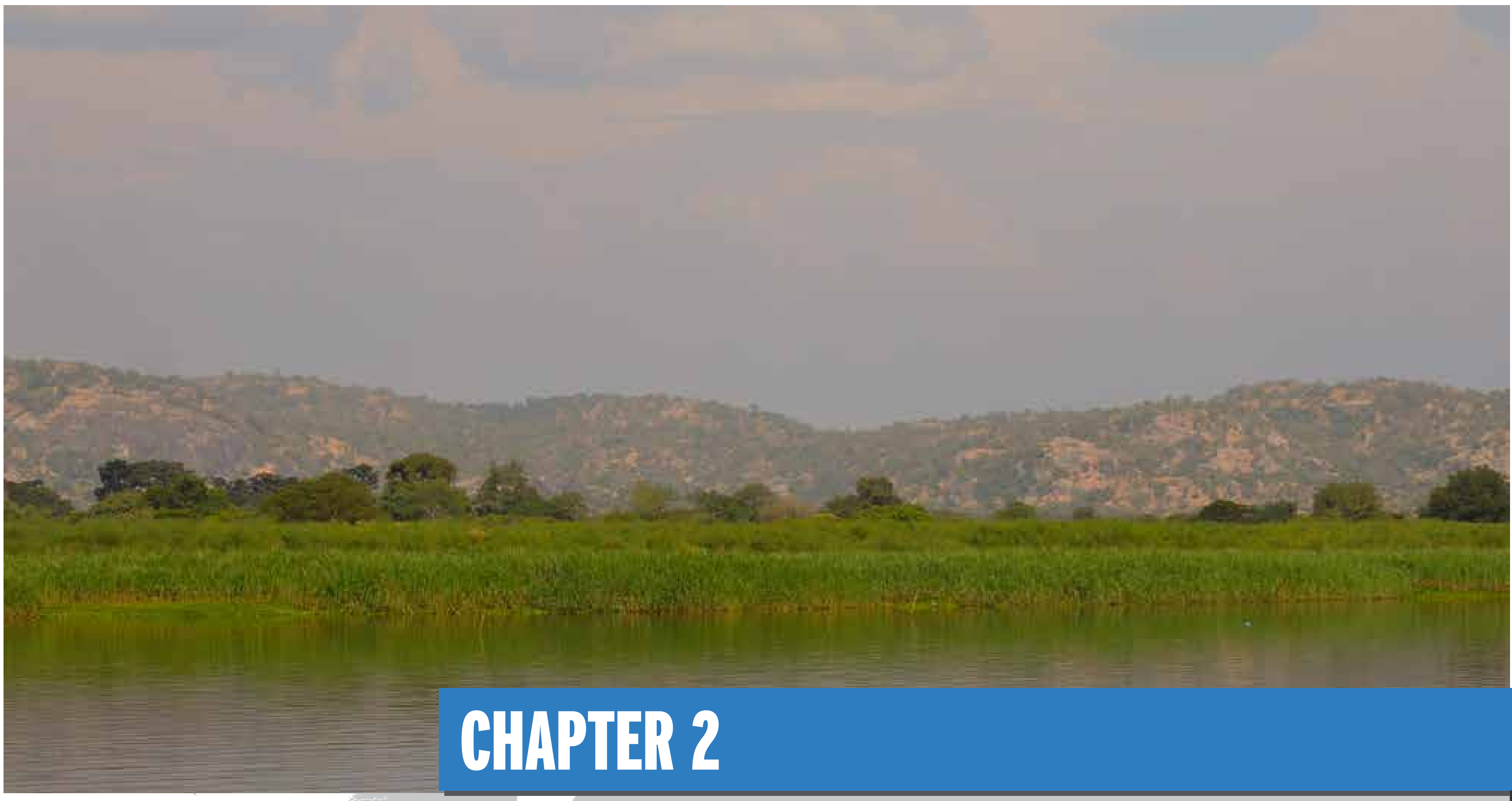


Photo: Dr. Nicholas Azza

CHAPTER 2

NILE BASIN PHYSIOGRAPHY

KEY MESSAGES

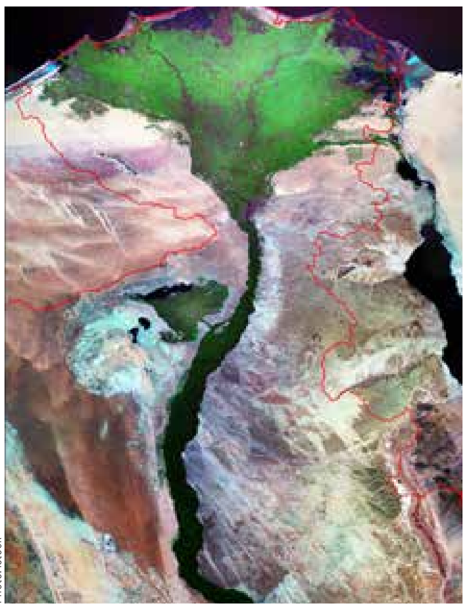


Photo: istock

Nile Delta

The Nile River basin is rich with variety of natural resources (lakes, wetlands, highlands, ecosystem, biodiversity, etc.). In the basin a large population depends on the biodiversity and flood plains for their livelihoods. However, these natural resources are under pressure and degradation from various natural forces (climate change) and human interventions. Collective actions at regional level are needed to protect, sustain resources and generate benefits.

Photo: Jørn Eriksson/flickr.com

Rwenzori mountains, Uganda

Each physiographic region in the Nile basin has a more or less unique combination of surface, slope, soils, topography and vegetation. It is rarely in the world to identify river basins with such rich diversity. Potentials of such rich diversity could be utilized to benefit its population and sustain its environment.

The topography of the Nile basin includes mountain ranges of the upper Kagera, White Nile, Blue Nile and Tekeze-Atbara rivers – to wide flood plains from the lower reaches to the delta. The patterns of topographic variables (altitude, slope and aspect) bring about the patterns, the heterogeneity and the complexity of climate, soil, vegetation, fauna, land cover and land use in connection with socio-economic interactions.

Photo: istock

Birds at Kazinga chanel, Uganda

Beside its length (the longest worldwide), the Nile River basin has many other unique features among the world large river basins, i.e. the Sudd wetland, the largest freshwater wetland in the Nile Basin; Lake Victoria is the second largest natural open surface water body; 17 wetlands sites registered by Ramsar; diverse species of flora and fauna.

Photo: A Melody Lee/ World Bank

Kitabi tea estate, Rwanda

The Nile basin is divided into sixteen terrestrial ecoregions, reflecting the great expanse of the basin. Moving through the basin from south to north, there is a gradual change in elevation and climatic conditions, producing a striking latitudinal gradation in vegetation and fauna. This gradation in ecoregions is accompanied by a marked decrease in the diversity of plant and animal species.

Land cover change by sub-basins indicates the decline of forest areas and increase of cultivated land in almost all the sub-basins.

INTRODUCTION

Photo: Vivek Bahukhandi

Albert Nile, Uganda

The Nile River flows through eleven countries (Burundi, DR Congo, Egypt, Ethiopia, Eritrea, Kenya, Rwanda, South Sudan, Sudan, Tanzania, and Uganda). The Nile basin comprises two broad sub-systems, these are the Eastern Nile sub-system and the Equatorial Nile sub-system. The basin was delineated into ten sub-basins (Main Nile, Atbara, Blue Nile, White Nile, Baro-Akobo-Sobat, Bahr El Jebel, Bahr El Ghazal, Lake Albert, Victoria Nile, Lake Victoria). These sub-basins featured five broad physiographic regions with diverse topography, drainage patterns and geomorphology.

These physiographic regions include (1) highlands - plateaus and mountains; (2) open water surfaces (lakes – both natural and man-made); (3) wetlands and swamps; (4) flat lands; and (5) deserts. Each physiographic region has a more or less unique combination of surface, slope, soils, topography and vegetation. The first two physiographic regions mainly in the upper sub-basin, and the later three regions covers mostly the mid and lower sub- basins.

The Nile River is the longest river in the world at 6,695 km, flowing northward through the tropics and the highlands of eastern Africa and drains into the Mediterranean Sea. The basin covers about one-tenth of the area of the continent, drains a total land area of 3,200,000 km^2. Beside its length, the Nile River basin contains other unique features among the world large river basins, e.g. the Sudd wetland, Lake Victoria; 17 wetlands sites registered by Ramsar and diverse species of flora and fauna.

Moving through the basin from south to north, there is a gradual change in elevation and slope (ranges 0 to 33 degrees) and climatic conditions, producing a striking latitudinal gradation in vegetation and fauna. The Nile River basin supports a range of wetland ecosystems and protected areas distributed across the entire length of the basin (national parks, wilderness areas, community conserved areas, nature reserves, and privately owned reserves).

This gradation in ecoregions is accompanied by a marked decrease in the diversity of plant and animal species in northward direction. The hydrological cycle of the Nile basin supports and maintains high productivity of biodiversity within the lakes and in the wetlands and swamps - particularly of fish, plant communities and wildlife. In the basin a large population depends on the biodiversity and flood plains for their livelihoods.

The topography of the Nile basin includes mountain ranges of the upper Kagera, White Nile, Blue Nile and Tekeze-Atbara rivers. The upper parts of the basin have a ridged topography and steep slopes. Most rivers in the Eastern Nile exhibit much steeper slope in their upper reaches compared to the rivers that originate in the Equatorial Lakes region. These steeper slopes, beside high contribution of flow, also contribute to erosion, land degradation of watersheds and downstream sediment transport.

Changes in land cover are determined by a complex set of interactions between environmental and socio-economic factors. Land cover change in sub-basins indicates the decline of forest areas and increase of cultivated land in almost all the sub-basins, indicative of increasing human activity in the basin. The Nile basin has 17 soil groups, the dominant soil group in the basin is vertisols (18.5% of basin area), followed by yermosols (16.7%). Bare areas are dominant in low lying areas, mainly desert area of the Main Nile but there are also significant bare areas in steep slopes. Soil moisture is highest in the three upper southern sub-basins (the lakes area) and lowest in the Main Nile and Tekeze-Atbara sub-basins. Agriculture is found in all categories of elevations but mainly in low lying areas (less than 502 m) and medium elevation areas (890 – 1,454 m) and also practiced in some steep slope areas. Forest is dominant in the elevation range between 500 m and 2,159 m and shrub-land is dominant in the elevation range between -47 and 1,454 m and in steep slope areas (30 – 33 degrees).

RELIEF CHARACTERISTICS

Topography

The topography of the Nile Basin includes mountain ranges of the Upper Kagera, White Nile, Blue Nile and Tekeze-Atbara rivers. The upper parts of the basin have a ridged topography and steep slopes. There are large plateau regions along the middle reaches of the basin and wide flood plains from the lower reaches to the delta.

