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ASSESSMENT OF THE NILE CONSERVATION SCHEMES IN THE EQUATORIAL REGION

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ملخص البحث

يستعرض التحقيق وصف هيدرولوجيا منطقة أعالى نهر النيل. فكونها تساهم بنسبة 15% من التدفق السنوي عند أسوان. تم التركيز فى هذه الدراسة على حوض أعالى نهر النيل والذى يتكون من منطقة البحيرات و بحر الجبل و بحر الغزال و بحر الزراف. بحيرة فيكتوريا هى المصدر الرئيسي لمنطقة أعالى نهر النيل ومنطقة البحيرات بالإضافة الى بحيرة جورج والبرت وادوارد.كما تم عمل دراسة على منطقة بحر الغزال والتى يتكون معظمها من مستنقعات تؤدى إلى إهدار كم كبير من التدفق. كما تم عمل دراسة عن أماكن التخزين المتاحة لتحقيق التصرفات المتوسطة والتى تضمن وصول كمية ثابتة من التصرفات على مدار العام.وتم استعراض بعض المناطق الطبوغرافية وذلك للتفادى إهدار المياه من المستنقعات نتيجة البخر والتسرب.

1 Abstract

The investigation reviews the description of hydrology of the Upper Nile Basin. The Upper Nile Basin contributes about 15% of the Nile inflow arriving annually at Aswan. Lake Victoria is the major sub-basin of the Upper Nile Basin (Lake Plateau, Bahr El Jebel, Bahr El Ghazal, Bahr El Zeraf, White Nile until Malakal) that contribute the 15% of the Nile inflow at Aswan. Recently, the Blue Nile becomes target for large scale unilateral water-based infrastructure development projects (dams, hydropower, and irrigated agriculture) in Ethiopia and Sudan. However, there is no focused study on the Upper Nile Basin, which could solve the problem of the Blue Nile projects. Even though several studies were carried to assess the impacts of the planned developments on downstream countries, this issue is still questionable and subject to further studies. The strategic objective of this study is to contribute towards the development of an integrated climate-hydrology-reservoir simulation system for the Nile river. The direct objectives are to provide base line conditions of the water level and flow conditions that can be utilized as reference for future studies in the basin, in addition to investigate the impacts of the proposed water-based development projects in the Upper Nile Basin on the inflow.

<u>Key words:</u> Reaches of Nile River, suspended load, bed load, erosion and deposition.

2 Introduction

The Nile River, with an estimated length of over 6800 km, is the longest river flowing from south to north over 35 degrees of latitude. It is fed by two main river systems: The White Nile, with its sources on the Equatorial Lake Plateau (Burundi, Rwanda, Tanzania, Kenya, Zaire and Uganda), and the Blue Nile, with its sources in the Ethiopian highlands. The sources are located in humid regions, with an average rainfall of over 1000 mm per year. The arid region starts in Sudan, the largest country of Africa, which can be divided into three rainfall zones: the extreme south of the country where rainfall ranges from 1200 to 1500 mm per year; the fertile clay-plains where 400 to 800 mm of rain falls annually; and the desert northern third of the country where rainfall averages only 20 mm per year. Further north, in Egypt, precipitation falls to less than 20 mm per year.

The Blue Nile and its main tributaries, the Dinder and the Rahad, rise in the Ethiopian mountains and around Lake Tana. The confluence of the White Nile and the Blue Nile is at Khartoum. Further downstream is the Atbara tributary, the last important tributary of the Nile system, again deriving from the Ethiopian plateau north-east of Lake Tana and forming the border between Ethiopia and Eritrea before entering Sudan. There are no important tributaries further downstream in Egypt.

3 Water Conservation Schemes of Lake Plateau and Bahr El Jebel

3.1 Water Conservation Schemes of Lake Plateau.

The Equatorial Lakes Basin consists of four main parts (Lake Victoria, Victoria Nile and Lake Kyoga, Lake Edward and George and finally Lake Albert) as shown in Figure 1.

The Lake Victoria sub-basin is the area covering the lake surface itself and the catchment areas of all its tributaries. The outlet hydrological station is at Jinja. The most distant source of the Nile is the Ruvyironza River, which flows into Lake Victoria through the Ruvubu and Kagera rivers. Other rivers converging into Lake Victoria – the largest of the Nile Equatorial Lakes – include the Simiyu-Duma, Grumeti-Rwana, Mara, Gucha-Migori, Sondu, Yala, Nzoia, Sio, Katonga and Ruizi, the lake's surface area is about 66,700 km2.

