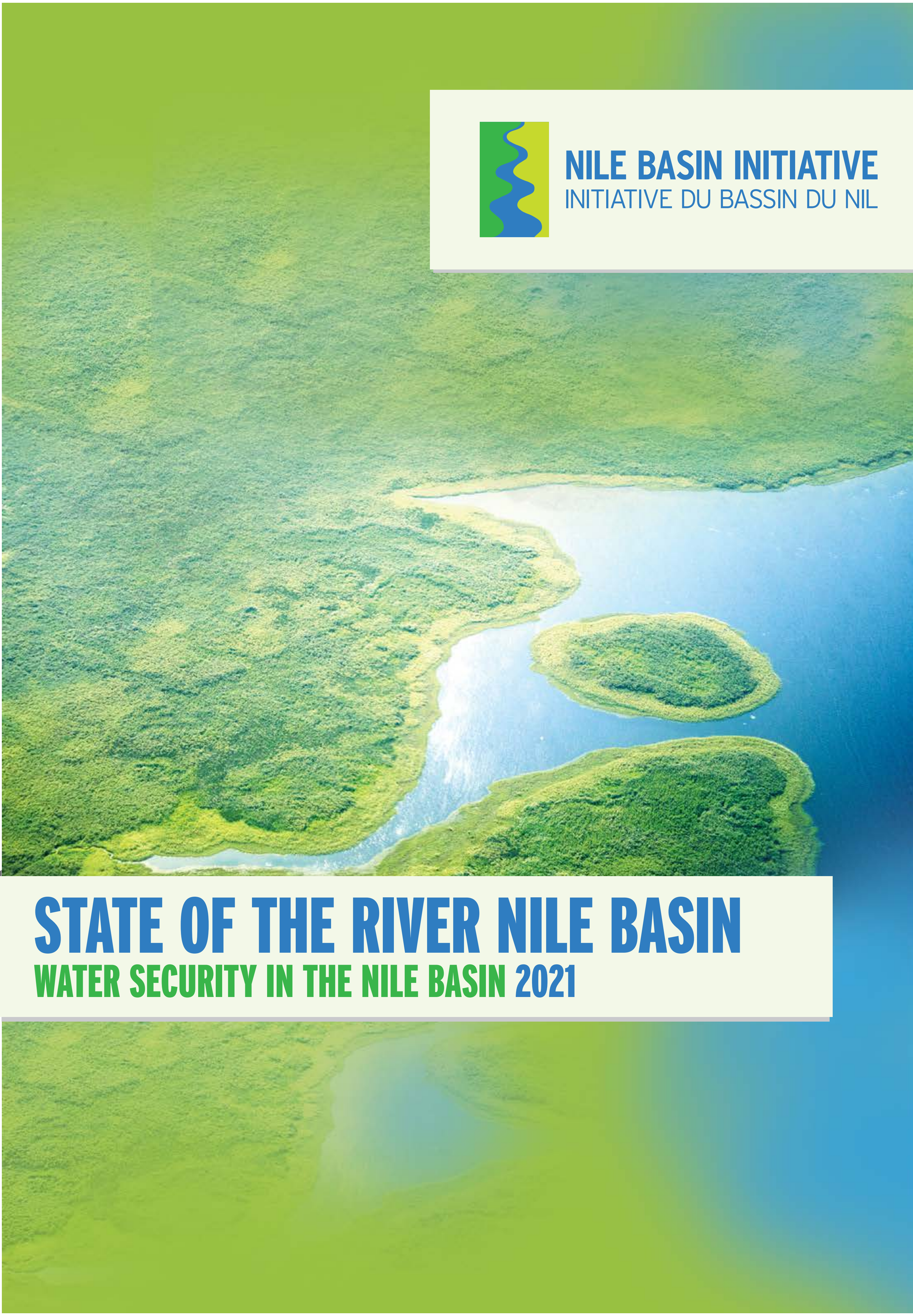

NILE BASIN INITIATIVE
INITIATIVE DU BASSIN DU NIL

STATE OF THE RIVER NILE BASIN

WATER SECURITY IN THE NILE BASIN 2021

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The Nile Basin Initiative (NBI) is an intergovernmental partnership of ten Nile riparian countries that is seeking to manage and develop the common Nile water resources in a cooperative manner and promote regional peace and security.