Photo: Lars Nilse/Flickr.com

Crater lake in western Uganda

Photo: The World Bank

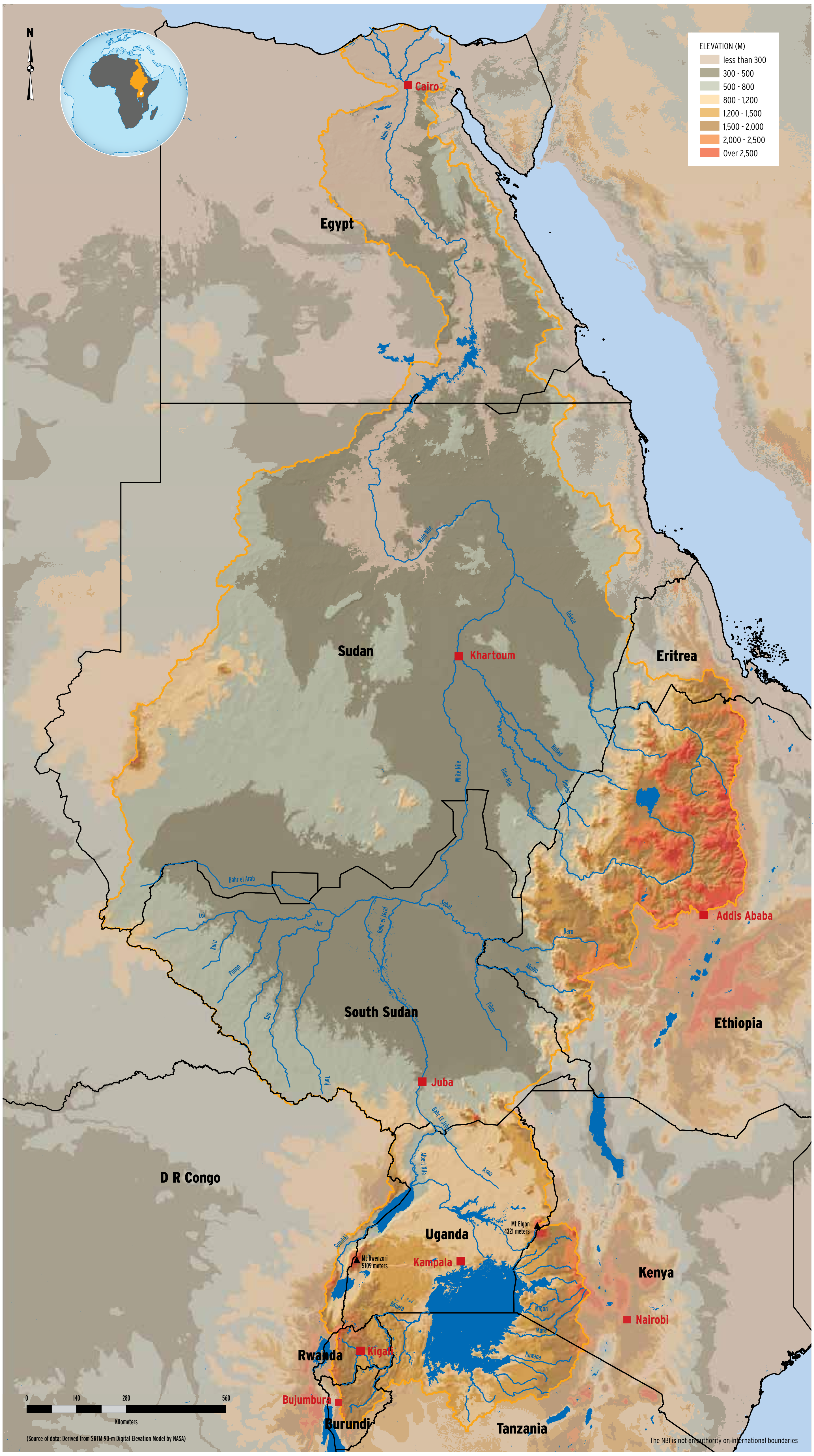
Kenyan grasslands

Photo: John Eriksson/flickr.com

Rwenzori mountain ranges

Photo: John Eriksson/flickr.com

Rwenzori mountains, Uganda

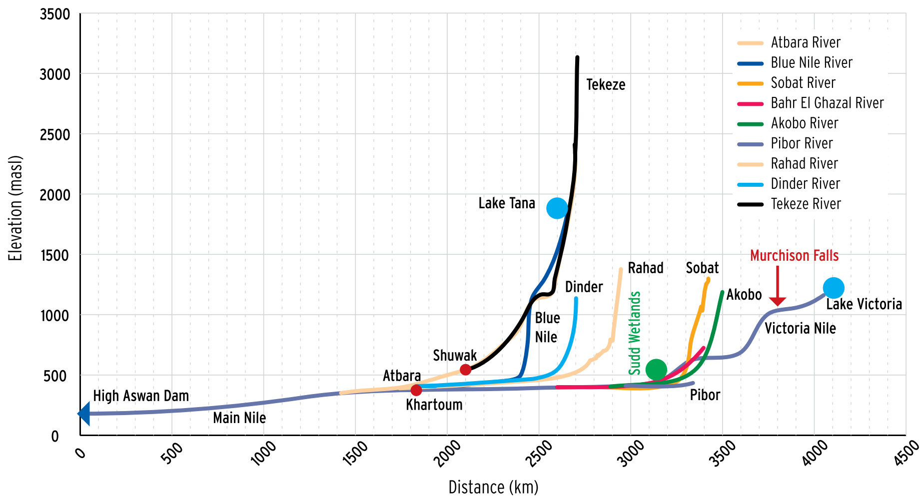


Slope range in the Nile Basin

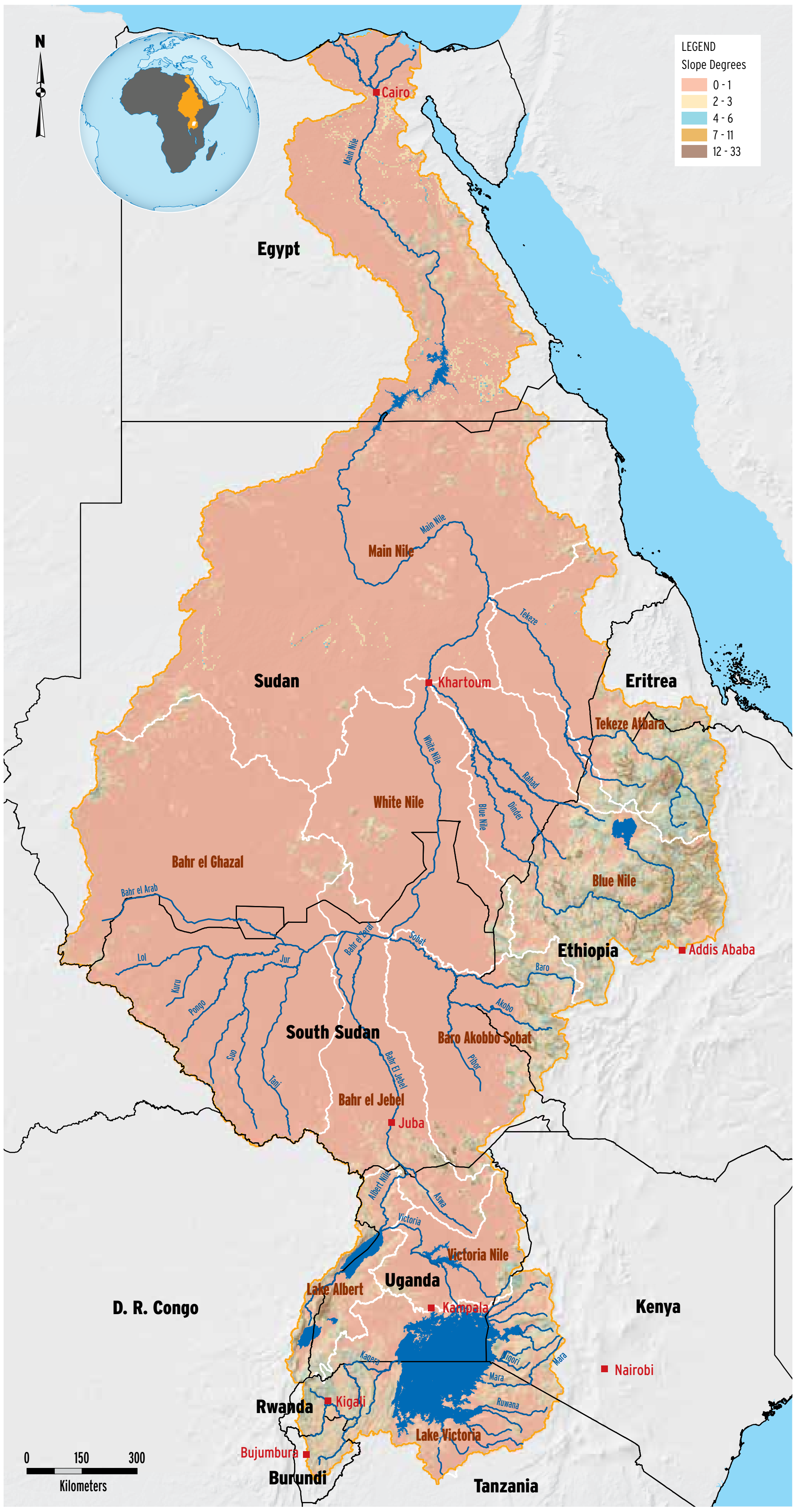
The slope gradient is one of the most important factors affecting soil erosion by the surface runoff. Under the same rainfall condition, the surface runoff velocity could be drastically different on different slopes, and thus the amount of eroded soil could also be very different. The slope in the basin varies between 0 and 33 degrees.

A valley in Rwanda with tea plants

Longitudinal profiles of major tributaries on the Nile



The longitudinal bed profiles of main rivers are shown in the adjacent figure. The graph shows elevation (metres above sea level, masl) of river bed as a function of distance from a selected common downstream point, in this case, the High Aswan Dam. Most rivers in the Eastern Nile exhibit much steeper slope in their upper reaches compared to the rivers that originate in the Equatorial Lakes region. The rivers in their steep slope reaches have high energy gradients and are capable of transporting high sediment loads, as observed in the rivers originating in the Ethiopian highlands. In contrast, the rivers originating from the Equatorial Lakes region (Victoria Nile, Albert Nile and Bahr El-Jebel) show breaks in the slopes of the river bed, which are points where the river passes through lakes and swamp areas.



(Source of data: SRTM 90-m Digital Elevation Model by NASA)

The NBI is not an authority on international boundaries

Simien mountain range in northern Ethiopia

Geology of the Nile Basin

Crystalline basement rocks, which comprise of crystalline igneous and metamorphic rocks of the Precambrian age are present across the area, but mainly in the upstream parts of the basin. With the exception of metamorphic rocks the parent material is essentially impermeable, and productive aquifers occur where weathered overburden and extensive fracturing are present.

Photo: Milly Mbuliro

Hills in Ethiopian highlands

Photo: Thomas Favre-Bulle/flickr.com

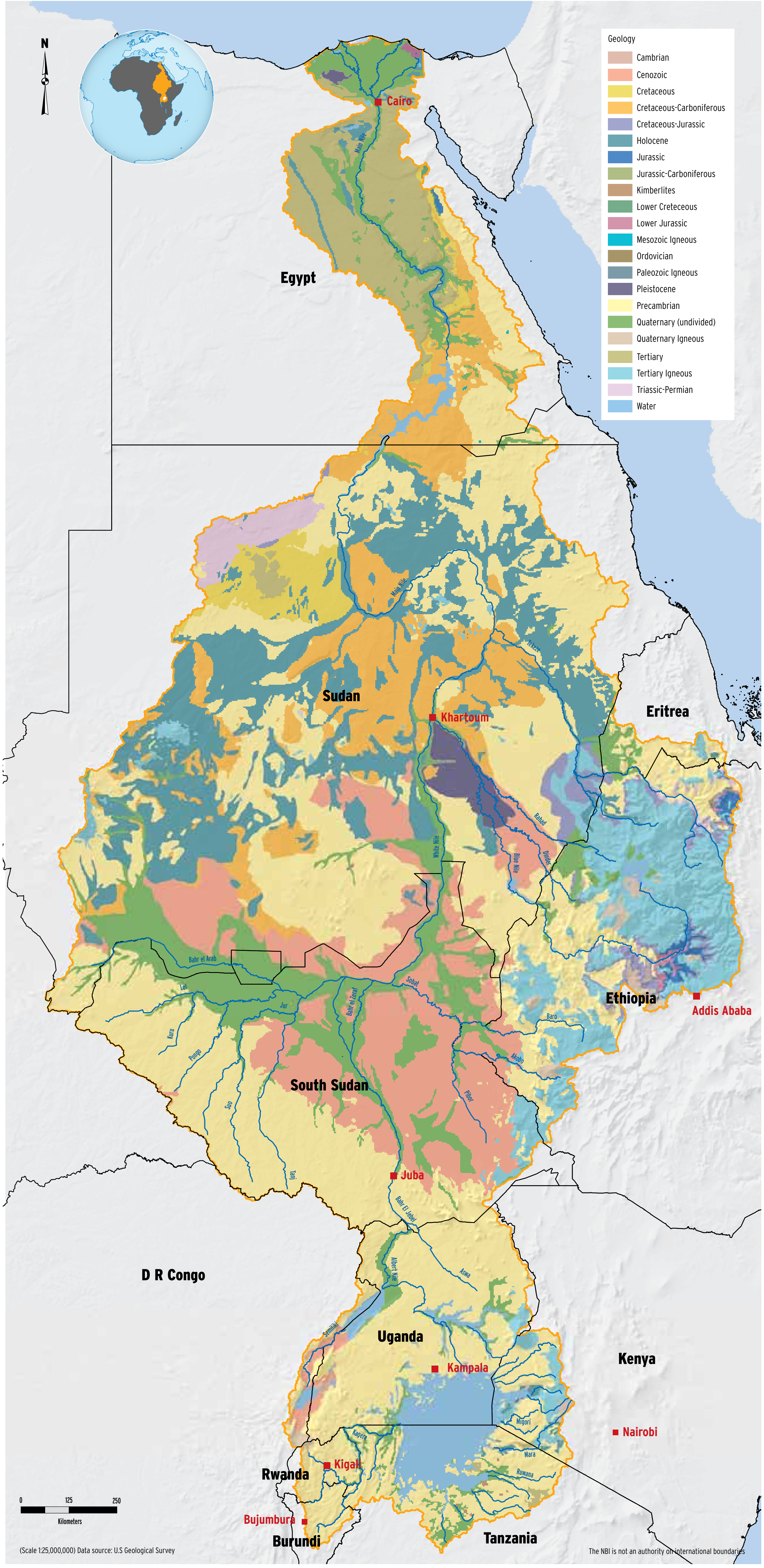
Egyptian desert

The crystalline basement upper and middle catchment watercourses collectively considered as making up the Bahr el Ghazal system.

The Muglad cretaceous rift basin underlies the very subdued topography of the Sudd and the lower reaches of the Bahr el Ghazal.

Tertiary and Pleistocene sedimentary infill dominates the lower parts of the basin. Consolidated sedimentary rocks are highly variable and can comprise low permeability mudstone and shale, as well as more permeable sandstones, lime stones and dolomites, forming some of the most extensive and productive aquifers.

Unconsolidated sedimentary aquifers are present in many river valleys. Volcanic rocks occupy the uplands (mainly the Ethiopian highlands), where they form highly variable, and usually highly important, productive aquifers.



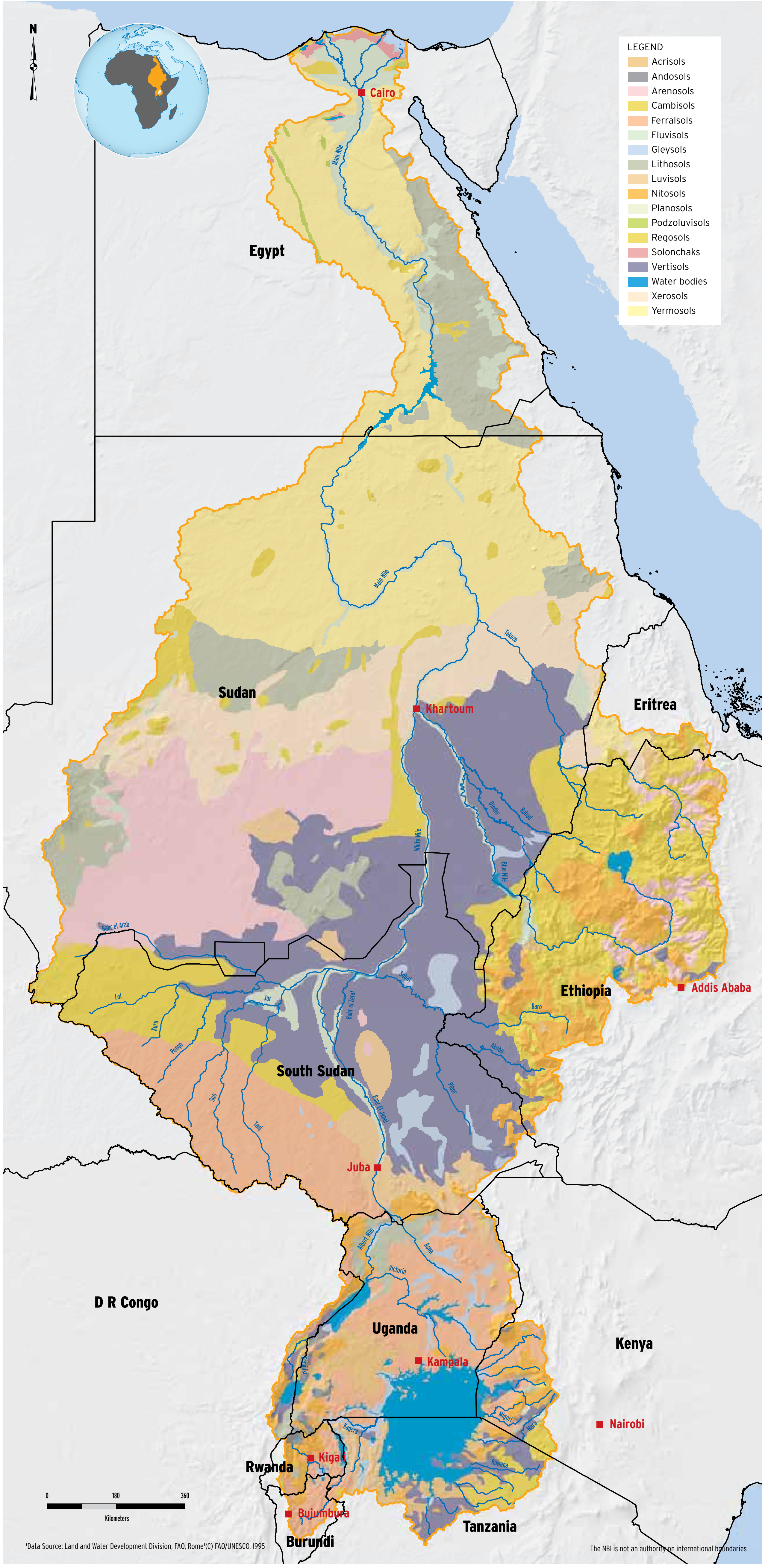
Soil types in the basin

According to the World Reference Base for Soil Resources (WRB), which is the international taxonomic soil classification system, Nile Basin has 17 dominant soil groups.

