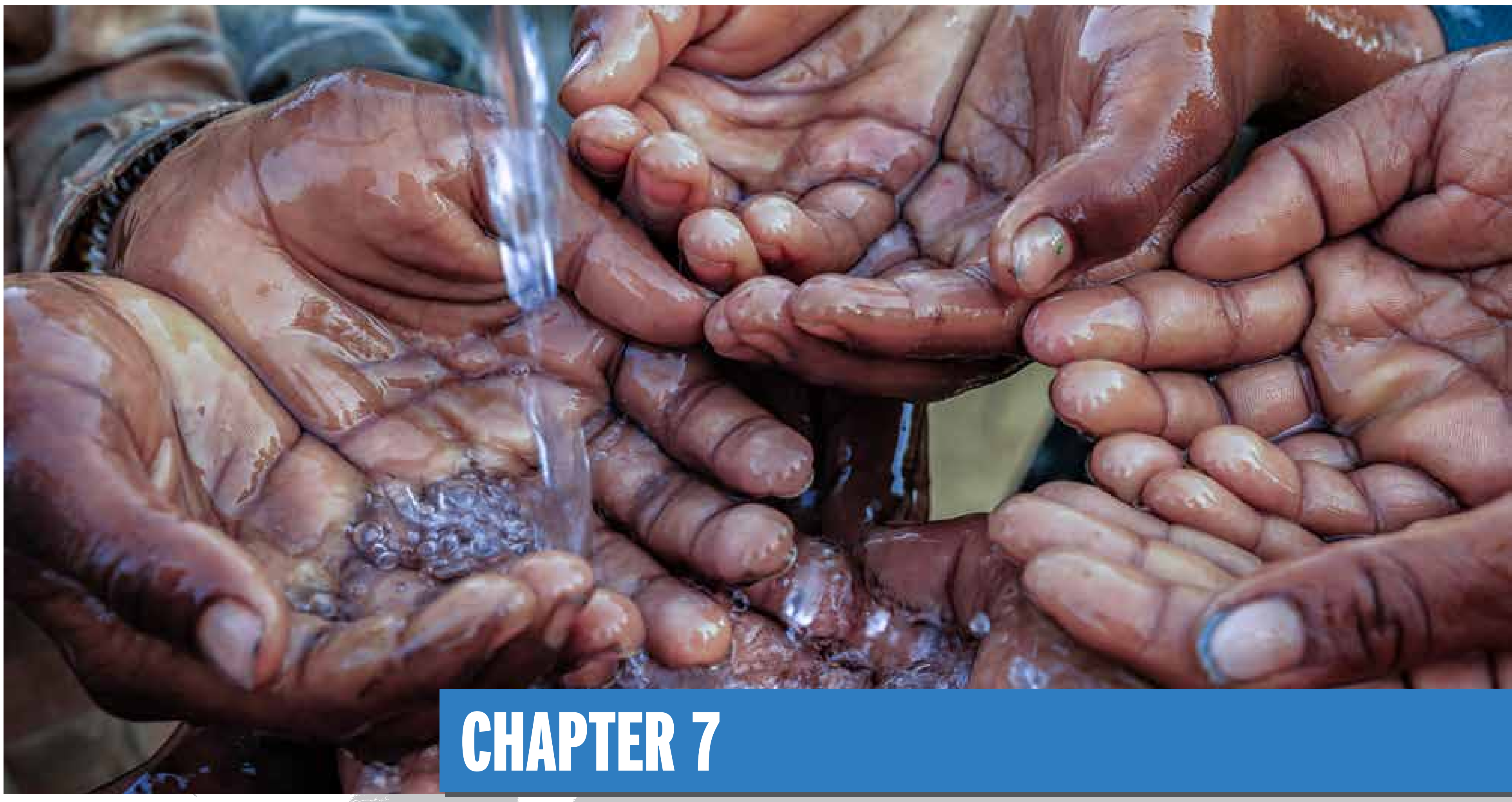

CHAPTER 7

WATER DEMAND, USE AND HYDRAULIC INFRASTRUCTURE

KEY MESSAGES

Photo: istock

Agriculture is a major livelihood strategy in the Nile Basin, sustaining tens of millions of people. It provides occupations for more than 75% of the total labour force and contributes to one-third of the GDP in the basin. An estimated 5.4 million hectares of land is under irrigation basin-wide, where over 97% of this area is in Egypt and Sudan. The actual area cultivated on average is approximately 6.4 million hectares. The total estimated annual irrigation water demand for irrigation is approximately 85 BCM; the actual basin-wide withdrawal of water from the Nile for irrigation is estimated as 82.2 BCM. In few irrigation schemes, due to mainly lack of sufficient water storage, all the irrigation water requirements are not met. Water scarcity in terms of both physical water scarcity and economic water scarcity remains the major limiting factor for agricultural development in the basin. Productivity is highly influenced by spatial variations of rainfall in the rain-fed system while in the irrigated areas scheme management is the main determining factor in the productivity variation

Energy is vital to the future growth of the Nile Basin riparian states. The per capita energy consumption in the Nile riparian states, except Egypt, is below the requirements for rural supply in sub Saharan Africa (250kWh/capita/year) which calls for increased production. Hydroelectric power is key in meeting the energy deficit in the partner states. The current installed capacity of hydropower on the Nile is estimated at 5660MW of which 40% is generated in Egypt. This is followed by Sudan (28%) and Ethiopia (18%). The topography of the Nile provides opportunities for power generation, especially Ethiopia. Hydropower is a major water user in the Nile, relying on water passing through turbines to generate electricity. Most power plants within the Nile are run of the river. However water can be consumed via seepage and evaporation from the reservoirs created for hydropower facilities. Factors determining the amount of consumed water – climate, reservoir design and allocations to other uses – are highly site-specific and variable.

The net evaporation from dams and reservoirs within the Nile basin is estimated at 17.6 BCM. Due to the size of the reservoir surface area and the climate, the evaporation from the High Aswan Dam is the highest.

Despite the power deficits in the Nile Partner states, power trade is low, and only restricted to limited exchange (Ethiopia-Sudan; Kenya-Uganda; Uganda-Rwanda and Rwanda-DRC-Burundi. The NBI in collaboration with the Eastern African Power Pool (EAPPP) promotes regional transmission interconnection. The regional interconnection backbone under development is

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expected to add more than 4600 circuit kilometers of new transmission lines at various voltage levels in the riparian states of Ethiopia, Uganda, Kenya, Tanzania, Rwanda, Burundi, DRC, South Sudan, and Djibouti (outside NBI). Such interconnection projects allow utilities to share reserve margins across a wider operating area, thus reducing the need for costly installed capacity to meet reserve requirements. As example the 500 kV HVDC Eastern Electricity Highway Project under the Eastern Africa Power Integration Program will allow Kenya to purchase relatively cheaper hydropower energy from Ethiopia and support Ethiopia's system when water is scarce.

The per capita water availability among the Nile riparian states is decreasing, due to rapid population growth, urbanization and inadequate investment of riparian states in hydraulic infrastructure over the last four decades. The very low per capita water storage capacity available to the Riparian States, Kenya (103m^3/capita) and Ethiopia (38m^3/capita), clearly illustrates the risks the countries are facing due to the high seasonality of the Nile and its tributaries, especially those in the Eastern Nile. This exposes Nile basin riparian states to flood and drought risks. Even more difficult hydrology is in the Blue Nile system, where rainfall is markedly seasonal – a short season of torrential rain followed by a long dry season which requires the storage of water. Perhaps most difficult of all is a combination of extreme seasonality (intra-annual) and variability (inter-annual) – characteristics of many of the Nile riparian states which affects the Nile riparian state economies.

The total water demand for Municipal and Industrial uses has been estimated at 12,900 MCM per year for the whole Nile Basin. Nearly 97% of this demand occurs in Egypt. Nearly 97% of this demand occurs in Egypt. While population in the Nile basin riparian states is estimated to nearly double by 2030, domestic water demand is expected to grow five-fold to five to six-fold during the same period.

Although fisheries are usually non consumptive users of water, they require particular quantities and seasonal timing of flows in rivers and their dependent wetlands, lakes, and estuaries. Freshwater fish resources in the Nile basin are probably among the most resilient harvestable natural resources, provided their habitat, including the quantity, timing, and variability of river flow, is maintained. The Nile Basin annual fresh fish production is estimated at three million tons of which 57% is apportioned to capture fisheries in the lakes and rivers. The total fisheries capture is estimated at three million tons annually in the Nile riparian states (WDI, 2016). Egypt has the greatest yield in fisheries production at 50%, followed by Uganda 19% and Tanzania 12%.

photo: istock

There has been a long history of water transport on Lake Victoria, contributing to domestic and international trade within the lake basin. However, deterioration of train service severely affected rail networks and the rail-dependant lake transport. Most cargo and passengers are now moving by road around the lake, whose economic life decreased. As for South Sudan, navigation is also a long established practice, although it suffered during the South/North political conflict. Cheaper and safer than roads, it now represents a mode of considerable importance for the country developing transport sector.

INTRODUCTION

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Water use is simply the amount of water used by a country or other lower entity such as a household. Some of the varied uses in the Nile basin riparian states include hydro-electricity generation, Municipal and Industrial water supply, agriculture, fishing, recreation, transport, tourism and waste disposal.

Water use includes consumptive as well as non-consumptive uses. The water use sectors that have been included in the Nile Basin water Resources Atlas are: Irrigated agriculture; Hydropower, Municipal and Industrial (M and I) uses for large urban centers. Evaporation from dams is also considered as water use. Water demands for other uses are not included due to lack of information.

Together, the countries of the Nile basin use almost 90% of the region's renewable water resources. Egypt and Sudan, which need water from outside their borders, account for the largest water withdrawals at 57 and 31 per cent of the total renewable water withdrawals, respectively. The per capita withdrawals for these two countries are almost 10 to 15 times the amounts withdrawn by other countries in the basin (FAO Aquastat 2005).

Recent strategic analysis by the Nile Basin Initiative secretariat supports this fact indicating that most of the stream flow of the Nile is allocated - used for industrial, domestic, agricultural and ecological water supply. Each year, on the average, 12 – 14 BCM reaches the Mediterranean.

HYDRAULIC INFRASTRUCTURE IN THE NILE

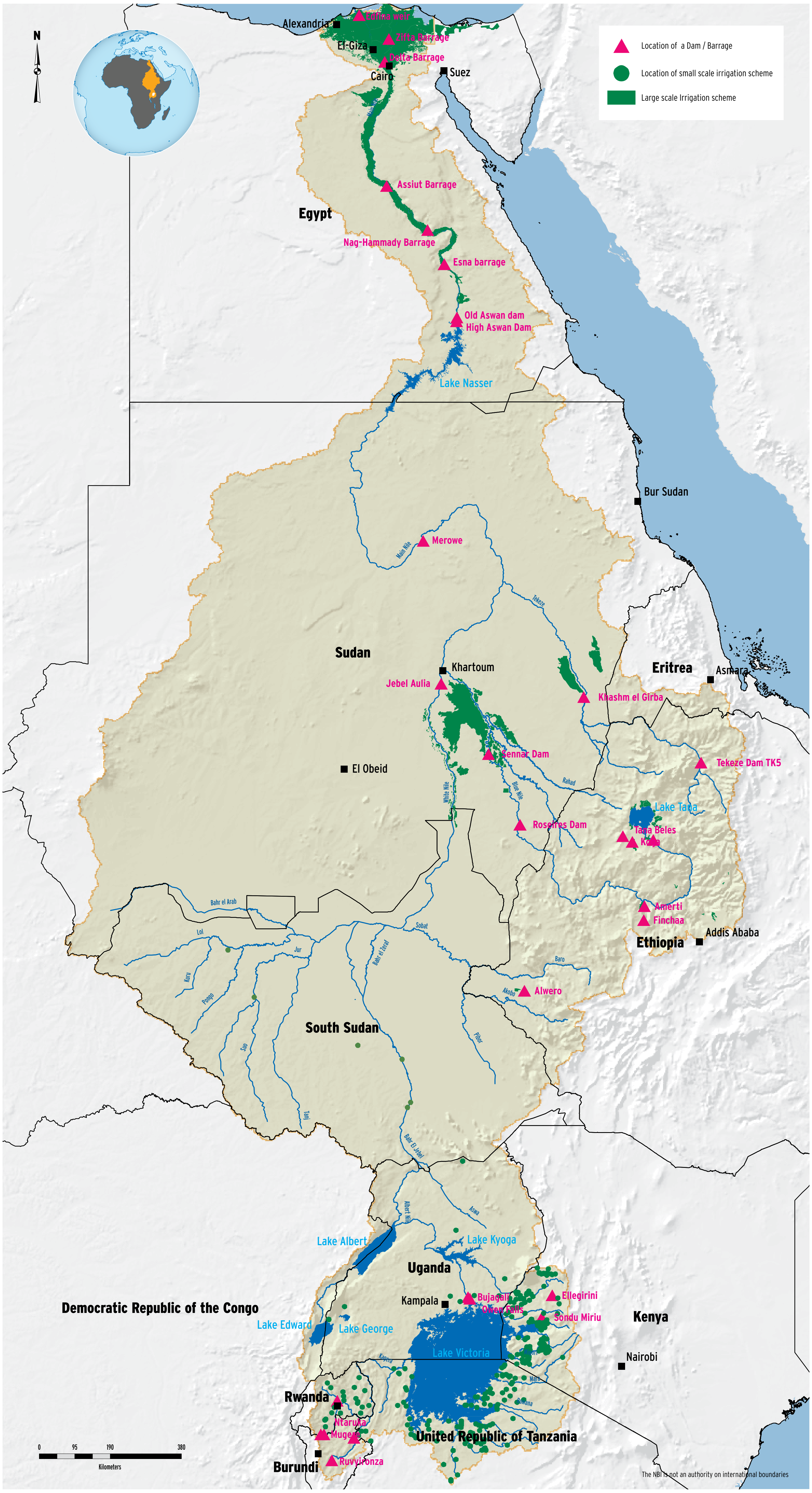


Photo: Milly Mbuliro

Jebel Aulia dam

Photo: ENTRO

Tekeze dam in Ethiopia

Photo: A'Melody Lee; World Bank

Kira power station Jinja, Uganda

Photo: istock

High Aswan dam

Photo: NBI

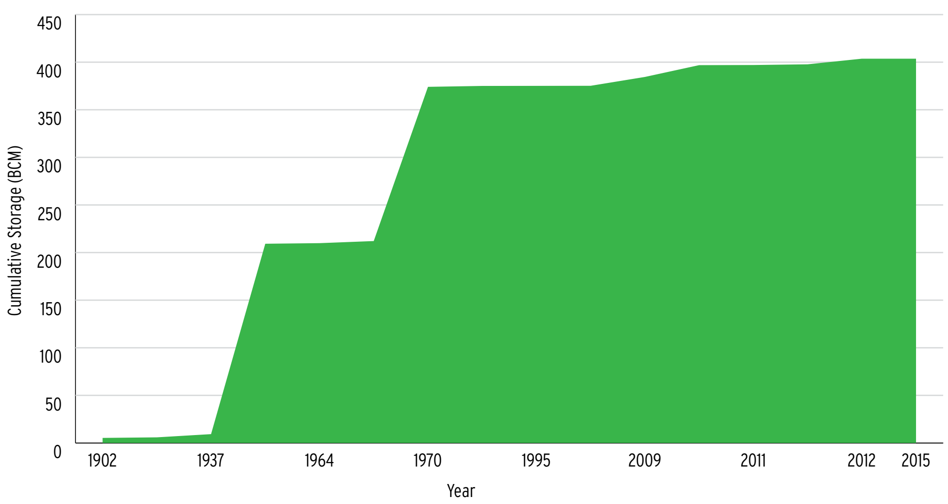
GERD dam under construction

Storage dams in the Nile Basin

Photo: Milly Mbuliro

Storage dam in Ethiopia

Growth in Cummulative Storage of Dams in the Nile Basin



Data obtained from NBI member states show that as of 2014, there are 14 storage dams basin-wide with a total storage capacity of about 203 BCM. The growth in aggregate storage capacities of all dams in the basin is shown in the adjacent figure.

It is interesting to note that, after a period of four decades of near stagnation in dam construction during 1968 – 2007, the basin is witnessing more and more storage dams added to the system. In addition, the Owens Fall (Nalubalee) dam built at the outlet of Lake Victoria in Uganda provides an additional 200 BCM of live storage to the Lake. Dams on the Nile conserve water and provide sustained supply for meeting demands. Lake Nasser, in Egypt was formed after the construction of the Aswan High Dam in 1970. The total capacity of the Aswan reservoir (162 BCM) consists of dead storage of 31.6 BCM, active storage of 90.7 BCM and emergency storage for flood protection of 41 BCM. After the construction of the High Aswan Dam, completed in 1970, no storage was added to the Nile Basin till 2009 when the Tekezze dam with capacity of 9.29 BCM was built. Other storage dams constructed since then include, the Merowe dam (12.39 BCM capacities) and Roseries heightening (to 5.9 BCM) completed in 2009 and 2012 respectively. Bujjagali dam with capacity of 0.75 BCM was built in Uganda. In Sudan, the main reservoirs are the Jebel Aulia reservoir on the White Nile, Senar and Roseries storage reservoirs on the Blue Nile, Merowe reservoir on the Main Nile and Khashm El Girba reservoir on Atbara.
In 2012, work began on Ethiopia's Grand Renaissance Dam, which has become the key project in the nation's plan to increase its electricity supply fivefold by 2015. It will have an estimated installed capacity of 6000 MW, and a reservoir capacity (74 BCM). The dam together with its power house, when finished, will be Africa's largest hydroelectric power plant.

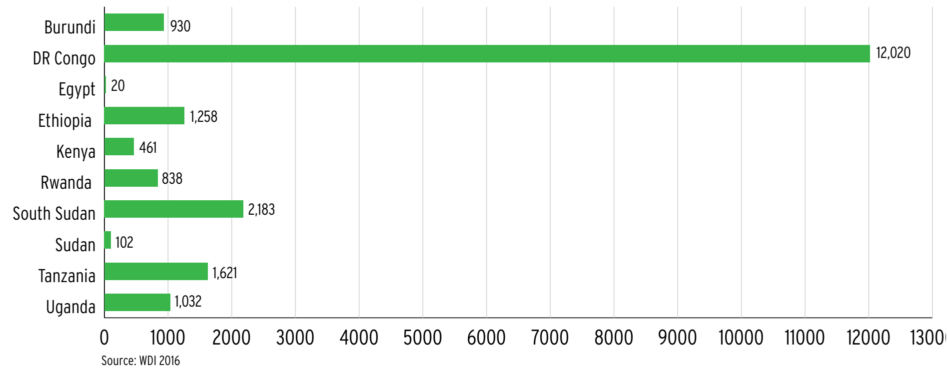
Per Capita Water Availability in the Nile Partner States

Population growth, urbanization and socio-economic growth are the major reasons for the decreasing per capita water availability in the Nile Basin states. With per capita internal water resources availability less than 1000 m³, Sudan, Rwanda, Kenya, Egypt and Burundi can be categorized as water scarce. The per capita storage capacity of the partner states is low. These trends call for improved storage in these Nile Basin States.

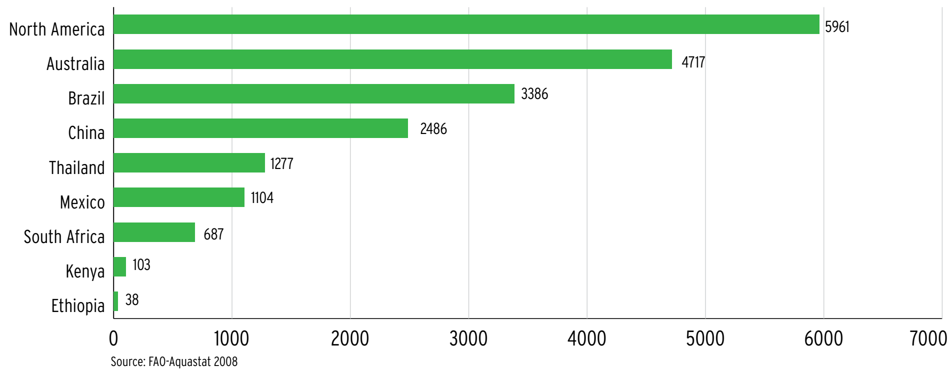
With an aggregate basin-wide storage capacity of just over 200 BCM (excluding the Nalubaale dam), most of the Nile Basin countries have the least per capita water storage by world standards. In a region with severe seasonal and intra-annual variability and anticipated climate change, absence of adequate storage capacity means more vulnerability to impacts of climate shocks.

There is a trend between a country's Human Development Index (HDI) and per capita water storage. Water storage in countries with a high HDI (>0.85) tends to be in the range of 2,500 and 3,000 m³/capita. Countries with HDI of 0.55 tend to have has a storage of about 173 m³ per capita.

