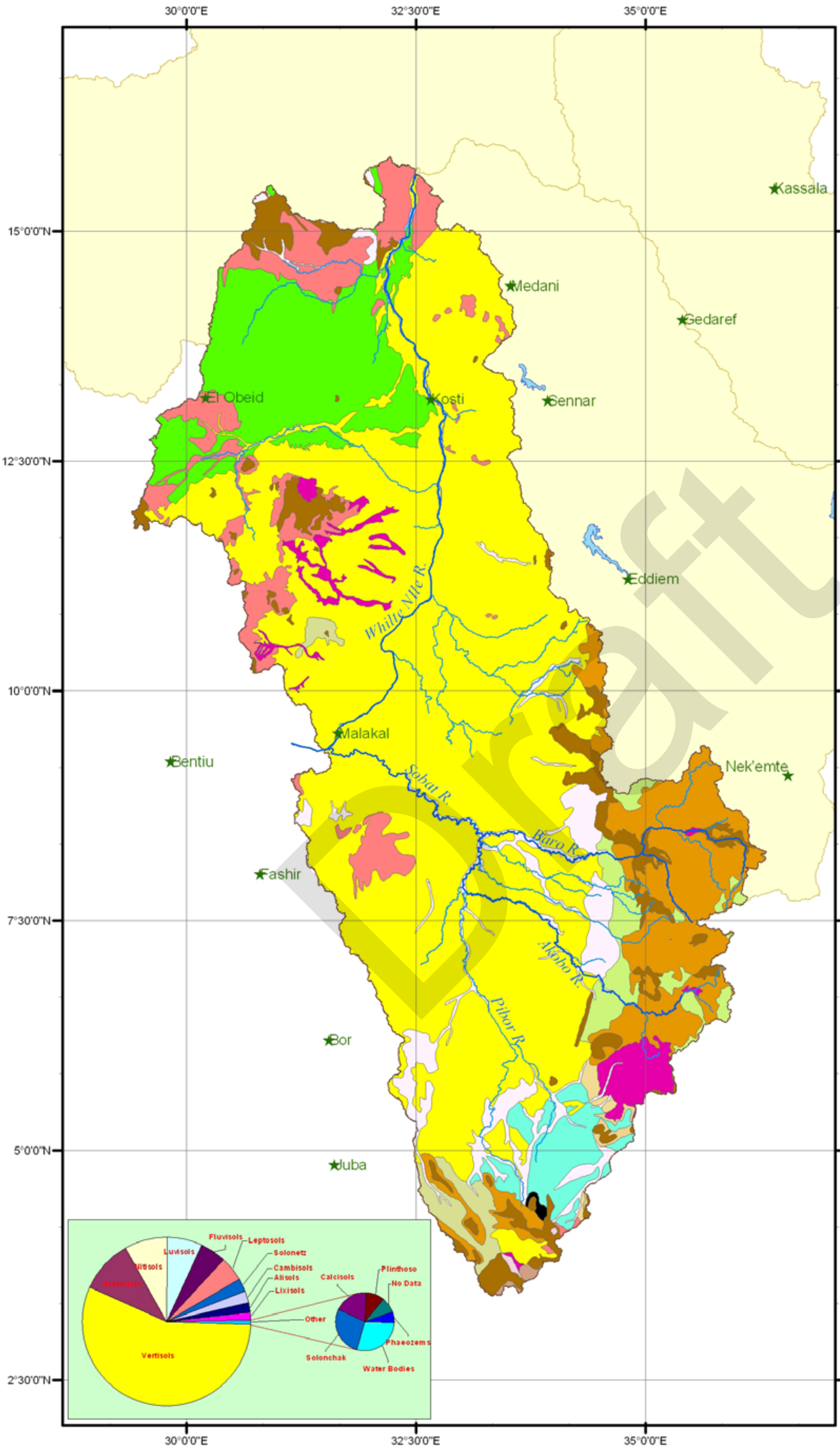




Soil Unit Distribution in the Baro-Akobo-Sobat and White Nile Sub-Basin

Data/Information Source :One System Inverntory Synthesis Report 2007

Map - 4.2 : Soil Map of the Baro-Akobo-Sobat and White Nile Basin



Legend

- Selected Populated Places
- Tributaries
- Main river Course
- Lakes/Reservoirs
- Baro-AKobo-White Nile Basin
- Eastern Nile Basin

Legend

Dominant Soil (FAO Classification)

- Vertisols
- Arenosols
- Nitisols
- Luvisols
- Fluvisols
- Leptosols
- Solonetz
- Cambisols
- Alisols
- Lixisols
- Calcisols
- Solonchak
- Phaeozems
- Plinthoso
- No Data
- Water Bodies

Soil Group	Percentage By area
Vertisols	21.6 %
Arenosols	4.01 %
Nitisols	3.24 %
Luvisols	2.55 %
Fluvisols	1.97 %
Leptosols	1.82 %
Solonetz	0.93 %
Cambisols	0.85 %
Alisols	0.80 %
Lixisols	0.49 %
Water Bodies	0.10 %
Solonchak	0.09 %
Calcisols	0.06 %
Plinthoso	0.03 %
No Data	0.02 %
Phaeozems	0.02 %

NILE BASIN INITIATIVE
Initiative du Bassin du Nil

N

1 centimeter equals 64 kilometers

0 62.5 125 250 Kilometers

0 37.5 75 150 Miles

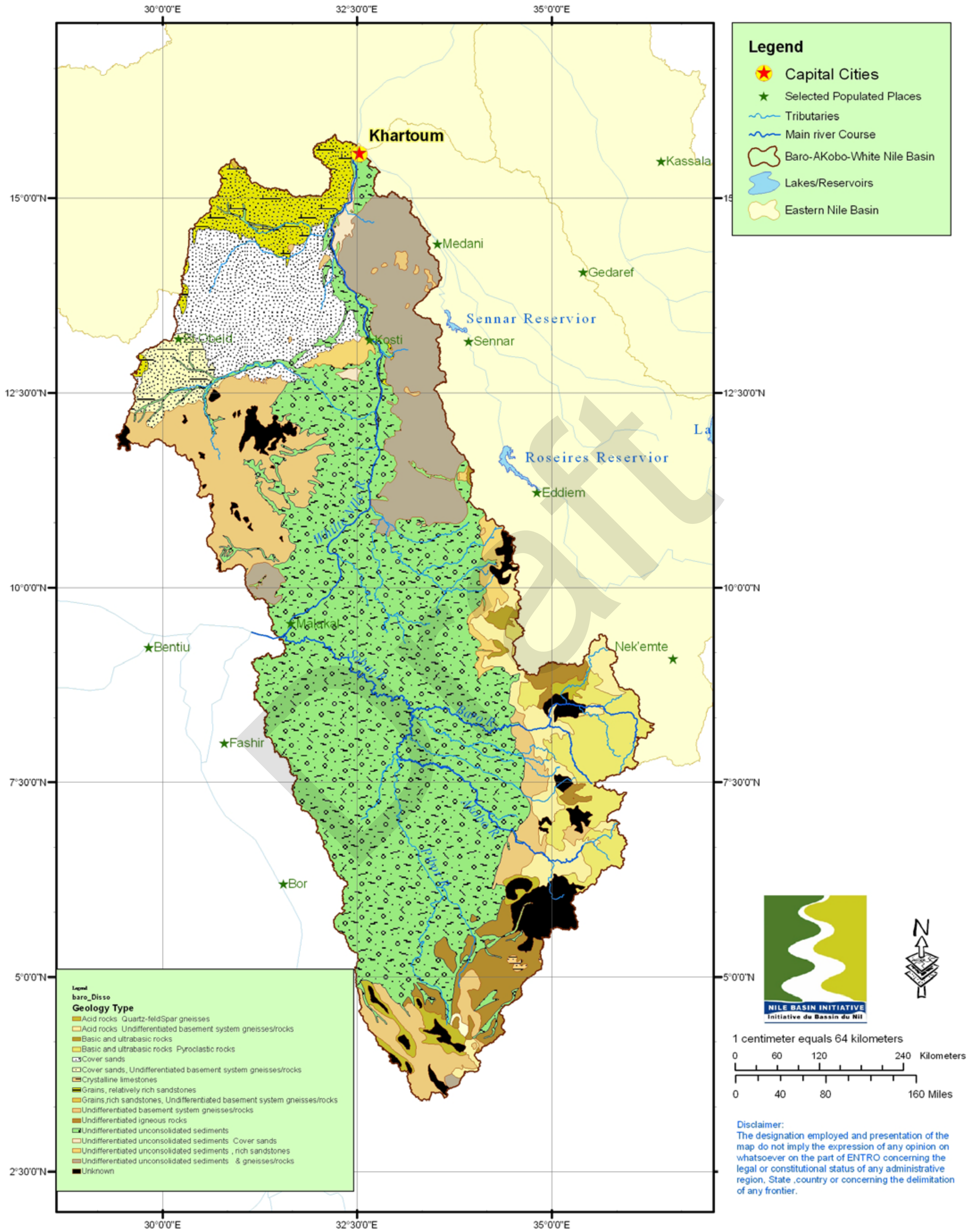
Disclaimer:
The designation employed and presentation of the map do not imply the expression of any opinion on whatsoever on the part of ENTRO concerning the legal or constitutional status of any administrative region, State ,country or concerning the delimitation of any frontier.

4.3 Geology of Baro-Akobo-Sobat and White Nile Sub-basin

The Baro-Akobo watersheds consist primarily of a high mountainous zone (2400masl to 3000masl) 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 (800masl to 1400masl) 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 500masl.