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FOREWORD

Dear Esteemed Reader,

I welcome you to the second Nile State of Basin Report, 2021. The first state of Basin report was published in 2012. The 2012 report put together wide-ranging data, and offered analysis on the condition of the water and environmental resources of the Basin, and of socio-economic status in 2012. The report added significant value to the common Basin knowledge-base and has since been used by practitioners, decision makers, researchers, academicians, media, planners, and several other groups as a reference for Basin planning and management.

The Nile is the second longest river on the planet and occupies a special place in world history, being the cradle of many great civilisations. It traverses 10 countries and runs through diverse climate, topographical, environmental and socio-economical landscapes. Since the previous River Nile State of Basin report, the Basin population has grown from 238 million to 272 million people. This population growth is in the face of dwindling resources that are threatened by emerging pressures like climate change, land use change and environmental degradation, urbanisation, etc.

This report builds on the 2012 report by taking stock of the developments that have occurred since then, critically assessing the evolving pressures on the Basin resources and effects in terms on sustainable utilisation of the Basin's water and related resources, and tracking progress towards overcoming the main Basin development challenges. It presents facts, trends, patterns, synthesis, and indicators for both the Basin health and multiple biophysical conditions. It also establishes the foundation and structure for reporting Basin health and monitoring of the impact of measures taken at national and regional levels.

Levels of socio-economic development remain low in most of the Basin countries despite recent signs of strong economic growth. In particular, reducing poverty, inequality, malnutrition, and providing access to basic services in the majority of Nile States still remain major challenges that governments are trying to address. Pressures on the natural environment stem predominantly from land-use changes, mainly driven by agriculture, yet increasingly also by expanding urban areas. Infrastructure and governance systems are already overwhelmed by the magnitude and pace at which water-related challenges develop.

This report is meant to be used as a reference document and source of data and information for when formulating or reviewing policies and also when making decisions on planning, design and implementation of water resources management and development projects. The report is also aimed at furthering cooperation among stakeholders as a key driver of sustainable and equitable utilisation of Basin resources. The report targets diverse audiences, including politicians, government officials, development workers, media experts, academicians, researchers, and all citizenry of the Nile.

I thank the Nile Basin Initiative Secretariat who prepared the report with support from GIZ, on behalf of the European Union and the German Federal Government who provided the funding. I also thank all the technical staff in the Nile Basin countries that actively contributed to the development of the report.

Wishing you pleasant reading

Hon. Minister Jeanne d'Arc MUJAWAMARIYA
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MESSAGE FROM THE EXECUTIVE DIRECTOR

Dear Esteemed Reader,

It is my pleasure to present to you the second Nile State of Basin Report, 2021. This follows the first state of Nile Basin Report published in 2012 which received a good reception among professionals in the Nile Basin including government officials, policy- and decision-makers, development planners, academia, and the general public. It has been used as a key document for assessing trends and patterns in the basin and to support joint assessments of alternative development pathways that lead to sustainable development of basin resources.

This second Nile State of Basin Report is meant to be part of the suite of basin monitoring tools (including, for example, the Nile Basin Water Resources Atlas). This report is aimed at critically assessing facts, trends, patterns, synthesis, and indicators for both the basin health and multiple biophysical conditions and also establishes the foundation and structure for basin reporting. The report gives policy makers, senior government officials, and the international development community a basis for well-informed decision-making.

The challenges facing the Nile Basin are complex and continue evolving. They include population pressure, land use changes and rapid urbanisation, uneven distribution of resources which are dwindling, pollution of water resources and disappearing ecosystem habitats as well as emerging pressures like climate change. Country plans for development of the Nile water resources are constrained by these challenges in addition to limited data and knowledge on the abundance and variability of the resource itself.

Therefore, countries need well synthesised and factual information to enable them make evidence based decisions.