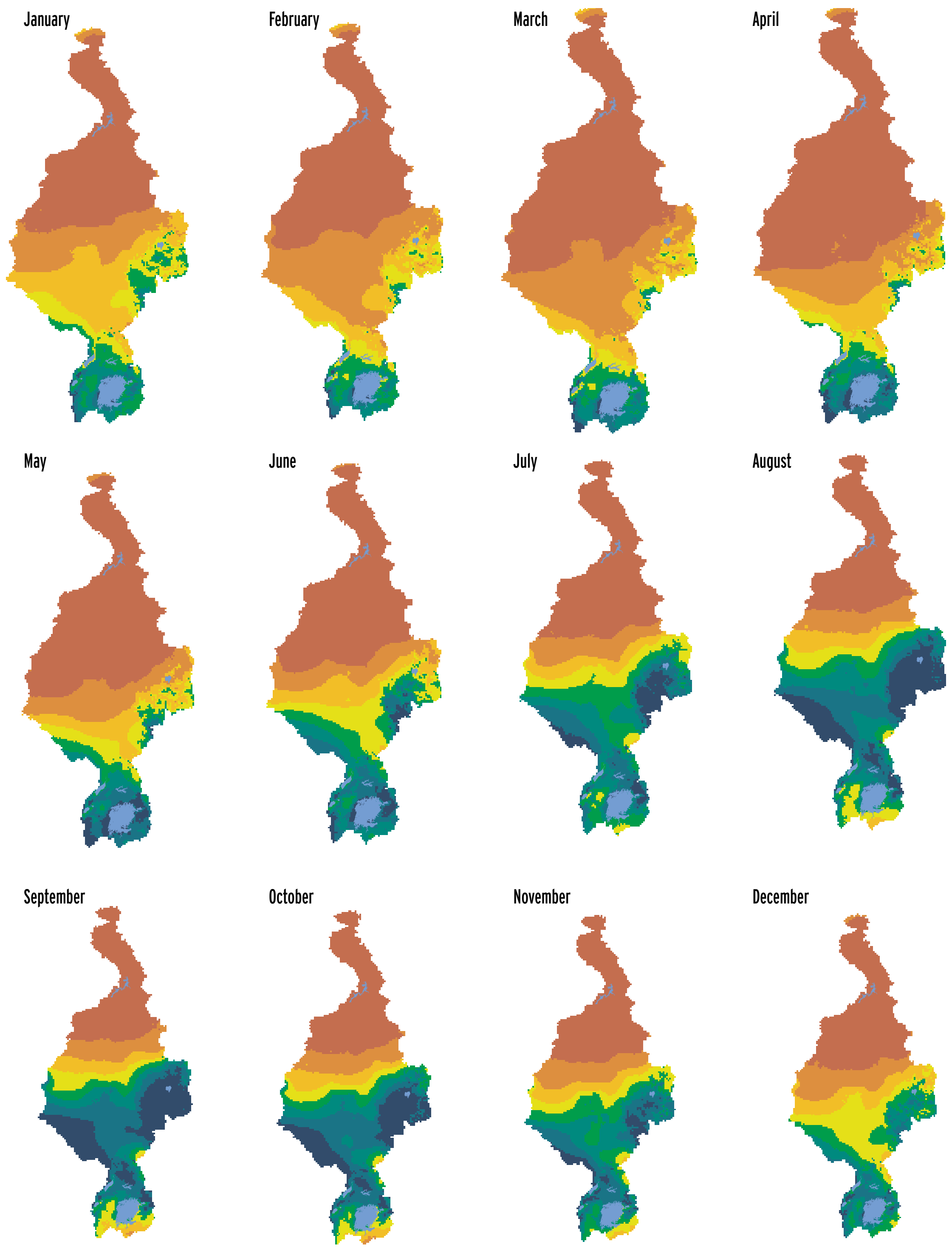
The characteristics of the soil groups are as tabulated in Annex A

The dominant soil group in the basin is vertisols (18.5% of the total basin area), followed by yermosols (16.7%).

Dominant Soil	Area (km^2)	Percentage of Area
Acrisols	44,985	1.4
Andosols	7,267	0.2
Arenosols	284,955	9.0
Cambisols	224,354	7.1
Ferralsols	314,978	9.9
Fluvisols	115,040	3.6
Gleysols	55,855	1.8
Lithosols	235,957	7.4
Luvisols	73,978	2.3
Nitosols	159,521	5.0
Planosols	860	0.0
Podzoluvisols	3,930	0.1
Regosols	210,591	6.6
Solonchaks	5,330	0.2
Vertisols	587,655	18.5
Water bodies	91,303	2.9
Xerosols	228,120	7.2
Yermosols	530,263	16.7



Spatial temporal variation of soil moisture in the basin



Fringing swamp

Soil moisture is defined as the ratio of water content in the soil in percentage of volume or weight. It is the measure of the amount of water in the vadose zone (unsaturated zone). Soil moisture is a key variable for understanding hydrological processes in the unsaturated zone. It plays an important role in weather and climate predictions from the regional to the global scale by controlling the exchange and partitioning of water and energy fluxes at the land surface. Agricultural and irrigation management practices, especially in semi-arid and arid regions, largely depend on timely and accurate characterization of temporal and spatial soil moisture dynamics in the root zone because of the impact of soil moisture on the production and health status of crops and salinization (Vereecken et al, 2008).

SOIL MOISTURE CONTENT (PERCENT)

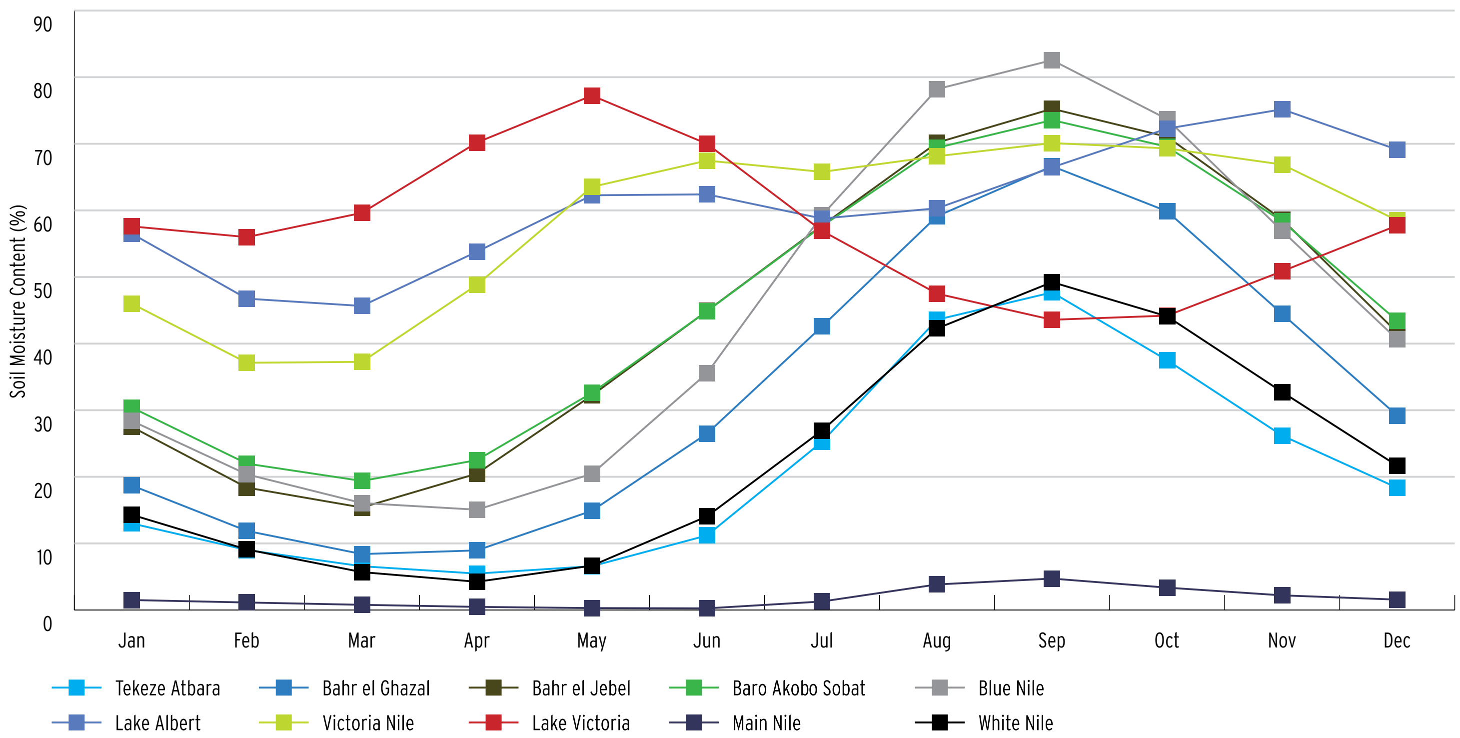
0 - 6
7 - 17
18 - 28
29 - 39
40 - 51
52 - 64
65 - 80
81 - 100

Data source: This dataset is based on modeling and analyses by Antonio Trabucco (Forest Ecology and Management Research Group, K.U. Leuven) with the support of the IWMI and ICIMOD and provided online by CGIAR-CSI

Average monthly soil moisture variation per sub-basin

Soil moisture variation is determined as the percentage of the maximum amount of soil moisture available for Evapotranspiration (ET) processes within the plant rooting depth which is equal to soil water content at field capacity minus soil water content at wilting point times the rooting depth.

The monthly variation of soil moisture shown in the maps track the rainfall season, as observed clearly in the eastern Nile, where high soil moisture content starts in June and continue in rise through October and in decrease in November and lowest in February – March. The soil moisture is highest in the three upper southern sub-basins and lowest in the Main Nile and Tekeze-Atbara sub-basins.



ECO-REGIONS IN THE NILE BASIN

An ecoregion is defined as a geographically dinstict assemblage of plants and animals that share similar environmental conditions and interact in such ways as to enhance their collective long term survival.

The Nile Basin is divided into sixteen terrestrial ecoregions, reflecting the great expanse of the basin. These are Victoria Basin forest savannah mosaic, Miombo woodlands, Acacia –Commiphora bushlands and thickets, the Ethiopian montane grasslands and woodlands, Sudanian savannah, Sahelian Acacia savannah, saharah desert and the Saharan woodlands and steppe.

Moving through the basin from south to north, there is a gradual change in elevation and climatic conditions, producing a striking latitudinal gradation in vegetation and fauna. This gradation in ecoregions is accompanied by a marked decrease in the diversity of plant and animal species.


Photo: istock

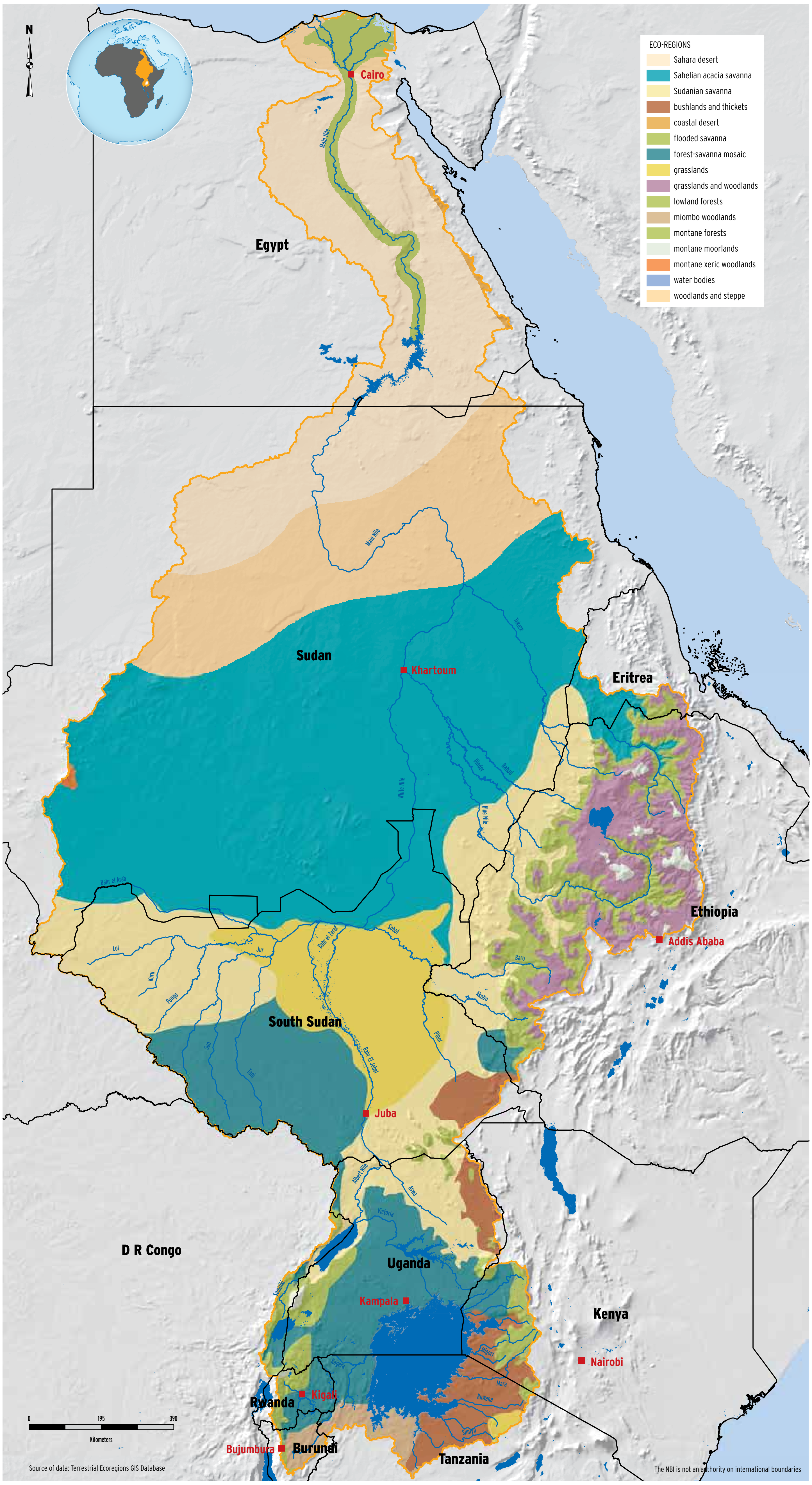
Mara River


Photo: Milly Mbuliro

Invasive cactus species in a woodland


Photo: Bernard Dupont/flickr.com

Mabira forest undergrowth



LAND COVER IN THE NILE BASIN

Land use/cover in the Nile Basin

According to ESA GlobCover project, 2009, the main land use/cover in the basin are bare areas (31%), shrublands (29%), cultivated land (23%), forest (7%) and grassland (6%).