Data/Information Source :One System Inverntory Synthesis Report 2007

Map - 4.3 : Geology Map of Baro-Akobo-Sobat and White Nile Basin



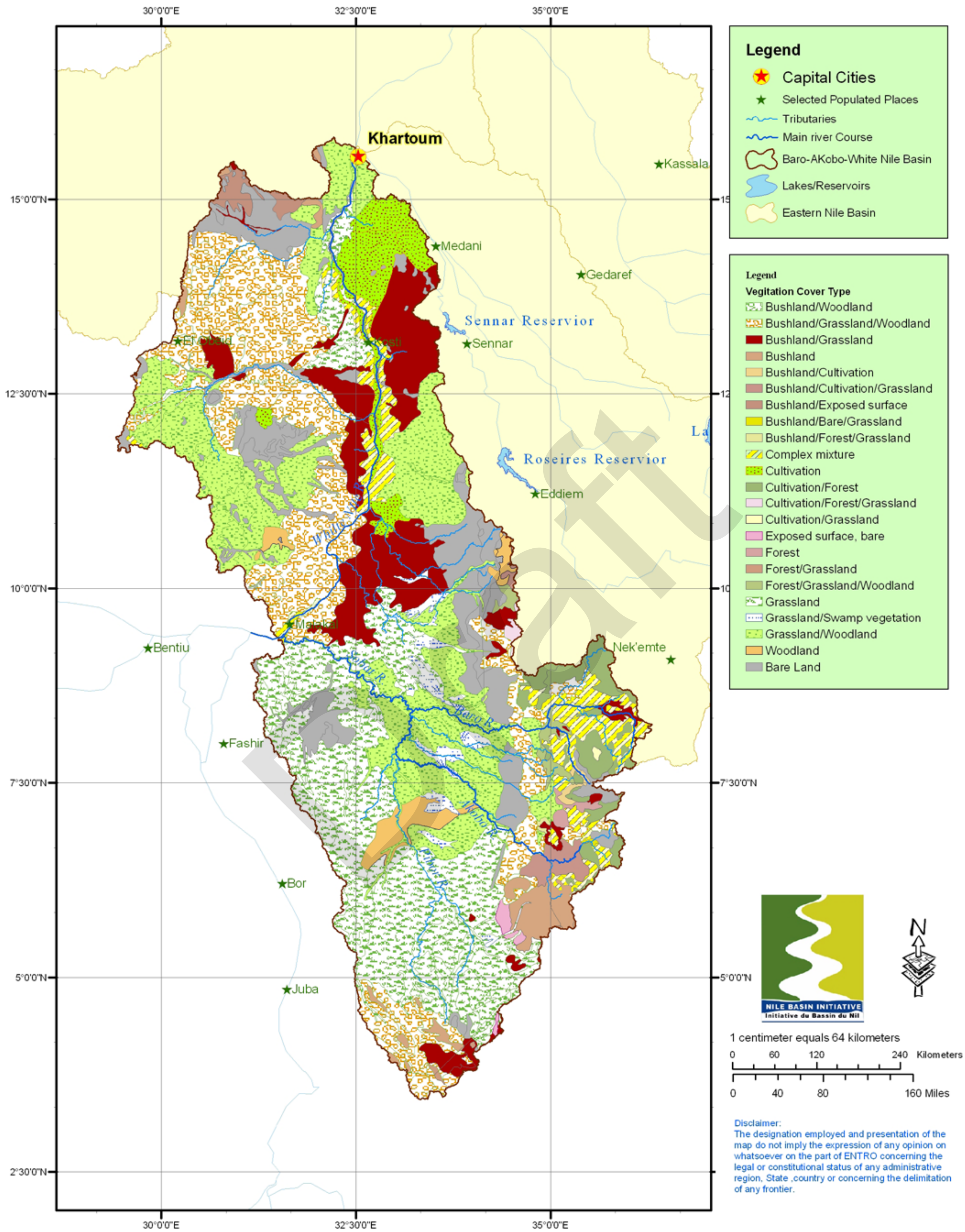
4.4 Vegitaion of Baro-Akobo-Sobat and White Nile Sub-basin

The major vegetations in the sub basin constituted: the forest type vegetations which constitutes six types of forest units (Aninegeria forest, Olea forest, Evergreen forest, Lowland Baphia forest, Tropical rain forest, Podocarpus forest & Riparian forests), the Highland and lowland bamboos, woodland type vegetations, seasonally river and rain flooded grass lands, the swamp vegetations and cultivated lands.

Vegetation Type	
Forest	Aningeria Forests
	Olea Forests
	Evergreen Forests
	Lowland Baphia Forests
	Tropical rain forest
	Podopcarpus Forest of the Imatong Mountains
	Riparian Forests
Highland and Lowland Bamboos	Highland bamboo thicket (Arundaria alpine)
	Lowland bamboo (Oxytenanthera abyssinicus)
Woodland	Mixed Deciduous Woodlands
	Acacia seyal-Balanites Savanna
	Acacia Thornland alternating with Grassland on Clays
	Acacia senegal Savanna and Combretum cordofanum Savanna on Sands
Seasonally River-flooded Grasslands	Oryza longistaminata Dominant Grassland:
	Echinochloa pyramidalis Dominant Grassland:
Seasonally Rain-flooded Grasslands	Echinochloa haploclada Grassland:
	Sprobolus pyramidalis Grassland:
	Hyperrhenia rufa Grassland:
Swamp vegetation	Cyperus papyrus Swamps:
	Typha domingensis Swamps
	Vosia cuspidata Swamps

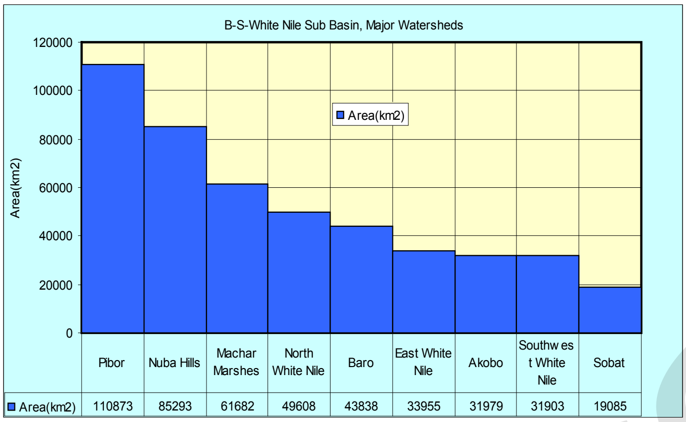
Data/Information Source :One System Inverntory Synthesis Report 2007
:Cooperative regional assessment for wateshed management Transboundary analysis

Map - 4.4 : Vegetation Map of Baro-Akobo-Sobat and White Nile Basin

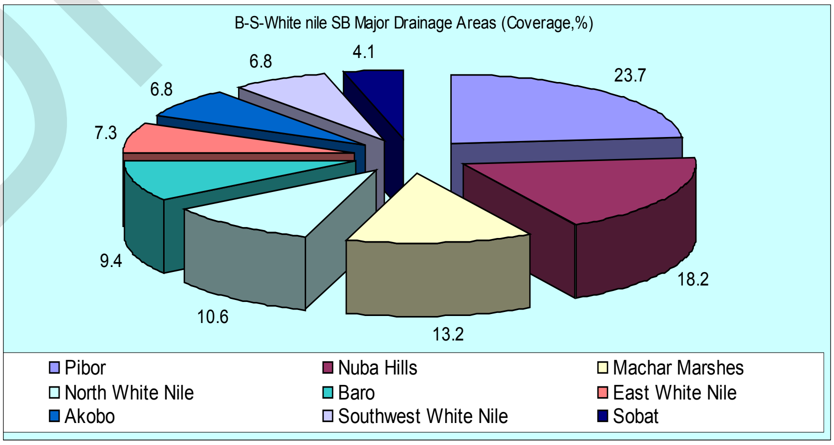


5.1 Drainage Network and Catchment of Baro-Akobo-Sobat and White Nile

The Baro-Akobo-Sobat-White Nile sub-basin can be sub divided in to nine major watersheds: the Pibor watershed (110873km2), the Nuba Hills watershed (85293km2), the Machar Marshes (61682km2), the North White Nile watershed (49608km2), the Baro watershed (43838km2), the East White Nile (33955km2), the Akobo watershed (31975km2), the South White Nile (31903km2) and the Sobat watershed (19085km2) which in total forms a drainage area of 468,216km2.

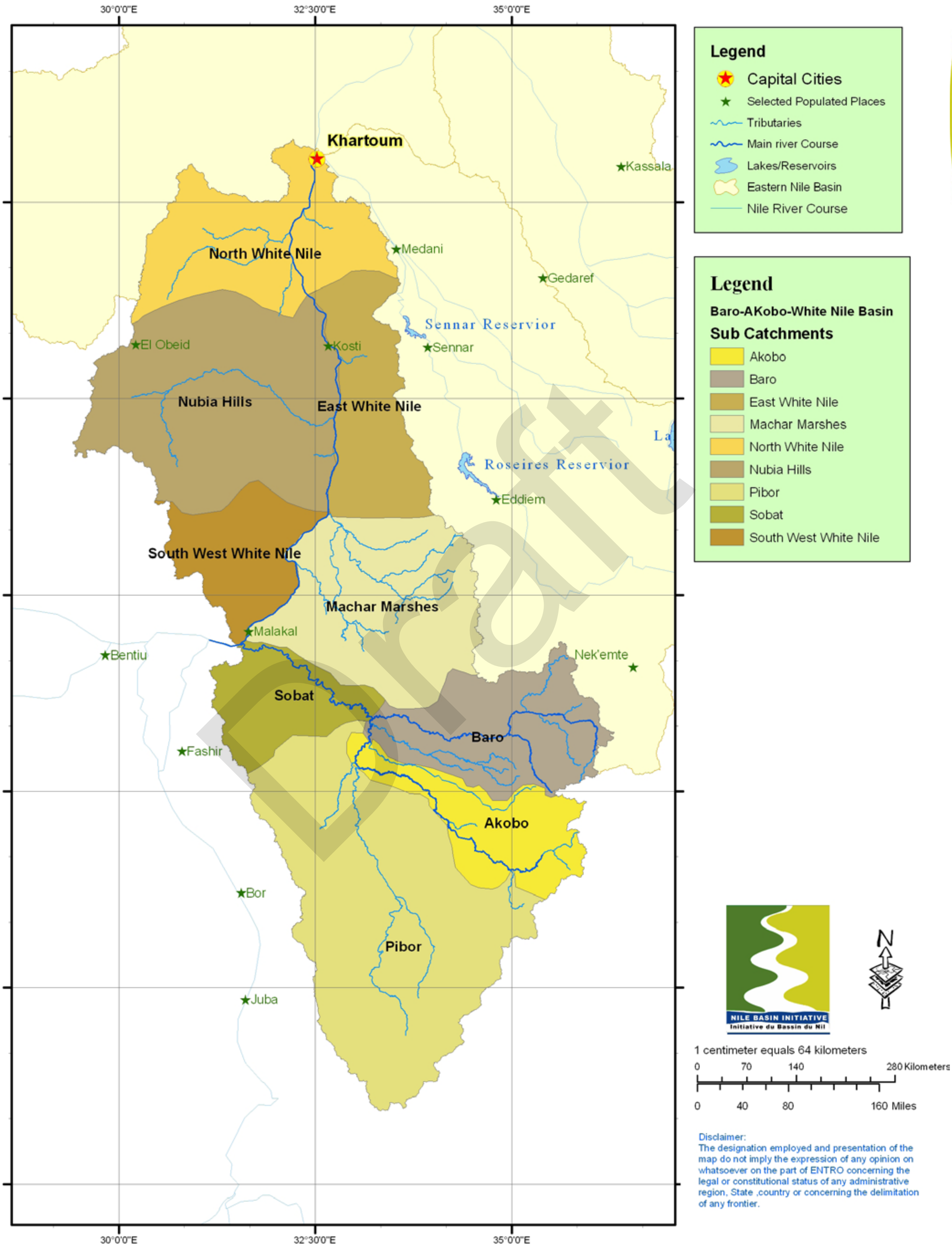


The Baro, Akobo (north eastern side of the watershed) and Gillo all originate from the south-western highland plateaus of Ethiopia and the Pibor together with the southern half of the Akobo watershed and the Machar wet land constitutes the major water system of the sub basin.