Renewable internal fresh water resources per capita (m³)



Water storage per capita in selected countries (m³/capita)



Storage and Economic Performance in Kenya

Water storage has been positively correlated with performance of Nile economies. Where economic performance is closely linked to rainfall and runoff, growth becomes hostage to hydrology. Kenya's limited water storage capacity leaves the country vulnerable to climate and hydrologic variability. Kenya's total water storage capacity is 4.1 bcm, or 103 m³ per capita, which is very low. Of the estimated 103 m³ per capita, 100 m³ per capita is single-purpose storage for hydropower production only. This means that only 3 m³ per capita of storage is available for water supply and other uses such as irrigated agriculture and livestock. No major dams have been constructed since Ndakaini dam in the mid-1990s, which supplies water to Nairobi. Kenya also experiences significant hydrologic variability throughout and between years. Without sufficient water storage to lessen the effects of variability, frequent and severe floods and droughts have been resulting in devastating economic and livelihood consequences. Kenya, with a HDI of 0.548 in 2015, has a per capita storage of 103 m³, which is low (adapted from UNDP, 2015)

Photo: Flore de Preneuf / World Bank

Siltation threatens hydropower, an important source of electricity in Kenya

Storage and Economic performance in Ethiopia

Hydrological variability seriously undermines growth and perpetuates poverty in Ethiopia. The economic cost of hydrological variability is estimated at over one third of the nation's average annual growth potential, and these diminished rates are compounded over time. Yet, with much greater hydrological variability than North America, Ethiopia has less than 1% of the artificial water storage capacity per capita to manage that variability. Economy-wide models that incorporate hydrological variability in Ethiopia show that projections of average annual GDP growth rates drop by as much as 38% as a consequence of this variability. In Ethiopia, so sensitive is economic growth to hydrological variability that even a single drought event within a twelve year period (the historical average is every 3-5 years) will diminish average growth rates across the entire 12-year period by 10%. During the 1984–5 drought, for example, GDP declined by 9.7%, agriculture output declined by 21%, and gross domestic savings declined by 58.6%. Drought also severely undermines hydropower generation, Ethiopia's main source of electricity. If rains fail, or simply come too early or too late, the entire agricultural cycle can be disrupted, because there is inadequate water storage capacity to smooth and schedule water delivery. Flooding meanwhile causes significant damage to settlements and infrastructure, and the inundation and water-logging of productive land undermines agriculture by delaying planting, reducing yields, and compromising the quality of crops, especially if the rains occur around harvest time


Photo: NBI

GERD dam under construction

Evaporation from Dams along the Nile

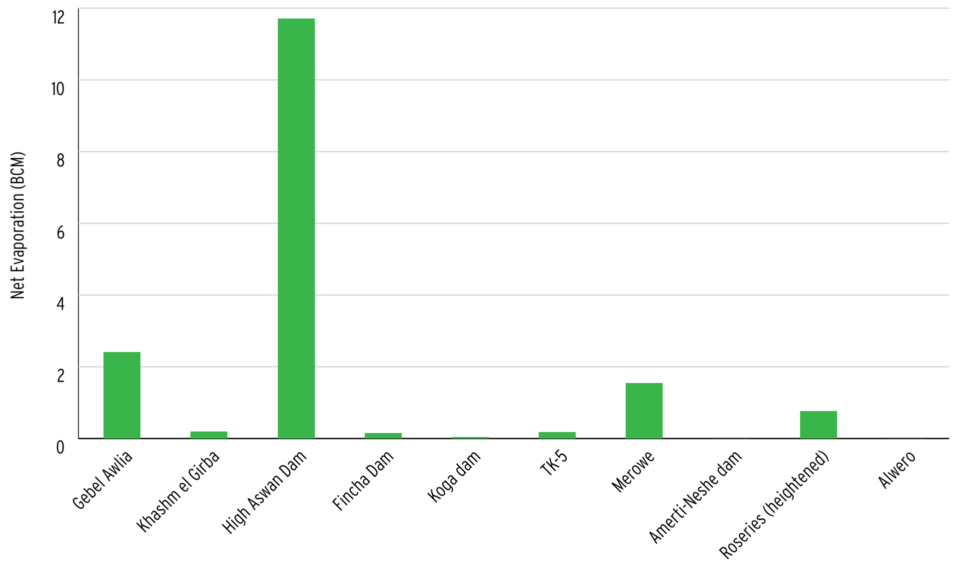
On the average an estimated 17.6 BCM of water evaporates from major dams in the Nile Basin. Net evaporation from dams is defined as the year total of evaporation from the dams reduced by the annual total of precipitation on the reservoir surface. As example, an estimated 10 – 12 BCM are lost through evaporation each year from the High Aswan Dam (HAD).

Due to its large reservoir surface area and the hot climate, the High Aswan Dam has the biggest net annual evaporation followed by Jebel Aulia dam. In most upstream dams, the net evaporation is very small due to partly the relatively cool/temperate climate and high rainfall. This is the case, for instance, for most Ethiopian dams.

Net Evaporation from selected dams on the Nile

Dam	Period	Net Evaporation (BCM)
Gebel Awlia	1950 - 2014	2.4
Khashm el Girba	1964 - 2014	0.19
High Aswan Dam	1970 - 2014	12.35
Fincha Dam	1973 - 2014	0.14
Koga dam	2007 - 2014	0.04
TK-5	2009 - 2014	0.18
Merowe	2009 - 2014	1.54
Amerti-Neshe dam	2011-2014	0
Roseries (heightened)	2012 - 2014	0.75
Alwero	1995 - 2014	0

Net Evaporation from Dams (BCM/year)



Hydro-electricity Power Generation in the Nile Basin Member States

Hydropower is one of the purposes most dams in the Nile Basin serve. The aggregate installed capacities of 22 hydropower plants basin-wide is approximately 5660 MW. The distribution of the existing hydropower installed capacity and annual generation capacity as of 2014 is shown in the figures below.

Hydropower offers an important low-carbon energy solution to meet the massive unmet demand and provides reliable base-load power in the Nile Basin states. Hydropower options remain the preferred source of energy in the region because they have long economic life which translates to very low per unit cost of energy and a renewable source of energy at that and with proper preparation of the reservoir, are pollution free and could be eligible for carbon credits

In the next section, details will be given on selected hydropower generation potential for the sub-basins of the Nile.

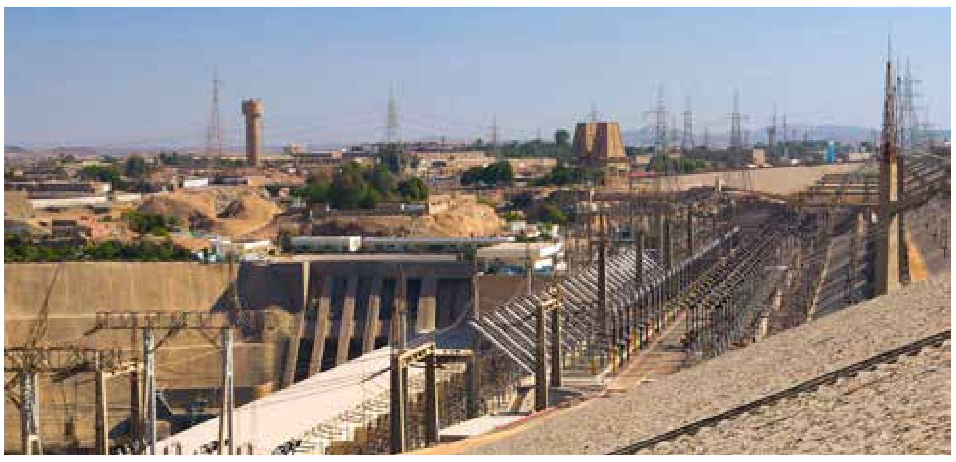
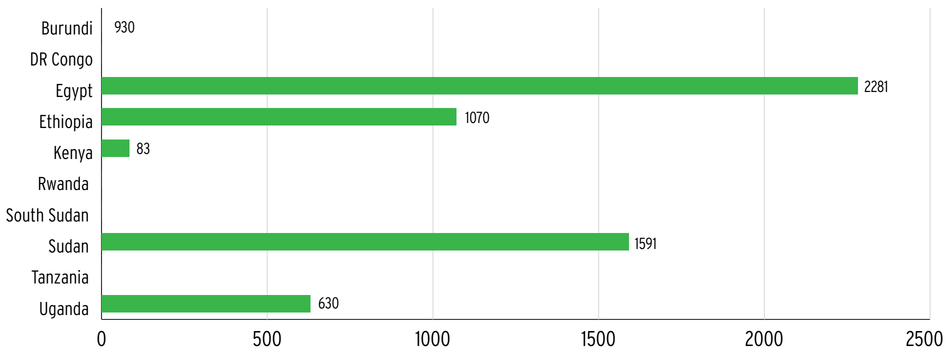


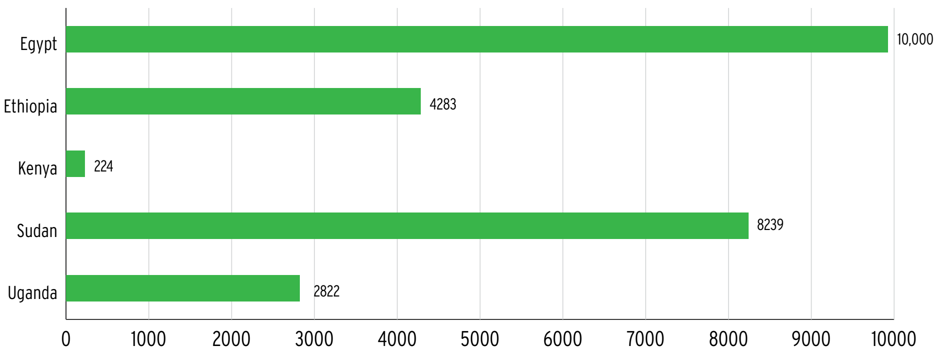
Photo: istock

Hydroelectric power plant in Aswan dam (Egypt). This plant produces over 70% of the electricity for all of Egypt

Baseline Installed capacity (Hydropower) by Country (MW)



Energy generation by selected member states (GWH/year)



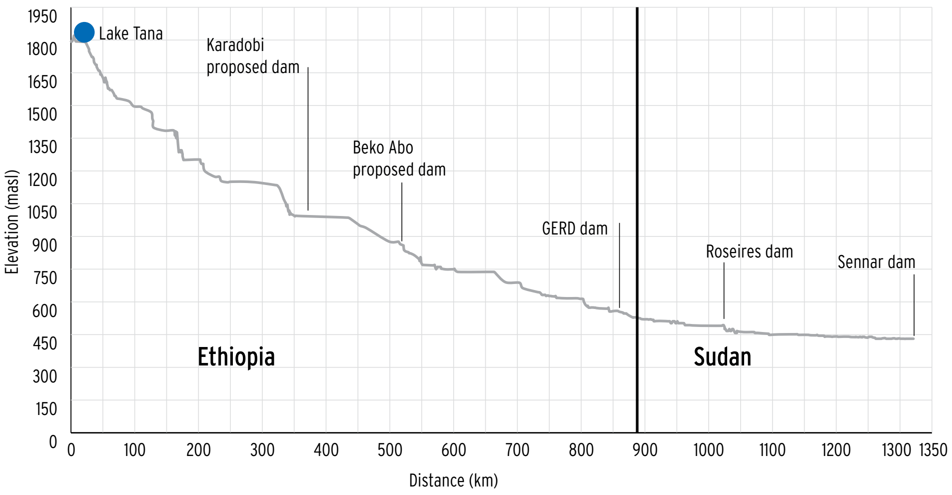
HYDROPOWER GENERATION POTENTIAL

Nile Basin's potential for hydroelectric power is quite substantial. The Blue Nile drops some 1,360-m between Lake Tana and its exit point into Sudan. Coupled with its substantial discharge, the Blue Nile has the largest hydropower potential in the Nile Basin. A number of sites with high hydropower potential have been studied in the past.

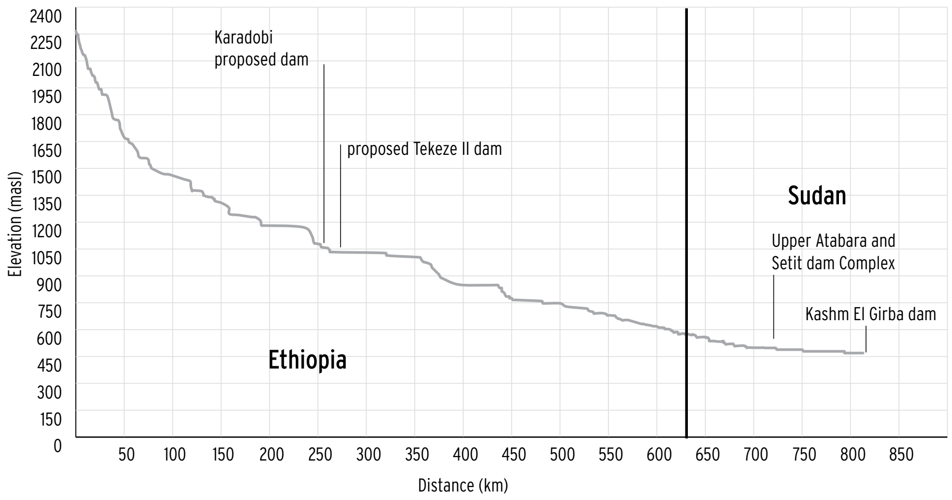
Photo: istock

Owen falls dam, Jinja Uganda

Blue Nile River Longitudinal Profile

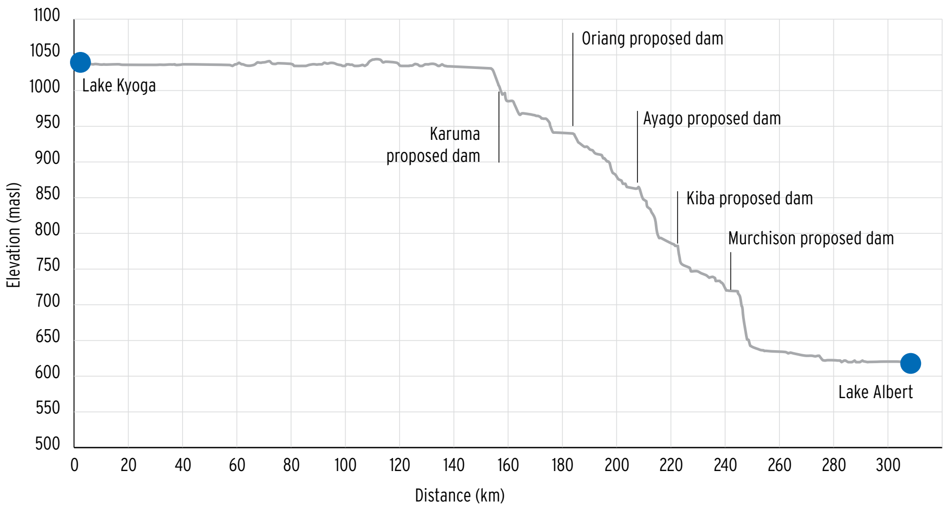


Tekeze-Atbara River Longitudinal Profile



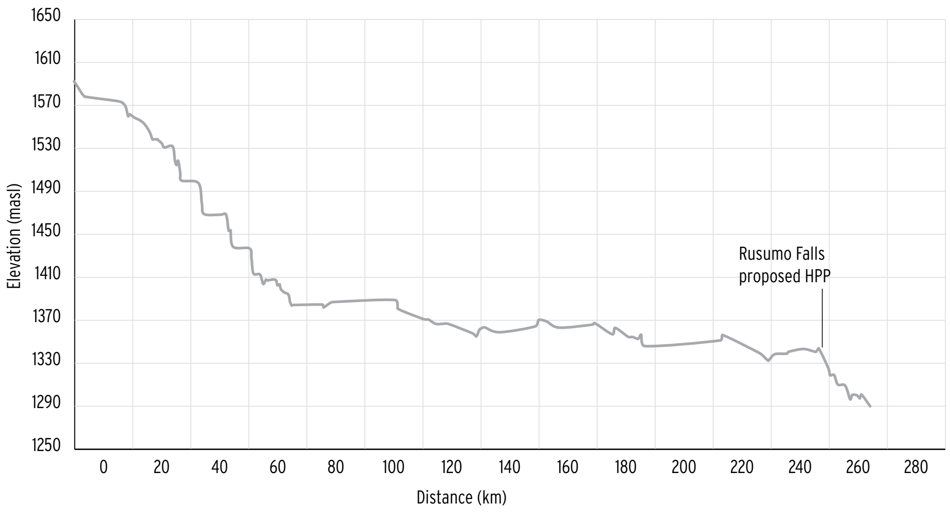
The Tekeze-Atbara river drops for about 1770-m between the Ethiopian highlands and Rumela-Burdana (Atbara Complex) dam on Atbara river. The identified potential hydropower site in the reach is Tekeze II (450 MW).

Victoria Nile Longitudinal Profile



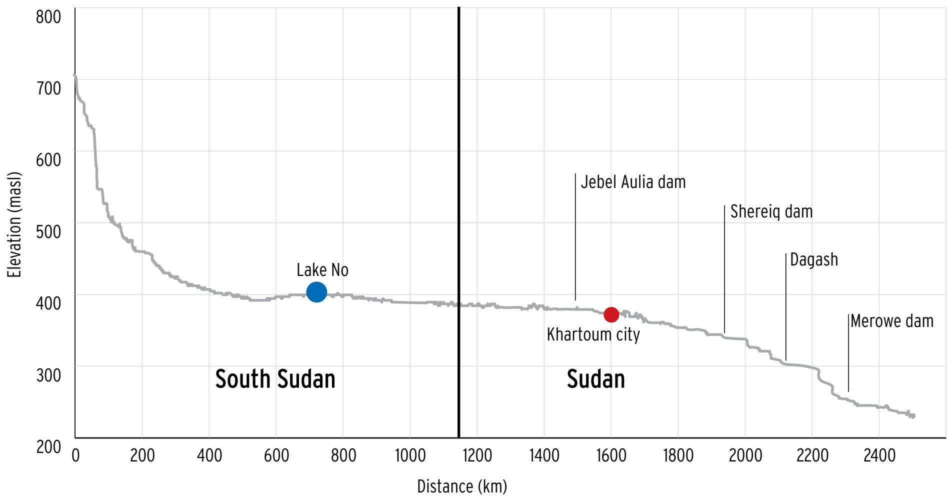
In the Nile Equatorial Lake Sub-basin, the Victoria Nile drops for about 415-m between Lake Kyoga and Lake Albert. The identified potential hydropower sites in the reach include Karuma (576 MW), Oriang (392 MW), Ayago (582 MW), Kiba (288 MW) and Murchison Falls (648 MW).

Ruvubu River Longitudinal Profile

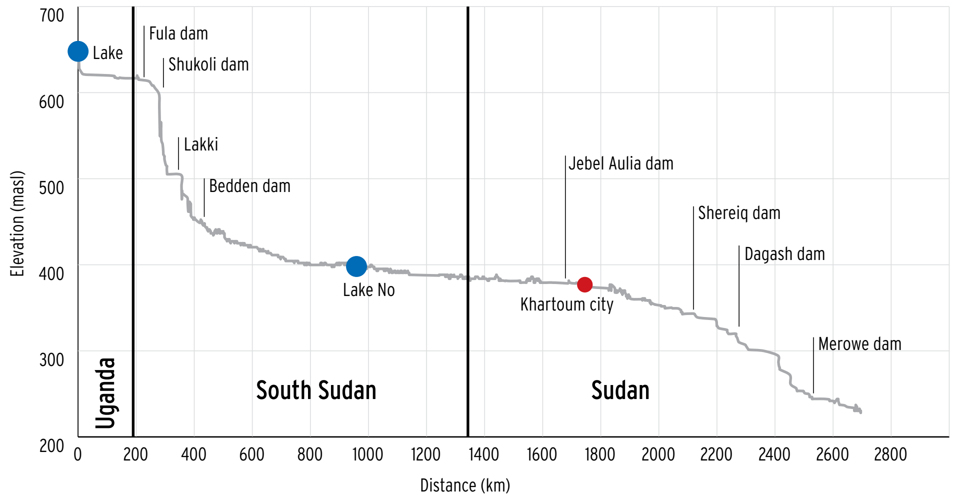


The Ruvubu river drops for about 300-m from upper Kagera mountains to the junction with the Nyabarongo river at Rusumo falls

Bahr El Ghazal river profile (originating Lol River to Lake No)



Bahr El Jebel River Profile and downstream part of main Nile



The Bahr El Ghazal is formed by a number of poorly defined streams. Many of these streams originate from the Nile Congo divide. The streams are Bahr El Arab, Lol, Jur, Gel, Tonj, Yei and Naam. Lol stream originates from the highlands at an altitude of about 700 masl and drops to about 400 masl before it joins other streams and forms Bahr El Ghazal river with confluence at Lake No with Bahr El Jebel. Lake No is a large shallow lagoon, where the sluggish Bahr el Ghazal joins the Bahr el Jebel.