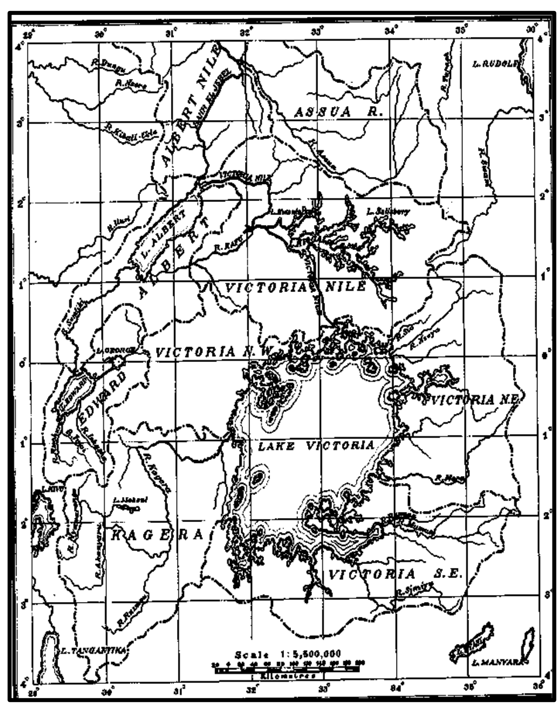

Figure 1 Lake Plateau

Lake Victoria is one of the wettest parts of the Nile basin its rainfall is not excessive as compared with that many regions in the Tropics since its average is only about 1368 mm/annum. Most of the Congo Basin has more than 1500 mm/annum and on parts of the west coast of Africa the rainfall exceeds 4000 mm.

Table 1 gives the normals of the Rainfall on various sections of the Lake Victoria Basin. The divisions of the basin are chosen so that in a given division the conditions which determine run-off of rainfall are similar throughout, and so the various divisions can be placed in order of run-off.

Table 1: Monthly Rainfall in Millimeter on Victoria Lake Basin

Stations	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Southern Division 4 stations	86	80	142	214	91	21	13	36	32	61	101	118	995
Kagera Basin 10 stations	90	96	157	214	147	34	24	46	70	110	136	118	1242
North-Western Division 11 stations	56	90	135	194	170	73	53	89	105	120	127	90	1302
North-Eastern Division 13 stations	49	75	118	199	166	105	94	117	92	75	86	72	1248
Stations on or near the lake between Latitude 1˚N. and 3˚S and long 31˚E and 35˚15'E. 25 stations	56	82	132	195	148	70	59	87	94	100	112	89	1224
Stations on the Lake 10 stations	68	81	135	222	152	58	39	61	57	70	102	106	1151
Mean for whole of Basin excluding the Lake	73	85	139	207	141	55	44	69	71	89	112	101	1186
Stations on or near the lake between Latitude 1˚N. and 3˚S and long 31˚E and 35˚15'E. 25 stations	56	81	133	195	149	69	59	87	93	96	115	90	1223

The rainfall on Lake Victoria taken as the average of the rainfall at eight stations on its shores is 1150 mm per annum, giving a total precipitation on the lake of 7.9 MCM.

The mean discharge out of the lake is 56.5 mcm/day and this is equivalent to a lowering of the lake level of 311 mm per annum.

3.2 Water Conservation Schemes of Bahr El Jebel

Exiting Lake Albert, the river flows north into Sudan and is known as the Bahr el Jebel. The Bahr El Jebel Sub-basin is the most complex of the Nile reaches due to having many seasonal inflows. Below the Sudan-Uganda border, the river receives seasonal flow from torrential streams before entering the Sudan, south of Mongalla as shown in Figure 2. The Sudan is a region of permanent swamps and seasonal wetlands, within which approximately half of the Bahr el Jebel flow is lost to evaporation. The average precipitation over the area is 1067 mm and the average annual potential evapotranspiration is 1,694 mm. Rainfall intensity decreases to the north where the annual average does not exceed 760 mm. Precipitation falls mostly in one season from April to October. This coincides roughly with the river flood period when the area is permanently flooded. Swamps expand in proportion to the magnitude of the inflow from the Mongalla and from local precipitation.