Data/Information Source :One System Inverntory Synthesis Report 2007

Map - 5.1 : Drainage Network and Catchments



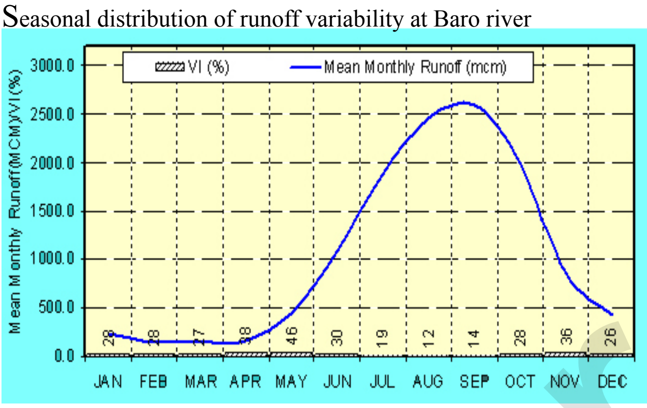
5.2 Surface Water Resource of Baro-Akobo-Sobat and White Nile Sub-basin

Contributing about 26bm3 every year to the Nile system at Khartoum, it is the sub basin with relatively less environmental degradation and high both rain fed and irrigated agriculture potential.

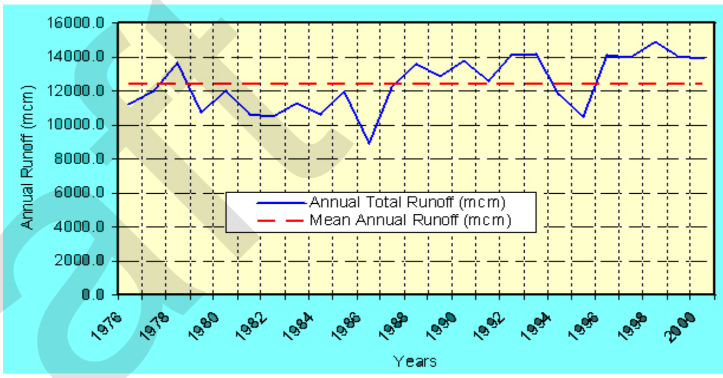
The Baro, Akobo (north eastern side of the watershed) and Gillo all originated from the south-western highland plateaus of Ethiopia and the Pibor together with the southern half of the Akobo watershed and the Machar wet land constitutes the major water system of the sub basin.

The mean annual runoff (1976-2000), at the Baro gauging station near Gambella is 12.412bm3 with an effective runoff of 415mm that indicates a runoff coefficient of 30%. In the upper course of the Baro watershed effective runoff is estimated at 750mm with mean weighted annual rainfall averaged at 1800mm indicating the runoff coefficient is more than 40% (Baro-Akobo Master Plan Studies, May 1997). Nearly 85% of this mean annual runoff happens in the wet (May – November) season.

Seasonal distribution of runoff variability at Baro river

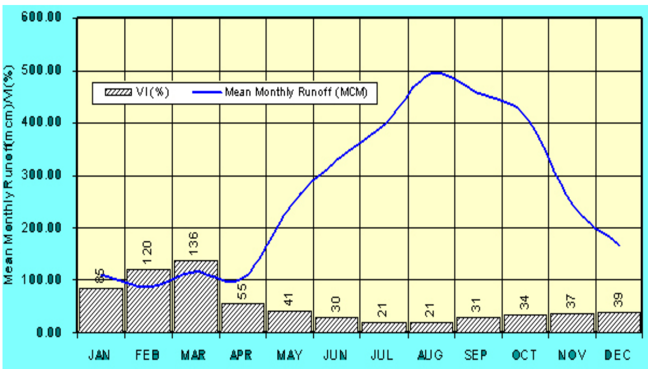


Annual runoff series of Baro River Near Gambella



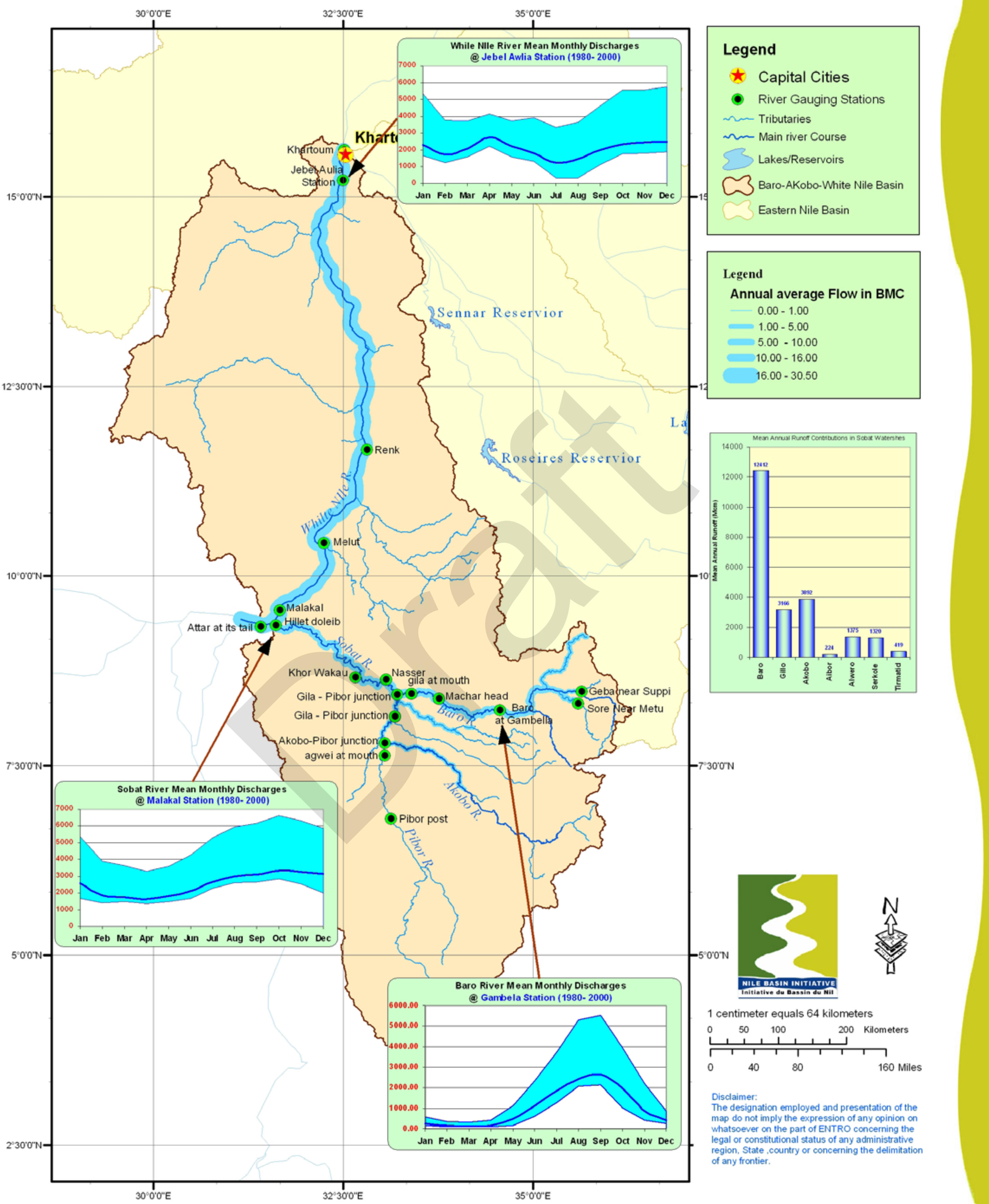
The hydrologic variability for the annual series is 12.8%. The hydrologic variability for seasonal series ranges from 46% (May) to 12% (August). Mean seasonal variability for the wet period (May to November) is computed to be 24% and for the dry season it is estimated at 26%.

The Gillo River is the second largest contributor of the Sobat and the White Nile system. Its watershed at the Ethio-Sudan border is estimated as 12,815km2 (Baro-Akobo Master Plan Studies, May, 1997). The mean annual runoff at the gauging station near Pugnido is recorded as 3.2bm3 (1977-2000) , out of which about 80% falls in the wet (May to November) season. With a watershed area of 10137km2 near Pugnido, mean annual effective runoff is estimated at 315mm indicating a runoff coefficient of 25% with mean weighted annual rainfall of 1300mm over the watershed.The mean hydrologic variability in the wet season is 31% and for the dry season it is 85%.



Seasonal distribution and variability of runoff at Gilo River Near Pugnydo

Map - 5.2 : River Runoff Map of Baro-Akobo-Sobat and White Nile Basin



The Akobo river has two major watersheds, the upper Akobo (draining the Ethiopian land, with estimated watershed area of 6036km2) and the lower Akobo (largely draining the Sudanese land with estimated watershed area of 7,209km2) . The river flows in a north-west general direction bordering Ethiopia and Sudan before it forms a confluence with Pibor river, then after forms a confluence with Gillo and Baro to form the Sobat river and the White Nile system. From the water component OSI report of the Sudan no data is made available for this synthesis work regarding the flow of this watershed. According to Sutcliffe & Parks (Sutcliff & Parks, Feb 1999) mean annual flow (1929-44) from Akobo river at its confluence with Pibor river is estimated to be 0.37bm3. According to the Baro-Akobo master plan studies (Baro-Akobo Master Plan Studies, May 1997), the mean annual runoff from this watershed is estimated to be 3.9bm3. With a total watershed area of 13245km2 at the border, this watershed yields mean annual effective rainfall of 295mm.

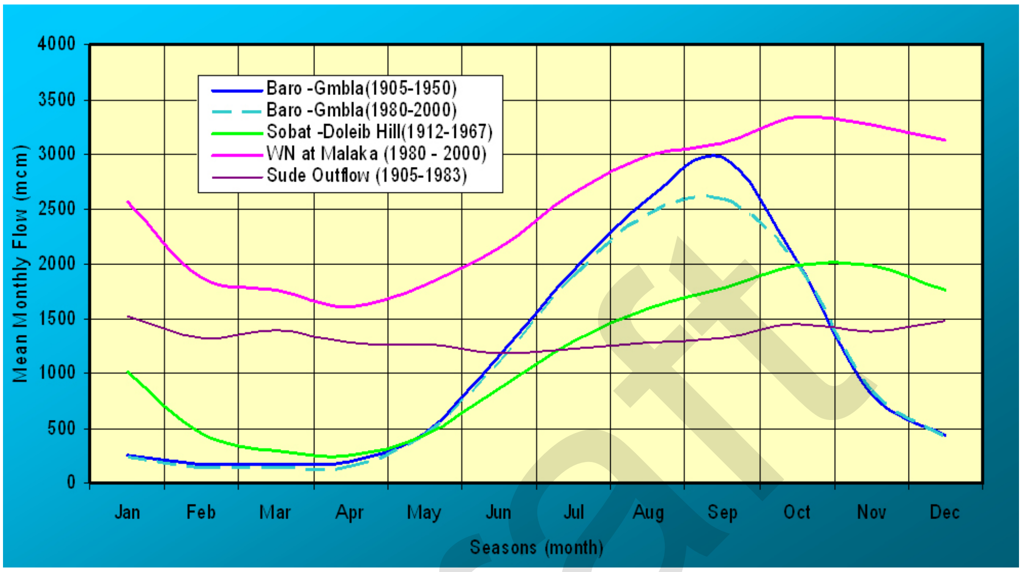
The Pibor river drains a wide area of plains extending to the mountains of southeast Sudan and few portion of the north east of Uganda. It also drains a wide area of the plains east of the Bahr el Jebel, from which there is little runoff in most years but considerable flows in some years. Its flow disappears in to a swamp about 5oN (Sutcliffe & Parks, Feb 1999).