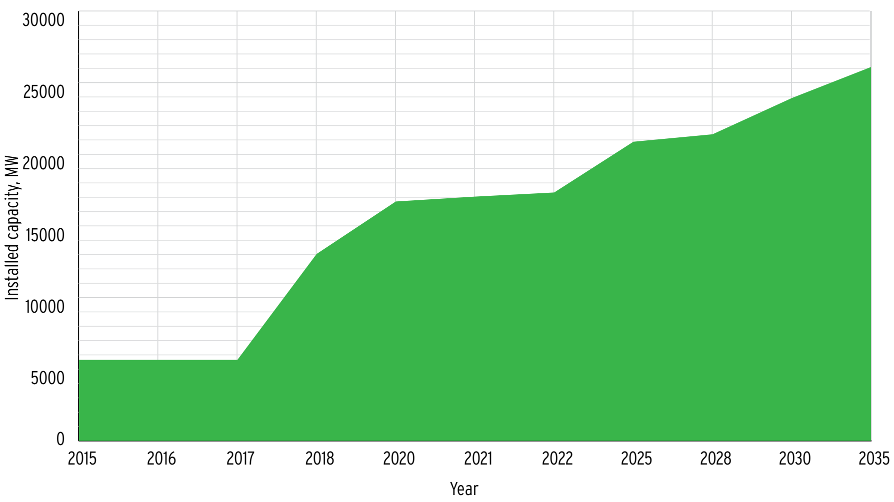
Bahr El Jebel River stretches a distance of about 1,000 km from the outlet of Lake Albert to the inlet of Lake No. The stretch has a drop of about 250m and has several potential hydropower sites such as Fula I, Shukoli, Lakki, and Bedden.

Projected increment in installed capacity

Looking into the future, existing national plans indicate a substantial increase in installed capacity in the period 2017 – 2050. Projected growth in aggregate installed capacity in the Nile Basin is shown in the adjacent chart. The total increase in installed capacity by about 2050 will be over 20,000 MW bringing the total installed capacity to about 26,000 MW.

Most of the increase is expected to be in the Blue Nile sub-basin. The GERD will inject 6000 MW of installed capacity. The Rusumo falls project, which is the first hydro-electric power project cooperatively implemented by Burundi, Rwanda and Tanzania with the facilitation of NBI will produce 81 MW.

Projected growth in total installed capacity of hp plants, MW



Power Plants in the Basin

Uganda's Bujagali Hydroelectric Power Plant Financing through Public-Private Partnerships[1]

Aerial view of the Bujagali plant

The project which was regionally identified through the NELSAP SSEA, will enhance power trade with neighboring Kenya, through the Nile Basin Planned Kenya-Uganda Interconnector.

Despite being one of Africa's fastest growing economies, Uganda had one of the lowest electrification rates in the world. Only 2% of its rural population had access to electricity, and the country suffered from frequent rolling blackouts – requiring expensive emergency generation, costing USD 9 million per month. In 2007, to meet these shortfalls, the government decided the least cost option - a USD 860 million hydroelectric power plant in Bujagali, 8 km down the Nile from Lake Victoria. However, it needed financiers and large hydropower developers to implement the project. The government established a public-private partnership called Bujagali Energy Limited, which would own the plant for a 30-year concessionary period before transferring it to Uganda.

The project which was regionally identified through the NELSAP SSEA, will enhance power trade with neighboring Kenya, through the Nile Basin Initiative Planned Kenya-Uganda Interconnector Multilateral lenders including the World Bank, the European Investment Bank, and the African Development Bank joined in with private financiers, such as South Africa's ABSA Capital and Standard Chartered Bank. Commissioning of the dam took place in August 2012. Today the 250 MW hydropower plant meets half of Uganda's energy needs. The project's construction created over 3,000 local jobs. Bujagali was registered in 2012 as a Clean Development Mechanism project, making it the largest ever registered in a Least Developed Country.

[1]International Renewable Energy Agency (IRENA)

Power Plants in the Basin- The Tekeze Hydroelectric Power Plant

The Tekeze Dam

The dam is located on the Tekeze River, a tributary of the Nile, in a mountainous region of Ethiopia. At 188m high, the Tekeze Arch Dam ranks as the highest dam in Africa, eclipsing the previous record height for an African dam of 185m held by the Katse Arch Dam in Lesotho. It generates 300 MW adding 40% energy to the 683 MW previously generated for the entire country. The dam impounds a 70-km-long reservoir. An underground powerhouse, containing four 75 MW Francis Turbines, is located 500 mm downstream from the dam and fed by a 75-m-high intake structure connected by a 500-meter-long concrete-lined power tunnel. A 105-km-long 230 kV double-circuit transmission line was constructed through rugged, mountainous terrain with minimal environmental impact to connect to the Ethiopian national grid.

REGIONAL INTERCONNECTION BACKBONE


Photo: istock

Panorama across Cairo skyline at night

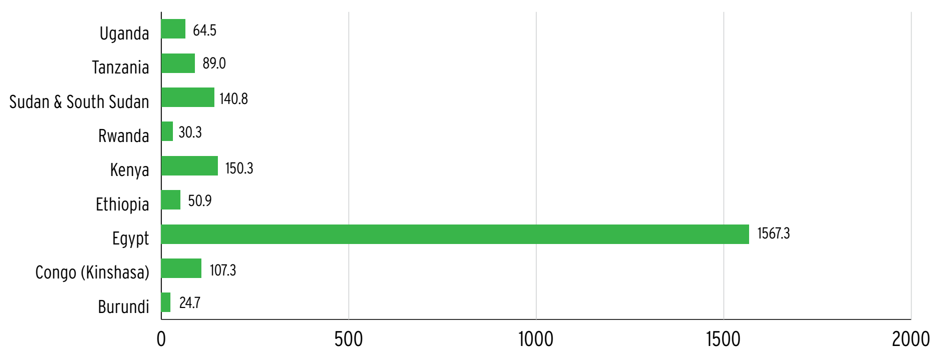
The Nile Basin Initiative promotes regional transmission interconnection projects in partnership with the Eastern Africa Power Pool. Such interconnection projects allow utilities to share reserve margins across a wider operating area, thus reducing the need for installed capacity to meet reserve requirements. Regional interconnection becomes even more important as the penetration of variable renewable energy grows. As example, the 500 kV HVDC Eastern Electricity Highway Project under the First Phase of the Eastern Africa Power Integration Program will allow Kenya to purchase relatively cheaper hydropower energy from Ethiopia and support Ethiopia's system when water is scarce.

Electricity Consumption

Electricity demand in much of the Nile Basin is constrained by available supply, resulting in people either not having any access or not being able to consume as much as they would like. Such unmet demand is not captured in electricity data and makes it difficult to measure electricity demand in a holistic sense.

Except Egypt, the Nile Basin member states all have a per capita electricity consumption which is lower than the initial threshold level of electricity consumption for rural households (250 kilowatt-hours per year). Investments are required in hydropower and transmission interconnectors, to raise the threshold to at 500 kWh per year (recommended for urban households).

Electricity net consumption (KWh/c), 2010



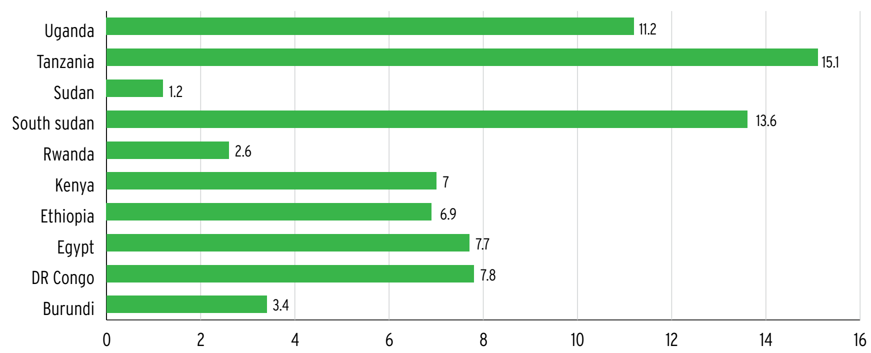
Source: US Energy Information Administration

Cost of Electrical Outages

Today, unreliable power services mean that businesses and factories are frequently interrupted, reducing profits and requiring an array of back-up sources. These often come in the form of diesel generators, which are polluting and require costly fuel inputs. The economic costs of power outages are substantial in the Nile basin partner states.

The immediate economic cost of power shortages can be gauged by looking at the cost of running backup generators and forgoing production during power shortages. As an example, the use of backup generators as a hedge against unreliable supply is estimated to cost the East African Economies of Kenya, Uganda and Tanzania, 2 %, 5% and 4% of GDP each year (AICD, 2012). Through Interconnectors, the distributed nature of renewable power generation can also help to alleviate the problem of power service unreliability.

Losses due to electrical outages as percentage of annual sales 2012



Source: US Energy Information Administration

Electricity Trade

The remote location of many Hydro Electric Power (HEP) plants (Victoria Nile, Bahr el Jebel or the Baro Akobo Sobat and Blue Nile systems) require new transmission infrastructure to connect power plants to load centers. Until recently, Nile Basin states developed their power systems largely independently of one another, focusing on domestic resources and markets, but there has been progress towards regional co-operation to permit concentrated resources, such as large hydropower, to serve larger markets. As shown in the adjacent chart, power trade within the Nile Basin is limited.

The transmission lines in the Ethiopia Power Trade project and the NEL Interconnector Project are being designed and built with a view to creating a backbone for enhanced future trade within the NBI region and with power blocks outside of it (such as SAPP to the south and the Maghreb to the north).

Net power trade (GWh), 2012

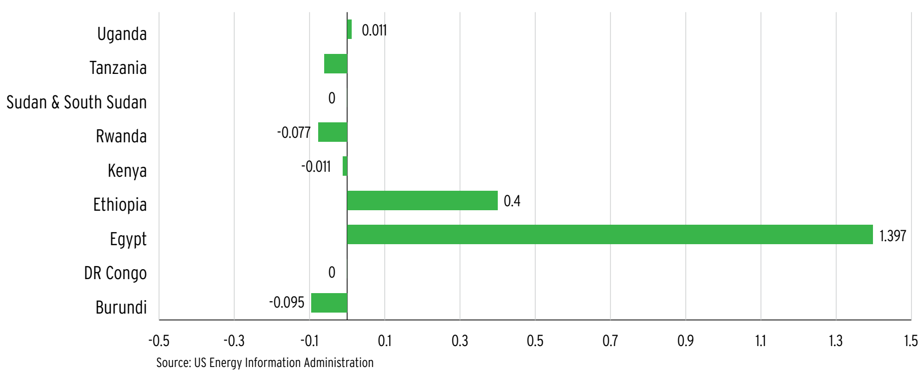


Photo: istock

Electricity substation

Photo: Mily Mbuliro

Troder Bugoye Hydropower plant in western Uganda

Eastern Nile Power Export Project

The Ethiopia Power Export Project (formerly called the Ethiopia-Sudan Interconnection Project) connects the power grids of Ethiopia and Sudan and facilitates cross-border energy trade and optimizes existing and planned generation capacity. This is needed in order to overcome the severe electricity shortage in both countries, which is a major constraint to poverty reduction and economic growth. It is considered a first step toward greater regional power trade. Other Interconnectors promoted by the NBI include:

- Ethiopia and Kenya 500 kV HVDC interconnection transfer capacity 3.200 MW
- Ethiopia to Djibouti 220 kV (282km) interconnection
- Ethiopia to Sudan 230 kV transmission line (335 km) from Gambela in Ethiopia to Malakal in South Sudan
- Ethiopia – Kenya 500 kV HVAC (1045km)

Photo: Mily Mbuliro

Mpaga Hydropower plant

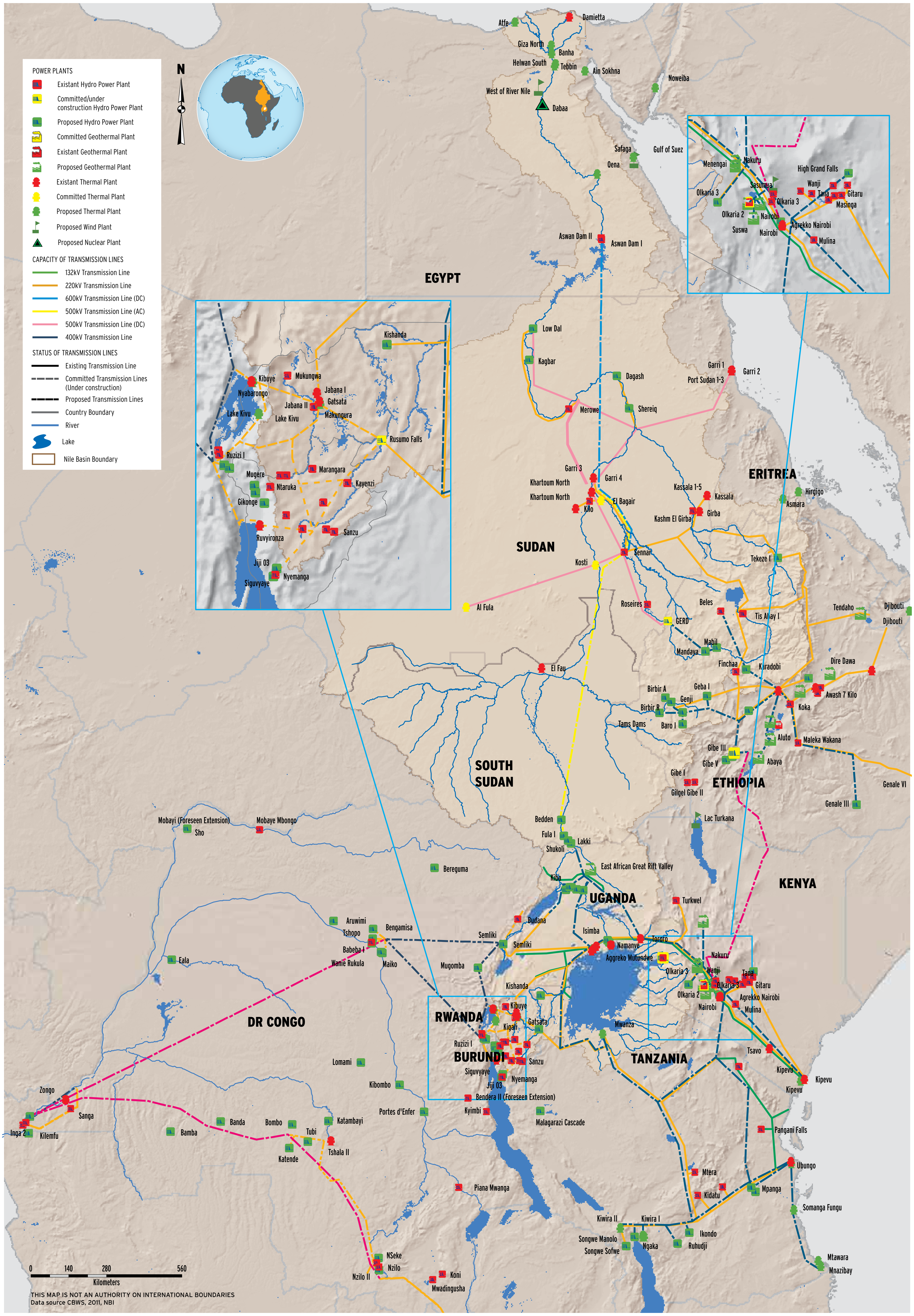
Nile Equatorial Lakes Power Export Project

Ethiopia has plans to increase electricity exports to Eastern Africa, based on new hydropower generation, and construction is underway to boost interconnections with Kenya. Rwanda –Burundi and eastern DRC. The present facilitated investments are expected to add more than 4600 circuit kilometers of new transmission lines at various voltage levels in the partner states of Ethiopia, Uganda, Kenya, Tanzania, Rwanda, Burundi, DRC, South Sudan, and Djibouti (outside NBI). The regional transmission network backbone for Victoria Lake countries includes:

- Kenya (400kV) - Uganda (220 kV) interconnections (260.5km)
- Uganda - DR Congo 220 kV interconnection (352km)
- Uganda - Rwanda 220 kV interconnection (164km)
- Rwanda – Burundi-DRC 220 kV interconnection (400km)
- Kenya - Tanzania 400 kV interconnection (507.5km)
- Tanzania (Iringa-Mbeya)- Zambia (Kabwe) 400kV Interconnector to SAPP (1247km)

Longer-term NBI ambitions for significant electricity trade are predicated on developing the substantial hydropower resources of the DR Congo (particularly Inga with 40,000 MW of potential in a single site) and of Ethiopia and Sudan.

REGIONAL POWER TRANSMISSION IN THE NILE BASIN



IRRIGATION IN THE NILE BASIN

Overall, agriculture dominates all other water uses in the basin, accounting for more than 80% of water withdrawals (Timmerman 2005, Karyabwite 2000, FAO 2011b). The total equipped area in the Nile Basin is estimated at 5.4 million hectares. Actual cropped area is estimated at 6.4 Million hectares. The cropped area is variable depending on what percentage of the irrigation equipped areas is covered by crops in any given year and whether more than one crop is planted. In most Nile Basin countries, the cropped area is much less than the area equipped for irrigation.

Egypt has the highest cropping intensity (cropped area divided by equipped area). Due to higher cropping intensity, approximately 79% of the total cropped area under irrigated agriculture in the Nile Basin lies in Egypt. The equipped irrigated area is dominated by the large schemes in Egypt (3.45 million ha) and Sudan (1.764 million ha), while in the remaining parts, only relatively small areas of irrigation have so far been developed. In Egypt, the use of double cropping means that the effective area in production is greater than the total area of land under irrigation. The vast majority of the irrigation water requirements are supplied from surface water. The table below shows estimated equipped and crop areas across the Nile riparian states.

The Growing agricultural production will further increase pressure on land and water resources. A realistic assessment of future food requirements is therefore essential for Nile Basin governments to take informed decisions about agricultural planning and water resource use. In most of the Nile Basin countries, irrigation systems use surface gravity method of water application where water is conveyed through open canals and finally distributed over the irrigation fields by gravity. However, some pressurized irrigation is practiced in Egypt, Sudan and in some schemes in Ethiopia, Kenya and Uganda. In all countries except Egypt and, to some extent in Sudan, there are no drainage systems whereby excess water is removed from the irrigation fields.

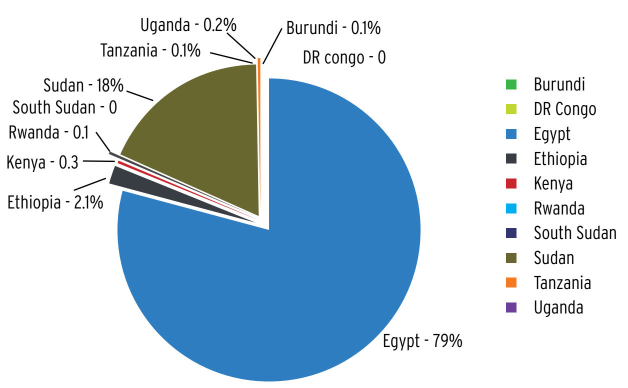

Photo: istock

Tea Plantation

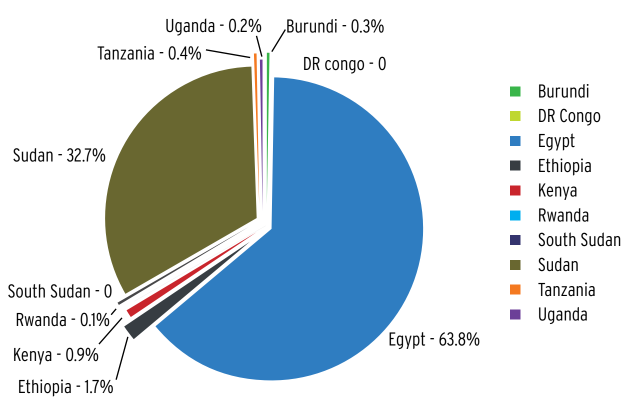
Estimated equipped and crop areas across the Nile riparian states

Country	Equipped Area ('000 ha)	Equipped Area (% of total)	Cropped Area ('000 ha)	Cropped Area (% of total)
Burundi	15.3	0%	8.7	0%
Dr Congo	0	0%	0	0%
Egypt	3447	64%	5021	79%
Ethiopia	91	2%	134	2%
Kenya	47.8	1%	20	0%
Rwanda	7	0%	7	0%
South Sudan	0.5	0%	0.15	0%
Sudan	1764.63	33%	1146.7	18%
Tanzania	19.753	0%	6.464	0%
Uganda	9.7	0%	9.7	0%
Total	5402.683	100%	6353.714	100%

Cropped Area (% of total)



Equipped Area (% of total)



Water Withdrawal for Irrigation in the Nile Basin

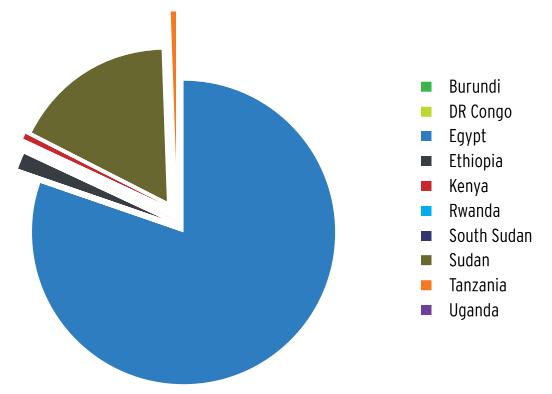
On average 82 Billion Cubic Meter (BCM) of water is withdrawn from Nile waters every year for irrigation where approximately 8.6 BCM is re-used drainage water in Egypt. An estimated 80% of the irrigation water abstraction in the Nile Basin occurs in Egypt followed by Sudan (about 17% of the total basin-wide abstraction for irrigation). The total abstraction for irrigation in the rest of the Nile Basin countries is estimated at 3%. In most countries, there are no appreciable deficits in meeting the total annual irrigation requirements. In few upstream countries, due to lack of adequate water storage facility, lower irrigation water demand satisfaction rate have been estimated.