Among the environmental variables, topography is of special importance. Topographic variables comprise altitude, slope and aspect. The patterns of altitude, slope and aspect bring about the patterns, the heterogeneity and the complexity of climate, soil, vegetation, fauna, land cover and land use in connection with socio-economic interactions. In Nile Basin, agriculture is found in all categories of elevations but mainly in low lying areas (less than 502 m) and medium elevation areas (890 – 1,454 m) and also practiced in some steep slope areas. Forest is dominant in the elevation range between 500m and 2,159 m and shrubland is dominant in the elevation range between -47 and 1,454 m and in steep slope areas (30 – 33 degrees). Bare areas are dominant in low lying areas, mainly desert area of the Main Nile but there are also significant bare areas in steep slopes.

Photo: FAO/ Matthias Mugisha

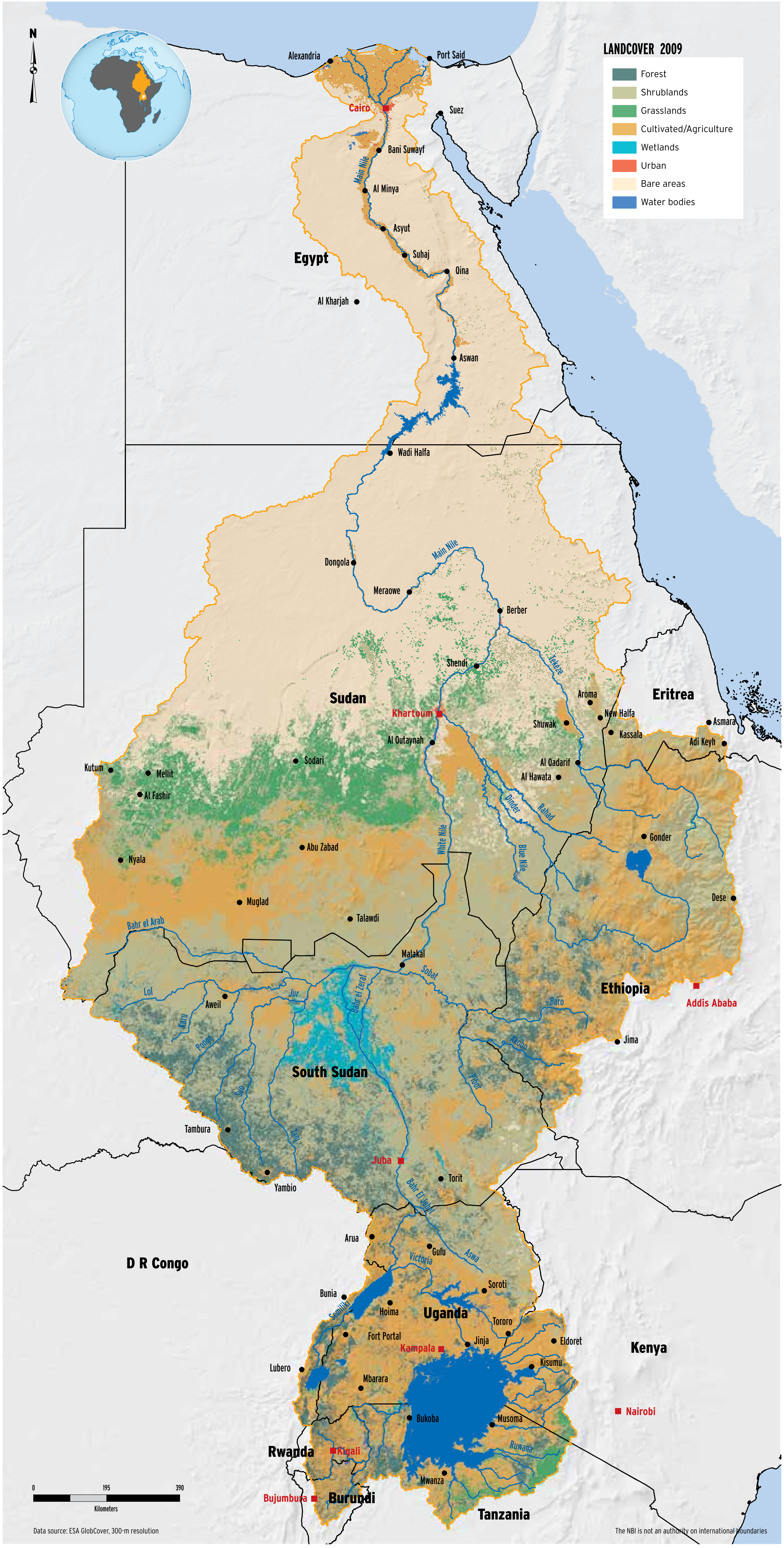
Kapchorwa, Uganda

Photo: istock

Cassava field

Photo: Vivek Bahukhandi

Bwindi Impenetrable Forest. Uganda

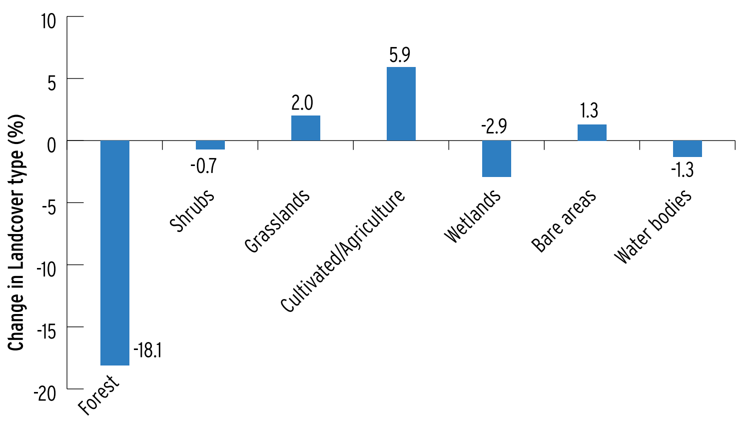


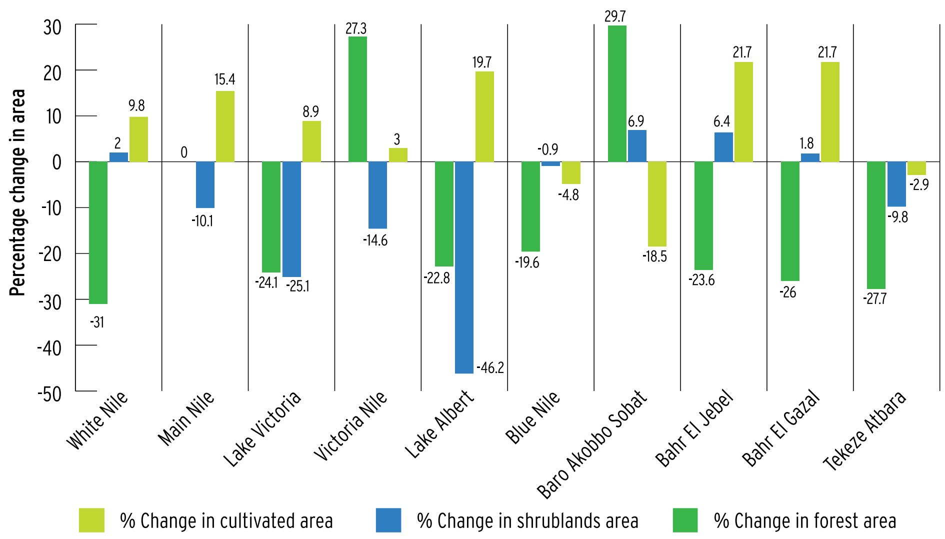
Change in land cover between 2005 and 2009

Changes in the land cover are determined by a complex set of interactions between environmental and socio-economic factors. Classified satellite images for the years 2005 and 2009 show substantial changes in different land covers. These changes are considered to reflect natural expansion and contraction in the area of vegetation types, as well as human induced land use changes. Major changes have been observed in the Mau Complex due to human encroachment. Other critical watersheds affected are the montane ecosystem of Mt. Elgon, Mt. Rwenzori and the Ethiopian Highlands.

Land cover change by sub-basins indicates the decline of forest areas and increase of cultivated land in almost all the sub-basins.

Tea plantations at Gikongoro, Rwanda





Name	Class	% change 2005 - 2009	Change (km²) 2005 - 2009
Forest	4	-18.1	-46803.29
Shrubs	6	-0.7	-6605.15
Grasslands	7	2.0	3609.61
Cultivated/Agriculture	8	5.9	40239.18
Wetlands	9	-2.9	-1458.22
Bare areas	12	1.3	12517.51
Water bodies	13	-1.3	-1261.41

Terrace farming in Rwanda

PROTECTED AREAS IN NILE BASIN

A protected area is defined as a geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long term conservation of nature with associated ecosystem services and cultural values.

Protected areas can take on many different forms, such as national parks, wilderness areas, community conserved areas, nature reserves and privately owned reserves.

The Serengeti and Masai Mara national parks feature the world famous annual migration of wildebeest, zebra and buffalo.

The Sudd in South Sudan features equally impressive mass migrations of large mammals. Other Transboundary conservation areas of considerable significance are the three connected national parks of the Virunga Mountain chain (Virunga National Park, Karisimbi National Park and Bwindi National Park), home to the world's only remaining population of mountain gorilla.

The Boma National Park, sometimes called - the Boma Jonglei National Park, is home to a variety of animals: elephants, giraffe and buffalo. It has numerous types of antelopes like: white-eared kob, common eland, lesser kudu, Bohor reedbuck, gazelles, tiang, Lelwel hartebeest, Beisa oryx and roan. And an impressive diversity and variety of birds; most of which are migratory.

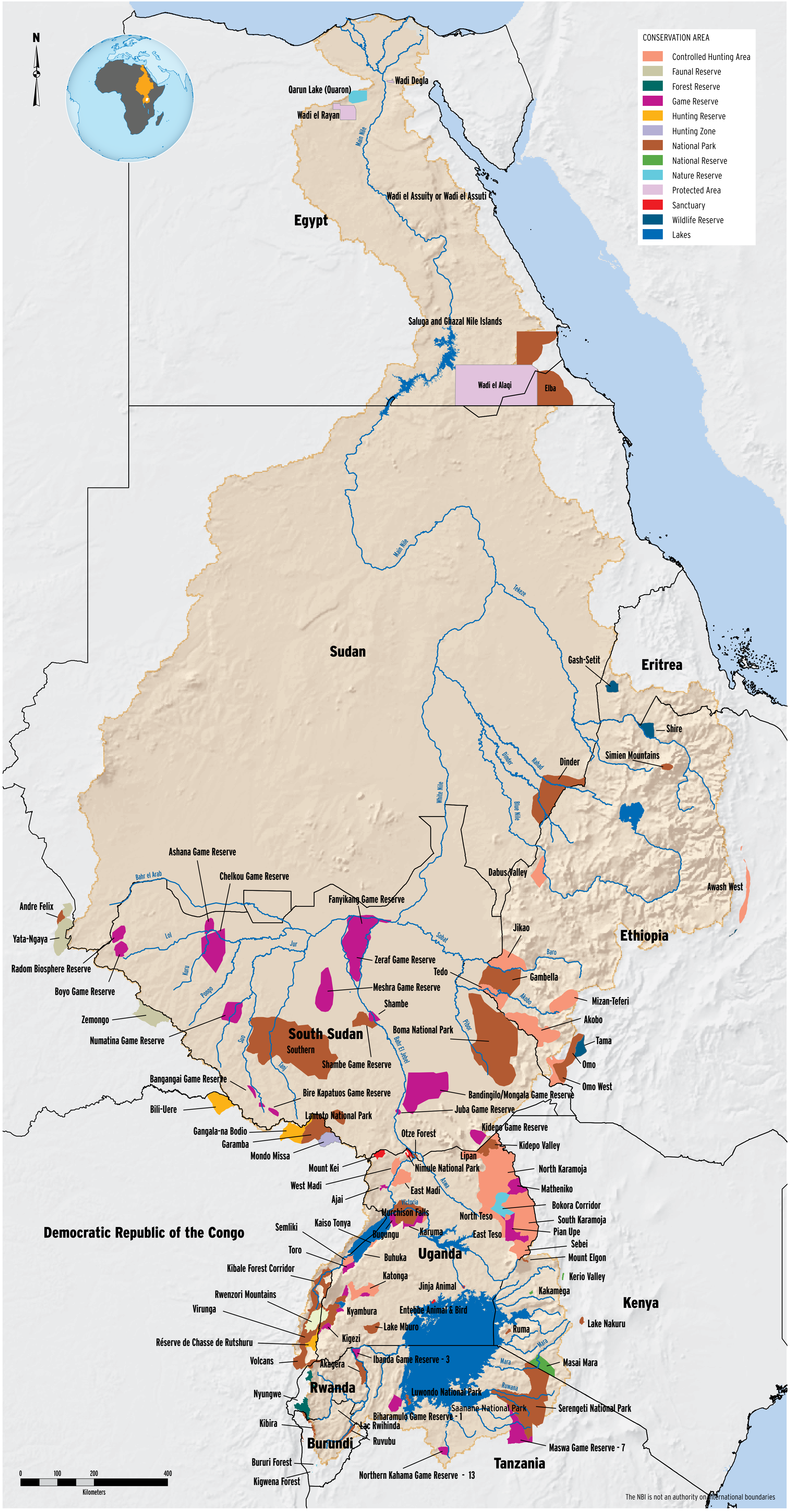
Gambela National Park is located on the Akobo river system, it hosts several wildlife not found elsewhere in Ethiopia. Originally the park was created for protection of extensive swamp habitat and wildlife species.