The contents and structure of the report are guided by the six priority areas of the Nile Basin Initiative (NBI) 10-year Strategy (2017–2027), which advocates key strategic directions that were agreed by the NBI member states and sets the ambition for delivery of impact on the ground. The priorities include (i) water security, (ii) energy security, (iii) agricultural development and food security, (iv) environmental sustainability, (v) climate change, and, (vi) transboundary governance. For each of these themes, the current state, main trends, drivers of change, and management responses have been identified.

The indicator matrices developed as part of this process shall form the basis of a Nile Basin Reporting Mechanism that will allow an accurate and comprehensive description of the state of the Nile Basin in a comparable manner, which will progress and the impacts of development to be assessed through future State of the Basin (SOB) reports.

I take this opportunity to thank the staff of NBI as well as members of the Regional Working Group who have contributed towards the development of this key report.

Finally, I extend my gratitude for the support from GIZ, on behalf of the European Union and the German Federal Government who provided the funding for preparation of this State of Basin Report.

Wishing you enjoyable reading,

Prof Seifeldin Hamad Abadalla
EXECUTIVE DIRECTOR, NILE BASIN INITIATIVE

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LIST OF ABBREVIATIONS

AC	Alternating current
AfDB	African Development Bank
AHD	Aswan High Dam
AU	African Union
BCM	Billion cubic metres
BOD	Biochemical oxygen demand
COMESA	Common Market for Eastern and Southern Africa
COMELEC	Comité Maghrébin de L'electricité
DC	Direct current
DO	Dissolved oxygen
DR Congo	The Democratic Republic of Congo
DSS	Decision support system
EAC	East African Community
EAPP	East African Power Pool
ECOWAS	Economic Community of West African States
EFR	Environmental flow requirements
ENSAP	Eastern Nile Subsidiary Action Program
ENTRO	Eastern Nile Technical Regional Office
ESIA	Environmental and social impact assessment
FAO	Food and Agricultural Organization
FAOSTAT	Food and Agricultural Organization Statistical Databases
GCM	General circulation model/global climate model
GDP	Gross domestic product
GERD	Grand Ethiopian Renaissance Dam
GIS	Geographic information system
GNI	Gross national income
GW	Gigawatt
Ha	Hectare
HDI	Human Development Index
HDR	Human Development Report
IGAD	Intergovernmental Authority on Development
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Intertropical Convergence Zone
IWRM	Integrated water resources management
Km	Kilometres
km^2	Square kilometres
KV	Kilovolts
KWh	Kilowatt hour
LVBC	Lake Victoria Basin Commission
LVEMP	Lake Victoria Environmental Management Program
m	Metres
M&I	Municipal and industrial
MCM	Million cubic metres
mg	Milligrams
mm	Millimetres
MW	Megawatt
N	North
NBI	Nile Basin Initiative
NBTF	Nile Basin Trust Fund
NEL	Nile Equatorial Lakes
NELSAP	Nile Equatorial Lakes Subsidiary Action Program
NELSAP-CU	Nile Equatorial Lakes Subsidiary Action Program – Coordination Unit
Nile-COM	Nile Council of Water Ministers
Nile-TAC	Nile Technical Advisory Committee
NSAS	Nubian Sandstone Aquifer System
NTEAP	Nile Transboundry Environment Action Programme
O^2	Oxygen
°C	Degrees Celsius
PET	Potential evapotranspiration
PPP$	Purchasing power parity in United States dollars
RAP	Resettlement action plan
REC	Regional economy community
REMA	Rwanda Environmental Management Authority
SADC	Southern African Development Community
SAPP	Southern African Power Pool
SOB	State of basin
SSEA	Strategic Sectoral Social and Environmental
TN	Total nitrogen
ton	Imperial measurements of weight equal to 1.016 tonne
tonne	Metric measurement of weight equal to 0.984 ton
TP	Total phosphorus
TSS	Total suspended solids
UN	United Nations
UNDP	United Nations Development Program
UNESCO	United Nations Educational, Scientific and Cultural Organisation
US$	United States dollars
WRPM	Water Resources Planning and Management (project)

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SYNTHESIS

WATER SECURITY IN THE NILE BASIN: A STATUS REPORT

Water security is the focus topic of this State of the Basin report. It is commonly defined as 'the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability' (UN Water, 2013). The underlying concept of water security is intersectoral and multi-dimensional, while water security also varies by country and even by location. Further, some measures taken to increase water security in one part of the Basin may reduce it in other parts. Hence, assessing the status of water security of the diverse and large Nile Basin is complicated and cannot be covered by a few simple indicators. This report, therefore, has attempted to base the water-security analysis of the Nile Basin as much as possible on quantitative analysis and a broad range of indicators.