In the next section, details will be provided on irrigation practices in the Nile Basin countries

Water withdrawals (MCM)

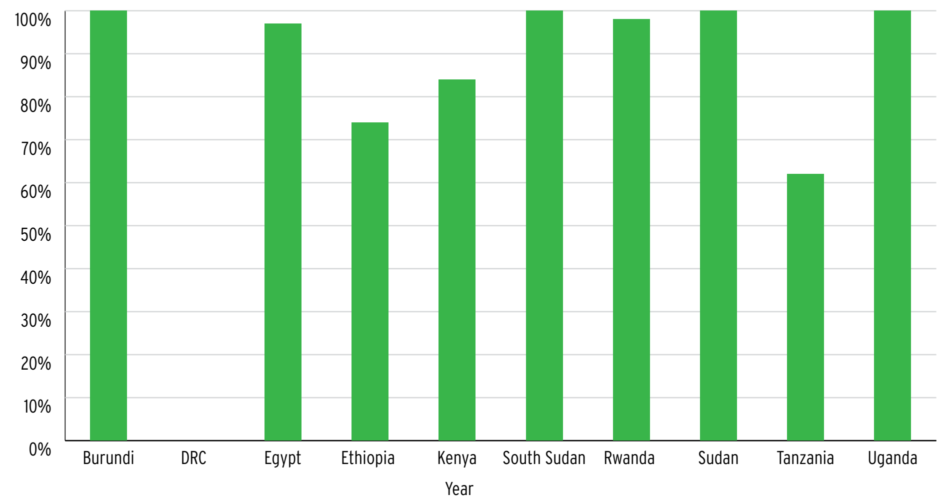
Country	Withdrawal requirement	Actual Withdrawal
Burundi	28.9	28.7
DRC	0.0	0.0
Egypt	66551.5	66054.0
Ethiopia	2018.2	1500.9
Kenya	367.4	307.5
South Sudan	3.4	3.2
Rwanda	58.6	57.4
Sudan	13959.8	13921.6
Tanzania	102.2	63.4
Uganda	260.4	260.3
Total	83350.4	82197.0

Actual Water Withdrawal [MCM]



Country	Unmet Demand [MCM]
Burundi	0.132
DRC	0.000
Egypt	499.379
Ethiopia	517.336
Kenya	59.874
South Sudan	0.000
Rwanda	0.853
Sudan	38.258
Tanzania	38.821
Uganda	0.054
Total	1154.708

Overall irrigation demand satisfaction rate



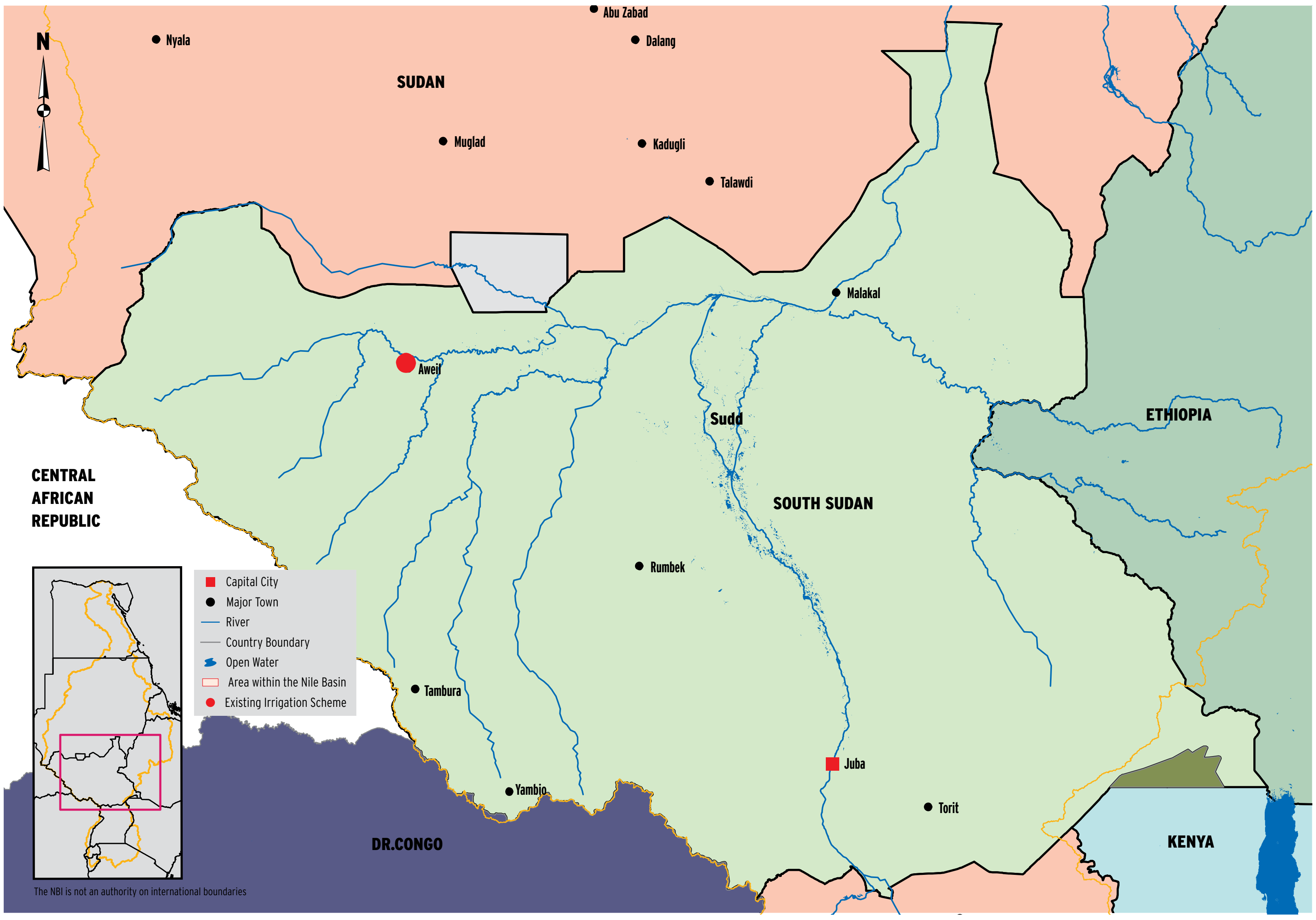
Irrigation areas in South Sudan

Infrastructure for irrigated agriculture in South Sudan is yet to develop. Currently, there is one irrigation scheme, the Aweil scheme located in the southern bank of the Lol river, with a total equipped area of 500 ha and an estimated cropping intensity of 30%. The main crop cultivated is rice. The total annual water demand is estimated to be 3.4 MCM with all the water coming from Lol River.

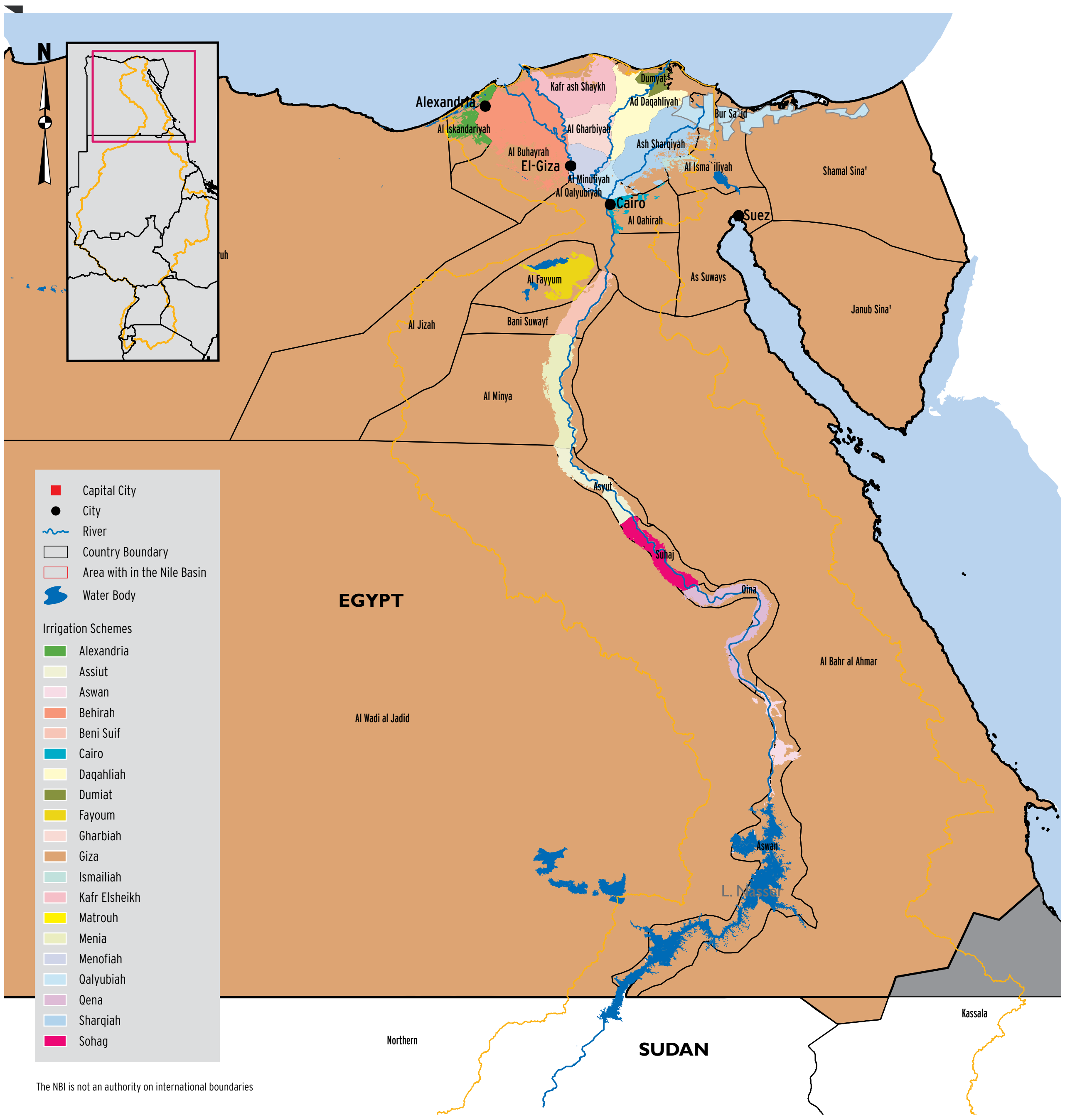
Photo: Robert Zakayo

Main canal in Aweil rice scheme during dry season

Secondary canal in Aweil rice scheme during dry season



Irrigation areas in Egypt



Area equipped for irrigation by governorate

S.No.	Governorate	% of total irrigation area
1	Janub Sina (South Sinai)	0.1%
2	As Suways (Suez)	0.2%
3	Al Qahirah (Cairo)	0.2%
4	Bur Said (Port Said)	0.3%
5	Al Jizah (Giza), West	0.3%
6	Dumyat (Damietta)	1.3%
7	Al Wadi/Al Jadid	1.5%
8	Shamal Sina (North Sinai)	1.7%
9	Aswan	1.8%
10	Al Iskandariyah (Alexandria)	1.9%
11	Al Jizah (Giza), East	2.2%
12	Al Qalyubiyah (Kalyoubia)	2.3%
13	As Ismailiyah (Ismailia)	2.6%
14	Beni Suwayf (Beni-Suef)	3.4%
15	Suhaj	3.8%
16	Al Minufiyah (Menoufia)	3.9%
17	Matruh	4.0%
18	Asyiut	4.1%
19	Qina	4.6%
20	Al Gharbiyah (Gharbia)	4.8%
21	Al Fayyum (Fayoum)	5.3%
22	Al Minya (Menia)	5.9%
23	Kafr-El-Sheikh	7.8%
24	Al Daqahliyah (Dakahlia)	7.8%
25	Ash Sharqiyah (Sharkia)	9.8%
26	Al Buhayrah (Behera)	18.2%


Photo: Terry Feurborn

Nile Valley, Egypt

The data on irrigated agriculture in Egypt has been compiled from NBI projects and global data sources notably from FAOSTAT (FAO). These values haven't been validated with ground observation as this was not available at the time of preparing the Atlas. Egypt has the largest irrigation area among Nile Basin countries. The total area equipped for irrigation in Egypt is estimated at 3.45 million hectares (3.4% of the total area of the country) and a cropped area estimated at about 5 million hectares. 85% of this is in the Nile Valley and Delta. The estimated cropping intensity is 146%. The irrigation system in the old land of the Nile Valley is a combined gravity and water lifting system (lift: about 0.5-1.5 m).

Most of the water used in irrigation in Egypt is surface water with some water taken from groundwater sources. Estimates of water used for irrigation by NB states based on globally available data sources show that an average of 66 BCM per year is used for irrigation where 57 BCM per annum is supplied from the Nile while the remaining 8.5 BCM supplied from groundwater and re-use of drainage water from agricultural fields.

The irrigation system in the new lands (reclaimed areas) is based on a cascade of pumping stations from the main canals to the fields, with a total lift of up to 50 m. Surface irrigation is banned by law in the new reclaimed areas, which are located at the end of the systems, and are more at risk of water shortage. Farmers have to use sprinkler or drip irrigation, which are more suitable for the mostly sandy soil of those areas. Egypt's irrigation system extends some 1,200 km. from Aswan to the Mediterranean Sea and includes 2 storage dams at Aswan (the Low and High Aswan Dams), 7 major barrages on the Nile that divert river water into an extensive network of irrigation canals. This includes 13,000 km of main public canals, 19,000 km of secondary public (Branch) and 100,000 km of tertiary private watercourses (mesqas) that form the main distributaries to farmer's fields. Complimentary drainage networks cover about 272,000 km with 17,500 km of main drains, 4,500 km of open secondary drains and 250,000 km of covered secondary & tile drains. Holdings average less than 1.9 fed (0.8 ha) one of the lowest in the world. The most limiting resource for Egyptian agriculture is irrigation water. Management of its water resources has always been a central feature of the country's development strategy.

Irrigation areas in Burundi

A total of about 8737 hectares of land is equipped for irrigation in Burundi. Nearly all areas are cultivated rice. The total annual estimated water use for irrigation for all schemes is estimated at 29 Million cubic meters per annum.

District	Equipped (ha)
Gitega	1186.47
Karusi	1857
Kyanza	1200.4
Kirundo	1413
Muramya	185.4
Muyinga	731.5
Mwaro	20
Ngozi	2144
	8737.77

Irrigation areas in Ethiopia

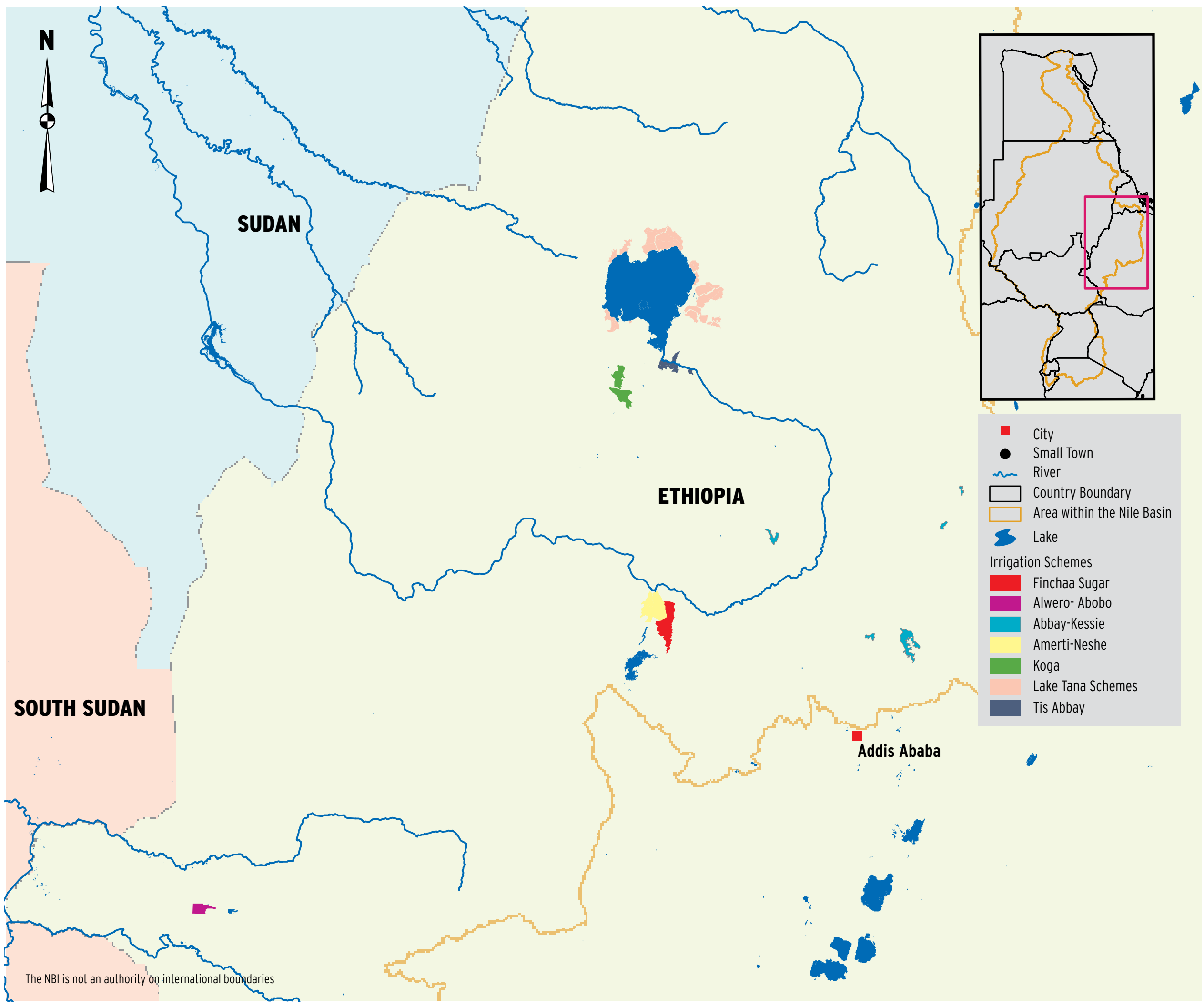
While small-scale individual farmer managed irrigation in Ethiopia has a relatively long history, large scale irrigation started in the 1970s as part of the government owned state farms. Broadly, irrigation schemes in Ethiopia can be of any of the following four types:

- traditional small-scale schemes of up to 100 ha in area, built and operated by farmers in local communities
- modern communal schemes of up to 200 ha, built by Government agencies with farmer participation
- modern private schemes of up to 2,000 ha, owned and operated by private investors individually,
- in partnership, or as corporations
- public schemes of over 3,000 ha, owned and operated by public enterprises as state farms

The total area equipped for irrigation in Ethiopia in the Nile Basin is about 91,000 ha. All except one scheme lie in the Blue Nile sub-basin. Lying in relatively high rainfall area, irrigation of these areas is supplemental where the rainfall is expected not to meet the crop water requirements. Nearly half (46%) of the irrigation area depends on the flow of the Blue Nile without a storage facility that would regulate the highly seasonal flows of the river. As a result, the schemes face shortage of water during the dry season. With the exception of the Fincha irrigation scheme, which uses sprinkler system, all irrigation in Ethiopia in the Nile Basin relies on surface – gravity method for water conveyance and application.