Alike the Akobo watershed, no inflow data is provided by the OSI water component report of Sudan. Sutcliffe & Parks have reported that the mean annual flow (1929-44) from Pibor watershed u/s of its confluence with Akobo is estimated at 1.04bm3. It flows in north-western general direction to form its first confluence with Akobo river and then with Gillo and Baro rivers to form the Sobat river. With an estimated total watershed area of 1435km2, the mean annual runoff is estimated to be 0.224bm3.

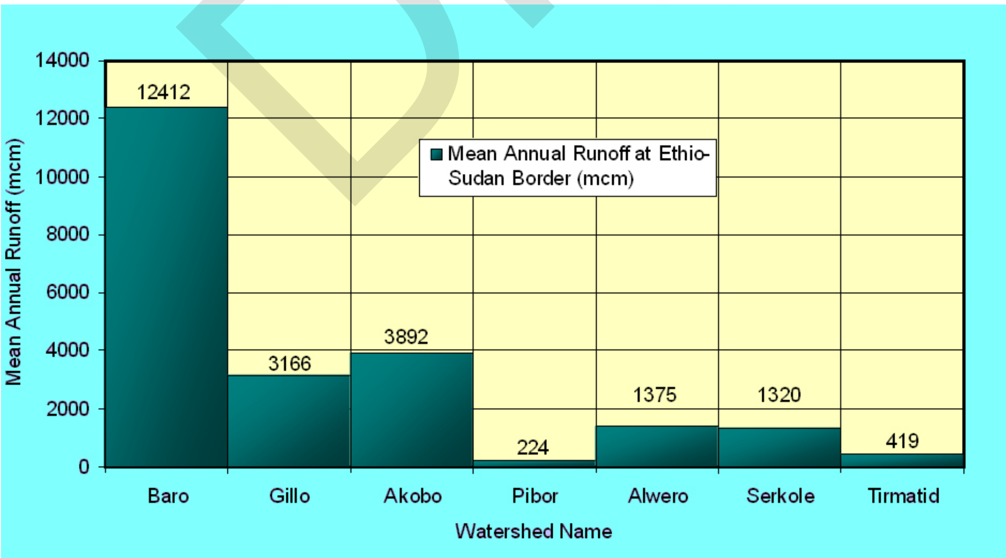
The Sobat watershed is constituted from four major tributaries, Baro, Gillo, Akobo and Pibor, and other three small watersheds, namely, Alewero, Serkole, and Tirmatid. At the Ethio-Sudan border the total watershed is estimated to be 76000km2, with an estimated mean annual runoff of 23.24bm3 (Baro-Akobo Master Plan Studies, May 1997) that yields mean annual weighted effective rainfall of 305mm. From similar sources, at the Ethio-Sudan border, the mean annual runoff from Alewero, Serkole & Tirmatid is estimated to be 1.375bm3, 1.32bm3 and 0.419bm3 respectively.

Together with the contributions coming from the Sude, it is one of the major constituents of the White Nile system. At mean annual inflow of 13.5bm3, at its mouth, its contribution to the White Nile system accounts almost 50%. The mean annual inflow from the Sude outflow is averaged at 16bm3. At estimated watershed area of 186,275km2 for the Sobat at its mouth, the mean annual weighted effective rainfall is estimated at 75mm.

The inflow to the White Nile (WN) system from the Sude is a regulated flow due to the routing effect of the wide wetland, the Sude. The Sude contributes nearly the base flow for the WN system (J V Sutcliffe & Y P Parks, Feb, 1999). It can therefore be concluded that seasonal element manifested in the WN system is contributed by the Sobat river, which it has in tern acquired it from the hydrologic variability's and seasonality's of the inflows coming from the Ethiopian highlands in the eastern



Seasonal Distribution of Mean Monthly flow for baro at Gambella ,sude outflow and White Nile at Malakal and Sobat at Doleib Hill

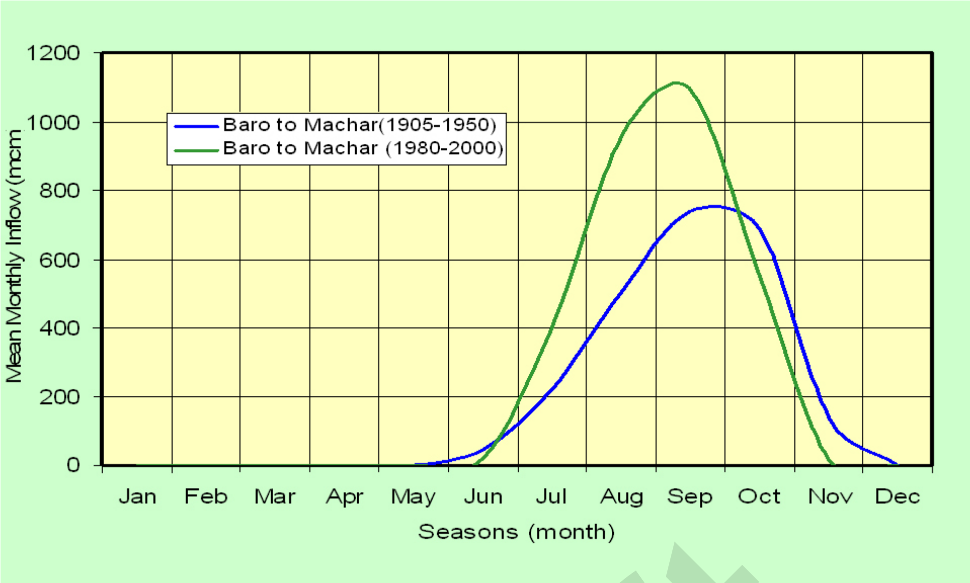


Contribution of the various sub watersheds in the sub basin at the Ethio-Sudan border as taken from the Baro-Akobo master plan studies.

The Machar flood plain/swamp is located north of the Baro river before its confluence with the Pibor river in the Sudanese land. It is hydraulically connected to the Baro river during high stage flows (flood flows over topping its embankments) from its south and to the ephemeral torrents originated from the foothills of the western highlands of Ethiopia from its east side

The Machar swamp is hydraulically connected to the WN system through an extended grass field channel named as Khor Adar. The inflow from the Machar swamp to the WN system through this channel was measured in 1948 and 1957 which appeared to be 0.058bm3 and 0.029bm3 respectively .
Below the bifurcation with Adura (a branch channel in the left bank of the Baro river before its confluence with Pibor) the Baro river receives inflow from the Jakao river at its right bank and losses water by spill over the right bank and through the Khor Machar channel towards the Machar wet land/swamp. The JIT (1954) has characterized the inflow to the Machar swamp from the Baro spills by further refining the conclusions made by Hurst as a result of their investigation. Based on the conclusions of the JIT, the inflow to the Machar swamp from the spillage of Baro river (for years 1980 – 2000) is estimated to be more than 2.374bm3. Further more the JIT has investigated the runoff entering the Machar marsh from the eastern torrents to be 1.744bcm. . The total drainage area of the eastern torrents is estimated to be 10,300km2, out of which the JIT has recorded for 5000km2 of the watershed and use area proportion extrapolations to estimate the un-gagged portion of the Machar watershed

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Spill from Baro towards Machar (1905 - 1955)	0	0	0	0	0	44	218	504	738	689	135	0	2,328
Spill from Baro River (1980 - 2000)	0	0	0	0	0	22.2	396.6	954.9	1096.3	551.1	11.4	0	3,032
Inflow of Yabus at Yabus Bridge (1950 - 1955)	9.88	4.7	3.39	3.15	8.59	17.7	30.1	88.7	118	108	42.8	19.6	455
Inflow of Daga at Daga Post (1950 - 1954)	1.78	1.24	0.31	1.04	5.85	16.4	48.1	113	93.8	91.5	36.3	10.9	421
Total Estimated inflows from east Torrents to the Machar Swamp (1950-1955)	23	12	7	8	29	68	156	401	423	398	158	61	1,744
Average Rainfall over the Machar Watershed	0	2	3	31	109	126	179	241	139	77	26	0	933
Average Evaporation (mm)	217	190	202	186	183	159	140	140	150	177	189	217	2,150



Comparision of mean monthly inflows from baro to machar inflow swam for the periods of 1980- 2000

Data/Information Source :One System Inverntory Synthesis Report 2007
:Sutcliffe & Parks, Feb 1999)
:JIT Investigations, 1954

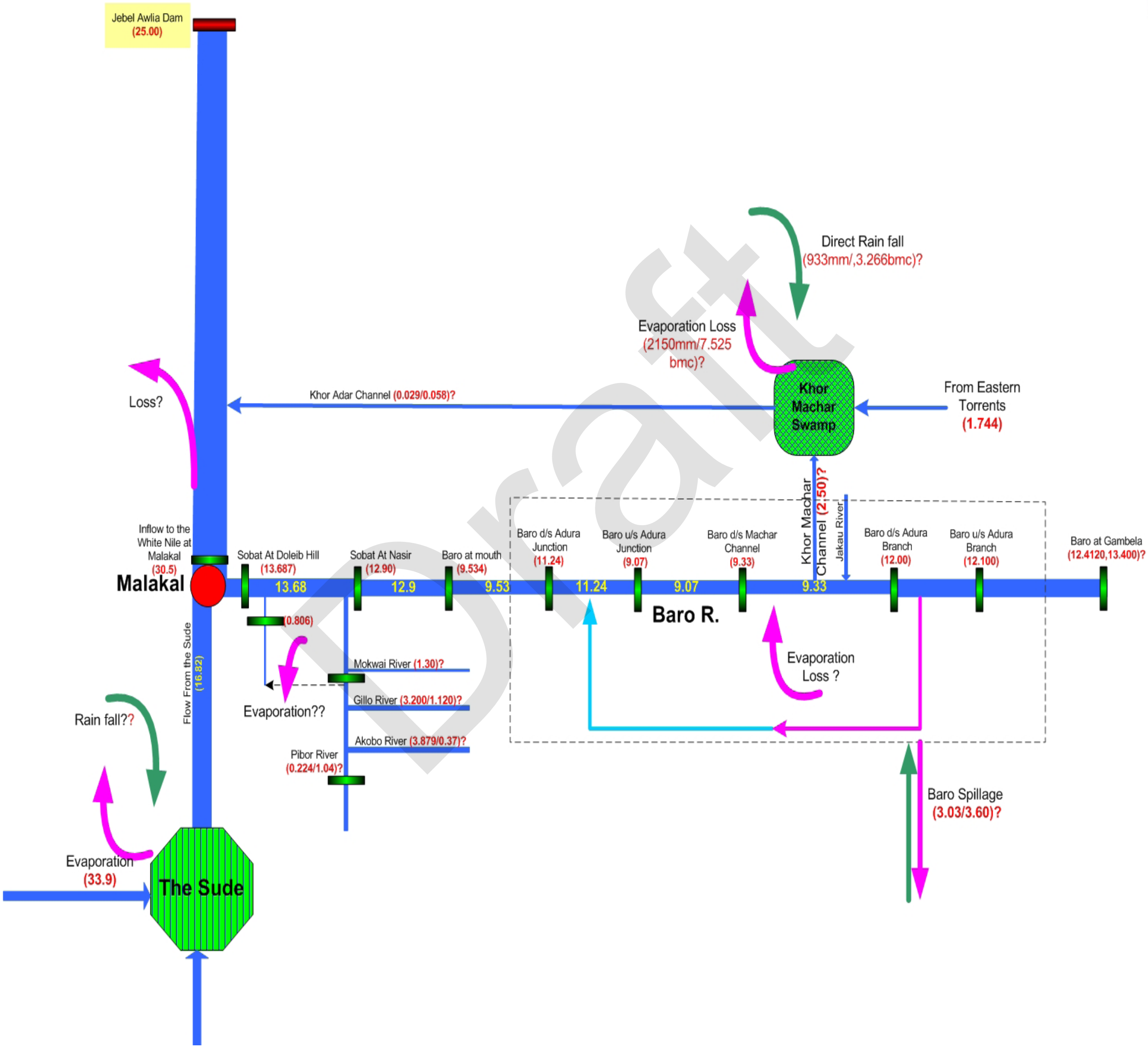
5.3 River System Schematics and Indicative Water Balance