The principal factor in the discussion on water security is water for agricultural production, as agriculture is by far the largest consumer of the renewable Nile waters. Food security for urban areas could, theoretically, be achieved through agricultural trade or imports from outside the Basin. But not so for rural areas; food security for the large rural population will depend on local produce. Additionally, there is a strong relation between agricultural modernisation – which requires secure water supply – and rural development.

The link between water security and energy security in the Nile Basin is caused by the preference of several Nile countries for hydropower. Energy security, in turn, is closely related to environmental sustainability, as a large share of the rural and urban population continues to rely on charcoal as their primary source of energy, with devastating environmental consequences. Land degradation will impact on the hydrological cycle and the timely availability of water resources, thereby closing the loop.

Environmental sustainability in the Basin is also closely related to water security. The water-related ecosystems in the Basin, especially wetlands and catchment forests, provide crucial functions for water security: they retain floods, store water for periods of drought, and purify water as it passes through them. But use of the water for agricultural and energy production, and the pollution of that water, is threatening these same ecosystems.

Water security concerns are exacerbated by climate change. It will probably affect every aspect of water security, but its exact implications and magnitude are yet undefined.

Lastly, efforts to ensure water security in the Nile Basin are complicated by the transboundary dimension.

It is within the above context that this chapter synthesises the findings of the water-security analysis in the Nile Basin.

INCREASING PRESSURE ON WATER RESOURCES

« There are increasing pressures on the finite water and other resources of the Nile Basin. »

« Irrigated agriculture is one of the main uses of the water resources of the Nile Basin. »

« The NBI Strategic Analysis has investigated current and projected water demand and use as the basis for analysing joint water resources development scenarios. »

It is evident that the water resources in the Nile Basin are under rapidly increasing pressure. The finite and modest Nile waters are now nearly fully utilised for various productive and environmental purposes, while water demand continues to rise due to population growth and socio-economic development. Additionally, climate change and environmental degradation may adversely impact on long-term water availability.

Two components currently dominate water demand. Irrigated agriculture in Basin uses the bulk of the Nile flows, and evaporation from constructed reservoirs. It is noted that the bulk of the evaporation losses occur in reservoirs whose primary function is to support irrigated agriculture. Hence, pressure on water resources in the Nile Basin is very much related to agricultural production in the arid zone.

From the entire Basin perspective, there is limited water available for further irrigation development. However, in each of the riparian countries – especially in upstream water source countries, there are plans for expanding irrigated agriculture substantially. In a study conducted by NBI, from a Basin perspective, the projected imbalance between available water and growing water demand is likely to be substantial. Nevertheless, water savings are possible if losses in existing irrigation schemes can be reduced. This includes potential reduction of losses, where the estimated direct evaporation losses are estimated from 100 to 250 mm per year.

Although hydropower is considered non-consumptive water use, developing the remaining potential capacity – exceeding 15 GW after completion of GERD – will require retention of extra surface water, leading to evaporation losses.

Reduction of costs for alternative power sources such as solar and wind would reduce the need for developing all remaining hydropower potential, particularly those facilities associated with high evaporation losses. Thus, it is unlikely that achieving energy security will be constrained by availability of water resources.

While projected water demand for municipal and industrial uses (M&I) shows exponential growth, it is generally low as a proportion of overall water demand, except for Egypt. However, most of the water diverted for M&I uses can be returned to the river system if collected and treated. It is noted that Egypt is already recycling an estimated 1.4 BCM/year of municipal wastewater.