Both irrigated and rain fed agriculture are important in the Ethiopian economy but virtually all food crops are rain fed with irrigation accounting for only about 3%. Export crops such as coffee, oilseed and pulses are mostly rain fed but industrial crops such as sugar cane, cotton and fruit are irrigated. Other irrigated crops include vegetables, fruit trees, maize, wheat, potatoes, sweet potatoes and bananas. Sugarcane is mainly cultivated as part of the Fincha sugar estate that also includes the Amerti-Neshe scheme. Overall, pulses make most of the crop cultivated in the irrigated systems

There is a marked value added in irrigated agriculture. The total estimated annual water use for irrigation in Ethiopia is estimated at 1.5 BCM. Growing population pressure in the highland areas of rainfed agriculture on a rapidly declining natural resource base has secured irrigated agriculture a prominent position on the country's development agenda.



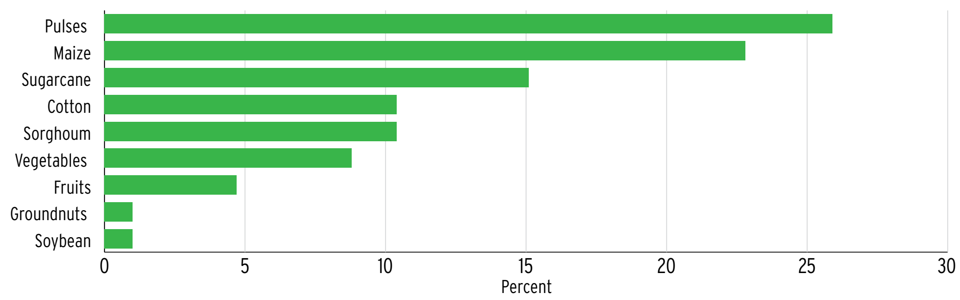
Irrigation Schemes

Scheme Name	District (Level 3)	Water Source	
		Type	Name
Koga	Merawi	Dam	Koga
Neshe	Abay Chomen	Dam	Amerti
Fincha Sugar	Abay Chomen/Guduru	Dam	Fincha
Lake Tana	Several	Lake	Lake Tana
Tis Abbay	Bahir Dar Zuria	River	Blue Nile
Us/ Abbay@Kessie	Several	River	Blue Nile
Abobo	Abobo	Dam	Alwero

Cropped Area

Crop	Area (Ha)
Groundnuts	1261.848
Soybean	1261.848
Fruits	5878.85
Vegetables	11011.848
Cotton	13000
Sorghum	13000
Sugarcane	19009.6
Maize	28628.85
Pulses	32500
Total	125552.844

Percentage area per crop



Irrigation areas in Kenya

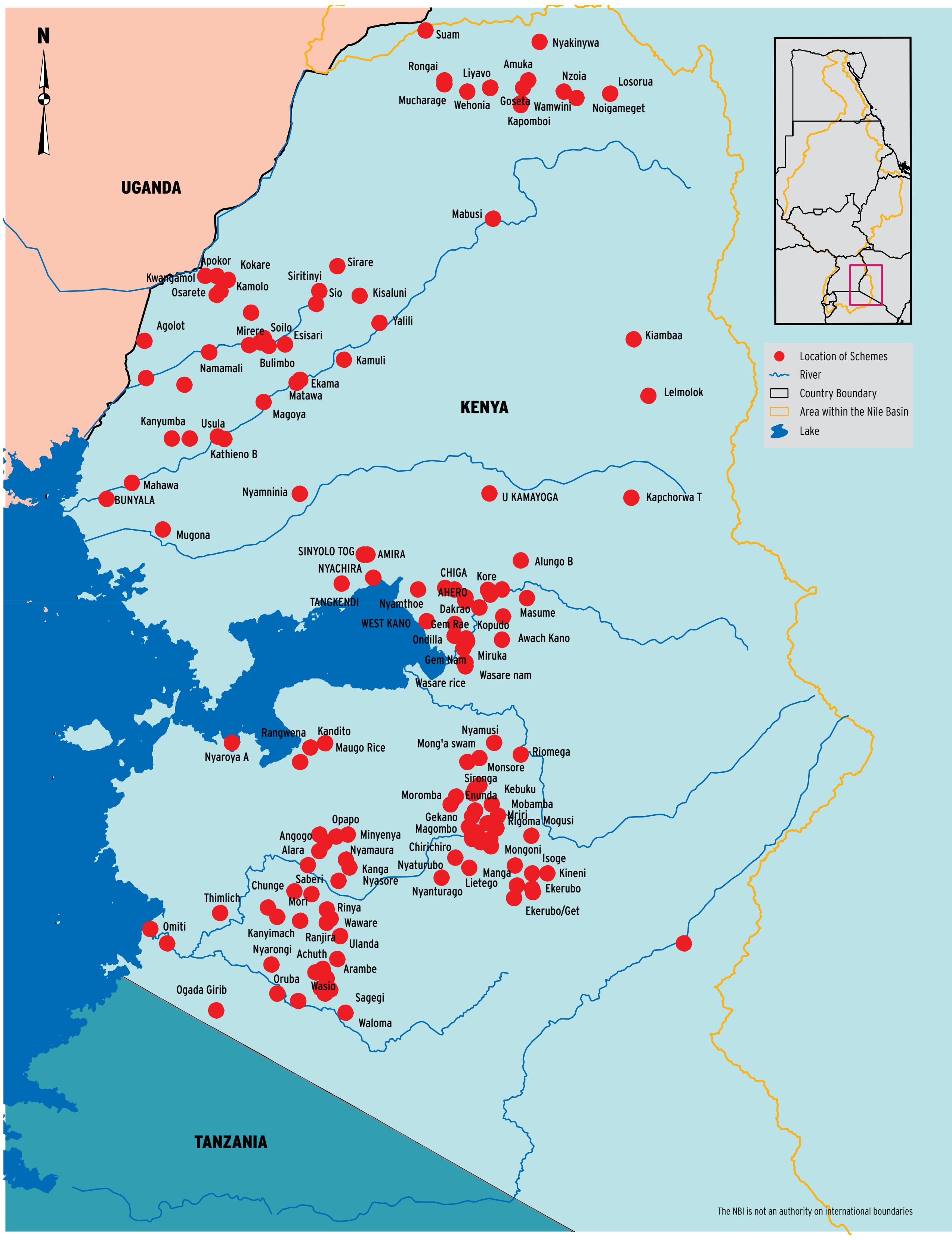
The total area equipped for irrigation in the Nile Basin parts of Kenya (Lake Victoria North and Lake Victoria South Catchments) is about 47500 hectares while the cropped area is on the average 20000 hectares. Most of these schemes are less than 300 ha in size. In 1957 some 1,691 hectares of this were under irrigation and by 2003, this had risen to 10,700 ha but this still represents only 5% of the irrigation potential in the Kenyan part of the Lake Victoria basin.

Public and Private Irrigation schemes in the Kenyan Nile basin include West Kano, Ahero and Bunyala irrigation schemes. Yala swamp development is being undertaken by a private investor called Dominion Farms Limited. The total annual average irrigation demand is estimated at about 367 MCM. The actual water use is estimated to be 307 MCM. The scheme level water supply reliability ranges from 66% for Sare to 100% for Nzoia downstream scheme.

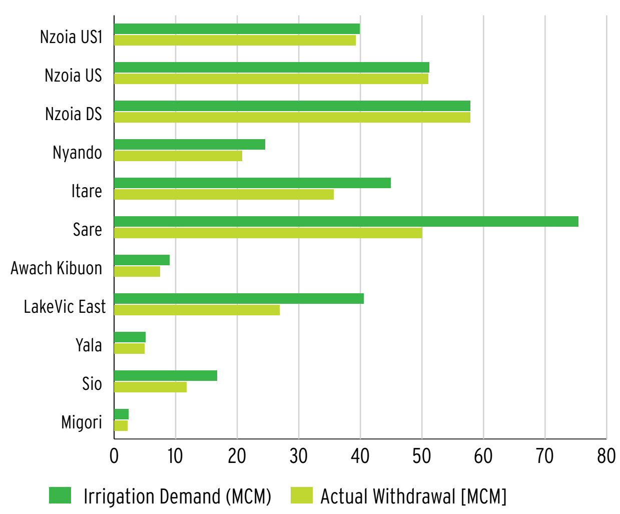
Almost all irrigation is achieved through run of river developments although water pans and small dams have been built the former being located in the medium potential zones. Basin, furrow and flood irrigation methods are used in most community irrigation schemes with sprinkler and drip being used on some private farms especially for the cultivation of flowers and horticulture crops. Greenhouses are used by commercial flower growers and also by some small-scale farmers in Kericho and Eldoret. The simple greenhouses are constructed from clear plastic material and are built on to timber structures. They cover on average ¼ acre and are irrigated by drip.

The total estimated irrigation water demand for all schemes is about 367 MCM and actual abstraction estimates lie at 307.5 MCM, which indicates a volumetric demand satisfaction rate of about nearly 84%.

The major constraints and challenges to accelerated irrigation and drainage development in Kenya include: (i) Inadequate Public and Private sector Investment in the sector; (ii) Inadequate development of irrigation infrastructure and water storage facilities; (iii) Weak Irrigation Water Users' Associations (IWUAs); and (iv) Inadequate support services.



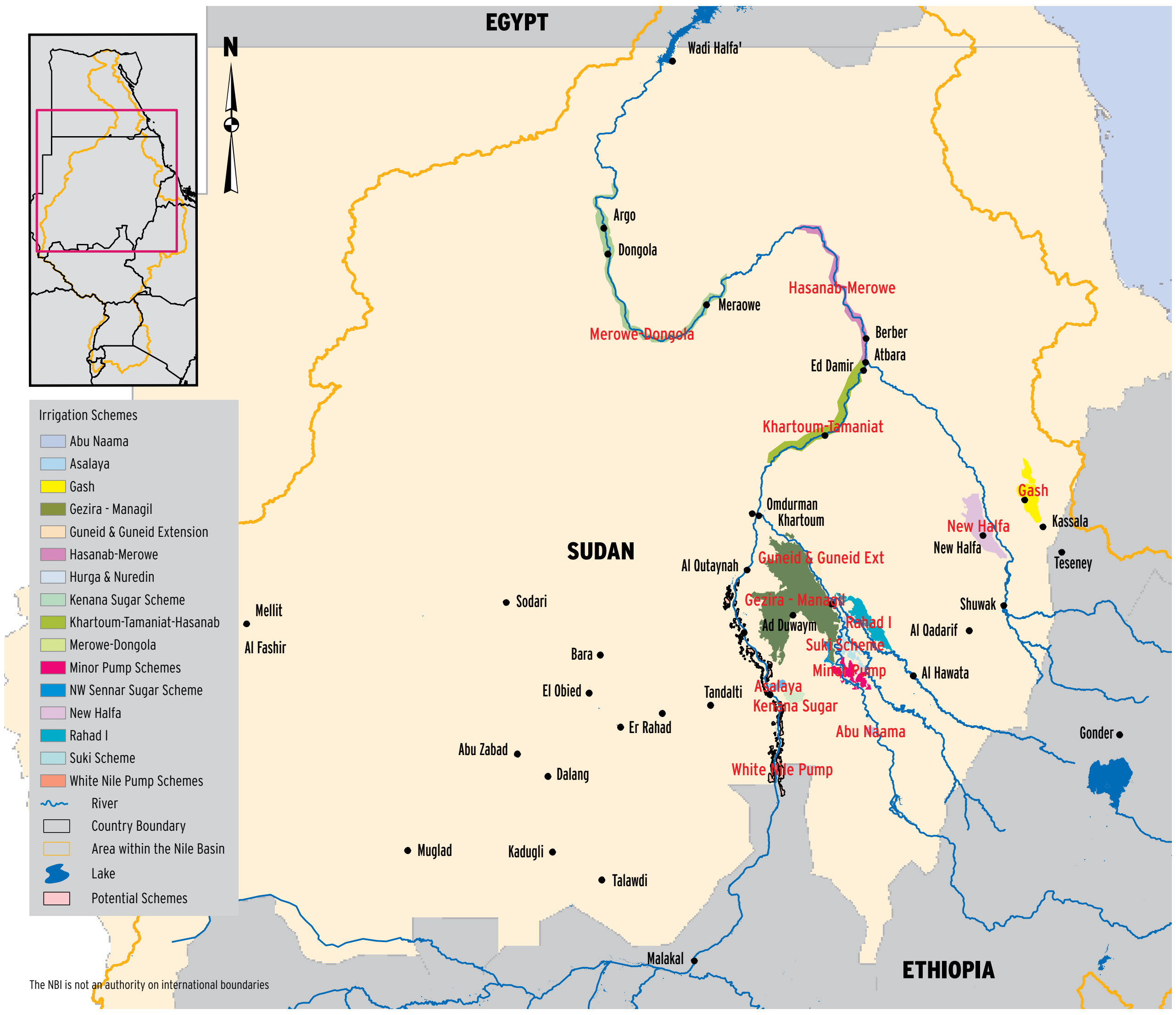
Irrigation Demand and estimated actual water use



Irrigation Water Demand, Kenya

Scheme	Net Irrigation Requirement	Irrigation Demand (MCM)
Nzoia US1	20	40
Nzoia US	25	51
Nzoia DS	28	58
Nyando	12	24
Itare	22	45
Sare	37	75
Awach Kibuon	4	9
LakeVic East	20	41
Yala	2	5
Sio	8	17
Migori	1	2
Total	180	367

Irrigation areas in Sudan



Scheme Name	Cropped (Ha)	Equipped (Ha)
Blue Nile System	9,09,652	13,19,176
Abu Naama	0	12,600
Pump schemes u/s of Sennar (inlcuding Shashena)	56,700	75,600
Hurga and nour-el-deen (Pump schemes as part of gezira)	9,352	42,000
Genaid (Sugar)	16,800	22,400
Seleit	6,300	12,600
Small Private Pump Schemes (through out blue nile)	75,000	1,00,000
Waha (Blue Nile)	9,450	12,600
Gezira - Managil (Al Jazira); c	5,88,000	8,46,720
Rahad I	98,700	1,26,000
Suki Scheme (Old and new)	28,350	37,800
NW Sennar Sugar Scheme	14,700	22,456
Guneid Extension (haddaf/wadel faddul)	6,300	8,400
White Nile System	79,413	1,40,259
Kenana Sugar Scheme	29,988	39,984
Kenana - mixed crop	4,725	6,300
Asalaya (sugar)	14,700	18,375
White Nile Pump Schemes	30,000	75,600
Atbara System	88,200	2,10,000
New Halfa	75,600	1,94,250
New Halfa Sugar	12,600	15,750
Main Nile System	71,400	95,200
Merowe - Dongola; Main Nile Pump schemes	31,500	42,000
Hasanab - Merowe	8,400	11,200
Khartoum_Tamaniat_Hasanab	31,500	42,000
Total	11,48,665	17,64,635

Sudan has the largest irrigated area in sub-Saharan Africa and the second largest in all Africa, after Egypt. The total estimated area fully equipped for irrigation is 1,764,635 ha and an estimated cropped area of 1,148,665 ha, i.e. an estimated cropping intensity of 65%. The irrigated sub-sector contributes more than 50% of the total volume of the agricultural production although the irrigated area constitutes only about 11% of the total cultivated land. It has become more and more important over the past few decades as a result of drought and rainfall variability and uncertainty.

The irrigated sector produces 95% of the long stable high quality cotton produced, 100% of sugar production, 36% of sorghum and 32% of groundnuts. Other main irrigated crops are fodder, wheat and vegetables with other crops comprising maize, sunflower, potatoes, roots and tubers and rice.

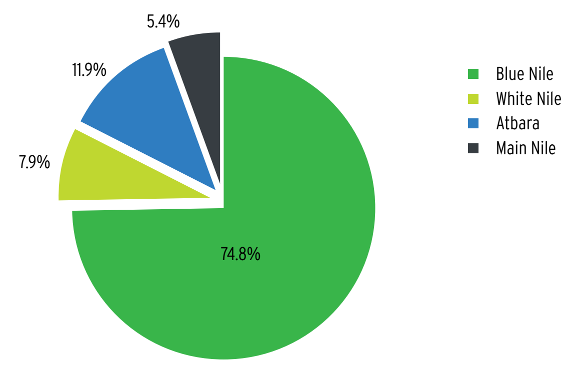
Irrigated agriculture falls into two broad categories: traditional and modern schemes. Traditional irrigation is practiced on the floodplains of the main Nile downstream of Khartoum and on substantial areas along the Blue and White Nile, and the Atbara river as well as on the Gash and Tokar deltas. Many schemes are fully equipped with infrastructure but have low cropping intensity due to scarcity of water during the long dry season.

Large-scale gravity irrigation started more than 100 years ago and was characterized by the promotion of cotton production in the Nile Basin. Irrigation by pumping water began at the beginning of the 20th Century, substituting traditional flood irrigation and water wheel techniques.

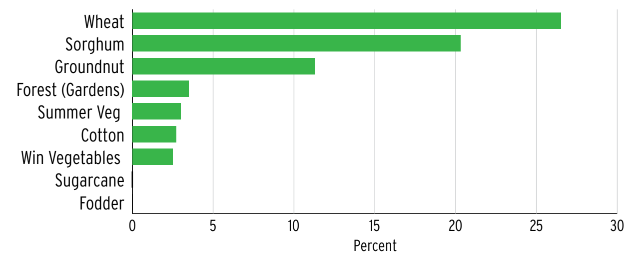
The Gezira Scheme is Sudan's oldest and largest gravity irrigation system, located between the Blue Nile and the White Nile. The scheme together with its extension of Managil scheme with a total equipped area of 846,772 ha is the largest single scheme in Sudan and one of largest irrigation schemes in the world. Nearly 75% of the total irrigation area is in the Blue Nile sub-basin in Sudan. Started in 1925 and progressively expanded thereafter, it receives water from the Sennar Dam on the Blue Nile and is divided into some 114 000 tenancies.

The total net abstraction of water for irrigation from the Nile system is estimated at 13.3 BCM per year. The lion's share of this amount is taken by the Gezira – Managil scheme with an estimated withdrawal of nearly 6.5 BCM followed by the New Halfa scheme with annual net abstraction of about 1.5 BCM.

Percentage equipped area by sub-basin



Distribution of area equipped for irrigation - kenya



Irrigation areas in Tanzania

There are approximately 64 schemes of irrigation with a total area of 19,753 ha in the Nile Basin parts of Tanzania. Most of the schemes are less than 200 ha and only 7 schemes have areas 1000 ha or greater. Main crops in most irrigation areas are maize, beans, rice and vegetables.

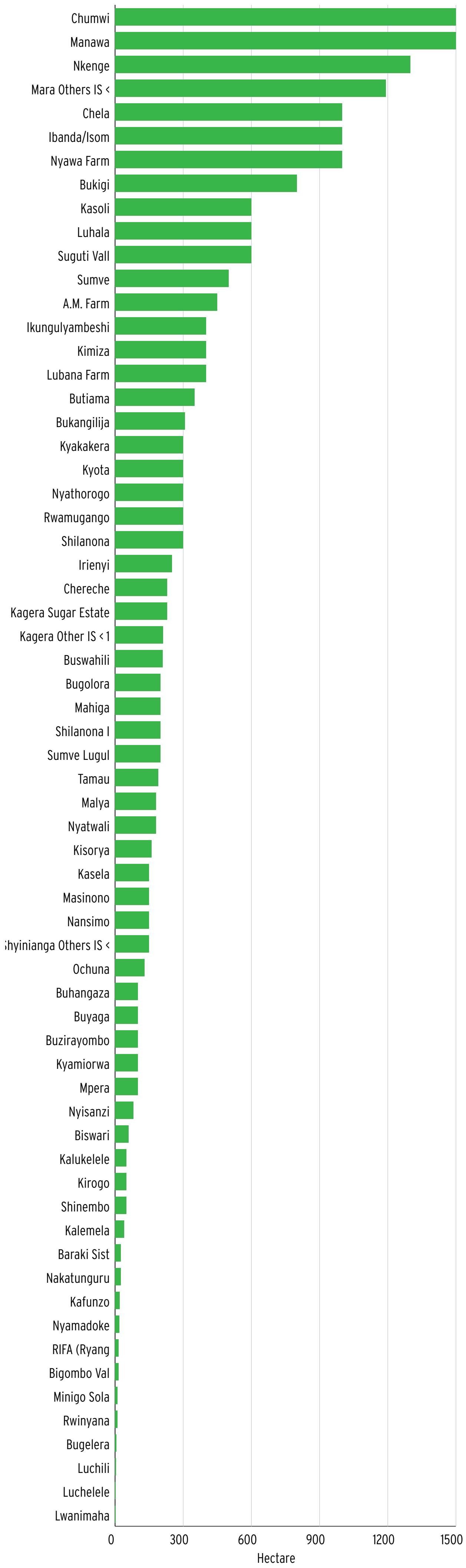
Almost all schemes are gravity-fed (99%) from surface sources with the remainder using pumps for water abstraction. Surface irrigation is practiced widely using furrows and basins with conveyance by both lined and unlined canals. Sprinkler irrigation is used by a few large-scale commercial farms with drip rarely used except on pilot schemes run by Government or in small-scale water harvesting.