For the first 225 km of this portion of its course, i.e. from Lake Albert to Nimule, the river is a board sluggish stream fringed with swamps and lagoons. It meanders through a flood plain which at its widest is about 6 km broad between hilly country on either side so that the area of swamp is well-defined. Table 2 gives the normal rainfall so obtained.

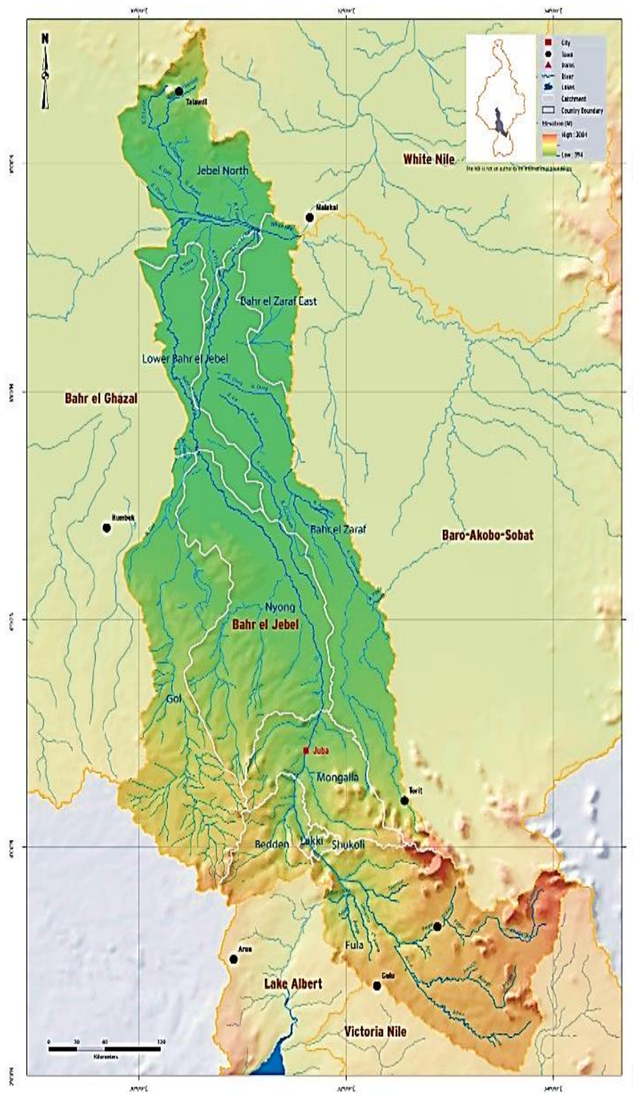

Figure 2 Bahr el Jebel Basin

Table 2: Normal Rainfall on the basin part between Albert and Mongalla:

Normal	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Total Normal Rainfall (mm)	8	26	65	139	168	124	138	163	143	135	77	31	1218

The area of the basin is about 79000 km2 and therefore the total rainfall on the area is 79,000 x 1.218 = 96000 mcm/year. The normal total discharge of the tributaries is about 4240 mcm/year and therefore the Run-off is about 4.4. % of the rainfall.

3.3 Water Conservation Schemes of Bahr El-Ghazal

A number of torrential streams rise on the Nile-Congo Divide and converge on to a central swampy area. As shown in Figure 3 The principal of these are the Jur, Lol and Tonj, while another stream, the Bahr el Arab, drains the more northern country of Darfur. All these streams with the exception of the Jur end in the central swamp. The Jur however has a continuous channel through the swamp, and in its lower course is known as the Bahr el Ghazal ultimately joining the Bahr el Jebel at Lake No. The principal feature of the hydrology of the region is the tremendous loss of water in the swamps. In spite of the large area and the good rainfall the amount of water which

reaches the Bahr el Jebel is only about 0.5 MCM per annum.