Given the high value of water for Municipal & Industrial purposes, non-conventional water sources – such as desalinated sea water – can be considered to increase water availability. Further, significant water savings are possible through diverse water conservation methods, pricing, policies for industrial use, and creating awareness about the importance of efficient water use. Economic growth and urbanisation will exponentially increase the volume of wastewater across the Basin. While most of this water can be re-used in principle, it will require large cumulative investments in drainage infrastructure and treatment facilities. However, such investments are also critical to support public health, water quality, and environmental sustainability.

Thus, it is unlikely that future municipal and industrial water use will lead to unsustainable water deficits provided that diverse efficiency improvement measures are put in place, adequate treatment facilities are established, and reasonable alternatives are developed.

Photo: Shutterstock

The quality of the Nile waters has generally deteriorated because of population growth and urbanisation, agricultural intensification, and industrial development. Localised high pollution is experienced mainly around urban centres. Hence, there is considerable risk that fresh water downstream of major urban areas may become polluted and de facto unusable.

Rainwater represents a very substantial water resource that is currently underused. Specifically, the productivity of rainwater is low in rainfed farming across the Nile Basin – which covers 87% of arable land. It suggests large untapped water resources and agricultural potential. Most of these areas receive substantial but highly variable rainfall, as illustrated by average transpiration values – representing rainwater used for biomass production – of 750 mm/year or above. This constitutes a very substantial volume of water.

Low rainwater productivity is primarily caused by low crop yields. However, water deficits during plant growth – specially during its last stage- that cause periodic crop failure and low yields are typically small. It implies that water security in rainfed agriculture can be achieved through a combination of local and smaller-scale measures concerned with supplementary irrigation from either surface or groundwater, land and water conservation, and water harvesting. Further, adoption of drought resistant/tolerant crop variants would reduce repeated crop failures due to dry spells. Note that groundwater recharge rates in the sub-tropical zone of the Basin average 250 mm/year, even though it is subject to high spatial variability. The water resources implications of these measures at Nile Basin scale are small because of the low runoff coefficient experienced in large parts of the Nile region, which means that most rainfall never reaches the Nile river system. Thus, water resources for agricultural purposes are available in principle in the Nile region but should be better managed. The huge practical difficulties in increasing yields and extending the productivity of these water resources – mostly rainwater – are acknowledged.

Thus, while pressure on water resources in the Nile Basin is increasing, a wide range of options still exist to achieve water security. Some of these require transboundary cooperation, while others can be implemented at national or even local level.

« NBI has initiated a Basin-wide strategic hydro-meteorological and water-quality monitoring system to strengthen transboundary water resources planning and management in the Basin »

« A significant amount of rainwater is uncollected and therefore unutilised »

« Water productivity from irrigated agriculture in the Nile Basin can be greatly improved »

IMPLICATIONS OF AGRICULTURAL DEVELOPMENT FOR WATER AND FOOD SECURITY

As discussed above, water scarcity in the Nile Basin is directly related to food security, as the agricultural sector is by far the largest consumer of the Nile waters, and because demand for agricultural produce is set to increase very substantially because of demographic trends and the socio-economic development to which countries aspire. Additional food is also needed to address the undernourishment experienced by some segments of the population in all Nile countries except Egypt. While food security can be achieved through a combination of local produce and imports, food for the large rural population must be produced in close vicinity to its actual consumers. It is noted that the dominance of the rural population in the Nile Basin will persist until 2030 and beyond.

Hence, the state of the agricultural sector has direct and profound implications for attaining water security in the Nile Basin.

The performance of the agricultural sector (irrigated and rainfed) in the Basin is generally poor and below potential, except for irrigated agriculture in Egypt and some schemes in Sudan. Food production is insufficient, and all Nile countries are currently net food importers. Additionally, the rural economy is adversely affected by the underperforming agricultural (mainly rainfed) sector , with attendant consequences for poverty alleviation, rural–urban migration, food security, and environmental degradation.