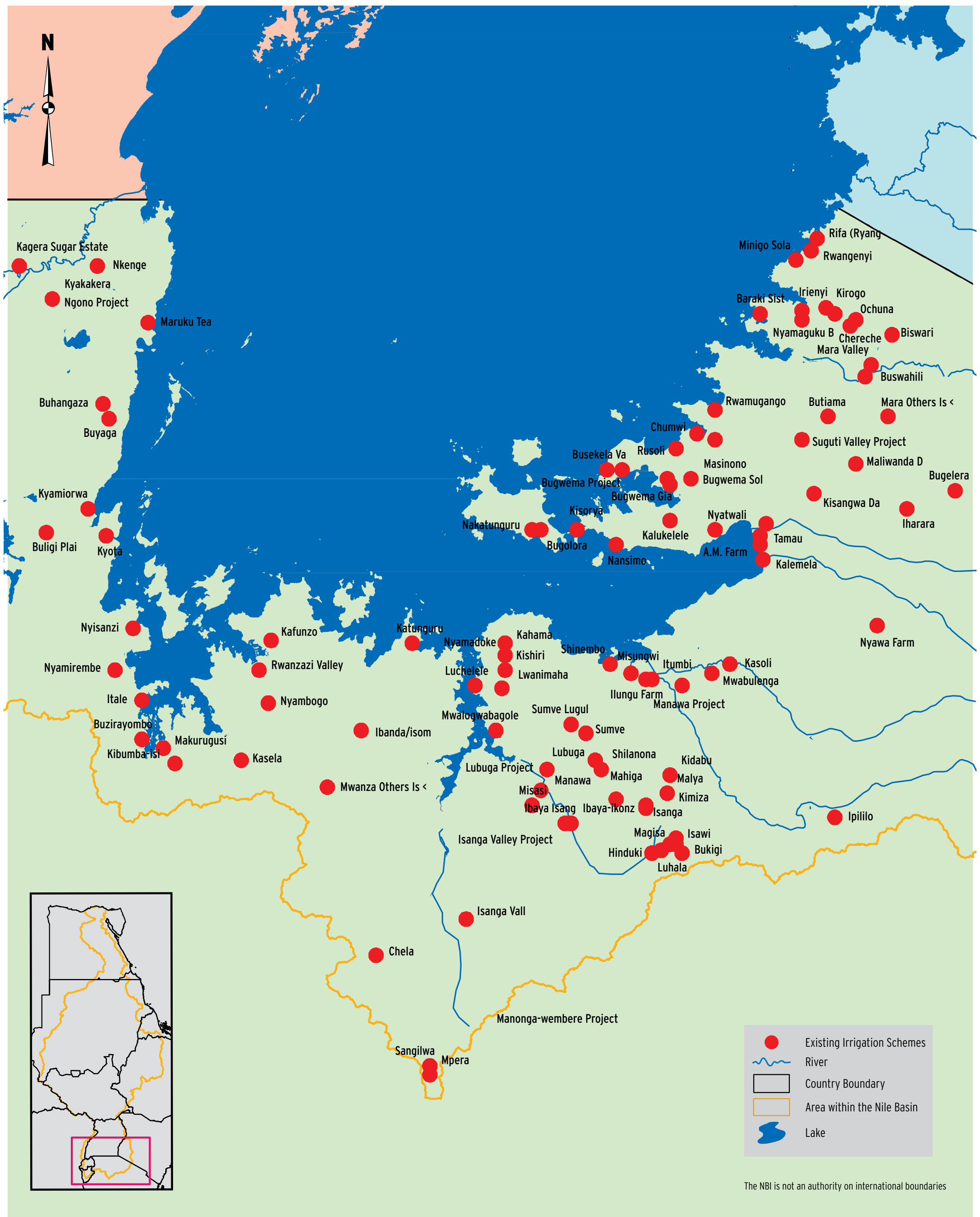
The main irrigated crops are paddy and maize, accounting for about 48% and 31% respectively of the irrigated areas in 2002. Other irrigated crops account for 44% of irrigated areas with an average cropping intensity of 123%. More recently government has been implementing irrigation schemes based on traditional rainwater harvesting technologies together with storage dams.

The average annual irrigation water demand is estimated at 102 MCM. The estimated annual volume of water used for irrigation is 63 MCM, which is about 62 percent of the annual irrigation water demand.

The major challenges to improved agricultural growth through irrigation as identified by the Ministry of Agriculture in the 2012 include (i) developing new sources of growth in response to markets, (ii) increasing farm productivity, (iii) improving agribusiness and processing to enhance rural employment, (iv) establishing producer incentives for export and food crops, (v) fostering the participation of the rural poor in agricultural growth and development, (vi) enhancing the sector investment climate, and (vii) improving public expenditures in the sector.

Distribution of Areas Equipped for Irrigation by Scheme



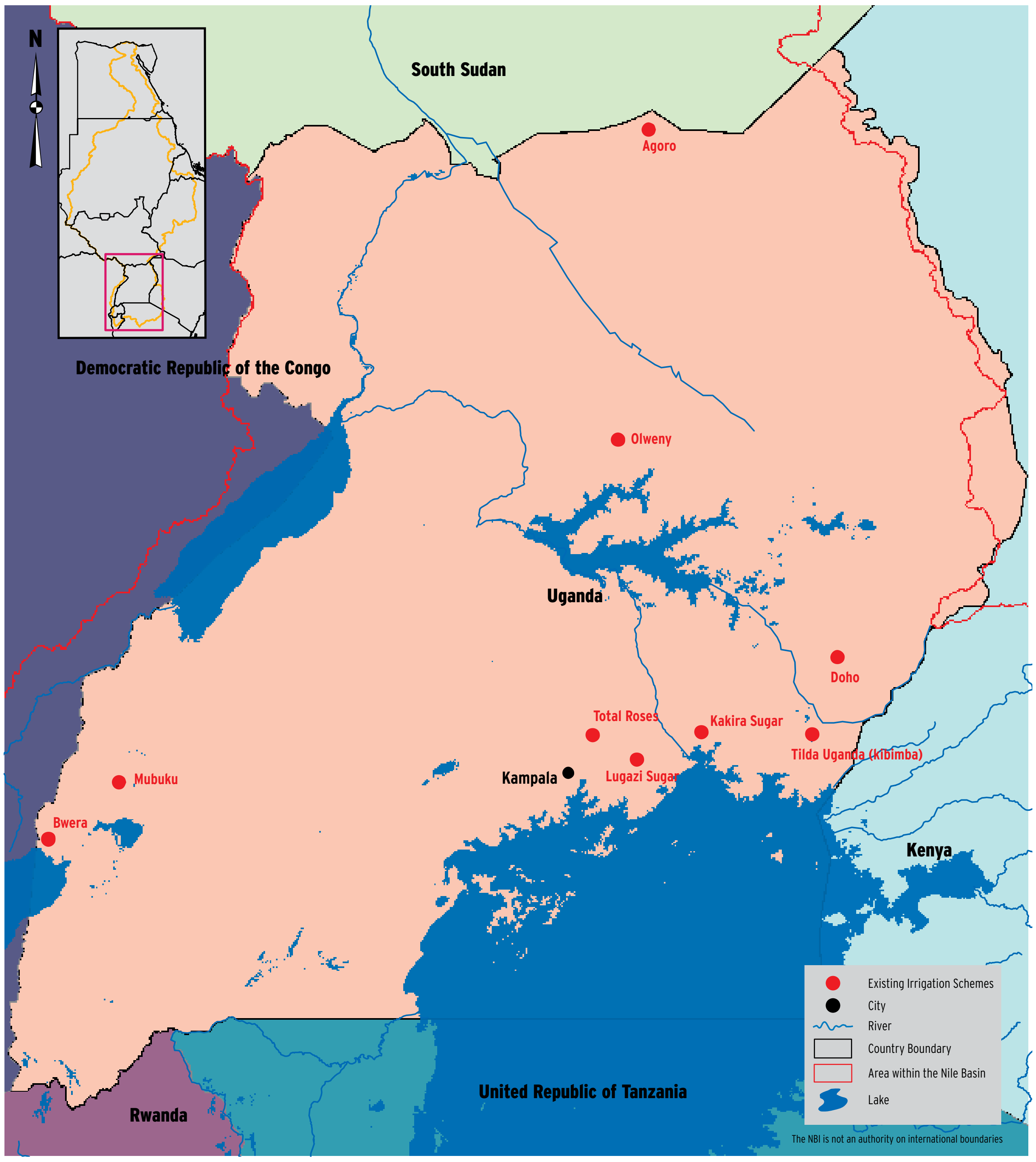


Irrigation areas in Uganda

Agriculture dominates the Ugandan economy. The average cropped area in a given year is estimated at 9,700 ha with a cropping intensity of about 80%t. Over 80% of the irrigation area gets water from Victoria Nile. Main crops cultivated are sugarcane, rice and vegetables. The total estimated total annual irrigation water demand is 260 MCM. Irrigation is a relatively new as rainfall has been more or less sufficient in the past. Most parts of the country experience at least one long rainy season and this has been sufficient for farmers to produce at least one crop a year. In the past, irrigation was only practiced during the dry season at small-scale informal level with most of this located on the fringes of swamps. Nowadays rainfall has become less reliable with supplementary irrigation needed in rain season at times and much of this has been developed by smallholders without planning and with little or no technical assistance. The technology used is basic and approaches are sometimes inappropriate.

Most smallholder schemes grow rice and vegetables, with the larger commercial estates cultivating rice and sugarcane. Most irrigation developments use surface methods although the more recent developments involving greenhouse irrigated flower farms that started in 1990s utilized drip and micro sprinkler.

Some work has started on the water for production component (WfP) for Uganda, but this has still a long way to go. An irrigation policy is in place. There is a strong need to clearly establish the needs for irrigation and drainage and the process by which it can be realized. This needs to go hand in hand with the training of technical staff to support any proposed interventions.



Sr. No	Scheme Name	District	Equipped area Ha
1	Nyamugasani	Kasese	360
2	Mubuku	Kasese	516
3	Olweny	Lira	500
4	Lugazi Sugar	Jinja	2000
5	Agoro	Kitgum	130
6	Kakira Sugar	Mukono	6800
7	Tilda Uganda (kibimba)	Iganga	600
8	Doho	Tororo	830
9	Total Roses	Wakiso /Mukono	280
Total			12,016

Photo: flickr.com

Drip irrigation in a flower farm in a green house in Entebbe, Uganda

Main water division canal from river Sebwe-Mubuku Irrigation Scheme

Water division box at secondary canal-Mubuku Irrigation Scheme

Photo: Albert Water Management Zone, Uganda

field ditches filled with water during irrigation-Mubuku irrigation Scheme

Irrigated Areas in Democratic Republic of Congo

The Nile basin in DRC covers less than 1% of the area of the country. The area is hilly and does not really lend itself to irrigation. This area is rather densely populated with most people engaged in cattle rearing and fishery activities around Lake Albert. It is considered that about 10,000 ha could be developed for irrigation (FAO, 1997).

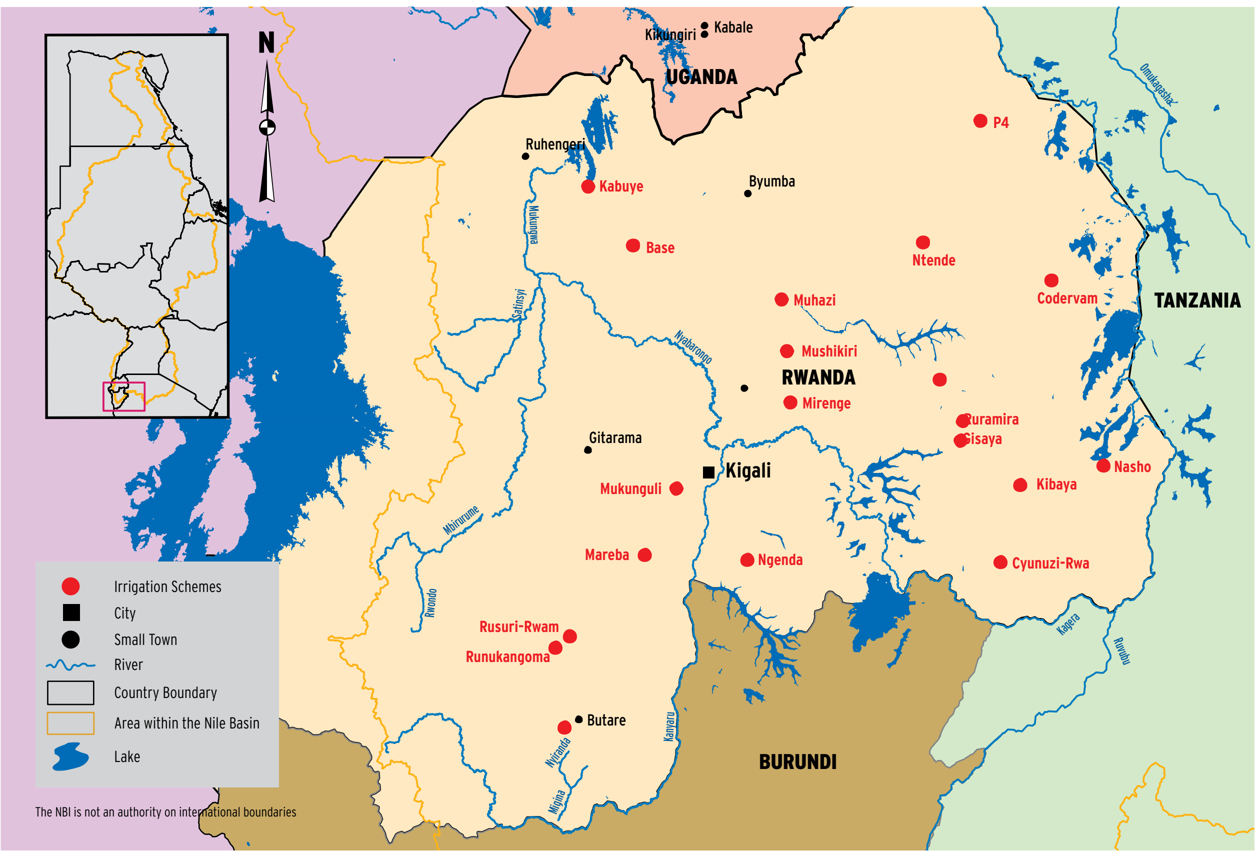
Major crops grown include Cereals (rice, maize), Tubers, Cash crops (coffee, cocoa) and Sugarcane. In the past, the national program for rice production (PNR) has managed 80 ha including the reparation of irrigation canals and drainage and the distribution of pumping material. It has also managed a total of 300 ha of valley bottoms in the Kikwit region, the Ruzizi valley in the south of Kivu, Lodja in East Kasai, Mbandaka-Bikoro, Gemena-Karawa and Bumba in the Equator Province. The total irrigated water withdrawal for the Nile basin part has been estimated at 600,000 m³ per year (FAO, 2010)

Irrigation areas in Rwanda

The total area equipped for irrigation in Rwanda is estimated at 11467 ha. With an estimated cropped area of 7000 ha, the overall cropping intensity is 61%. Main crop planted in most irrigation schemes is rice. The total estimated irrigation water demand for all schemes is about 58 MCM and actual abstraction estimates lie at 57.4 MCM, which indicates a volumetric demand satisfaction rate of about nearly 99.%

Irrigation in Rwanda dates back to 1945 when the Belgians built the main Ntaruko – Rubengera canal with 8 km of length to irrigate a small farm. From 1962 to 1994, the total cultivated and irrigated lands were estimated to be 4000 ha. The major part of irrigated lands (8.3% of the estimated potential) are located is in the marsh lands that cover 164,947 ha with around 57% already cultivated with an estimated 11,467 ha currently managed with moderate irrigation structures (regulators, diversions, head works, etc.).

Rice is an important crop and approximately 62,000 tons are produced annually on about 12,000 ha. Due to the retention of flood flows, the marshlands are important to downstream users as they maintain relatively continuous flow rates in the dry season.



Ser No	Scheme Name	District	Equipped area (ha)
1	Base	Gitarama	170
2	Codervam	Umutara	460
3	Gisaya	Kibungo	300
4	Kabuye	Kigali-Ngali	344
5	Mareba	Kibungo	200
6	Mirenge	Kibungo	600
7	Muhazi	Kibungo	96
8	Mukunguli	Gitarama	440
9	Ntende	Umutara	120
10	Mushikiri	Kibungo	160
11	Ngenda	Kigali-Ngali	756
12	P4	Umutara	460
13	Cyunuzi-Rwa	Kibungo	400
14	Kibaya	Kibungo	240
15	Nasho	Kibungo	160
16	PRB (8 schemes)	Butare	4358
17	Runukangoma	Butare	170
18	Ruramira	Kibungo	90
19	Rusuri-Rwam	Butare	600
20	Rwamagana (5 schemes)	Kibungo	1343

Photo: Adam Cohn

Rice paddles in Rwanda

RAIN-FED AGRICULTURE

Rain fed agriculture

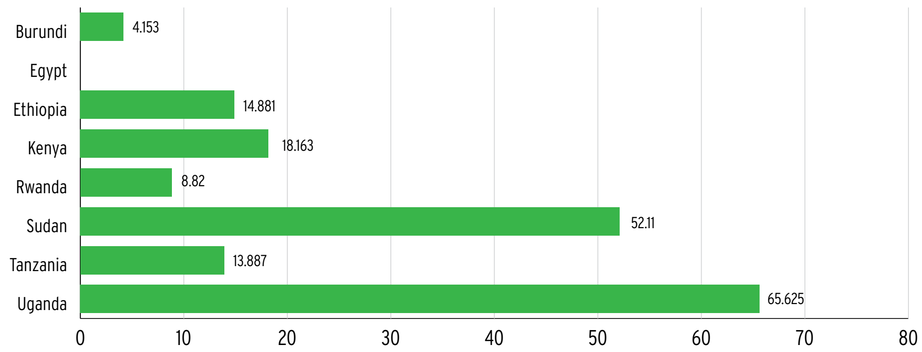
Photo: Simone D. McCourtie / World Bank

Rain-fed farming, covering 33.2 Million ha, is the dominant agricultural system in the Nile Basin. Over 70% of the basin population depends on rain-fed agriculture (Seleshi et at., 2010). Sudan, with 14.7 million ha accounts for 45% of the total rain-fed lands, followed by Uganda, Ethiopia, Tanzania, Kenya, Rwanda and Burundi. Low rainfall does not allow rain-fed farming in Egypt, and rain-fed areas of Eritrea that fall within the Nile boundary are almost negligible. The main rain-fed crop in the Nile Basin in terms of cultivated area is sorghum, followed by sesame, maize, pulses and millet, covering 7.39, 3.68, 3.35, 2.94 and 2.86 million ha, respectively. Rain-fed agriculture in the Nile Basin is characterized by low yields with the majority of crops having an average yield of less than 1ton /ha. Different sets of reasons have been proposed for the low yields in rain-fed systems from natural causes such as poor soils and drought-prone rainfall regimes to distance from urban markets (Allan, 2009). However, the opportunity of favorable rainfall in many rain-fed areas of the basin provides a high potential for yields to increase by improved farm water management techniques such as rainwater harvesting.

While the proportion of (evapotranspiration) ET from rain-fed crops remains relatively stable between years, the absolute amount varies very significantly, from 180 to 256 km³, representing a large difference in potential crop production between years and at the same time illustrating the risks associated with rain-fed agriculture in the region. The variability is in low rainfall areas: the ratio of rain-fed crop ET between the driest and the wettest years is around 0.7- 0.9 in the humid uplands, but falls to around 0.5 in the semi-arid catchments of central Sudan and the Atbara basin. In terms of food security, this annual variability is exacerbated by the occurrence of multi-year droughts.

Under these conditions, opportunistic cropping in wet years may be a viable strategy commercially, although it is difficult to reconcile it with the need for subsistent smallholders to produce crop every year to ensure food security. Much of the additional food demand in the Nile partner states is expected to be met through improvements in rain fed agriculture. The vast untapped potential of rain fed agriculture could be unlocked through knowledge-based management of land and water resources, bridging the yield gaps (a factor of two to four) between the current farmers' yield and the researcher-managed or commercial plot yields (Rockström et al. 2007).

Evapotranspiration for rainfed production for selected Countries (km³)



Source: FAO, 2010

Small-scale agricultural water management techniques, such as rainwater harvesting and groundwater within a watershed management approach have important potential roles in securing rain-fed crops in these regions. Araya and Stroosnijder (2011) found that in northern Ethiopia, where crops failed in more than a third of years in the period 1978-2008, one month of supplementary irrigation at the end of the wet season could avoid 80 per cent of crop yield losses and 50 per cent of crop failures. Other strategies used in the area to manage erratic rainfall include supplementary irrigation to establish crops (to avoid false starts to the wet season), postponement of sowing until adequate soil moisture is available, and growing quickly maturing cash crops such as chickpea at the end of the growing period, to utilize unused soil water reserves.