Photo: Vivek Bahukhandi

Kobus kob thomasi in Queen Elisabeth National Park, Uganda

Photo: Vivek Bahukhandi

Mountain gorilla at Bwindi Impenetrable Forest, Uganda



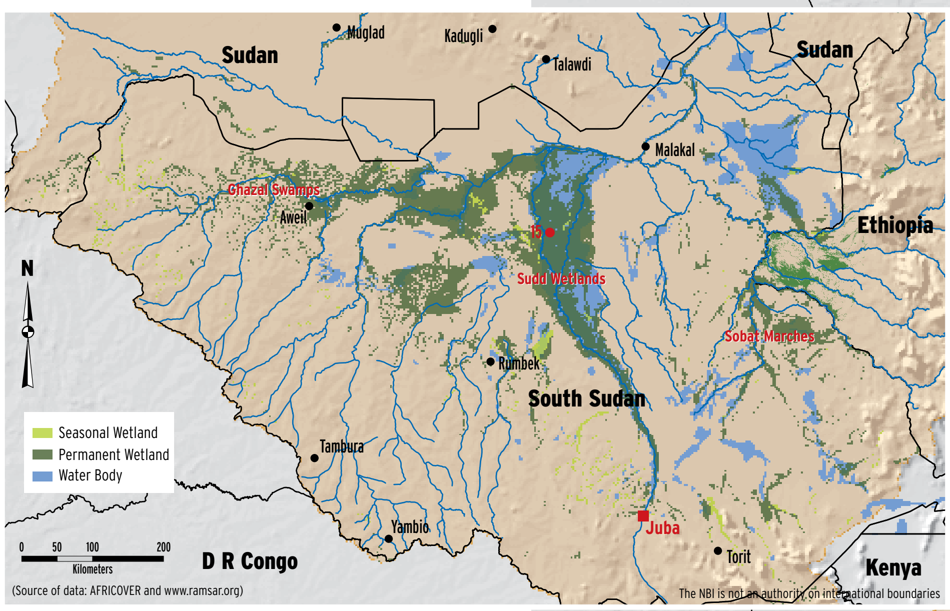
WETLANDS IN THE NILE BASIN

Wetlands are valuable ecosystems that play an important role in maintaining environmental quality, sustaining livelihoods and supporting biodiversity. The wide range of animal and plant species wetlands support provide ecosystem that services in the form of fisheries, fuel-wood, timber, medicines, and the local and global biodiversity, providing high ecological, cultural and economic value through recreation and tourism. Wetlands also exert significant influence on the hydrological cycle, altering flood flows, maintaining low flows and groundwater recharge. Wetlands that are registered by Ramsar as wetlands of international importance in the Nile Basin are presented below.


Photo: Dr. Nicholas Azza

Papyrus on River Nile, Uganda

Wetlands of Bahr El Ghazal and Bahr El Jebel sub-basin



(Source of data: AFRICOVER and www.ramsar.org)

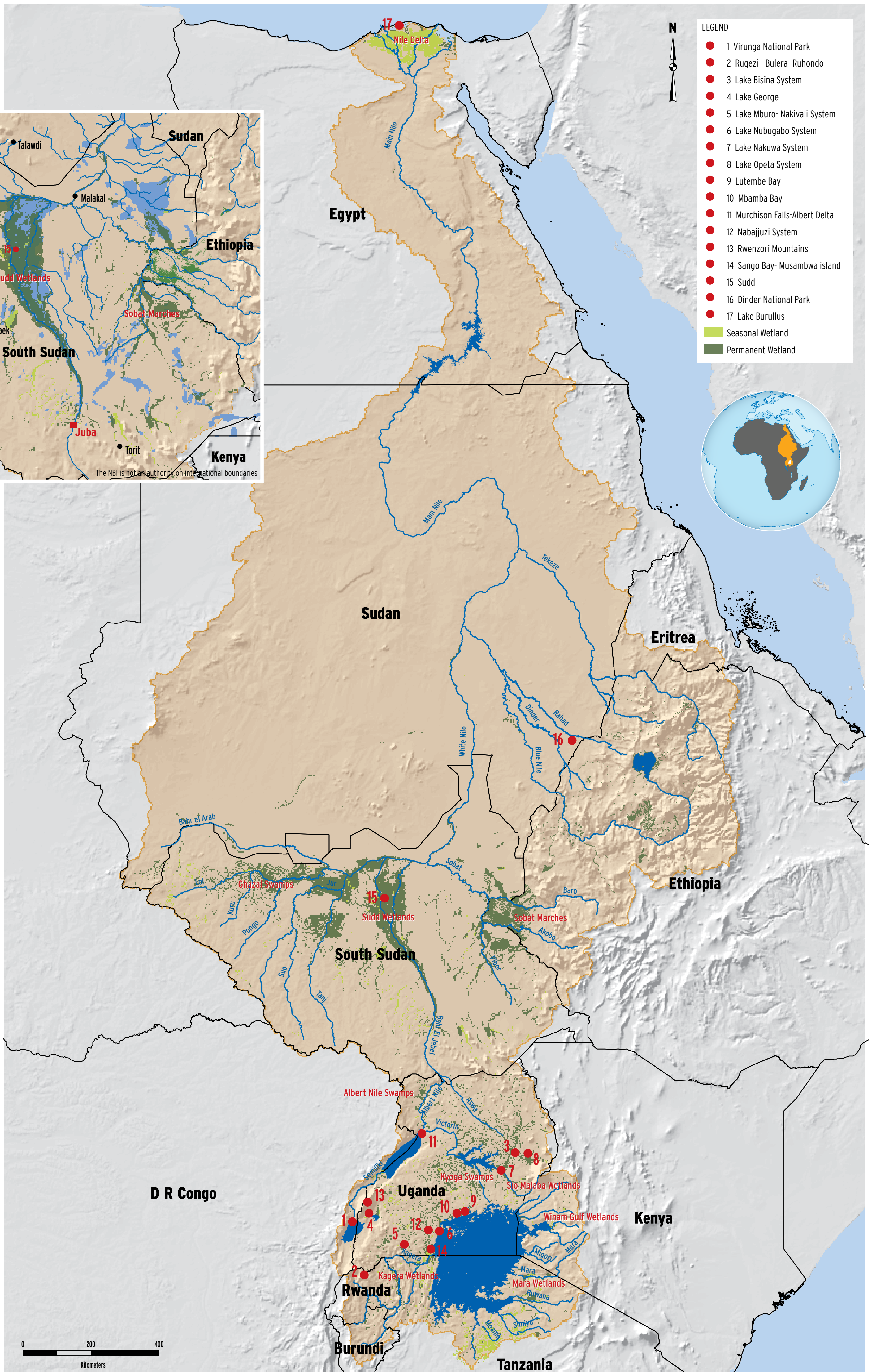
The NBI is not an authority on international boundaries

The Sudd wetland is one of the largest wetland areas worldwide and is located along the Nile in southern Sudan between Mongalla in the south and Malakal in the north, covering an area between 57,000km² - 130,000km². The size of the wetland is variable, consisting of permanent swamps during the dry season (November until March) and seasonal swamps, created by flooding of the Nile (Bahr el Jebel), in the wet season (April until October).


Photo: istock

Papyrus plant, common in Nile basin wetlands

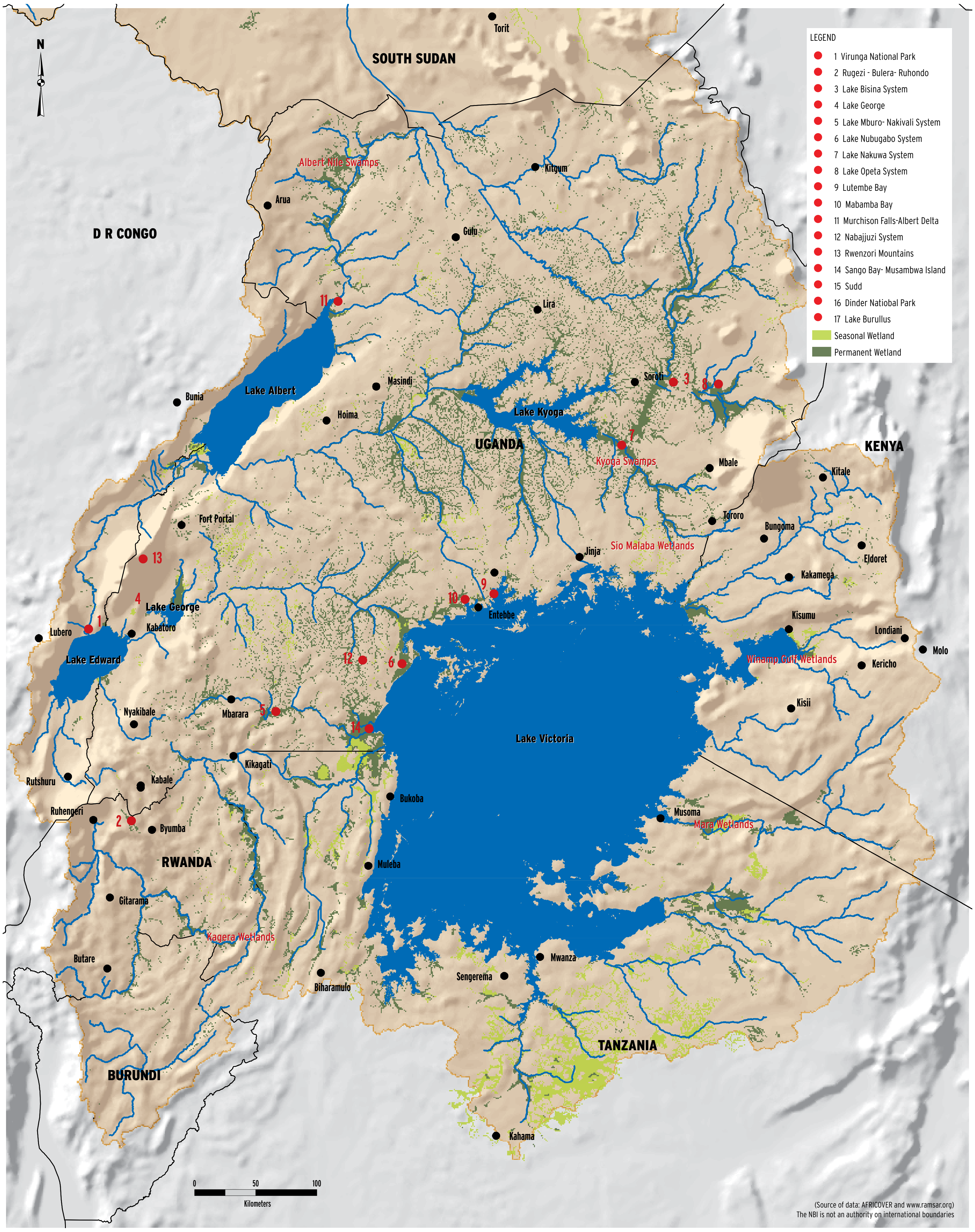
Wetland and Ramsar sites in Nile Basin



(Source of data: AFRICOVER and www.ramsar.org)

The NBI is not an authority on international boundaries

Wetlands in the Nile Equatorial Lakes Region



Name	Country	Sub-basin	Area (km²)	Dominant Type
Virunga National Park	DRC	Lake Albert	8,000	Permanent freshwater lakes
Rugezi- Bulera Ruhondo	Rwanda	Lake Victoria	85	Permanent freshwater marshes
Lake Bisina Wetland System	Uganda	Victoria Nile	542	Permanent freshwater lakes
Lake George	Uganda	Lake Albert	150	Permanent freshwater lakes
Lake Mburo- Nakivali Wetland System	Uganda	Lake Victoria	268 - 837	Permanent freshwater lakes
Lake Nabugabo	Uganda	Lake Victoria	220	Permanent freshwater lakes
Lake Nakuwa	Uganda	Victoria Nile	911	Permanent freshwater marshes or pools
Lake Opeta	Uganda	Victoria Nile	689	Permanent freshwater marshes or pools
Mbamba Bay	Uganda	Lake Victoria	24	Permanent freshwater marshes or pools
Murchison Falls-Albert Delta	Uganda	Victoria Nile	172	Permanent freshwater marshes or pools
Nabajjuzi	Uganda	Lake Albert	17	Permanent freshwater marshes or pools
Rwenzori Mountains	Uganda	Lake Victoria	995	Seasonal/intermittent freshwater lakes/rivers
Sango Bay- Musambwa island	Uganda	Lake Albert	551	Seasonal/intermittent freshwater lakes
Sudd	South Sudan	Bahr El Jebel	57,000	Permanent/seasonal rivers
Dinder National Park	Sudan	Blue Nile	10,846	Seasonal/intermittent freshwater lakes/rivers
Lake Burullus	Egypt	Main Nile	426	Permanent freshwater marshes or pools
Bahr El Ghazal swamps	South Sudan	Bahr El Ghazal		Permanent/seasonal rivers
Sobat/Machar Marches	South Sudan	Baro Akobbo Sobat	4,041	Permanent/seasonal rivers

Hydrological functions of major wetlands in the Nile Basin

Wetland	Hydrological functions
Wetlands of Uganda	Most of the individual wetlands link to other wetlands through a complex network of permanent and seasonal streams, rivers. and lakes, making them an essential Part of the entire drainage system of the country (UN-WWAP and DWD,2005)
Headwater wetlands of the Baro Akobo	Regulate flow in the Baro Akobo River while believed to play an important role in maintaining downstream dry-season river flows
Lake Albert	Critical link between the White Nile and its headwaters; without the flow regulation of this lake the White Nile would be reduced to a seasonal stream and could play no significant role in maintaining the base flow of the main Nile (Talbot and Williams, 2009)
Sudd, Machar Marshes and wetlands of the Bahr Ghazal	Significantly attenuate flows of the White Nile and its tributaries reducing flood peaks and supporting dry-season river flows, thereby minimizing the seasonal variation in the flow of the White Nile (Sutcliffe and Widgery, 1997; Sutcliffe and Parks, 1999)
Nile Delta	Limits saline intrusion from the Mediterranean Sea, thereby protecting coastal freshwater sources (Baha El Din, 1999)

(Source: IWMI, 2012)

MAJOR SUB-BASINS OF THE NILE

The Nile Basin covers an area of about 3,176,541 km² in eleven countries. The Nile Basin Comprises two broad sub systems. These are the Eastern Nile sub system and the Equatorial Nile sub system. The basin is further divided into ten Major sub-basins. The Eastern Nile sub sytem comprises the Main Nile Sub-basin, Tekeze-Atbara Sub-basin, Blue Nile Sub-basin and the Baro- Akobo-Sobat Sub-basin. The Equatorial Nile sub system comprises of Lake Victoria sub-basin, Albert Nile Sub-basin, Victoria Nile Sub-basin, Bahr el Jebel Sub-basin, White Nile Sub-basin and Bahr el Ghazal Sub-basin.