Agriculture in the Nile Basin remains dominated by rainfed farming and livestock grazing. Given the large rural population in the Nile region, this situation is unlikely to change in the near or medium-term future. Basin

Yields – and associated water productivity – are low in rainfed farming and some irrigated schemes across the Nile Basin. The very substantial yield gap points to large agricultural production potential that is currently not realised. While yields are increasing in some countries, the rate of increase is very modest.

Hence, scope for improvements in the agricultural sector are large. Barriers to increases in yield and production remain high, however. Constraining factors are multiple and diverse and must often be addressed in concert to achieve the intended results.

First and foremost, secure supply of water must be guaranteed. The absence of a secure water supply is among the principal factors that have prevented farmers in many parts of the rainfed zone of the Basin from adopting modern farming practices that are associated with high yields.

It is clear, however, that water scarcity will constrain a large expansion of areas under full irrigation supplied by surface water from the Nile or its tributaries.

A very large share of the additional food produce required, therefore, needs to come from the use and improvements – regarding yield, total production, and water productivity – in irrigated systems and large available arable lands in the Basin and more importantly, from improvements in the large rainfed sector.

Most of the rainfed areas receive substantial but highly variable rainfall. Moisture deficits that lead to periodic crop failure are typically small. It implies that the volume needed for a secure water


Photo: World Bank/ 2010 Arne Hoel

supply in this zone are modest and best achieved through a combination of local and smaller-scale measures concerned with supplementary irrigation or land and water conservation.

It is noted that the above practices (i.e. supplementary irrigation, water harvesting, soil and water conservation, etc.) directly strengthen the resilience of the vulnerable rainfed agricultural sector to the anticipated effects of climate change. At present, this sector is virtually unprepared for the warmer and more variable weather that is predicted for the Basin, with potentially very severe environmental, economic, and social consequences.

However, the large-scale adoption of these practices – which are proven and well-established – are contingent on improving the economic viability of agriculture, including smallholder farming, and on providing adequate support in terms of extension services, rural electrification and roads, establishment of value chains, agricultural research, farm commercialisation, etc. Providing a secure water supply alone will not automatically translate into higher yields and production. Rather, all constraining factors need to be addressed simultaneously. Currently, little progress is being made in the Nile countries to provide the all-encompassing enabling environment for agricultural modernisation. It is noted that agricultural transformation requires an active role by governments but will primarily be implemented by the private sector.

Two more issues deserve mentioning. The first is concerned with agricultural trade. Since none of the Nile countries is currently a consistent surplus producer, food security cannot be achieved in the near and medium-term future through intra-Basin trade of agricultural produce. Trade, however, can contribute to alleviating local and sub-regional food deficits.

The second issue is concerned with the very large food losses observed in the Nile Basin. Although no data are currently available, these losses are estimated at 50% or more. Food is mainly lost during the early (harvesting) and middle stages (processing) of the food supply chain. Food losses represent a waste of scarce natural resources, reduce the profitability of agriculture, and translate into poor water productivity. Hence, reducing food losses is an effective means to strengthen water and food security in the Basin.

« Energy supply in the Nile Basin is inadequate, unreliable, expensive and fails to reach many rural dwellers »

GRADUAL DIVERSIFICATION OF ENERGY PRODUCTION MIXES

« Pressures on rivers, lakes, wetlands, and forests are already huge but will further increase as human populations in the Basin grow. »

« Nile Basin countries are making good progress in establishing the physical and institutional infrastructure to promote power trade »

« More economically competitive sources of energy need to be considered as alternatives to hydropower »

The preference of several Nile countries for hydropower provides the link between water security and energy security in the Nile Basin. Currently, some 19% of the Nile Basin's hydropower potential has been developed, but this figure will significantly increase in the near future, when several large hydro-electricity projects in Ethiopia and Uganda will have been completed and be online. Hydropower is the preferred choice for several riparians because of its long economic life and low per unit energy costs. Being able to produce electricity at low cost is imperative to attaining diverse development objectives, since power is currently too expensive for many low- and middle-income consumers.

While the energy sector has made good progress since the SOB 2012 towards meeting SDG 7.1 – which is related to universal access to affordable, reliable, and modern energy by 2030 – electricity supply in all Nile countries except Egypt is still inadequate, and large segments of the population have no access to electricity, in particular in rural areas. The goal to ensure universal access in a region with high population growth and an upward trend in socio-economic development, points towards rapidly rising demand for electricity in the coming decades.