The mean annual contribution of the Baro river u/s of Gambella is 12.412bm3 (1980-2000) and constitutes about 40% of the balance of the Wite Nile system at Malakal. According to the investigation made by JIT in 1955 this inflow was averaged at 13.4bm3 (1905-1955). In its lower course b/n Gambella and its mouth or the confluence with Sobat the flow spills over the extended wide low-lying flood plain taking place on both sides of the river bank, with large proportions spilling through the right (north) bank to the Machar swamp.Annual spillage is estimated to be above 3.03bm3 (1980-2000). As per to JIT investigations this spillage is estimated to be 3.6bm3 (1905-1955). Large proportion of this spillage (more than 2.374bm3 (1980-2000) enters the Machar swamp through the Khol Machar channel and some portion is returned back to directly the Baro system through the Adura channel and to the Pibor river and the Sobat system through the Mokwai and other flood plain channels. Mean annual inflow of Baro u/s of the Adura junction is averaged at 9.068bm3 (1905 – 1955) which is less than the mean annual inflow at Gambella, indicating spillage losses in the system. Mean annual inflow of Baro d/s of the Adura junction is recorded to be 11.236bm3 (1905-1955, JIT, 1954), which indicates that some of the spilled water might have met the Baro system through the Adura and some other channels at their junction with the Baro river. At its mouth mean annual inflow is recorded to be 9.534bm3 (1905 – 1955) indicating the loss due to spillage again through the Baro itself. D/s of its mouth mean annual inflow in the Sobat system is recorded to be 12.893 (1905-1955) indicating gains from the Pibor river and also the return of some of the spillages through the Mokwai channel.

The mean annual inflow from the Gillo river at Pugnido, to the Pibor river is recorded as 3.2bm3 (1977-2000). The mean annual inflow of Gillo river at its confluence with Pibor is, however, averaged at 1.12bm3 (1905 – 1955, JIT Investigations, 1954). The inflow from Pibor river u/s of the Akobo confluence is estimated as 0.224bm3 (Baro-Akobo master plan studies, May 1997) and this inflow is averaged at 1.04bm3 (1905-1955, JIT investigations, 1954). The contribution from Akobo river is estimated to be 3.879bm3 (Baro-Akobo Master Plan Studies, May 1997) and at its confluence with the Pibor this inflow was reported by the JIT investigation (1954) to be 0.37bm3 (1905-1955). From similar sources the inflow to Pibor from Mokwai is averaged at 1.3bm3. However, the inflow of Pibor river u/s of its confluence with the Mokwai is recorded at 1.95bm3 indicating the possibility of spillage from the Pibor river u/s of its confluence with the Mokwai. Some of this spillage joins the Sobat system in its further d/s reach. This is probably demonstrated by an increased mean annual inflow record, 13.687bm3 (1905-1955), at the Doleib hill located u/s of the Malakal station in the east. At Malakal, mean annual inflow from the Sude is estimated as 16.813bm3 and together with the Sobat system, producing a mean annual inflow of 30.50bm3 to the WN system. At Jebel Awlia station, the mouth of white Nile, the mean annual inflow of the WN system is averaged at 25bm3 (1980-2000), the difference could be attributed to evaporation losses at the Jebel Awlia reservoir and from the swamps between Malakal & the Jebel Awlia reservoir, which all together are estimated at 4.5bm3 (evaporation loss from Jebel Awlia reservoir is averaged at 2.5bm3, Sudan OSI water Component Report, May 2006). The WN system is thus believed to contribute about 30% of the Nile inflow at Aswan. At Malakal the Sobat and the Sude contributes 16% and 20% of the Nile inflow at Aswan dam respectively.

Data/Information Source :One System Inverntory Synthesis Report 2007
:Sutcliffe & Parks, Feb 1999)
:JIT Investigations, 1954

Map - 5.3 : Flow Schematics of Baro-Akobo-Sobat and White Nile Basin



5.4 Sediment in Baro-Akobo-Sobat and White Nile Sub-basin

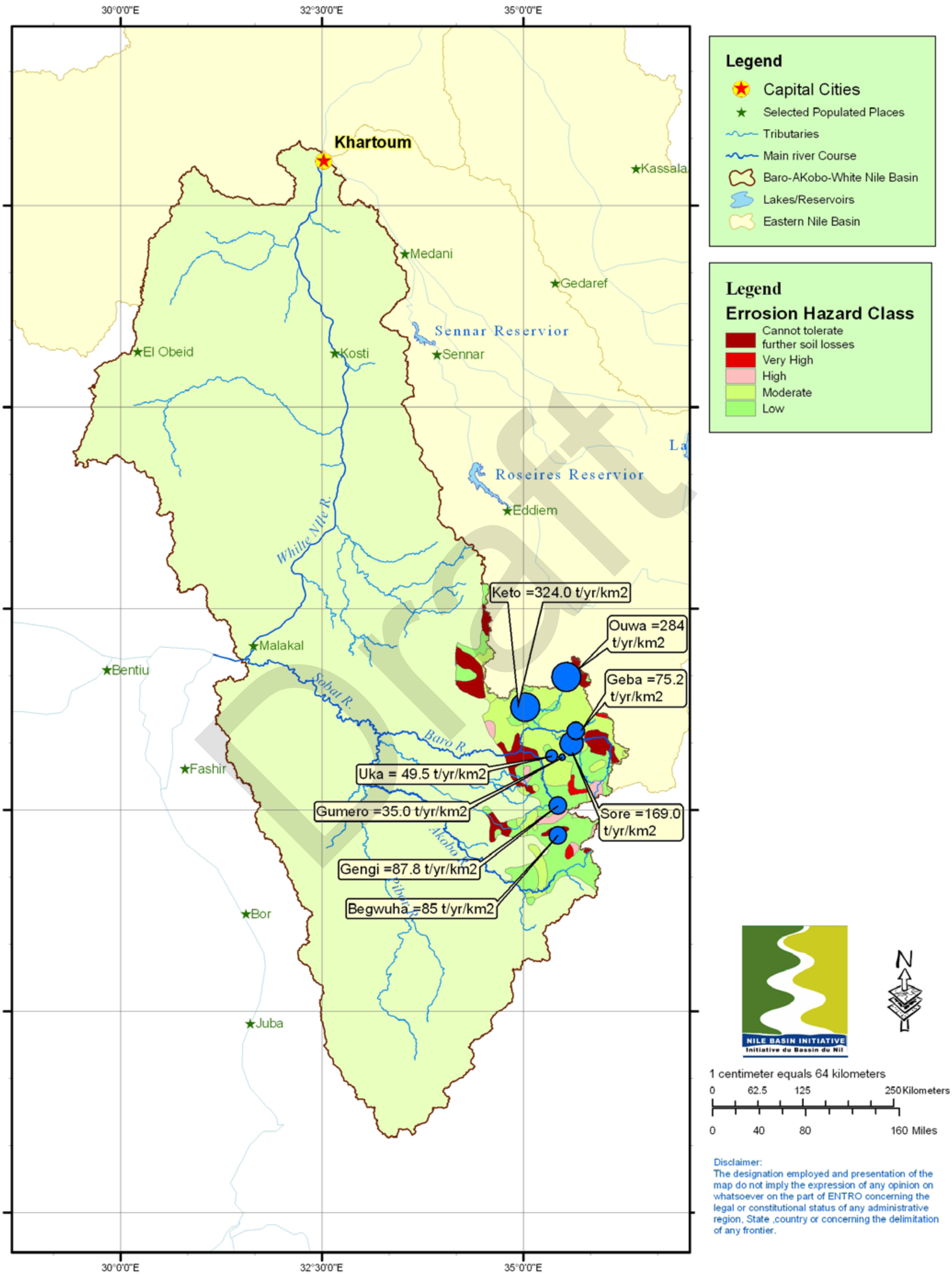
Mean annual sediment yield in upper course of the Baro Sub-Basin ranges from 35t/km2 (Gumero river 106km2, and mean annual flow of 2.05m3/s) to 324t/km^2 per year (Keto river, 1006km2 & mean annual flow of 17.6m3/s). This sediment load is equivalent to mean annual loss of 3mm depth of soil from the agricultural land in this upper course of the sub basin. This magnitude is obviously a threat both for reservoirs life and agricultural productions. It can be inferred from this figures that the threat for the existing Alewero reservoir is significant. It is also a threat for crop production as it would result soil loss from agricultural land and causes land degradation, which virtually impacts food security situation of the sub watershed in this upper course of the sub basin.

On the other hand, it is indicated that reservoir sedimentation is not a threat in the lower course of the sub basin at Jebel Awlia, for instance. After being set in operation phase for nearly seven decades, reservoir sedimentation is not yet a threat for the Jebel Awlia reservoir. It still maintains nearly, its original designed storage capacity. The presence of 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 at the reach 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, all of them serving as a filter for any sediment load coming from the highland portions of the sub basin, are perhaps the very reasons for the Jebel Awlia reservoir is not threatened by the sediment load, as the Sennar (lost its 60% storage), Roseires (lost its 35% storage) and El-Girba (lost its 57% storage capacity) do in the Blue Nile and Tekeze-Setite-Atbara sub basins.