Figure 3 Bahr El Ghazal Basin

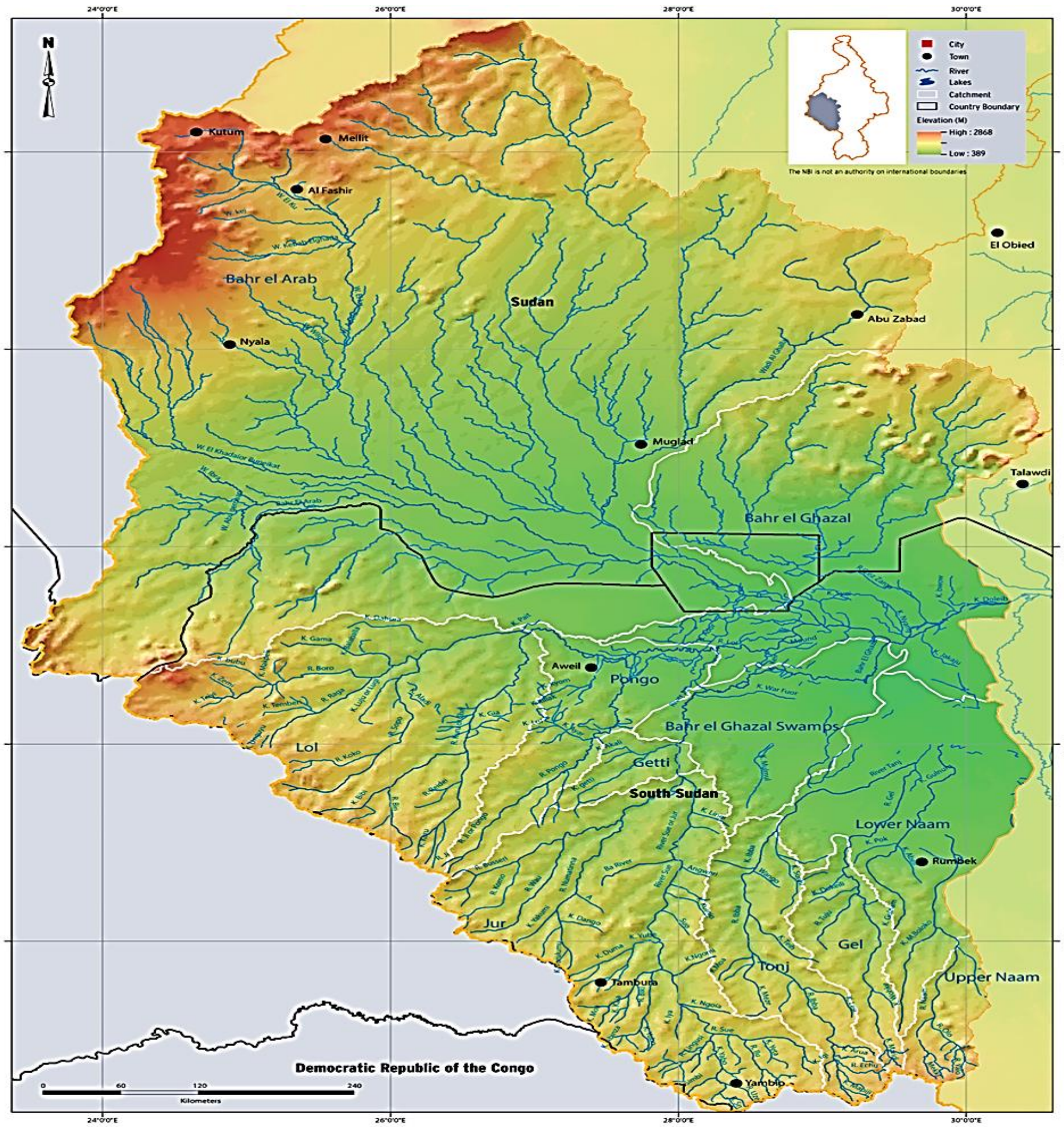

Table 3 gives the normal monthly rainfall by districts. Owing to the small number of stations the normal for a district is the unweighted mean of the normals of the stations in that district.

Table 3: Rainfall on Bahr el Ghazal Basin

Portion of Basin (mm)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Lol and Tributaries	0	3	18	52	134	183	233	234	184	84	8	0	1133
Jur and Tonj	5	14	48	84	141	168	170	195	176	142	40	8	1191
Gell and Lau	5	22	54	139	172	159	182	189	158	129	53	10	1272
Bahr el Arab	0	1	2	19	79	126	170	194	135	53	3	0	782

Two types of schemes have been suggested and proposals were made some years ago. One type consists of a channel running more or less from west to east interception the various tributaries above the swamps and conveying the water to the Bahr El-Jebel. This involves work on the Bahr El-Jebel to reduce its own losses and to produce a channel capable of carrying also the economies from Bahr El-Ghazal. The intercepting channel would be of the order of 350 km long, and to deal with all the losses would have to carry an increasing volume of water beginning with that of the Loll and then of the Jur, Tonj and Gell, and the total of this for the last 100 km to the Bahr El-Jebel, probably somewhere near the Jebel-Zeraf cuts. After that there would be extensive works on remodeling Bahr El-Jebel to carry its own and the added quantity with only ordinary transmission losses.