It is evident that long-term power demand cannot be met with hydropower alone. However, the combined Nile countries have adequate alternatives to achieving energy security. The continuous reduction of costs of other renewable technologies – such as geothermal, wind, and solar is worthy of note. These increasingly cost-effective technologies are poised to make up a growing share in the optimal power-generation mixes in the Nile countries.

The dependency on hydropower generated from Nile waters is high in some countries, including Ethiopia, Sudan, and Uganda. In the short-term, this dependency will further increase in Ethiopia and Uganda. By contrast, Egypt obtains only about 6% of its electricity from hydropower. The average for all Nile countries is 22%.

Climate change carries considerable risks to energy supply in countries with a high dependency on hydropower, since the direction and magnitude of the change of flow of the Nile and its tributaries – because of a changing climate – has not yet been established but could be significant. Nevertheless, it is expected that the dependency on Nile waters for energy supply will progressively decrease in the longer term, with the expected diversification of the energy production mixes in combination with the establishment of functional regional power markets.

Important progress is being made in establishing regional power grids, and in linking the Nile Basin countries to regional grids such as the Southern African Power Pool. Work to construct transmission infrastructure between several riparians and other grids is ongoing and scheduled for completion soon.

Additionally, the application of off-grid and mini-grid systems offers an increasingly viable and cost-effective alternative for electricity access in rural areas and could encourage a shift towards decentralised systems. As it will reduce the rural populations' dependence on biomass energy sources, this development will have major positive implications for the environment. In this regard, one could argue that the link in the Nile Basin between energy security and environmental protection is stronger – at least in the longer term – than the relation between energy security and water security.

Photo: Boris Rumenov Balabanov / World Bank

The combined developments described above – diversification of energy production, functioning power markets, and decentralised systems in rural areas based on renewable technologies – substantially strengthen the supply of reliable and affordable energy in the Nile Basin. They also provide the mechanisms to absorb a possible reduction in hydropower in circumstances where climate change – or upstream consumptive water development –led to less or more variable water resources.

Hence, the key challenge to achieving energy security in the Nile Basin is currently related to mobilising large investments for power generation, transmission, and on-grid distribution, rather than with the availability of water resources.

IMPERILLED ECOSYSTEMS

« Investment in and across different economic sectors is required to achieve water security in the Nile Basin »

« Important water-related ecosystems stretch across several Basin countries, and the NBI is key in coordinating and aligning national efforts to protect them »

« National and transboundary initiatives have made considerable advances in safeguarding water-related ecosystems but more efforts are needed as pressures grow rapidly »

The rich natural resources and outstanding biodiversity in the Nile Basin face unprecedented threats. Rivers, wetlands, lakes, and forests provide various ecosystem services that form the foundation of livelihoods for millions and the Basin's economy, which is based largely on subsistence farming. To safeguard them for decades to come, the protection of water-related ecosystems needs to be at the heart of decisions in the management and development of water resources.

Rapidly growing populations and economic growth drive the demand for food. Consequently, rivers and wetlands increasingly compete with agriculture for sufficient fresh water, which is the lifeline of these ecosystems. Meanwhile, more and more dams regulate the Nile River.. Progress concerning environmental flows – a key tool for protecting the flow regime of freshwater ecosystems – is slow. Only Tanzania and Kenya have integrated environmental flows in policies. Recently completed or currently constructed hydropower dams have not been guided by environmental flow assessments. In the backdrop of a planned five-fold increase in hydropower capacity by 2050 – and most of which is associated with large scale water storage, there is an urgent need to expand work on environmental flows. Additionally, enforcement of environmental water targets has generally proved challenging.