River	Drainage Area(km2)	Mean annual flow (m3/s)	sediment load (t/yr/km2)
Keto	1006	17.6	324
Gumero	106	2.05	35
Ouwa	288	5.8	284
Sor	1620	53.6	124
Gecheh	79	1.9	63
Begawuha	125	3.3	85
Sor nr Metu	1622	50.1	169
Geba nr Chora	1582	49.3	137
Geba nr Suppi	3894	54.8	75.2
Uka at Uka	53	1.3	49.5
Gummero nr Gore	106	1.9	31.6
Baro nr Masha	1653	56.8	155
Genji nr Gecha	115	4.6	87.8

Data/Information Source :One System Inverntory Synthesis Report 2007

Map - 5.3 : Sediment and Land erosion Baro-Akobo Sub-Basin



6. Infrastructure and Utilities

6.1 Dams and Reserviors in Baro-Akobo-Sobat and White Nile Sub-basin

Alewero reservoir in the upper course of the Baro watershed in Ethiopia, and the Jebel Awlia reservoir at the mouth of the White Nile in the Sudan reservoirs and the respective irrigation infrastructures (Kanan & Assalaya sugar schemes in Sudan & the Alewero command area in Ethiopia) are currently available water resources infrastructures in the sub basin.

The Baro-Akobo master plan study (May, 1997) in Ethiopia, has also identified 24 dams/reservoirs out of which five are for irrigated agriculture development purposes, one multi-purpose and others are for hydropower development purposes.

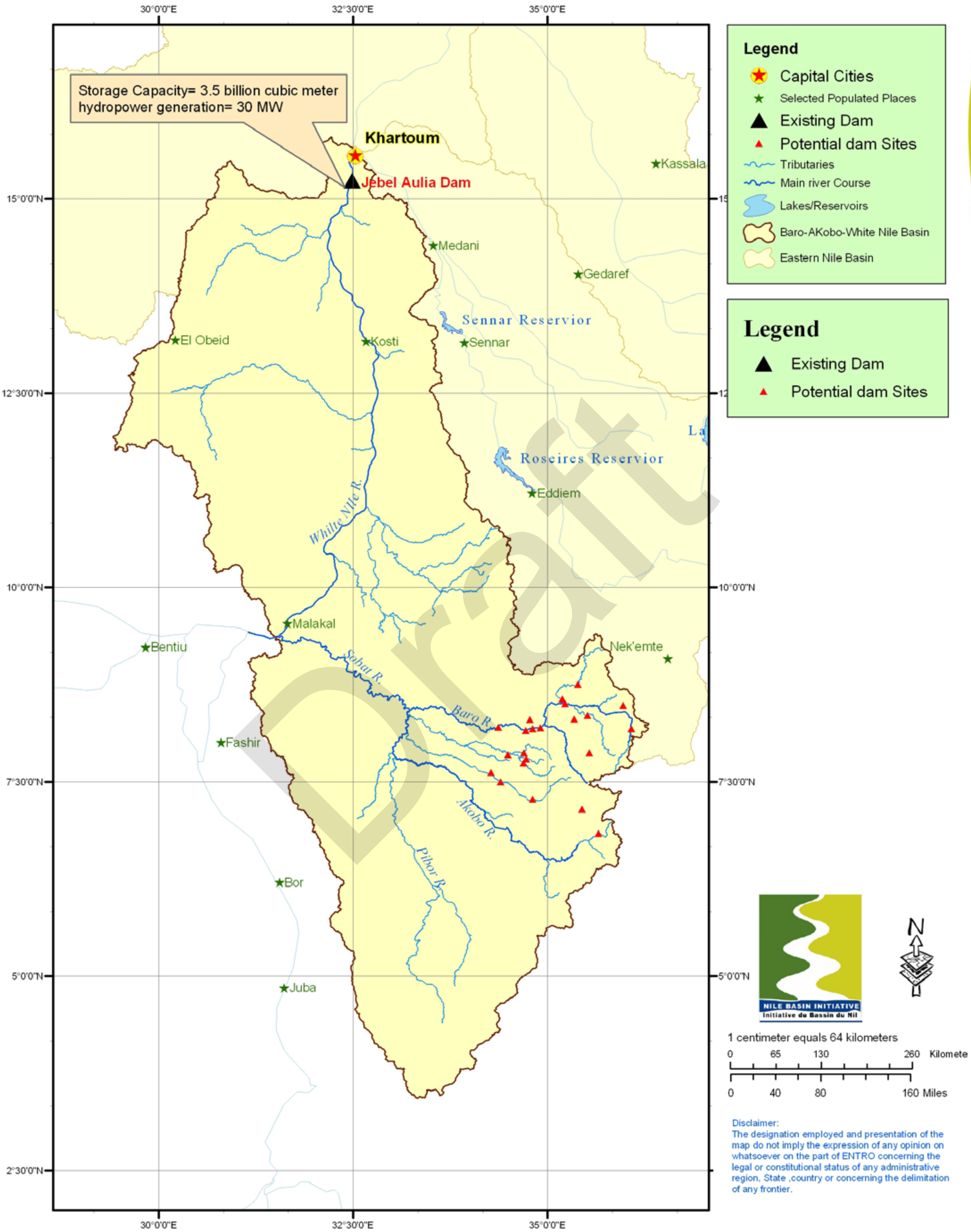
Jebel Awlia Dam/Reservoir is located at the mouth of the White Nile. It was built in 1937 with a storage capacity of 3.5bm3. Mean annual evaporation from the reservoir is averaged at 2.5bm3. In between the Malakal and the reservoir there exists a wet land which is flooded seasonally and mean annual evaporation loss is averaged at 2bm3. Its current storage capacity remains to be as its original capacity- So far, after being in the operation of for nearly seven decades, reservoir sedimentation is not yet a threat for the Jebel Awlia reservoir. It still, maintains its original designed storage capacity.

Jebel Aulia dam is located at the mouth of the White Nile. It was built in 1937 with a storage capacity of 3.5bm3 and is used for multi-purpose ,i.e. irrigation,hydropower and flood control.

Alewero Dam/Reservoir is located in the upper course of the Baro river, at Alewero river, in Ethiopia. The reservoir was initially built for irrigation purposes and currently its operation is not active.

Data/Information Source :One System Inverntory Synthesis Report 2007

Map - 6.1: Dams/Reservoir in Baro-Akobo-Sobat and White Nile Basin



6.2 Irrigation and Agriculture in Baro-Akobo-Sobat and White Nile Sub-basin

The Kanan (63,531ha) and Assalaya (16,613ha) together constitutes 80,144ha of command area largely meant for sugar cane production. Small pumping public schemes with total area of not exceeding 300ha is also under operation in the Sudanese land of the sub basin. Moisture stress in this lower course of the sub basin is considerably high as observed through the prevalence of high computations for irrigation water.

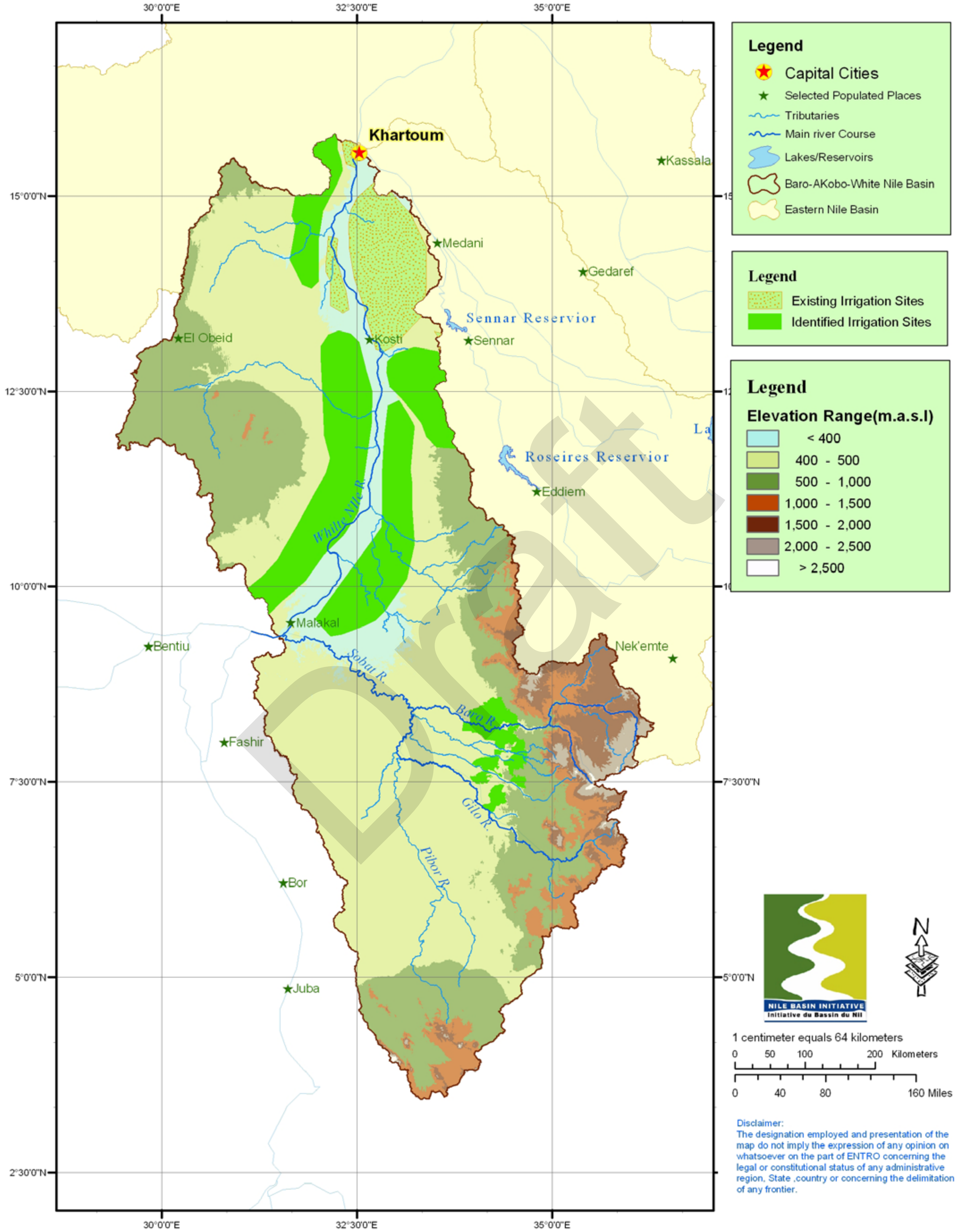
In the upstream reach the Alewero reservoir is initially designed to command some 14000ha largely for food security purposes. Currently the system is not active. In this upstream course of the sub basin the issue of food insecurity resulted from high rainfall variability, largely in the low-lying areas is considerably high requiring the development of irrigated agriculture in the system.