The alternative is to improve present channels in their passages through the swamps and this involves hundreds of kilometers of embanking and improvement of channels. At the end of this, there is the question of how to get the extra water away down the White Nile and to prevent extra losses due to back-water on Bahr El-Jebel. The level from Lake No to the Sobat mouth is affected by the annual rise and fall of the Sobat. The annual range at the Sobat mouth is about 2.5 m and at Lake No about 0.5 m. The average slope between these points is about 2 cm/km. The valley is definitely contained and its wetted area varies from about 300 to 700 km2.

In the present work it is proposed to construct a collecting canal "Figure 4" to collect water from

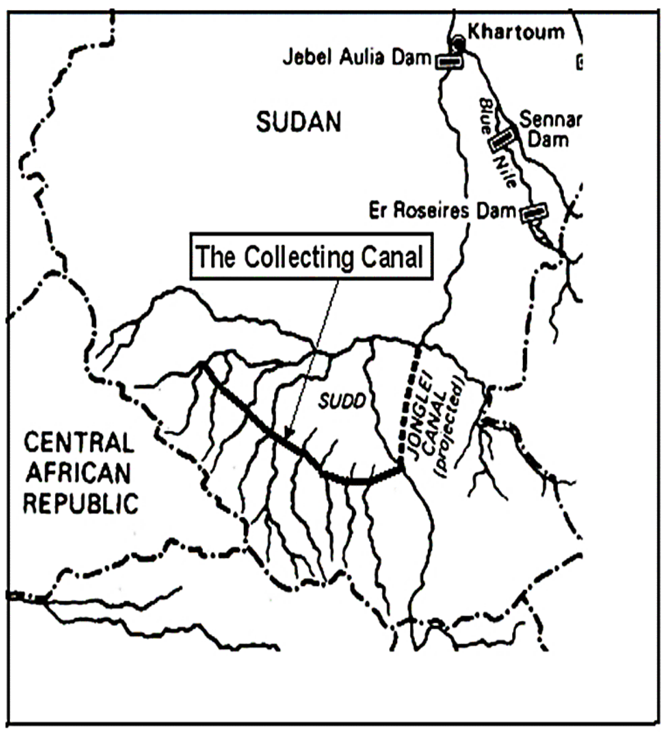

Figure 4 Plan of the Proposed Collecting Canal

the tributaries of Bahr El-Ghazal U.S the swamps, starting from river Lol at Nyamlell to Bahr El-Jebel at Jonglei, and passes through Jonglei canal. The collecting canal crosses river Pongo upstream Lol, river Jur at Wau, river Tonj at Tonj, river Jell downstream Meridi, river Naam downstream Mvolvo, and river Yei downstream Ngopp. The canal length is about 590 km.

3.4 Water Conservation Schemes of White Nile from Lake No to Sobat

Below the junction of the Bahr el Jebel and Bahr el Ghazal at Lake No the stream is known as the White Nile and runs eastward through flat country with a very small slope for a distance of 123 km to the mouth of the Sobat where it turns northward and continues northward to Khartoum. In this reach the river is usually fringed with swamp and There are parallel swampy depressions which are no doubt the remains of former channels of the White Nile, but dry ground is never far from the river and the valley is defined, though in flood time practically the whole of it is swampy.

From the Zeraf mouth to the Sobat the White Nile flows along the southern edge of its valley with a firm bank on its right. The region has been contoured by the Sudan branch of the Egyptian Irrigation Service and the maps, which show clearly the topography of the district. Besides the Zeraf and Sobat the White Nile receives a number of swampy khors which at times have an appreciable discharge, and these are shown in Figure 5.

During a large part of the year the Sobat has the predominating influence on the levels of the White Nile, and it is useless to use data from this season in attempting to find the relations of the Zeraf and White Nile discharges to the levels. For this investigation the only period of the year which has been considered is when the Sobat is low and its contribution small and to this end the months in which the Sobat discharge was below 8 mcm/day were selected from all the available years. The relations between Tonga gauge and the discharges of the White Nile, Zeraf and Sobat were then examined.