Photo: istock

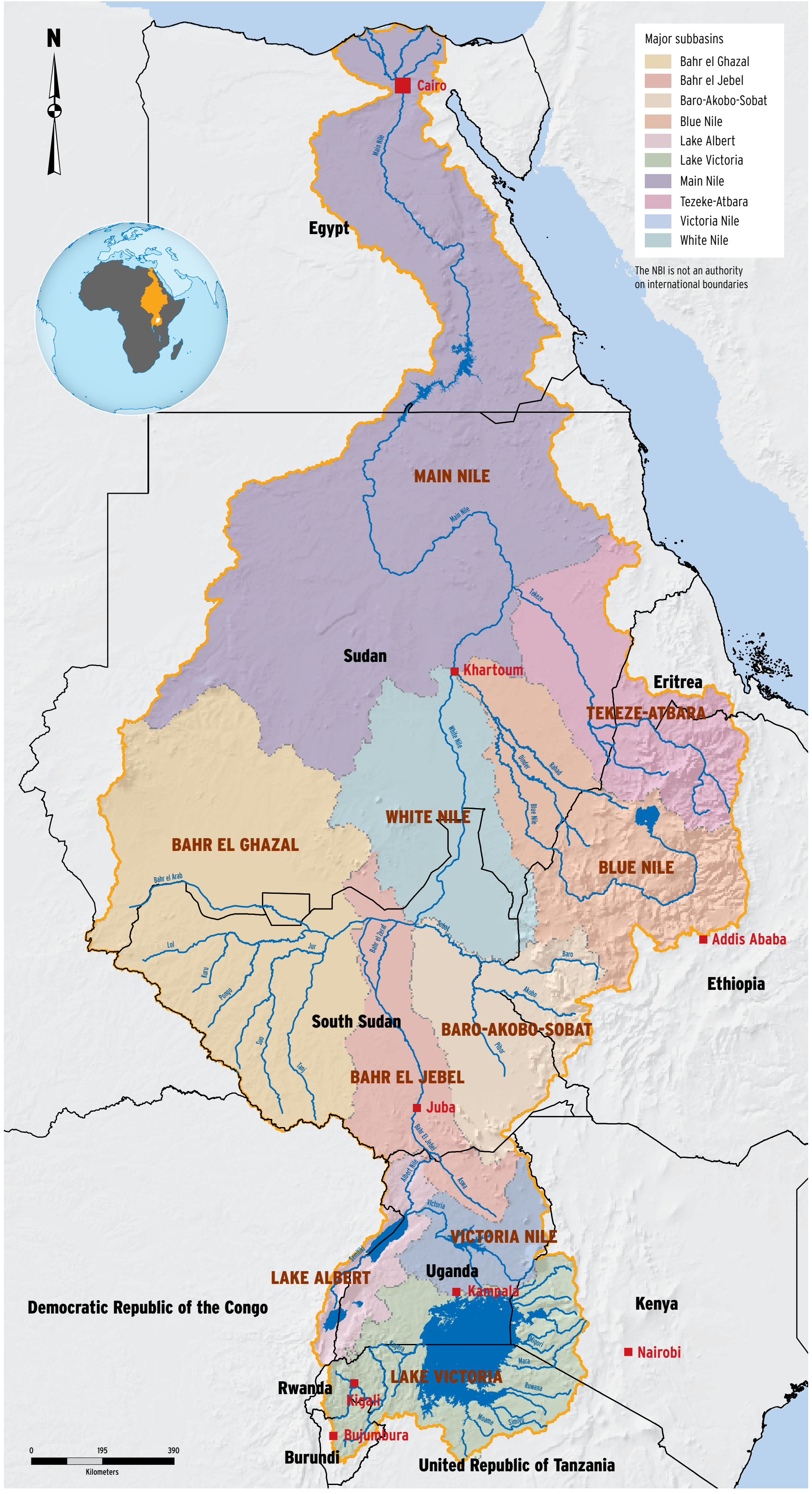
Landscape in Ethiopia near Ali Doro

Photo: istock

Lake Kivu Rwanda

Photo: istock

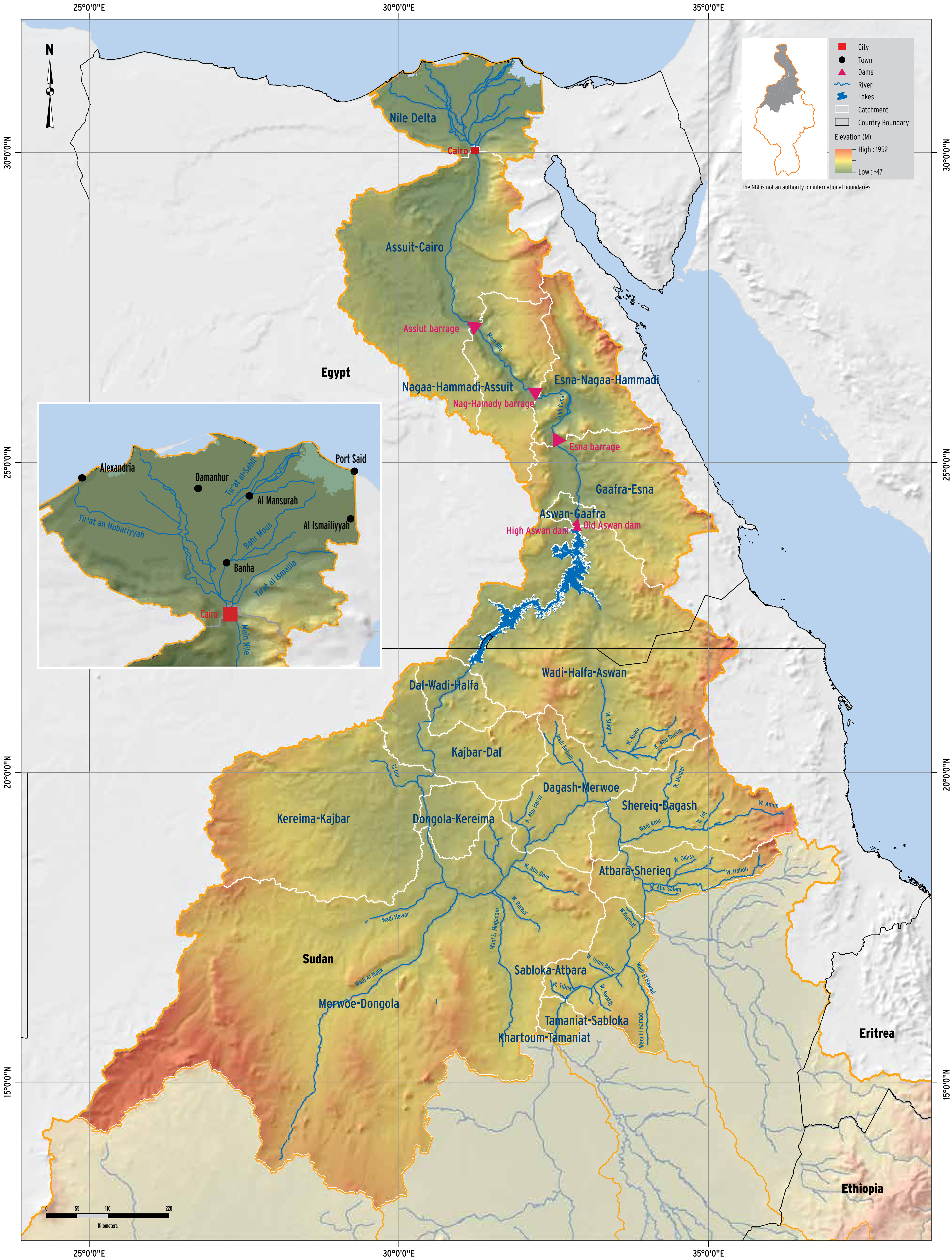
Aswan view



Sub-basin	Area (Km²)
Lake Victoria	241,893
Lake Albert	96,807
Victoria Nile	85,521
Bahr el Jebel	185,364
Bahr el Ghazal	604,746
Baro-Akobo-Sobat	204,288
White Nile	258,803
Blue Nile	304,656
Tekeze-Atbara	232,374
Main Nile	958,872

The Main Nile Sub-basin

The Main Nile encompasses the downstream river reach, starting at the Blue–White Nile confluence at Khartoum. The Main Nile system, divided into two distinct sections – Main Nile in Sudan upstream of the High Aswan Dam; and Egyptian Nile below Aswan, including the Nile Valley and Delta. This large area generates virtually no runoff, and in-stream evaporation results in a net loss. The average annual precipitation in the sub-basin is 198mm and average annual potential evapotranspiration is 2,206mm. River flow in the lower reaches is controlled by Lake Nasser, which is subject to considerable evaporation losses. Most river flow is diverted to the irrigation schemes in the north of Sudan and in Egypt, and very often most of the river discharge into the Mediterranean is drainage and re-used water.



The Tekeze-Atbara Sub-basin

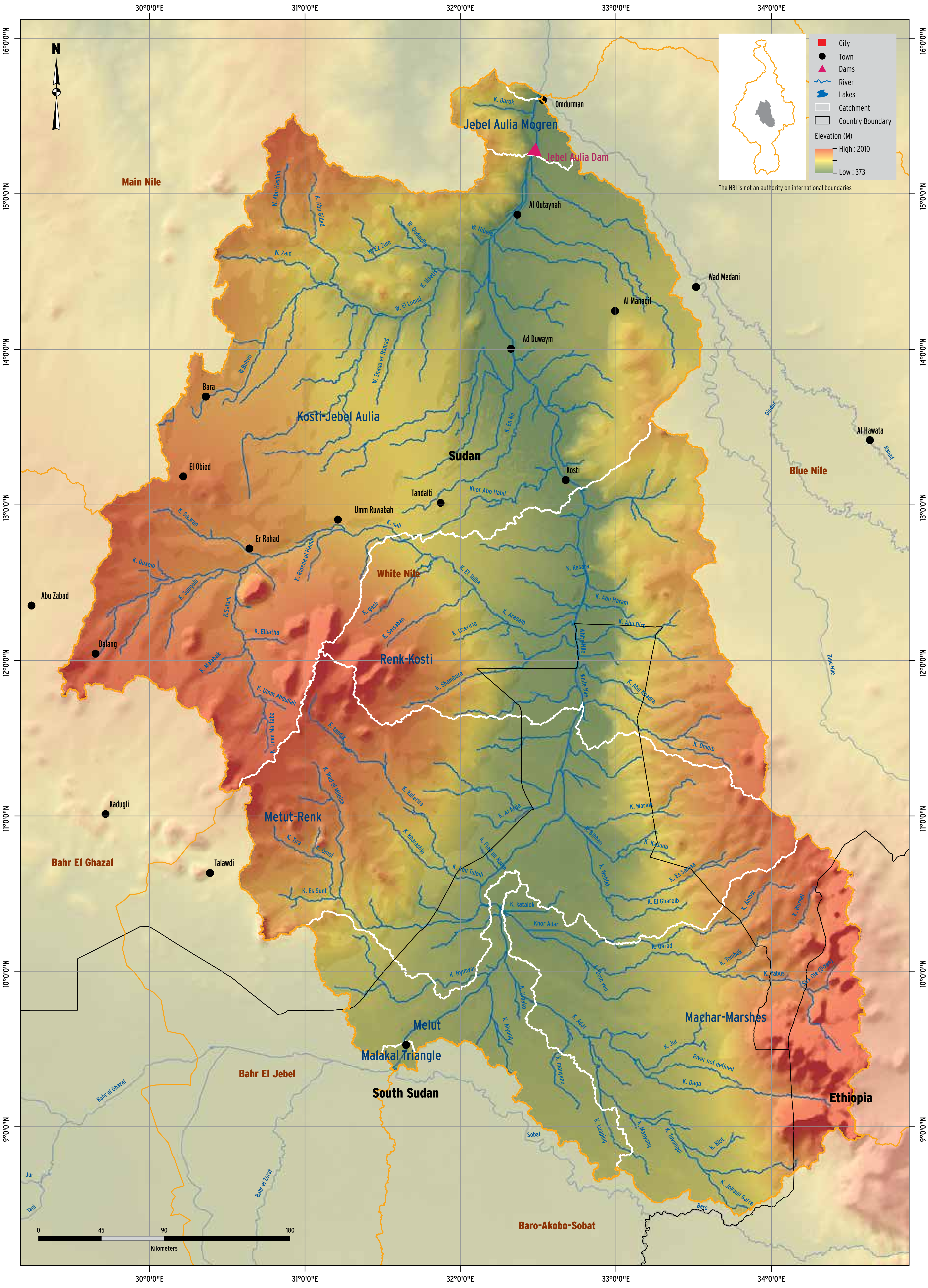
The Tekeze (Setit in Sudan) River originates from the highlands of Ethiopia as the Goang (Atbara in Sudan) and Angereb Rivers. Flows are highly variable with very little retention in wetlands or floodplains anywhere in the basin and the sediment flows are very high. The rainfall is uni-modal concentrated in August and September with mean annual rainfall 900mm. The average annual potential evapotranspiration in the sub-basin is 1,778mm.

The Blue Nile Sub-basin

The source of the Blue Nile is the Little Abbay River in the Ethiopian Highlands. The Little Abbay flows into Lake Tana, which discharges into the Blue Nile and runs 900 km down through the highlands into Sudan (Roskar, 2000). Other rivers which flow into Lake Tana. Blue Nile contributes about 60% of the flow of Main Nile (Sutcliffe and Parks, 1999). From the Sudanese-Ethiopian border the Blue Nile flows north from humid to semi-arid conditions and there is usually little additional runoff north of Roseires. The exceptions are the two tributaries, the Ayma-Dinder and the Rahad. This part of the sub-basin is characterized by a highly seasonal rainfall pattern, most of the rain falling in four months (June to September), with a peak in July or August. The precipitation over the Blue Nile sub-basin (in Ethiopia) varies from 1000mm in the north-eastern part to 1450-2100 mm over the south-western part of the sub basin. The average annual potential evapotranspiration over the sub-basin is 1,765mm. Soil erosion is a major threat in the Blue Nile Basin (Conway and Hulme, 1993).