The total gross command area for the five reservoirs (at Baro river 326566ha, at Alewero river, 48265ha and at Gilo river 256 178ha) is estimated at 631,000ha. The net command area is estimated at 480,000ha with the Baro (250,000ha), Alewero (34,000ha) and Gilo (196,000ha) are the three major sub watersheds used as a source of irrigation water (storage) in the system. Considering identified projects irrigated agriculture development potential for the u/s reach of the sub basin (watershed in Ethiopia) is estimated at 750,000ha. This estimate excludes the flood plain of Gambella along the Sudan border. No data is provided in the Sudan OSI water component report regarding the future expansion and/or potential development works of irrigated agriculture in the d/s reach of the sub basin. The proposed cropping pattern is designed to have a cropping intensity of 100% for the dry season and 66% for the wet season that constitutes an annual cropping intensity of 166%. Dry season crops constitute; Cotton (25%), Maize (40%), Sorghum (19%), Soya Bean (10%), Groundnuts (5%) and Green Manure (fodder, 1%). Wet season cropping constitute, cotton, maize and groundnuts each 15%, Sorghum and Soya Bean each 10% and green manure 1%.

At 60% project efficiency the hydro module for the upper course of the sub basin is estimated at 10922m3/ha per year, which is on the higher side as compared to the current practice (10125m3/ha per year in the Jebel Awlia irrigation projects) in the lower course of the sub basin.

Data/Information Source :One System Inverntory Synthesis Report 2007

Map - 6.2: Irrigation in Baro-Akobo-Sobat and White Nile Sub-basin



6.3 Hydropower and Transmission in Baro-Akobo-Sobat and White Nile Sub-basin

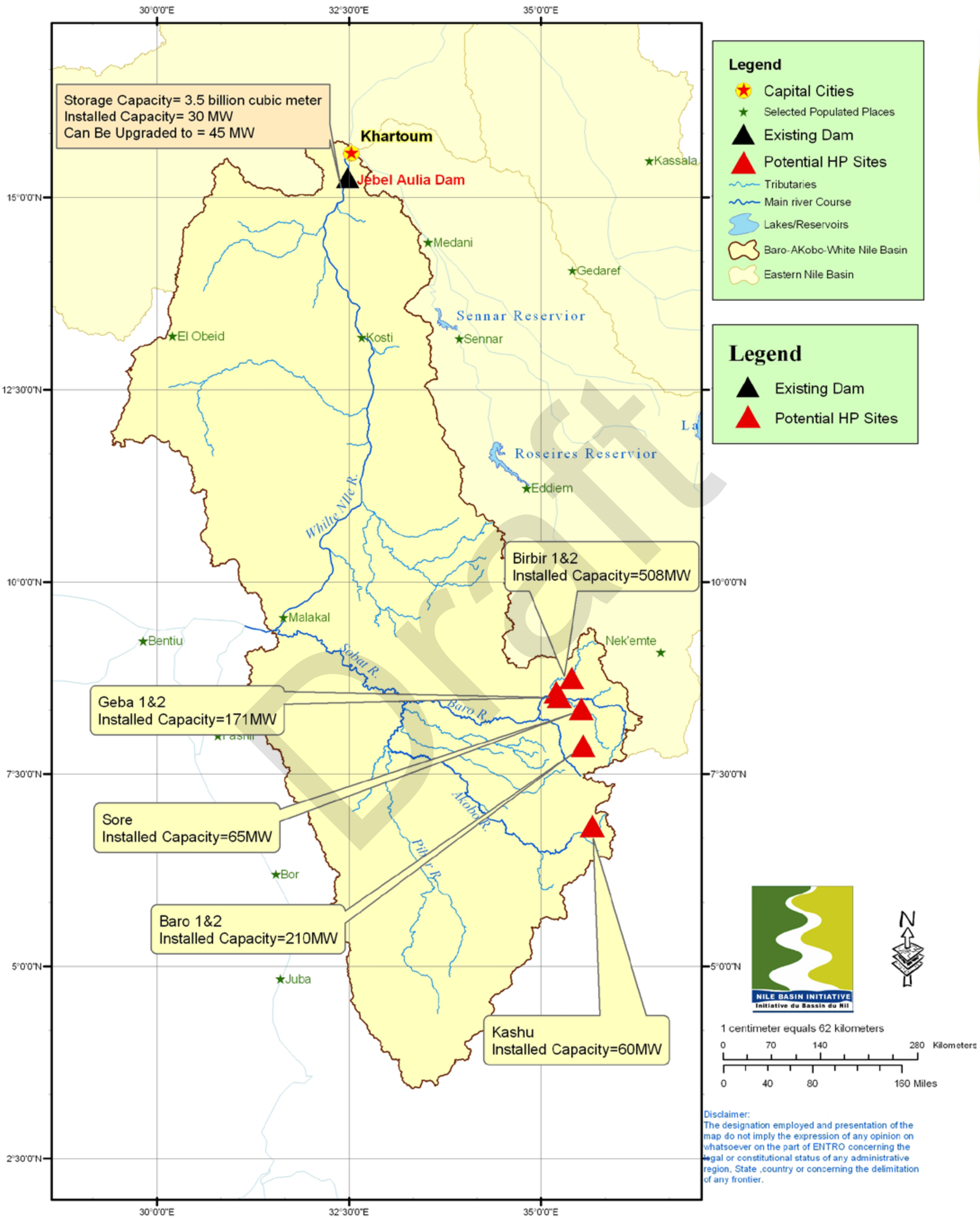
The Jebel Awlia reservoir is the only dam currently available in the sub basin meant for hydropower development. Installed capacity at the current situation is 30MW and could be upgraded to 45MW.

Most small towns in the upper course of the sub basin are served by small diesel or hydroelectric plants, with a combined total installed capacity of 9MW.

Identified hydropower projects constitute; eight large scale projects (>150MW installed capacity) with a total installed capacity of 3320MW; eight medium projects (>50MW installed capacity) with a total installed capacity of 610MW; and eight small projects (<50MW installed capacity) with a total installed capacity of 220MW. The total hydropower potential of the sub basin in Ethiopia is estimated at 19,826GWH/year.

Five projects are candidate projects (Baro 1&2, 210MW; Geba 1&2, 171MW; Birbir A&R, 508MW; Kashu, 60MW; and Sor A&R, 65MW) for national ICS out of which the first three are candidate projects for energy export. Large and medium scale hydropower plants are envisaged to be interconnected to the national ICS of Ethiopia. Interconnection with the Sudan has been studied twice (IVO, in 1980 & mid nineteen ninety's), which suggests two possible routes: the first is from Debre-Markos to Roseires, a distance of about 430km, where the Baro-Akobo projects are connected to Debre Markos, and the second proposal is from Ghedo via Ghimbi to Roseires over a distance of 617km and it is found to be more promising if the envisaged large hydropower plants in the upper course of the sub basin (Baro-Akobo basin of Ethiopia) are realized. The interconnection proposed by IVO is a single circuit 345KV line with 315mm2 aluminum conductors. These studies indicate that the interconnections could be justified on the basis of exchange of surplus energy b/n the two systems rather than firm energy exchange as hydropower will continue to play important role in the Ethiopian expanding system, there will be periodic surplus of energy by the time the envisaged hydropower plants are commissioned.

Data/Information Source :One System Inverntory Synthesis Report 2007

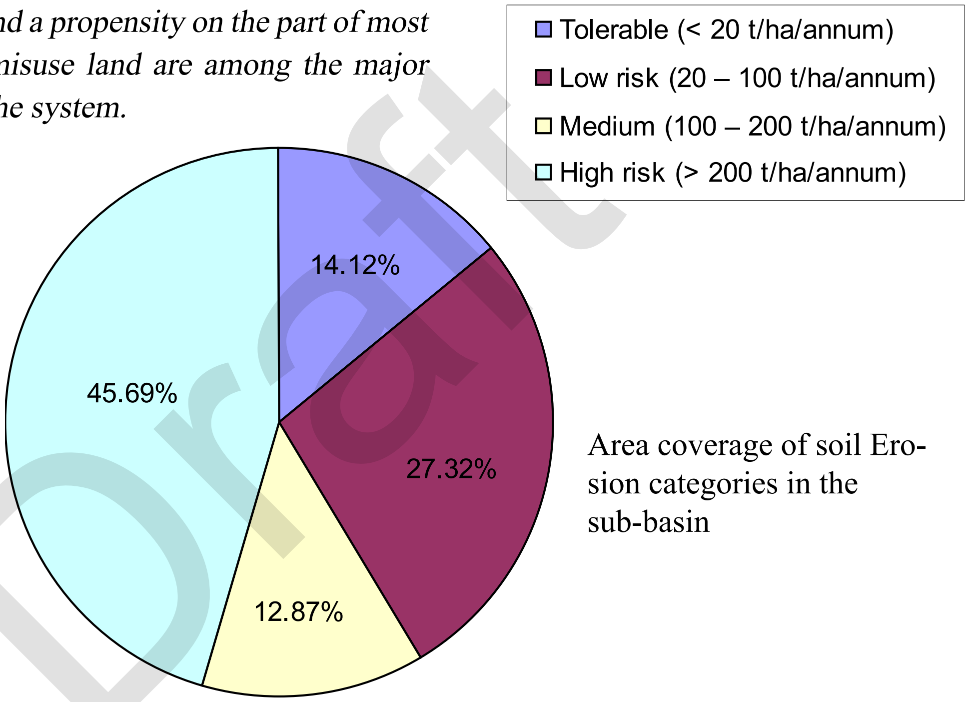

Storage Capacity= 3.5 billion cubic meter
Installed Capacity= 30 MW
Can Be Upgraded to = 45 MW
Khartoum
Jebel Aulia Dam
Kassala
Medani
Gedaref
Sennar Reservior
El Obeid
Kosti
Sennar
Roseires Reservior
Eddiem
White Nile R.
Birbir 1&2
Installed Capacity=508MW
Malakal
Bentiu
Nek'emte
Sobat R.
Baro R.
Geba 1&2
Installed Capacity=171MW
Sore
Installed Capacity=65MW
Akobo R.
Pibor R.
Bor
Baro 1&2
Installed Capacity=210MW
Juba
Kashu
Installed Capacity=60MW
Legend
Capital Cities
Selected Populated Places
Existing Dam
Potential HP Sites
Tributaries
Main river Course
Lakes/Reservoirs
Baro-AKobo-White Nile Basin
Eastern Nile Basin
Legend
Existing Dam
Potential HP Sites
NILE BASIN INITIATIVE
Initiative du Bassin du Nil
N
1 centimeter equals 62 kilometers
0 70 140 280 Kilometers
0 40 80 160 Miles
Disclaimer:
The designation employed and presentation of the map do not imply the expression of any opinion on whatsoever on the part of ENTRO concerning the legal or constitutional status of any administrative region, State ,country or concerning the delimitation of any frontier.
Draft

7. Environmental

7.1 Land Degradation/Errosion in Baro-Akobo-Sobat and White Nile Sub-basin

Land degradation largely in the upper course of the sub basin occurs in various forms: water-caused soil erosion, chemical degradation (leaching bases), physical degradation loss of beneficial soil properties such as porosity), and biological degradation (loss of humus). Each one of these poses a potent risk to food production, taken together, they threaten agriculture and the benefits of the many projects to come or/and envisaged in the system.