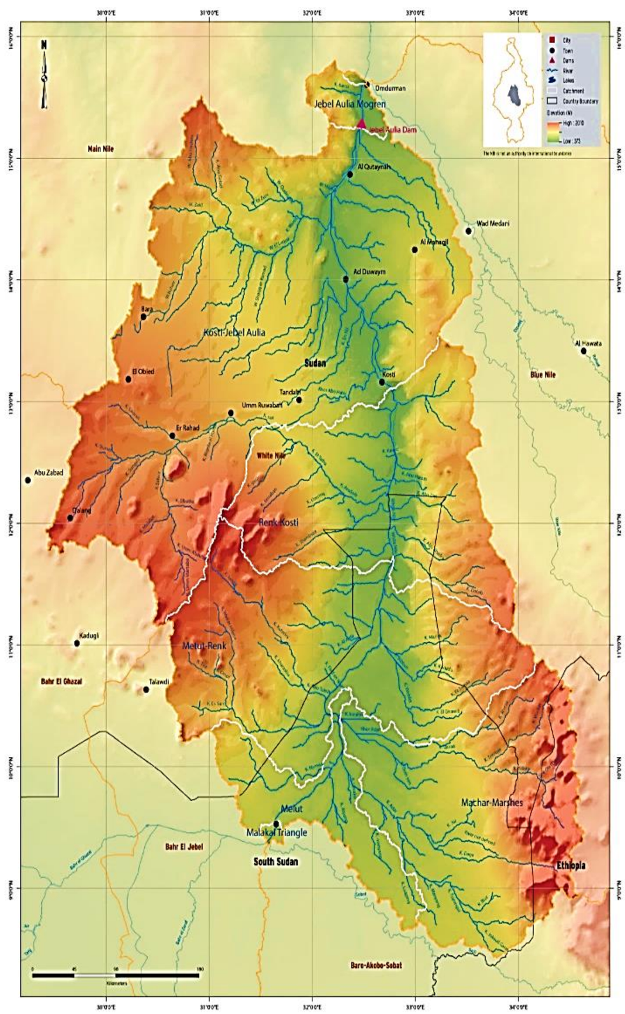

Figure 5 White Nile Basin

4 Conclusion and Recommendation

The hydrologic regime of the Nile River, in particular the discharge regime, is distinctly influenced by the south and eastern highlands precipitation patterns. The hydrology of the Nile is mainly characterized and influenced by high variations in climate and altitude/topography which have a great bearing on flow magnitudes and patterns in the different parts of the basin. The Nile receives its flow from a network of various hydraulic systems, draining the Ethiopian Plateau and the Equatorial Lake Plateau. The network within the basin is of diverse hydrological processes, e.g. tributaries and streams, wetlands, open water, man-made infrastructures.

Since the early years of the 20th century, records have been kept of the discharge at key stations of the Nile and its main tributaries. However, due to the fact that the stations records were for different time spans, they can be used to provide a good picture of the seasonal variation and quantify the relative contribution of the respective tributaries to the total Nile flow. The mean annual flow at Dongola station (immediate station upstream Aswan) is about 72 MCM. Inter-annual variability is very high for the long-term annual yield of the Blue Nile and Atbara rivers. Further upstream, the flow at Malakal averages 31 MCM (at the outlet of Baro-Akobo-Sobat, Bahr El Jebel, Bahr El Ghazal sub-basins), compared to an averages of 32 MCM at Mongalla (upstream station of Bahr El Jebel sub-basin), which is close to the outflow from Lake Victoria averages 33 MCM. With average annual flow at Gambeilla of about 11.4 MCM, the Sudd outflow can be computed as 17 MCM. The outflow from the Bahr El Jebel varies little throughout the year because of the regulatory effect of swamps and lagoons of the Sudd region, about half of its water is lost in evaporation (or transpiration through plants), and seepage. Also, the flow duration curve depicts storage characteristics of the Southern stations (e.g. Malakal) compared to the Eastern tributaries.

In a not too distant future, the Nile Basin will be in a critical situation, where increases in consumptive use in one sub-basin will have to be covered by decreases in consumptive use in another sub-basin and reallocation of water will have to be negotiated.

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