CROP WATER PRODUCTIVITY IN THE NILE

Photo: Arne Hoel/World Bank

Dina farms, Egypt

Large gaps between actual and potential crop yields reflect the presence of socio-environmental conditions that limit production. In much of the Nile, lack of farmers' access to available water is the prime constraint to crop production. With increasing numbers of people and their growing demand for food, combined with little opportunity to access new water sources, great need exists to make more productive use of agricultural water. Based on Crop Water Productivity, the spatial distribution of the basin can be divided into three zones: the high productivity zone, the average productivity zone and the low productivity zone. The WP index serves as a useful indicator of the performance of rain-fed and irrigated farming in water-scarce area

High productivity zone

The high productivity zone includes the delta and irrigated areas along the Nile River in the northern part of the basin. This zone is characterized by intensive irrigation, high yields and high-value crops. These characteristics collaboratively contribute to the high level of the WP attained and art' in fact correlated. Access to irrigation results in higher yields; higher yield results in higher incomes; and higher incomes result in higher investment in from inputs by farmers.

Average productivity zone

The average productivity zone consists of two major areas, one in the eastern part (Ethiopia mainly) and the other in the southern part (areas around the Lake Victoria). Despite the fact that most of the areas in this zone receive relatively good amounts of rainfall, the predominantly rain fed agriculture has rather low yields and, therefore, relatively low Water Productivity. The fact that rainfall is sufficient to grow crops in this zone opens a wide prospect for improvement in this region. Two parallel strategies that could be applied are, first, improving farm water management and, second, promoting irrigated agriculture. The main obstacle for irrigated agriculture in this zone is accessibility to water rather than its availability. For example, in Ethiopia, due to lack of storage infrastructure the majority of generated run-off leaves the country without being utilized. Controlling these flows and diverting the water to farms can drastically improve both land and water productivity

Low productivity zone

The low productivity zone covers the central and western part of the basin. Agriculture in this zone is rain-fed and it receives a low amount of rainfall in most areas rainfall amounts received cannot meet the crop water demands and therefore crops suffer from high water stress. As a result, yields are extremely low. In this zone improving water and land productivity is contingent upon expanding irrigated agriculture. A good example that shows how irrigation can bring improvements is the Gezira scheme in Sudan.

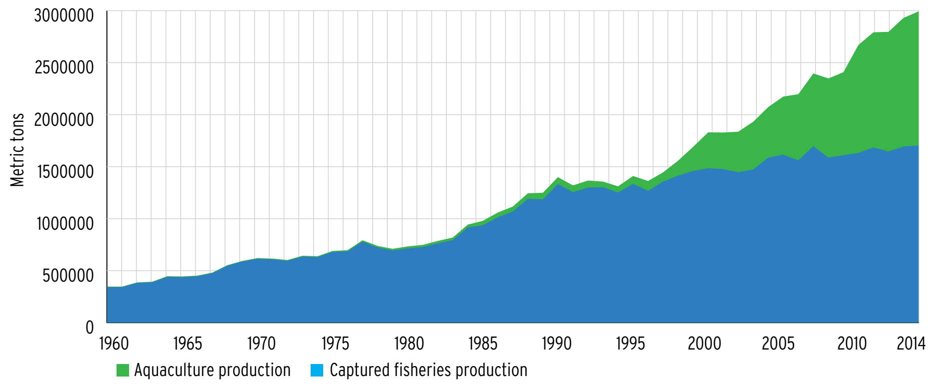
This scheme is located in the same zone (geographically) but irrigation has resulted in significantly higher WP in the scheme compared to its surrounding rain-ted areas. However, due to poor water management, WP in the Gezira scheme is much lower than in irrigated areas in northern parts of the basin (i,e. in the delta).

INLAND FISHERIES MANAGEMENT AND DEVELOPMENT

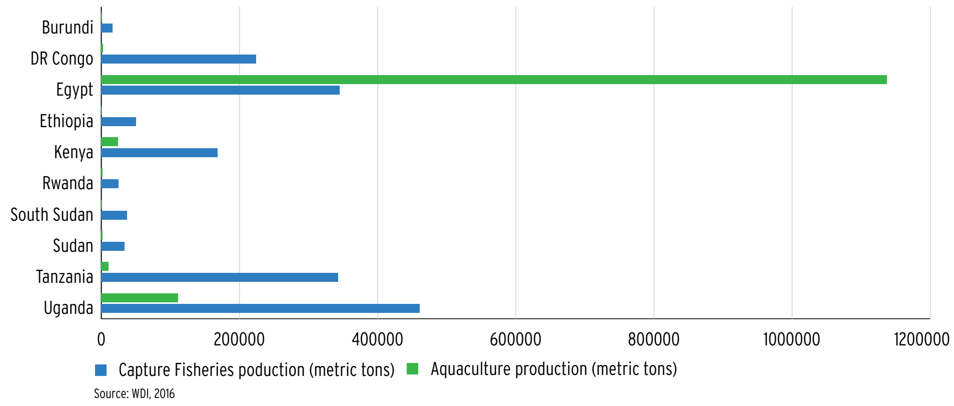
Fisheries and aquaculture are important components of agricultural production and productivity in the Nile. Nile Basin fisheries are mainly freshwater lakes, rivers and marsh sources and human-derived aquaculture. Freshwater fisheries have a large potential to enhance income opportunities for many thousands of people and contribute towards food and nutritional security of millions in Kenya, southern Sudan, Tanzania and Uganda. Fisheries are non-consumptive users of water, but require particular qualities, quantities and seasonal timing of flows in rivers and dependent wetlands, lakes, and rivers.

Fish being washed

Fisheries production in the Basin



Total Fish Production by Country



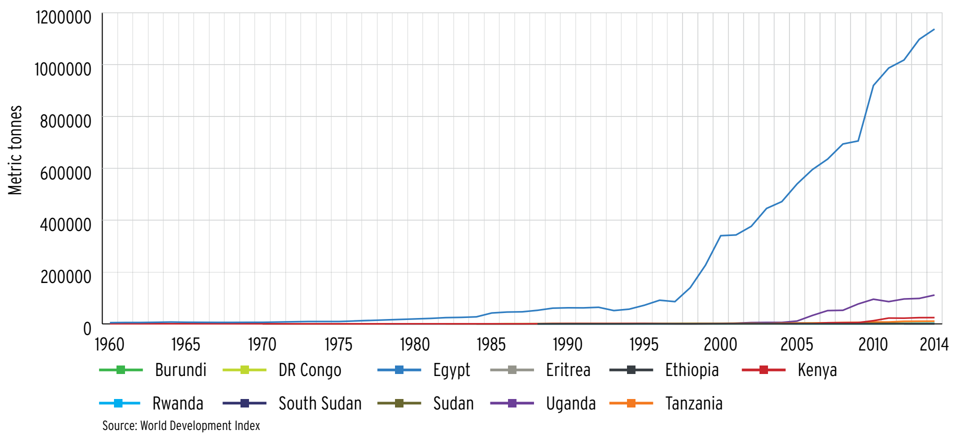
Aquaculture production (metric tons)

Aquaculture is understood to mean the farming of aquatic organisms including fish, mollusks, crustaceans and aquatic plants. Aquaculture production specifically refers to output from aquaculture activities, which are designated for final harvest for consumption.

In 2014, aquaculture production in the Nile Basin countries reached 1,289,234 tons, 88% of which is farmed in Egypt. Egypt is the main producer of farmed fish; since the mid-1990s it has rapidly expanded its aquaculture. Aquaculture expansion has contributed to increasing the total fisheries production in Egypt. Aquaculture activities in Egypt are more concentrated in sub-regions of the Nile Delta, where the water resources are available. Most of the aqua culture production is derived from farmers' use of earthen ponds in production systems. Uganda is a distant second of the total basin aquaculture production. Kenya, Rwanda and Sudan are developing fisheries with the help of foreign aid to boost production which, together with other basin countries, represents 1 per cent of the farmed fish in the basin.

Uganda's aquaculture export market, regional use and employment have risen dramatically over the past 10 years. Aquaculture production is still negligible in most of the sampled countries, although in countries such as Kenya,– in addition to Tanzania which mostly cultivate seaweed - aquaculture is developing and its contribution to GDP is rising. Most aquaculture is conducted in earthen ponds, but at a wide range of intensities.

Aquaculture production (metric tonnes)



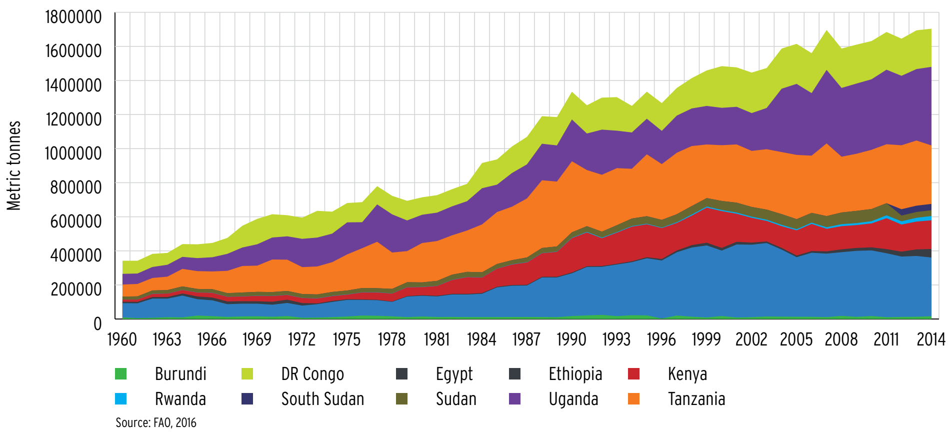
At the low end are small ponds of less than 500 square meters, which contribute to the stability and durability of small-scale farming systems in Africa. When regularly stocked and fertilized, these units produce 1,000–2,000 kg per hectare per year of fish for household consumption and sale or barter. However, aquaculture has also contributed to serious water pollution when not well managed, a problem that is likely to intensify with increased aquaculture activities.

Capture fisheries production (metric tons)

Capture fisheries production measures the volume of fish catches landed by a country for all commercial, industrial, recreational and subsistence purposes.

Diminishing water level, and pollution have acute consequences for several economic sectors that depend on the basin lakes, It greatly affects the fishery by changing water levels. Water-level variations affect shallow waters and coastal areas which are of particular importance for numerous fish species, at least in certain stages of their lives. Pollution also poses a problem for fishery productivity in the Nile Basin. Some of the rivers feeding the lake and the shoreline are particularly polluted by municipal and industrial discharges. Cooperation between all concerned authorities is necessary to search for coherent solutions to ensure the sustainability of the fisheries.

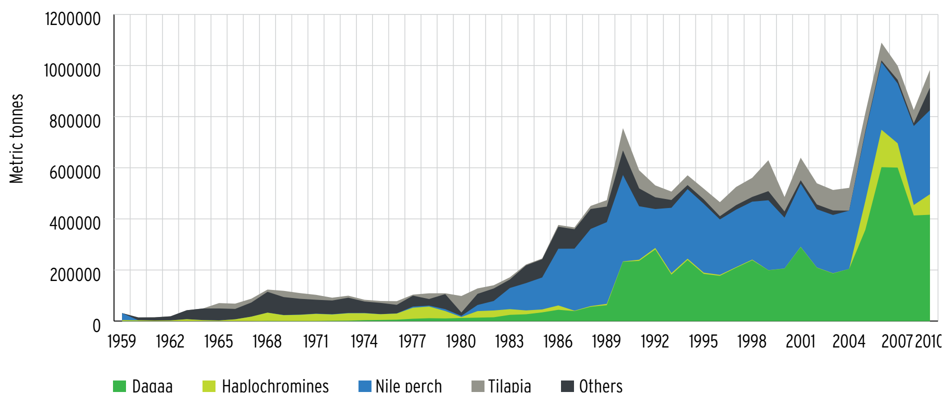
Captured fisheries production (metric tonnes)



Lake Victoria Fisheries Trends in the most important fish stocks

Lake Victoria is the second largest lake in the world, covering an area of 68,000 km² and surrounded by a dense and fast growing human population of at least 25 million people. In addition to its size, the lake is unique in several ways. It supports one of the world's biggest inland fisheries aimed at both domestic consumption and international export and it has experienced some of the most extreme ecological perturbations ever observed in a large freshwater environment. The total catch from Lake Victoria by species is shown in the adjacent chart. The most notable change in the demersal Lake Victoria fish community and fishery is the fundamental metamorphosis in the mid 1980's when it suddenly changed from being dominated by the diverse species flock of endemic haplochromines (contributing around 90% of the demersal biomass) to a much simpler fauna consisting of three primary species: Nile perch, Dagaa in the open waters and the introduced Nile tilapia along the shores.

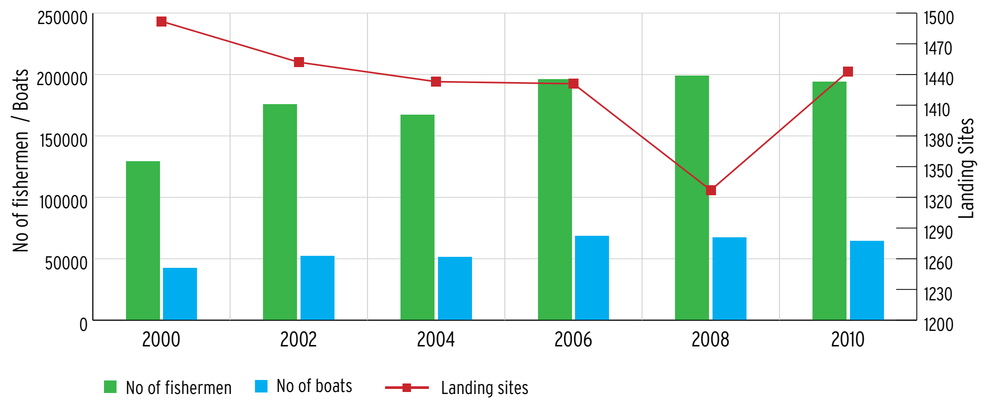
Lake Victoria: Total annual Catched by species or species groups



Trends in effort and estimated total catch rates

Effort statistics prior to 2000 are less reliable than the catch statistics, but the overall pattern largely mirrors the changes in overall catches. There have been three main periods intersected with periods of rapid growth: the mixed cichlid fishery from the 1950s to the 1980s; the fast growing Nile perch fishery during the 1980s; the relatively stable Nile perch/Dagaa fishery from 1990 to the turn of the century; a doubling of the Dagaa fishery 2003 - 2006 and a possible new stable phase since 2005/6. Water levels, flows modification, pollution, affects fisheries production. From late 2000 to 2005, L- Victoria level receded on the coastline by ~5m, reducing fish habitats and spawning grounds.

Indicators of fishing effort in the Lake Victoria Fishery

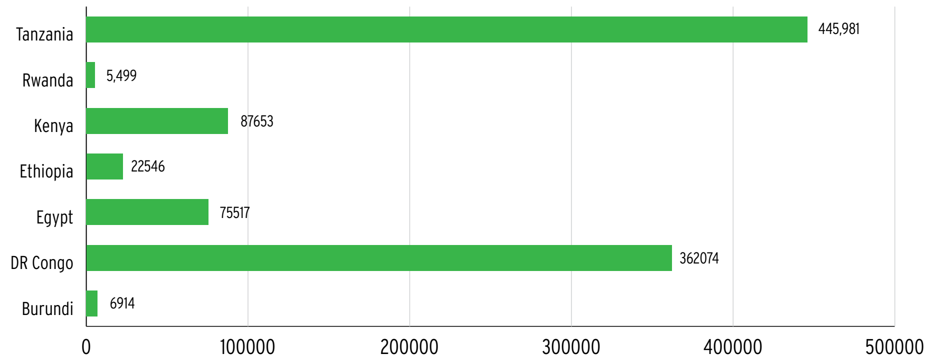


Benefits from Fisheries Management in the Nile

Based on current stock estimates, the lake has the potential to yield fish valued at over US$ 800 million annually on a sustainable basis. Further processing and marketing the fish in the local and export markets could provide opportunity to generate additional earnings. Currently, however, only about 500,000 tons of fish is landed annually, with an average landing value of approximately US$ 600 million. Further processing and marketing of this fish in the local and export markets can generate an additional value of about US$ 57 million.

Inland fisheries, and related export and regional trade, can play a significant role in the economy of regions and countries. The sector contributes 4% to GDP in DR Congo and 2.5% in Tanzania (2013). Inland fisheries provide employment and income for several million people (estimated employment population employed in the sector amounts to 445,981 people.

Employment in inland fisheries in sampled countries 2013

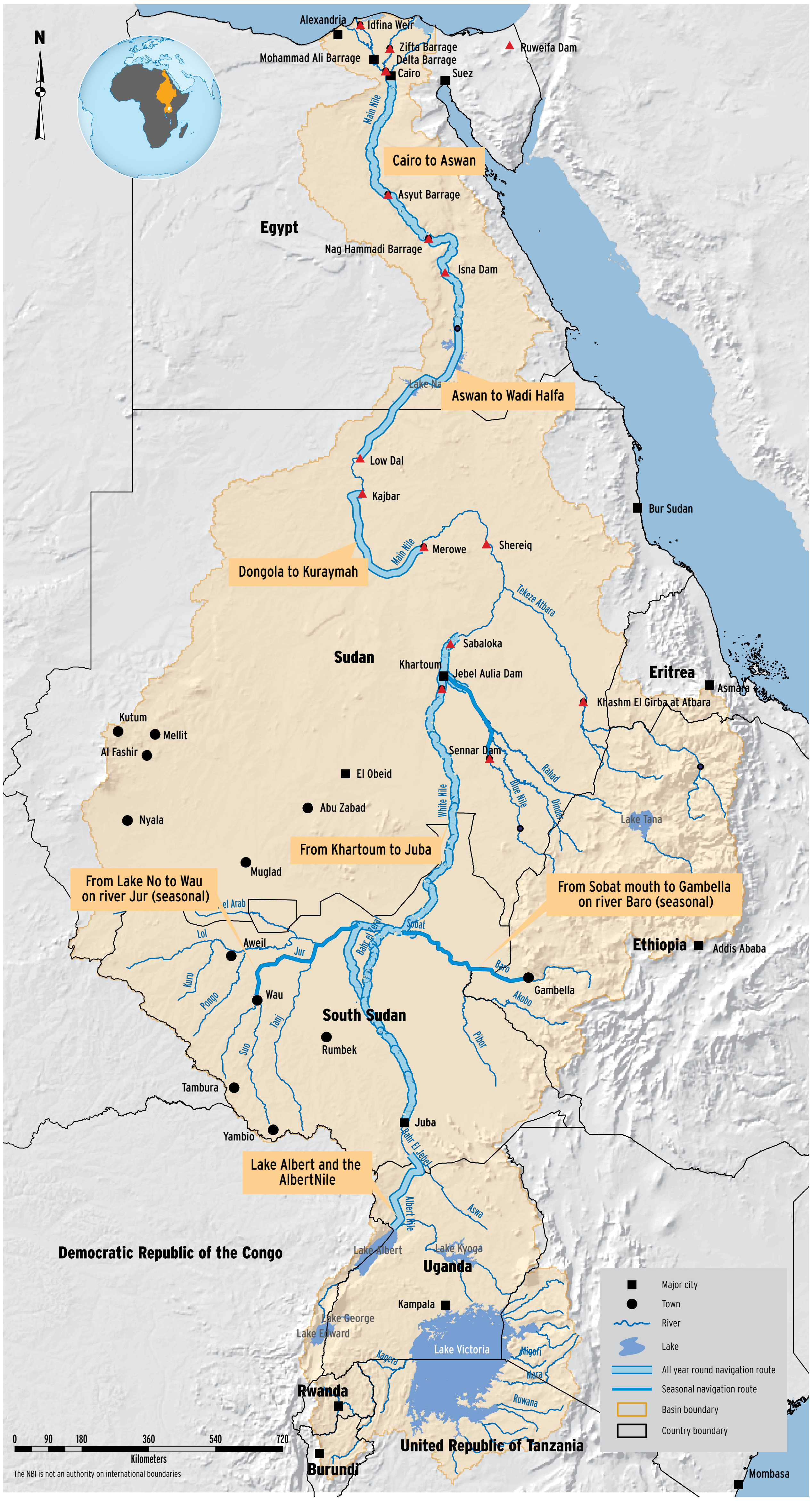


Industrial sector contribution to national water withdrawal, 2014

Types of benefit	Kenya	Uganda	Tanzania
Production (US$ Million)	115	156	180
Contribution to GDP	0.5%	1.5%	1.8%
Employment of fishermen (2002)	54163	41674	80053
Foreign Exchange Earnings (US$ Million)	50	88	112
Per Capita Fish Consumption (Kg/year)	5	12	12
Contribution to Animal Protein (1994-97)	10.6%	29.7%	32.6%
Balance of Trade	N/A	N/A	N/A

Fisherman in Uganda

INLAND WATERWAY TRANSPORT



Inland navigation is often the most cost-effective and least polluting means of transport and, with improved trade and exchange, has contributed to the development of the Nile Basin riparian states economies. Inland waterways can efficiently convey large volumes of bulk commodities over long distances. However, inland shipping remains an underdeveloped sector on most waterways.