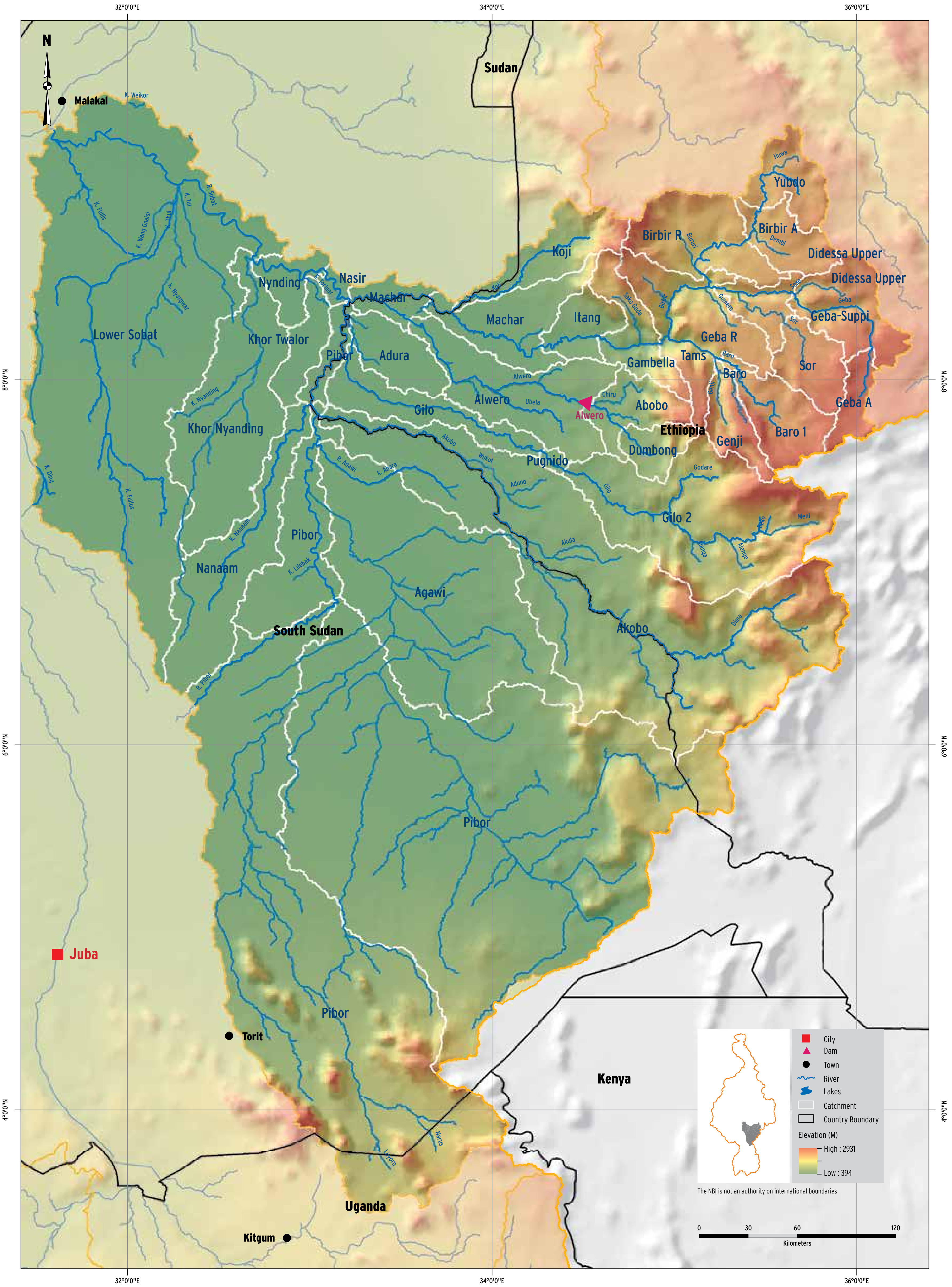
The White Nile Sub-basin

The White Nile Sub-basin originates at the confluence of Bahr el Jebel River and Baro-Akobo-Sobat River above Malakal. The sub-basin is shared by South Sudan, Ethiopia and Sudan. Tributary inflows are sporadic and small and flood plain storage results in delay of outflow and increased loss to evaporation. The average annual rainfall in the sub-basin is 754mm and the average annual potential evapotranspiration over the sub-basin is 1983 mm. The Sudd wetland provides the base flow component and the Baro-Akobo-Sobat basin contributes the seasonal component.



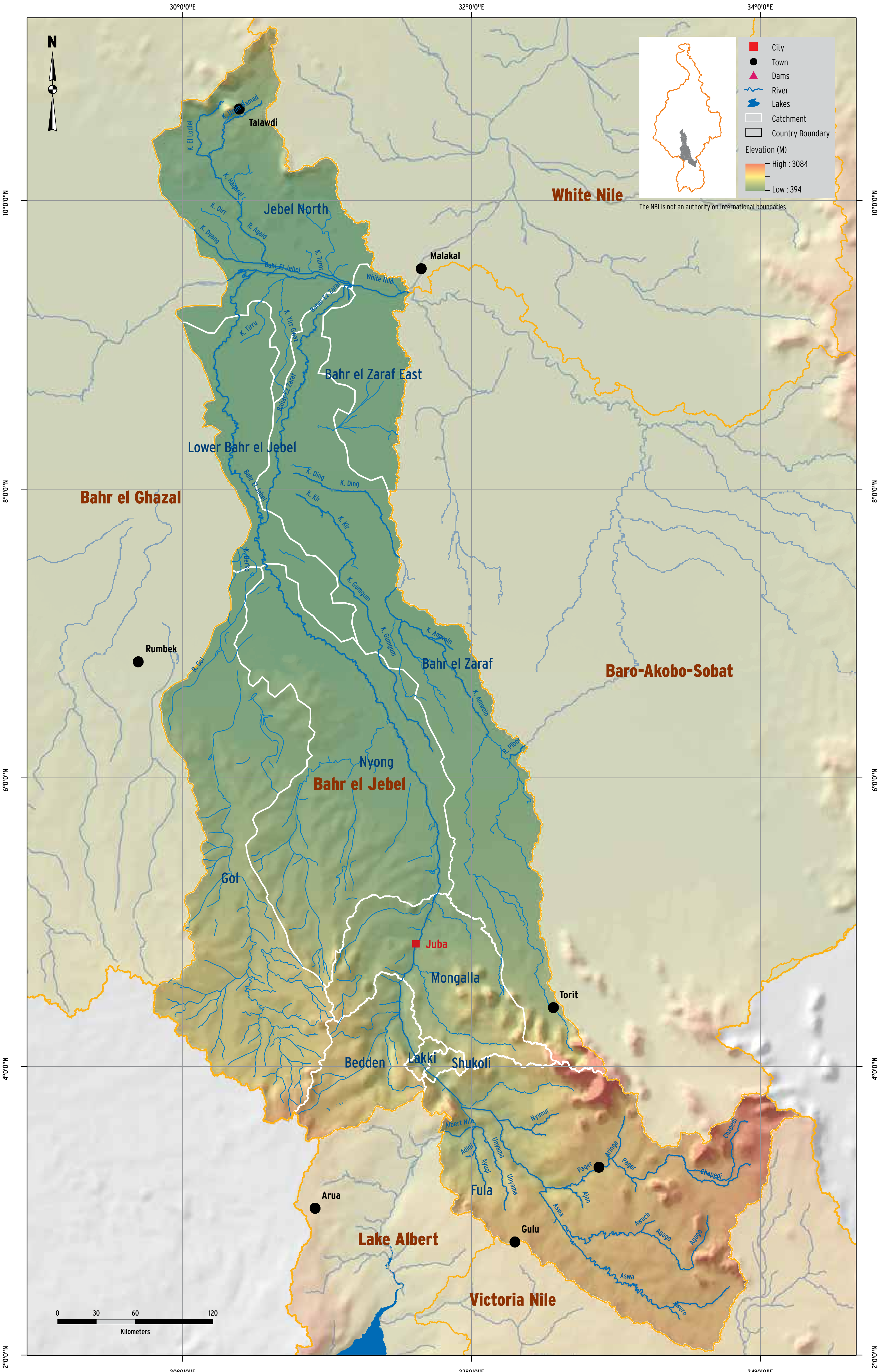
The Baro-Akobo-Sobat Sub-basin

The Baro-Akobo-Sobat River includes the discharge from two tributaries: the Baro River from the Ethiopian Highlands and the Pibor River from southern Sudan and northern Uganda. Most of the runoff develops in the mountains and foothills of Ethiopia. Portions of the Baro flow spill through a series of channels to large wetlands known as the Machar Marshes. Pibor drains a wide area of plains, but only contributes significantly in times of high rainfall. The highest rainfall is over the Baro basin in the east of the sub-basin where the average annual precipitation almost reaches 2,000mm. The lowest is over the southeast over a tributary of the Pibor River with an annual precipitation only slightly over 300mm. The average annual precipitation over the entire sub-basin amounts to 1,338 mm and the average annual potential evapotranspiration is 1,592 mm.



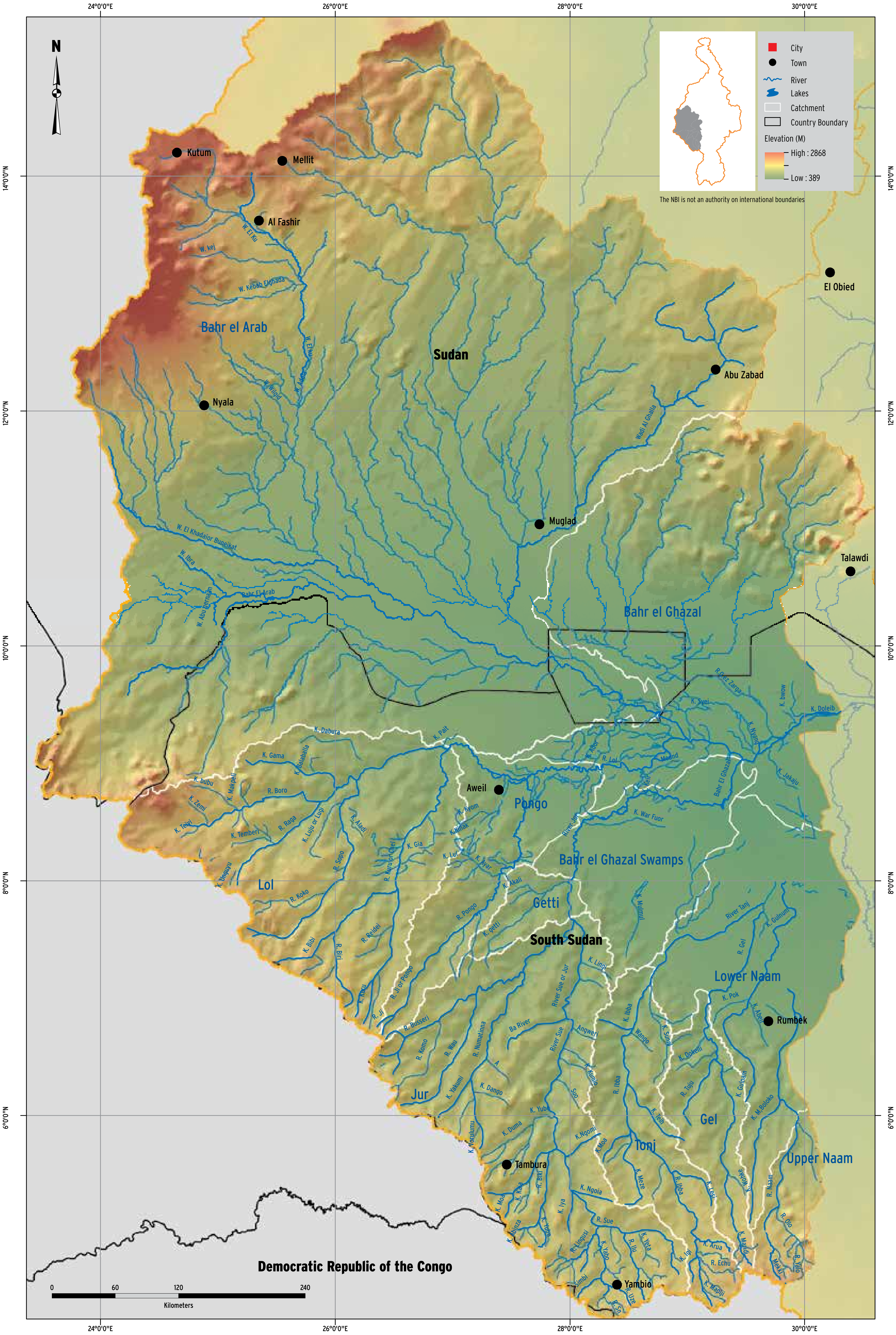
The Bahr el Jebel Sub-basin

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



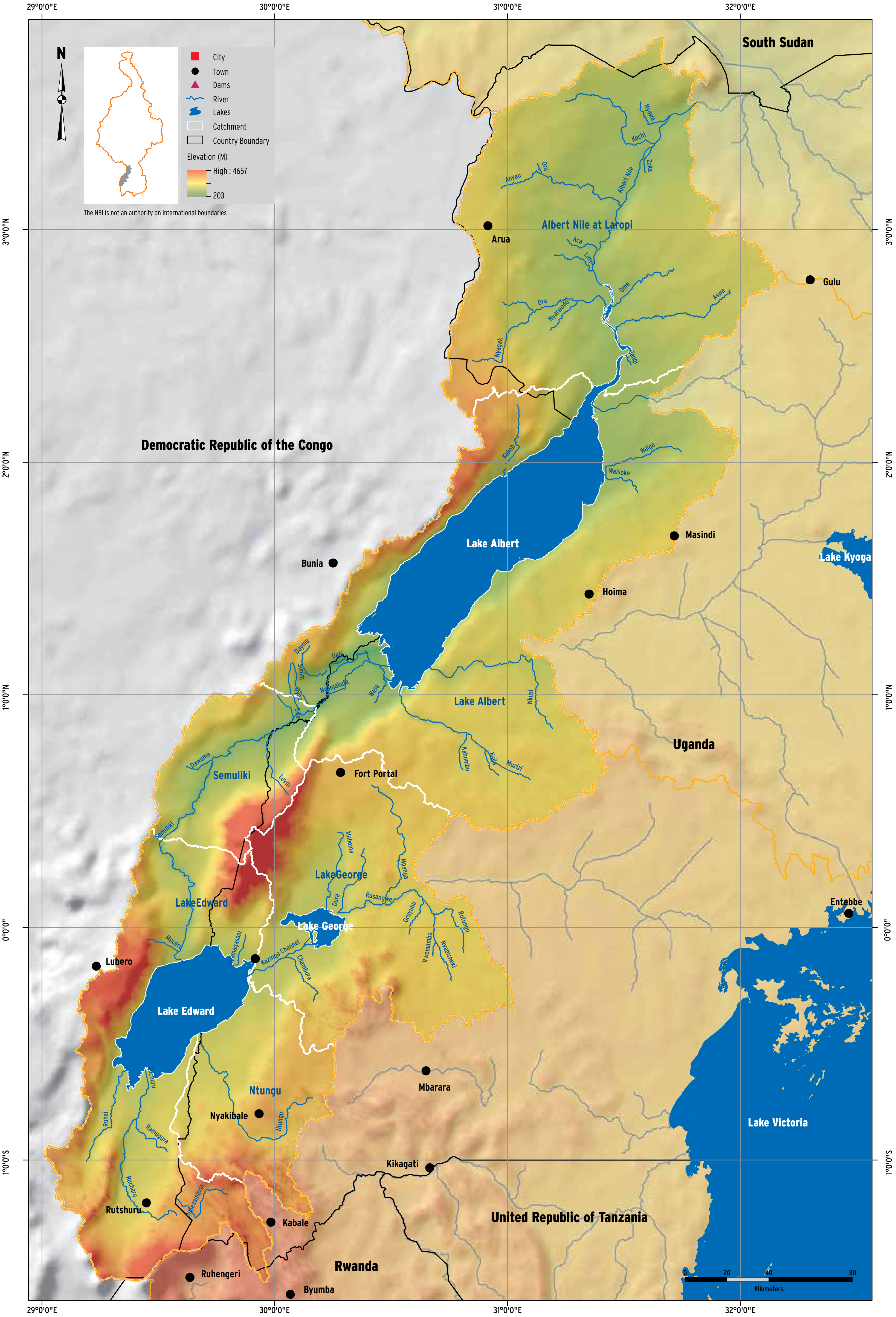
The Bahr el Ghazal Sub-basin

The Bahr El Ghazal Sub-basin consists of a number of tributaries that run from the border of the Congo Basin to the Nile. The sub-basin is shared by Sudan and South Sudan. The peak of rainfall in the south-western part produces over 1,550mm of average annual rainfall, which decreases toward the northeast where the annual precipitation does not exceed 500 mm. The average annual precipitation over the entire area is 826 mm and the average annual potential evapotranspiration over the sub-basin is 1,807 mm. The sub-basin is divided into many tributaries with bank overflow and flooding. In this large area of very low slope, nearly all the basin runoff and precipitation evaporates.