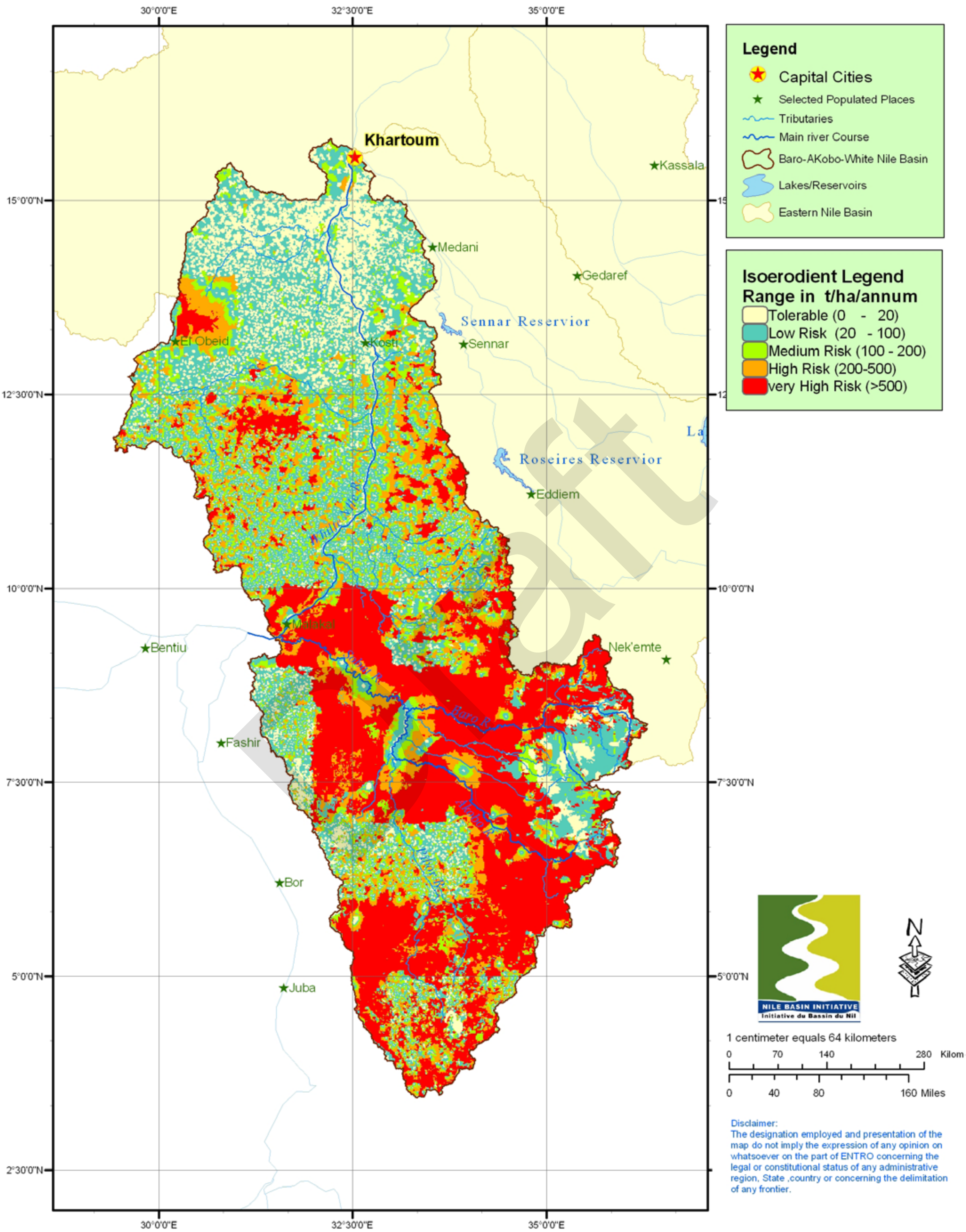
According to the study conducted during the Baro-Akobo master plan studies soil erosion (largely water-caused) is equivalent to mean annual loss of 3mm depth of soil from the agricultural land in this upper course of the sub basin. This magnitude is obviously a threat both for reservoirs life and agricultural productions. High rainfall intensities, land slope, and a propensity on the part of most farmers, acting innocently, to misuse land are among the major factors for land degradation in the system.



Area coverage of soil Erosion categories in the sub-basin

Data/Information Source :One System Inverntory Synthesis Report 2007

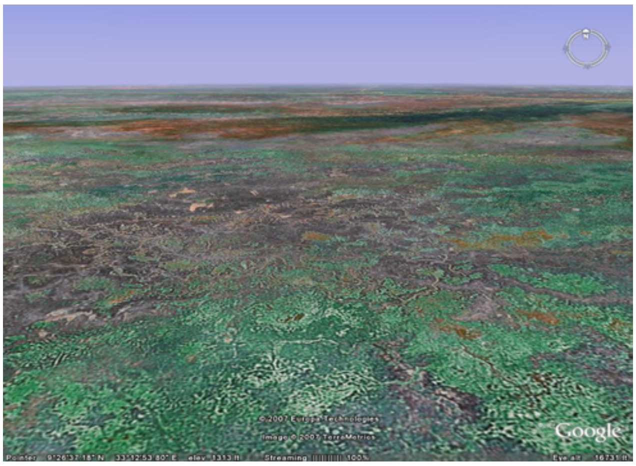
Map - 7.1: Isoerodient map of Baro-Akobo-Sobat and White Nile Basin



7.2 Parks , Wetlands and Protected areas

Wetlands

The Machar Marshe of upper river Sobat on the Ethiopian-Sudan border is an important environmental feature in the sub basin.It has an estimated area of 6500km^2.. It is characterized by permanent and seasonal swamps each with distinctive plant life. The rain flooded pastures are an important source of summer grazing for the distinctive Nilotic livestock. The swamp area is also an important fishing ground and supports wildlife.Upper Kenamuke and Kobowen swamps are also located in this sub-basin.Major wetlands identified in Ethiopian are Cheffie Gebo, Ginina, Abol, Alwero and tata (thata) located in the Baro-Akobo river Basin. Cheffie Gebo is wooded wetland which is used for farming,pasture and forestry.Apart from that It also owns Religious Importance.



Sattelite View of Machar Marshes in Sudan

National Parks

The lowland part of Baro Basin in Ethiopia is the site of Gambela National Park: three controlled hunting areas, Jikau, Akobo, and Tado, are also located in the sub-basin.Gambela National Park is 5060 square kilometers in area, and its altitude ranges between 400 and 768 meters.The Park contains about forty-one dif-


A Lion in Gambela National Park

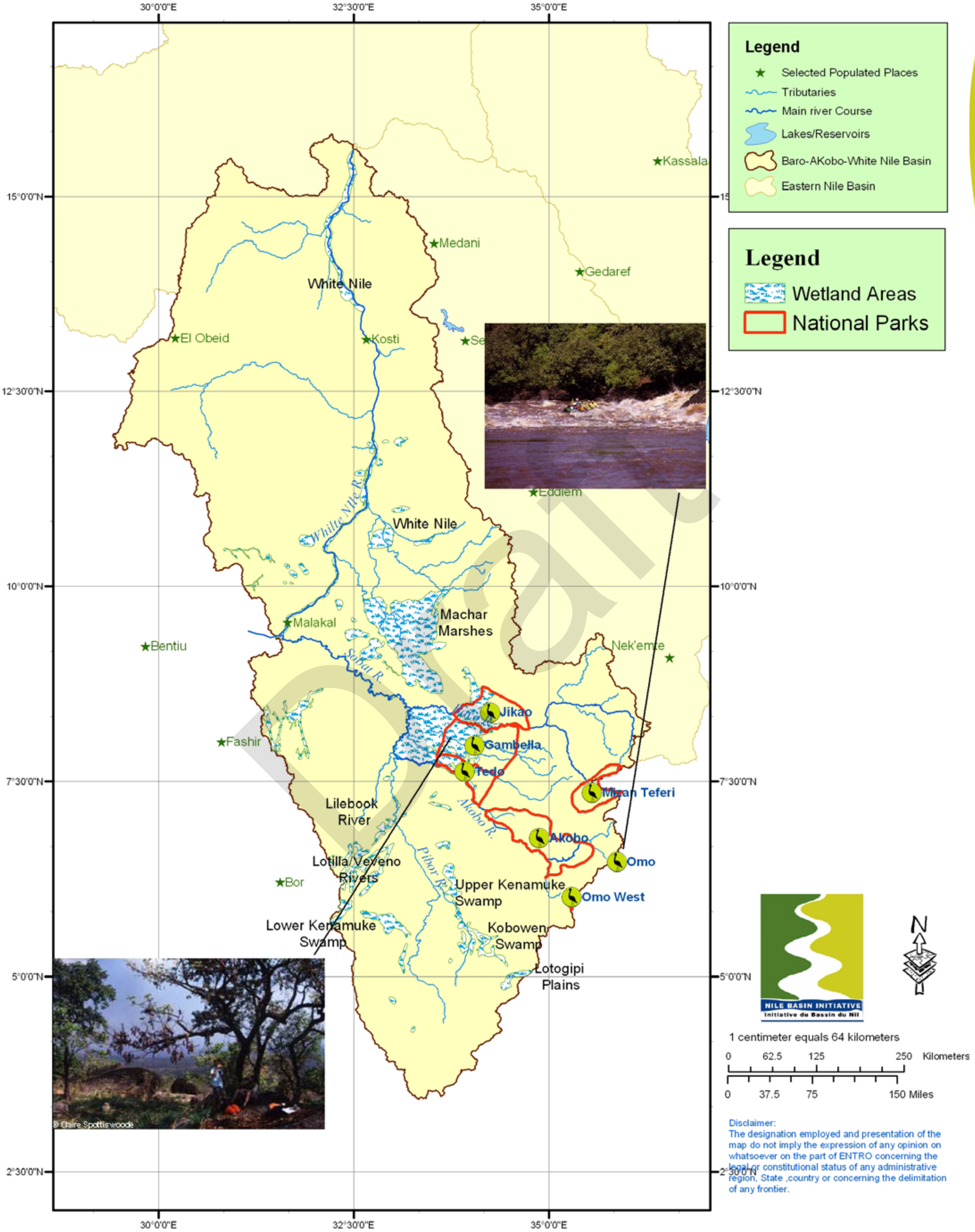
Wild Life

High density of wild life in the south and south west of the basin were reported. Migration pattern of large mammals were inferred from air photographs, giving a general account of unglate movement (predictable dry season dispersal to the wetter grassland of the west, with rainy season movment to the higher levels of the watershed.

The basin was once abundant with wildlife: At least 27 species of large mammal were recorded 25 years ago, atwell (1996), the basin has undergone such severe hunting, Civel unrest, and depletion oh habitat in recent years a that its population of significant mammals is mach reduced.

Data/Information Source :One System Inverntory Synthesis Report 2007

Map - 7.2 Parks and Wetlands in Baro-Akobo-Sobat and White Nile Basin



7.3 Water Related Disease in Baro-Akobo-Sobat and White Nile Sub-Basin

Of the water related diseases in Baro-Akobo-Sobat and white nile sub-basin, 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.

Map - 7.3 Climate Suitability for Maleria in Baro-Akobo-Sobat and White Nile