Nine of the 11 Nile riparian countries have navigable water bodies, and a total of 72 inland water ports between them, with Egypt and Uganda having the highest number. The main areas important for inland water transport are Lake Victoria which provides a vital transportation link for Kenya, Uganda and Tanzania with the main ports being Jinja and Port Bell in Uganda, Kisumu in Kenya, and Mwanza, Musoma and Bukoba in Tanzania; Sections of the White Nile in South Sudan, and the Main Nile in The Sudan and Egypt.

In Egypt, the Nile is navigable by sailing vessels and shallow-draft river steamers as far south as Aswan. In South Sudan, steamers still provide the only means of transport facilities, especially where road transport is not usually possible from May to November, during the flood season. The Blue Nile has an 800 km stretch that is navigable during high water times. The main types of goods and services transported comprise agricultural produce, livestock, fish, general merchandise, and passengers. Inland ports, linked to other modes of transport connecting to international markets, also handle export/import traffic of agricultural products and manufactured goods.

Navigation is a sector that does not consume water. It depends on the state of water resources in terms of quantity (a minimum depth is needed) and, quality (invasive aquatic plants or excessive solid waste in the water bodies would obstruct engines and waterways). It also brings the threat of potential hazards to water quality, such as oil spills from tankers operated on Lake Victoria, or ships degassing.

Inland waterway transport on Lake Victoria

Lake Victoria is the primary inland waterway servicing both the central and northern corridors. Lake Victoria acts as a principal waterway with commercial traffic. In conjunction with train services, Uganda and Tanzania operate train wagon ferries on the lake between railhead ports of the two countries and Kenya.

The three main lake ports are: (i) Kisumu for Kenya, located in the North Eastern corner of the Winam Gulf, fronting Kenya's third largest city, (ii) Mwanza South for Tanzania, located within a natural shallow bay on the Eastern shore of Mwanza Gulf, and (iii) Port Bell for Uganda, located at the end of Murchison Bay, South-East of Kampala. They are directly included in the regional multimodal trade routes, namely the Northern and Central Corridors

Traffic across all public ports on Lake Victoria is estimated at 500,000 tons a year. However, it should be noted that local traffic has increased since 2005 while international transit traffic has been decreasing (imports to Uganda estimated at 3,000 tons in Port Bell over the last years).

However, developing rivers for navigation often results in irreversible transformation of river courses, with negative impacts on vulnerable groups and ecosystems (such as fish mortality from propeller impact and larvae stranding due to drawdown).

Photo: Pierre Lesage

Ship on the Nile Egypt

Water use for Navigation

The hampering of port and navigation activities due to low water levels received much attention in the 2005/06 water level crisis on Lake Victoria. Lake Victoria transport system for passenger and goods suffered as well as its essential role for island connection. Declining water levels cause a decrease in draft and so ships cannot enter ports safely when the water depth is too shallow. During the water level crisis, various vessels had known difficulties to berth properly. Loading and offloading of passengers was severely affected in Tanzania. And several accidents involving their vessels found to be related to low lake levels. The minimum and maximum levels for days when accidents were reported are 10.76m and 11.05m (JJG) respectively.

Generally it may be concluded that the safety of marine navigation in Lake Victoria cannot be guaranteed below an elevation of 11.33 m, which corresponds to the highest level in 1957 when the lake was surveyed. The operation of vessels below this level is risky and if it has to be done, reassessment of the routes to ensure safety would be required. Low lake levels would also compromise most of the maintenance structures functioning, leading to a high operational cost of navigation.

In Kenya and Tanzania, maintaining the lake level between 11.5 and 12.5m (higher than the present 11m level) would rejuvenate navigational activities with positive effects to the livelihood and environmental sector. The opposite could be said of Uganda who heavily relies on power generation for livelihood at national scale. In general, it is envisaged that in all the five countries sharing Lake Victoria, the infrastructure, navigation risk and revenue will not be seriously affected while navigation and dredging cost may go up. These will in turn affect livelihoods and the environment.

CONCLUSIONS

Photo: Milly Mbuliro

River Nyamugasani

The water resources in the Nile Basin is serving multiple purposes and are essential for sustaining life, the economy and a healthy environment. Water is used off-stream (withdrawn e.g. for agriculture, municipal or industrial use), in-stream (e.g. hydropower, fisheries, environment) or on-stream (e.g. navigation, tourism and recreation). By far, the largest consumptive use is for agriculture/irrigation (roughly 2600 m^3/s) although part of the abstraction is returned as drainage water. Egypt and Sudan are the largest users accounting for 96% of the total. Municipal and industrial consumption is estimated at over 400 m^3/s. Population in the Nile Basin is forecasted to double by 2030 and municipal water demand will grow fivefold during the same period due to urbanization and increase in standard of living. Industrial demand will be likely to grow at a comparable rate. The largest municipal and industrial consumption is taking place in Egypt (close to 97%) followed by Sudan and Uganda. Drainage water from irrigation and sewage from urban areas and industries present pollution threats to the aquatic environment.

A survey made in 2014 showed the existence of 14 storage dams basin-wide. The existing dams are highly beneficial from a power generation point of view and are also helping equalizing flows. However, there is substantial evaporation from the reservoir surfaces causing loss of water. The loss reaches an estimated 540 m^3/s with 70% occurring from the reservoir of the High Aswan Dam.

The total reservoir capacity per capita in the basin is very low compared to world benchmarks. In a region with severe seasonal and inter-annual variability and anticipated climate change, absence of adequate storage capacity adds to the vulnerability of the population as prudent reservoir operation can help reduce flood and drought impacts.

Hydropower is generated primarily in Uganda, Sudan, Ethiopia and Egypt but is only meeting a small part of the power demand. However, there is a large untapped potential for hydropower especially in the Blue Nile, where the Grand Ethiopian Renaissance Dam (GERD) is under development and will become Africa's largest hydroelectric power plant with an installed capacity of 6000 MW.

Fisheries and aquaculture are important users of water although not consumptive. Nile Basin fisheries are mainly seen in freshwater lakes, rivers and marsh sources as well as in human-derived aquaculture and has significant impact on the socio-economy. Fisheries require particular water qualities, quantities and seasonal timing of flows and water depths in lakes, rivers and wetlands.

The environment is another, though silent user. A sound aquatic environment is essential to maintain the productiveness of the water bodies and the wetlands and providing suitable habitats for diverse fauna and flora populations. Water pollution from urban and industrial sources endangers the soundness of the environment and the furthest downstream environment is at greatest risk.

Nine of the 11 Nile riparian nations have navigable water bodies and a total of 72 inland water ports with Egypt and Uganda having the highest numbers. Navigation is a sector that does not consume water. It depends on the water resources in terms of quantity (minimum water depths) and quality which can cause excessive amounts of, for instance the water hyacinth. Such plants can block harbors and prevent the launching of small crafts at landings.

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. Changes in climate could very well aggravate the situation. These conditions require a very high degree of trust, cooperation and sharing of water and benefits between the riparian nations. The Nile Basin Initiative has a vital, strategic mission in facilitating the cooperation, promoting Integrated Water Resources Management, providing access to Decision Support Systems and reliable databases and raising awareness on known or innovative ways of demand management, water conservation and efficiency in water use.

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OVERALL CONCLUSION

The Nile Basin Initiative, established in 1999, has initiated the preparation of the Nile Basin Water Resources Atlas as part of their quest for basin-wide cooperation, enabling water resource management and water resource development. The primary objective of the Atlas is to support collaborative monitoring the water and related resources of the Nile Basin by Riparian States and thereby contribute towards achieving their shared vision objective "to achieve sustainable socio-economic development through the equitable utilization of, and benefit from, the common Nile Basin water resources".

The Atlas provides a snap-shot of the present water resources situation and aims to give overviews of the conditions and the huge variations in water resources parameters in the Nile Basin that is roughly 10% of the African continent and comprises eleven countries. In such a huge area with large variations the Atlas will give aggregated information. The Nile flows from its spring in the highlands southwest of Lake Victoria and join the Kagera River, which empties into Lake Victoria. Totally the Nile flows roughly 6700 km to the north before reaching the delta and eventually the Mediterranean Sea.

The physiography of the basin represents the result of the processes, which have formed the landscape over millions of years. In historical time, humans have started influencing erosion and sedimentation, land cover, soils and the wetlands. The physiography divides the Nile Basin into two broad sub-systems. The Equatorial Nile sub-system comprises the sub-basins of Lake Victoria, Lake Albert, Victoria Nile, Bahr el Jebel, White Nile and Bahr el Ghazal. The Eastern Nile sub-system comprising the Main Nile sub-basin and the sub-basins of Tekeze-Atbara, Blue Nile and Baro-Akobo-Sobat. Totally, there are ten sub-basins with large variations in characteristics.

The Nile and its tributaries is the lifeline for a population of 257 million or more than 10% of the population of the African continent. The Nile and the socio-economy of the 11 riparian countries are intimately connected. Agriculture, hydropower production, wetlands, water supply, navigation, fisheries and tourism are among the many sectors depending on water resources and providing livelihoods for the riparian population.

The settlement patterns also reflect the availability of water, which seems to overshadow other factors such as social and economic infrastructure. In the downstream countries, population is concentrated along the course of the Nile and in the Nile Delta. Upstream population densities are highest in the Equatorial Lakes region and in the Ethiopian Highlands, both being regions of high rainfall and abundant water resources. The trend in migration is from rural areas to urban areas. For the Nile Basin as a whole, the rural population is larger than the urban population. Projections for 2050 shows that the urban population will reach above 60% of the total population in 4 of the 11 Nile Basin riparian nations. In the remaining seven nations the urban population will increase but stay well below 40%. Urbanization will increase the pressure on urban services and facilities as well as on the natural resources and the environment. Water pollution will be one of the serious challenges for the water resources management.

The Human development index (HDI) is an aggregation of the average achievement in the key dimensions, a long and healthy life, being knowledgeable and having a decent standard of living. All Nile Basin countries fall into the Low Human Development category with the exception of Egypt, which is in the middle category. However, all basin countries show improvements compared to year 2000. The higher the HDI, the higher the potential for involvement of the broad population in the stewardship of the environment, the water resources and the battle against water pollution. Poverty is widespread and by income, around 40% of the population of the basin countries live below a poverty line of USD 1.25 per day.

The full dependence of the socio-economy on shared basin water resources makes a fact based management and development essential. Monitoring of water resources is therefore done by all countries and close to 1,000 meteorological stations for rainfall and temperature recording exists. Almost 450 hydrometric stations for gauging of streamflow were registered. Technical and financial resources to operate the networks of stations have been dwindling in most countries and station densities can become inadequate. The need for improvements have been realized by the Nile Basin Initiative, which has completed a design of a Nile Basin Regional Hydromet System based primarily on upgrading of existing stations adding water quality monitoring and laboratory strengthening. Groundwater monitoring is generally very sparse. Automated water level registrations and telemetric transfer of data are still underused. Calibration of hydrometric stations is often not adequate and data reliability suffers.

Climatically, the Nile Basin has large variations ranging from the tropical climate in the Equatorial Lake region to the Mediterranean climate of the Nile Delta. This is brought about by the latitude range (4o S to 32o N) and the variation from sea level to an altitude of around 3,000 m. Regarding rainfall, the Equatorial Lakes region and the Ethiopian Highlands receive an average annual rainfall above 1,000 mm, while the high altitude areas (Rwenzori mountains, Mount Elgon and the Ethiopian Highlands receive an average annual rainfall in excess of 1,500 mm. The northern part of Sudan and Egypt receives less than 50 mm and there are years, which are completely dry. This accentuates Egypt's and Sudan's full dependence on a steady flow of the Nile as very little surface runoff is generated there.

Temperature is a significant factor in for instance evapotranspiration and is, together with water, essential for plant growth. In the Equatorial Lakes region and the Ethiopian Highlands, maximum temperatures are recorded in the range of 30oC while parts of the Blue Nile, Tekeze-Atbara and the White Nile in Sudan are measuring maximum temperatures of 45oC. High temperatures entail large evaporation losses from water surfaces like lakes and reservoirs.

Climate change as a result of global warming, is a challenge for water resources management and development. Adaptation is the immediate response to climate change and trends and statistics have to be closely monitored as they are no longer stable. Even small changes in temperature averages or extremes can have serious consequences for water resources availability, floods and droughts, agriculture, power and transportation systems, the natural environment and even health and safety.

The Nile Basin streamflow patterns are influenced by the variations in meteorological parameters such as rainfall and evaporation as well as by the physiography in terms of among others, topography, land cover, soils and geology. This is evident when comparing the White Nile and the Blue Nile being key tributaries to the Main Nile. The Blue Nile is highly seasonal with most of its flow occurring between July and September, while the White Nile flow is almost stable over the year mainly due to the regulating effect of Lake Victoria, Lake Kyoga, Lake Albert and the Sudd (a huge wetland in South Sudan). The Blue Nile contributes almost 160 percent of the annual flow of the White Nile and has a large potential for development of dams and reservoirs, among others, for hydropower production. Seasonality is a dominant hydrologic feature in the Nile riparian nations. This exposes the countries to floods and droughts with a devastating effect on the national economies and the affected communities.

Kagera River is the southernmost river discharging into Lake Victoria. The reservoir effect of Lake Victoria makes the outflow almost constant and Jinja Dam is operated to simulate the natural outflow of roughly 900 m^3/s as an annual average. The Nile continues through Lake Kyoga and the surrounding wetlands and run through a stretch with a good hydropower potential before it joins Lake Albert at Murchison Falls. The Nile continues through South Sudan and enters the Sudd, one of the largest wetlands in the world. A huge amount (approx. 50%) of the Nile inflow is lost to evaporation when passing the Sudd. The Nile proceeds towards Khartoum, where it is joined by the Blue Nile and now, combined flows of close to 2300 m^3/s are recorded. The last significant contribution to the Nile flow comes from the Tekeze-Atbara Sub-basin where about 350 m^3/s is received on the average. The Nile enters the reservoir created by High Aswan Dam. The reservoir, Lake Nasser, has capacity to regulate Nile flows on an inter-annual basis, but causes a huge water loss by evaporation estimated at roughly 10 – 12 BCM on the average. The Nile ends its 6700 km journey at the two branches at the Delta and close to 12BCM reaches the Mediterranean Sea – with a good proportion of this volume being drainage water from irrigation fields in Egypt. Surface water quality is mainly influenced by human activities relative to urban areas and industrial activities. Sediment production takes place in the upland areas with the Ethiopian Highlands as the main source compared to other parts of the Nile Basin.

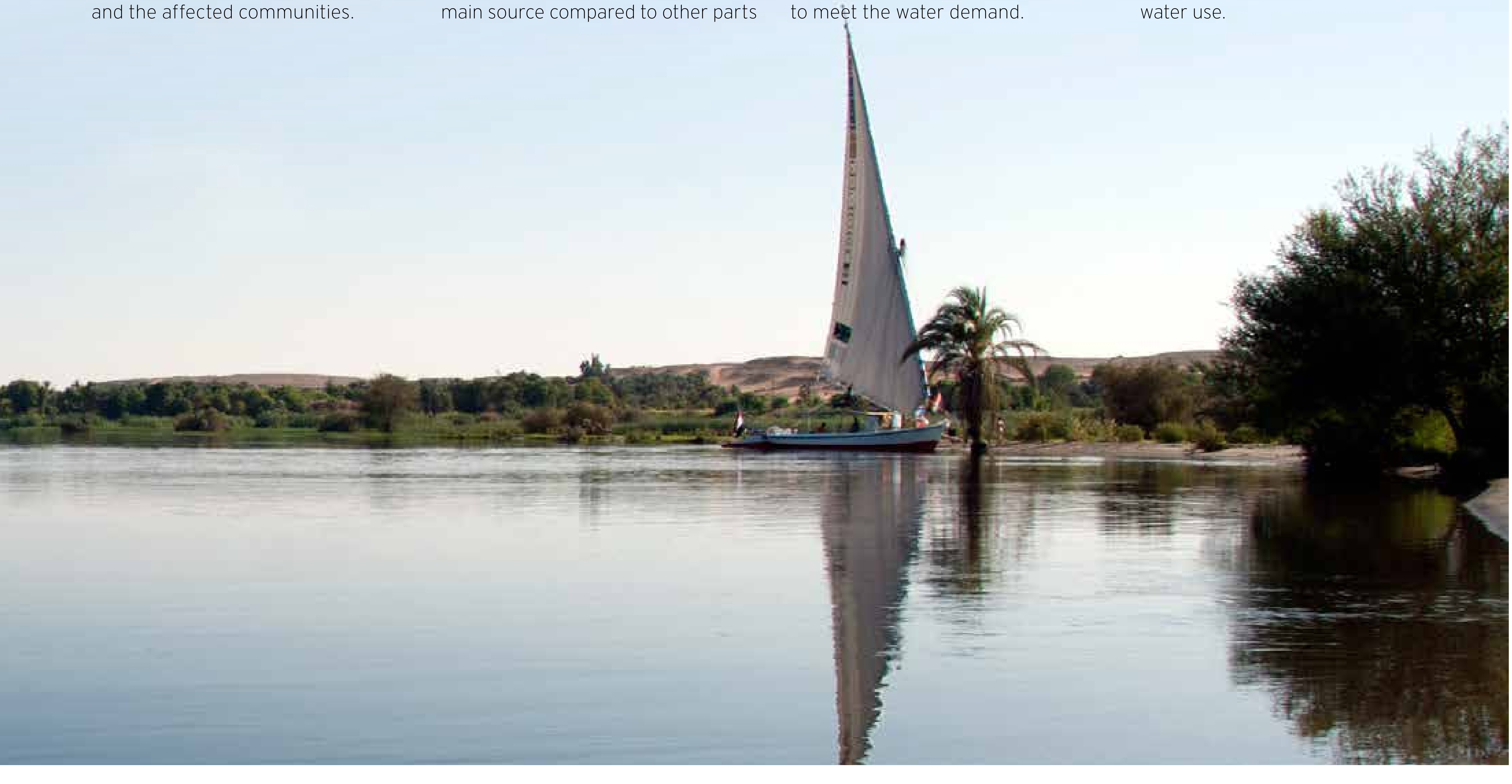
Another source of water is groundwater, which is, however, not well studied and inadequately exploited. The most significant groundwater aquifer is the Nubian Sandstone underlying part of Egypt, Sudan, Chad and a part of Libya.

The water resources in the basin are essential for sustaining life, the economy and a healthy environment. Water is used off-stream (withdrawn e.g. for agriculture or domestic use), in-stream (e.g. hydropower, fisheries, environment) or on-stream (e.g. transport, tourism). The total area under irrigated agriculture in the Basin is estimated at 5.4 million hectares – over 97percent of the area lie in Egypt and Sudan.

By far, the largest consumptive use is for irrigation, which has been estimated at 82 BCM per year with over 96 percent of this occurring in Egypt and Sudan. In a region that is beset with strong seasonal and inter-annual variation of climate, storage dams provide one way of reducing vulnerabilities of water use sectors to climate shocks. The total storage capacity of dams in the Nile Basin is estimated at about 200 BCM. Water demand for municipal and industrial use, estimated at 12.9 BCM per year is rapidly increasing from the present estimates of roughly 400 m^3/s. Forecasts for 2030 are expecting a five-fold increase and the Nile Basin population seen as a whole, will become unable to meet the water demand.

The Nile Basin is expected to undergo substantial changes as more and more hydraulic infrastructure is realized to meet the growing water demands the riparian states. According to consulted national planning documents, the total storage capacity of dams in the Basin is expected to double by around 2040 – 2050; total area under irrigation can grow to 8.7 Million Hectares – an increase of some 60 percent of current size of irrigated areas; aggregate installed capacity of hydropower plants is expected to grow from a current value of 5600 MW to over 25,000 MW.

Unless actions are taken to enhance the water supply and manage the growth of consumptive demands, in a not too distant future, the Nile Basin will thus 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. Changes in climate could very well aggravate the situation. These conditions require a very high degree of trust, cooperation and sharing of water and benefits between the riparian nations. The Nile Basin Initiative has a vital, strategic mission in facilitating the cooperation, promoting Integrated Water Resources Management, providing access to Decision Support Systems and reliable databases and raising awareness on known or innovative ways of demand management, water conservation and efficiency in water use.



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