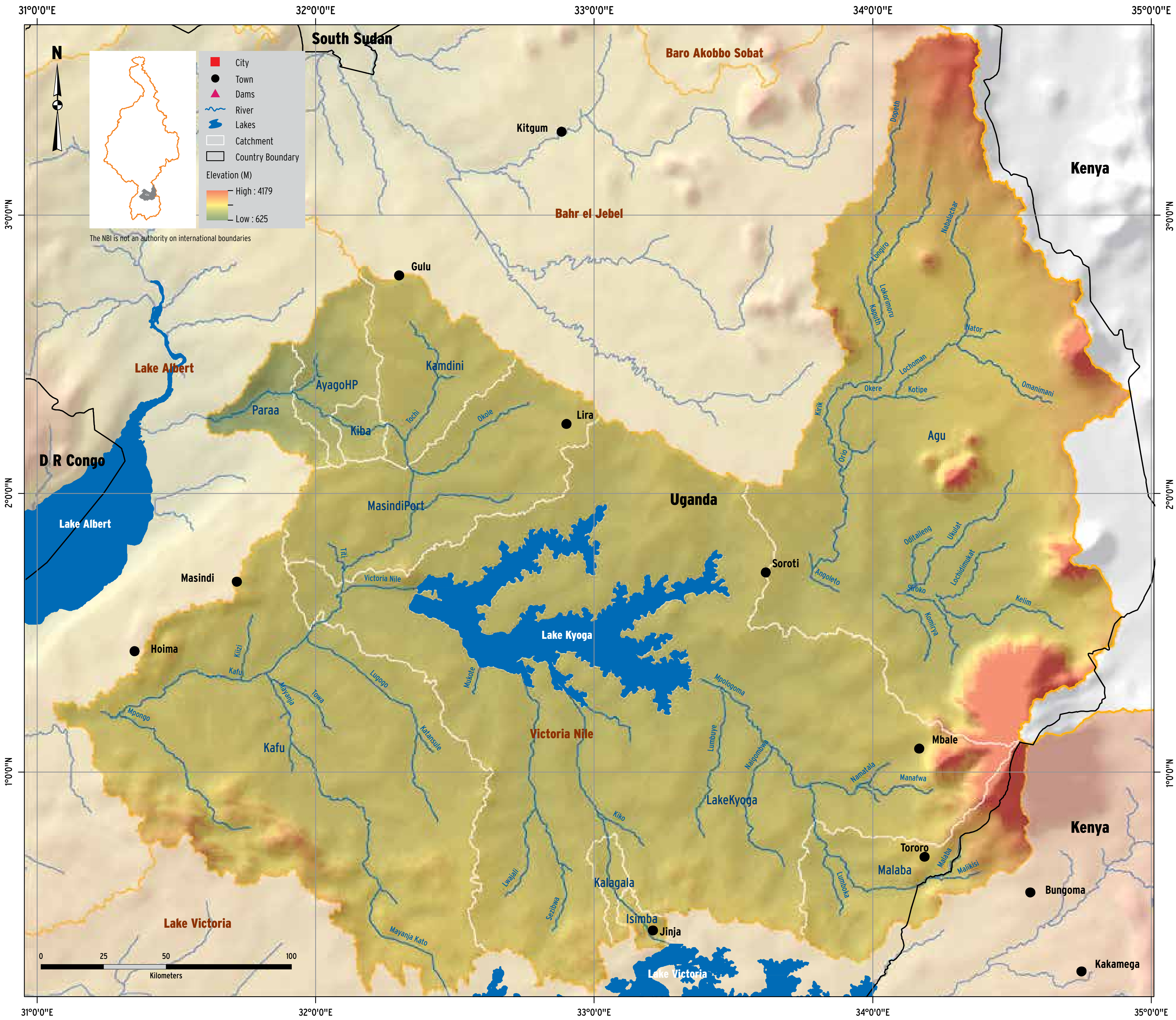
Albert Nile Sub-basin

In addition to the Victoria Nile, the lake also receives inflow from the Semliki River in the south, which drains an additional area that includes Lakes Edward and George. The direct rainfall and inflow from Albert's immediate basin is thought to be offset by evaporation over the lake surface. Therefore, the net contribution of Lake Albert to the main Nile flows is believed to be a result of the Semliki inflow (Shahin, 1985). The river leaves the northern end of Lake Albert as the Albert Nile, flows through northern Uganda, and at the Sudan border becomes the Bahr el Jebel. The average annual precipitation over the sub-basin is 1,179 mm and the average annual potential evapotranspiration is 1,544 mm.



The Victoria Nile Sub-basin

From the outlet of Lake Kyoga, the Lower Victoria Nile flows north and west, passing through a series of rapids and dropping 415 m along its course toward Lake Albert. The average annual basin rainfall is nearly 1,300 mm and the average annual potential evapotranspiration is 1,544 mm. The net water contribution of Lake Kyoga to Victoria Nile flows has historically been very low and often negative due to evaporative losses over the lake and wetlands (Sutcliffe and Parks 1999; Shahin 1985).



River Nile in northern Uganda

The Lake Victoria Sub-basin

The Lake Victoria sub-basin is the area covering the lake surface itself and the catchment areas of all its tributaries. The outlet hydrological station is at Jinja. The most distant source of the Nile is the Ruvyironza River, which flows into Lake Victoria through the Ruvubu and Kagera rivers.

Other rivers converging into Lake Victoria – the largest of the Nile Equatorial Lakes – include the Simiyu-Duma, Grumeti-Rwana, Mara, Gucha-Migori, Sondu, Yala, Nzoia, Sio, Katonga and Ruizi. The lake's surface area is about 66,700km² and occupies a large proportion of the entire sub-basin.

Three countries Kenya (6%), Tanzania (51 %) and Uganda (43%) share the lake shoreline, and six countries share the basin: Burundi, DRC, Kenya, Rwanda, Tanzania and Uganda. The area around Lake Victoria has the fastest-growing population in East Africa, estimated to be more than 40 million in 2015. Lake Victoria is important for agriculture, industry, domestic water supplies, hydropower, fisheries, travel, tourism, and environment. The average annual precipitation over the sub-basin is 1368mm and the average annual potential evapotranspiration is 1486mm.

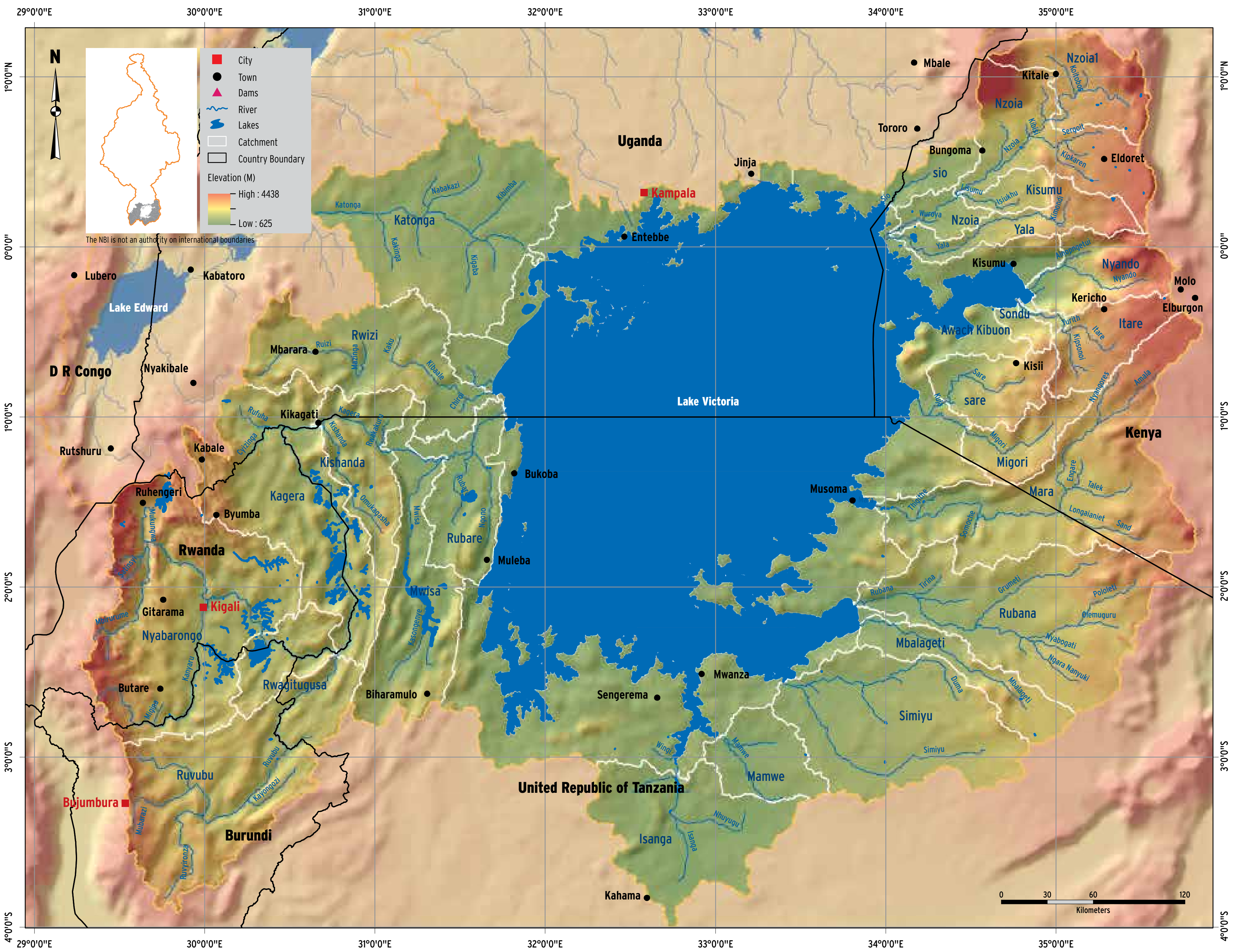



Photo: vivek Bahukhandi

Lake Bunyoni, Uganda

ANNEX A

The characteristics of the soil groups

Code	Soil type	Drief description
AC	Acrisols	These are soils that are characterized by low activity clay. Most extensive on acid rock weathering, notably in strongly weathered clays, which are undergoing further degradation. Low-input farming on Acrisols is not very rewarding. Undemanding, acidity-tolerant cash crops such as pineapple, cashew or rubber can be grown with some success.
AN	Andosols	These are black soils of volcanic landscapes. Parent material is mainly volcanic ash. Andosols have a high potential for agricultural production
AR	Arenosols	Soils having a texture, which is loamy sand or coarser to a depth of at least 100 cm from the soil surface. Arenosols occur in vastly different environments and possibilities to use them for agriculture vary accordingly. All Arenosols have a coarse texture, accountable for the generally high permeability and low water and nutrient storage capacity. Arenosols are further marked by ease of cultivation, rooting and harvesting of root and tuber crops.
CM	Cambisols	Medium and fine-textured materials derived from a wide range of rocks, mostly in colluvial, alluvial or aeolian deposits. Cambisols make good agricultural land and are intensively used. The Eutric Cambisols are among the most productive soils on earth. Cambisols on steep slopes are best kept under forest; this is particularly true for Cambisols in highlands.
FR	Ferralsols	Red and yellow tropical soils. Parent material: strongly weathered material on old, stable geomorphic surfaces; more in weathering material from basic rock than in siliceous material. Have low water holding capacity. The chemical fertility of Ferralsols is poor; weatherable minerals are absent and cation retention by the mineral soil fraction is weak.
FL	Fluvisols	Soils developed in alluvial deposits. Environment: periodically flooded areas alluvial plains, river fans, valleys and (tidal) marshes. Fluvisols are normally planted annual crops and orchards and many are used for grazing. Flood control, drainage and/or irrigation are normally required.
GL	Gleysols	Gleysols holds wetland soils that, unless drained, are saturated with groundwater for long enough periods to develop a characteristic "gleyic colour pattern". Parent material consists of a wide range of unconsolidated materials, mainly fluvial, marine and lacustrine sediments of Pleistocene or Holocene age, with basic to acidic mineralogy. Adequately drained Gleysols can be used for arable cropping, dairy farming or horticulture.
LT	Lithosols	Lithosols, which are found in all the agroecological zones of Africa, are very shallow, occurring mainly on steep slopes often with exposed rock debris. These soils are at risk of very severe erosion.
LV	Luvisols	Soils in which clay is washed down from the surface soil to an accumulation horizon at some depth. Parent material is a wide variety of unconsolidated materials including glacial till, and aeolian, alluvial and colluvial deposits. Luvisols are fertile soils and suitable for a wide range of agricultural uses.
NT	Nitosols	Nitisols accommodates deep, well-drained, red, tropical soils with diffuse horizon boundaries and a subsurface horizon with more than 30 percent clay and moderate to strong angular blocky structure elements. Nitisols are predominantly found in level to hilly land under tropical rain forest or savannah vegetation. Nitisols permit deep rooting and make these soils quite resistant to erosion. The good workability of Nitisols, their good internal drainage and fair water holding properties are complemented by chemical (fertility) properties that compare favourably to those of most other tropical soils.
PL	Planosols	Planosols holds soils with bleached, light-coloured, eluvial surface horizon that shows signs of periodic water stagnation with abrupt textural discontinuity. Many planosols areas are not used for agriculture.
PZ	Podzoluvisols	Podzol has an ash-grey, strongly leached eluvial horizon under a dark surface horizon with organic matter, and above a brown to very dark brown. The low nutrient status, low level of available moisture and low soil-pH make Podzols unattractive soils for arable farming. Podzols have some potential for forestry and extensive grazing.
RG	Regosols	Soils with no significant profile development. Regosols are extensive in eroding lands, in particular in arid and semi-arid areas and in mountain regions. They are not used for cultivation but mainly serve as source of murram for various civil works.
SC	Solonchaks	The most extensive occurrences of Solonchaks are in inland areas where evapotranspiration is considerably greater than precipitation, at least during a greater part of the year. Salts dissolved in the soil moisture remain behind after evaporation/transpiration of the water and accumulate at the surface of the soil or at some depth. Excessive accumulation of salts in solonchaks affects plant growth.
VR	Vertisols	Vertisols are heavy clay soils with a high proportion of swelling. These soils form deep wide cracks from the surface downward when they dry out, which happens in most years. Vertisols become very hard in the dry season and are sticky in the wet season. Vertisols are productive soils if properly managed.
X	Xerosols	Aridic (dry) soils. A horizon and an aridic moisture regime; lacking permafrost within 200 cm of the surface.
Y	Yermosols	Aridic (dry) soils, soil horizon that is typical of deserts. A horizon and an aridic moisture regime; lacking permafrost within 200 cm of the surface.

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