Land-use change has contributed to significant loss of wetlands and forests in the Nile Basin. Agriculture is the main driver behind the increasing need for land, yet the expansion of urban areas is becoming increasingly important too. Moreover, unsustainable agricultural practices such as overgrazing or the over-exploitation of fuel wood or fish stocks are a considerable cause of degradation of many water-related ecosystems. Significant progress in protecting water-related ecosystems has been achieved. However, protected areas and restoration projects cover too little of the rivers, wetlands, lakes, and forests, and are often inefficiently managed. Unprecedented pressure from human activity hence requires a significant ramping up of conservation efforts.

Pollution is a rapidly increasing threat to water-related ecosystems in the Nile Basin. Discharge of untreated wastewater and sludge, fertilizer and pesticides from farming, and sediments from land degradation comprise the prime pollutants. They cause direct mortality of species, the destruction of habitat, or changes in aquatic plant composition. Water-quality problems are predicted to grow as more people live close to rivers, wetlands, and lakes. To keep them at bay in the future, the Nile Basin countries need to expand wastewater collection and treatment and redouble efforts to control nutrients, sediments, and pesticides across the watershed.

In summary, the drivers of environmental degradation are growing in the Nile Basin. While policies and management interventions are improving, measures to preserve water-related ecosystems are generally weak and their scope is inadequate. It is noted that implementing many of these measures – such as increasing access to cheap electricity or strengthening the enabling environment for good land husbandry – falls within the mandate of agencies outside the environmental and water domain. This emphasises the multi-sectoral dimension of protecting water-related ecosystems.

IMPROVING RESILIENCE TO CLIMATE CHANGE IMPACTS

Recent climate projections (IPCC, 2018) predict that the Nile region is subject to a warming and more variable climate. The main climate impacts over the Basin are manifested in 1) increased aridity, 2) higher temperatures, 3) more frequent and more severe flooding, 4) more frequent and more intense droughts, and 5) higher variability of rainfall and associated streamflow. However, the extent of future climate change in the Nile region is yet unclear, and different parts of the Basin will be affected in different ways.

Changes in rainfall patterns remain uncertain and vary per region and sub-region. While some models tend to predict a rainfall increase in the equatorial regions, there is little consistency between models, and projections of mean rainfall are subject to high uncertainty. Because river flow in the Main Nile tributaries – specifically those originating in the Eastern Nile region – is very sensitive to a small shift in mean rainfall, the changing rainfall patterns could have considerable impacts on the availability of water resources. However, the magnitude and direction of possible change is still unclear, and model runs show a wide range of outcomes for all sub-basins. By contrast, there is that higher temperatures lead to increased reservoir evaporation losses.

In any case, climate change is impacting on the water resources in the Nile Basin and could impair the functioning of the economic, livelihood, and natural systems that are reliant on them. The Nile Basin is highly vulnerable to climate impacts because of high poverty levels, the expansive and fragile dryland zone, poor farming practices in the large rainfed area, and the large rural population – still expanding in absolute numbers – that is reliant on the natural resource base for its livelihood.

Thus, in face of significant uncertainties about projected climate, strengthening resilience to climate impacts is important in order to meet diverse socio-economic development goals and preserve the progress made so far. In the context of the Nile Basin, strengthening climate resilience will also strengthen resilience to the natural variability of the climate and a broad variety of other climatic, socio-economic, and environmental disturbances. Thus, improving Basin resilience to climate impacts will have multiple co-benefits related to poverty alleviation, sustainable development, catchment management, food security, and associated development objectives.

The analysis of the state of resilience to climate impacts in the Nile Basin reveals that preparations are currently inadequate, and that climate change poses serious challenges to the people living in the Nile Basin.

Specifically, the large rainfed agricultural sector is very vulnerable to climate impacts. Farmers are almost totally unprepared to cope with more and more frequent dry spells of uncertain duration. Higher risks of crop failure will impede agricultural modernisation and hamper the crucial objective to improve yields in rainfed farming. This has adverse consequences for rural development, poverty alleviation, land degradation and environmental sustainability, and rural–urban migration. Additionally, it is unlikely that food security in the Nile Basin – specifically for the large and growing rural population – can be achieved without improving crop yields, which is becoming more difficult because of climate impacts.

Preparations in the pastoralist sector

« To enhance resilience, NBI is assessing the climate of major water systems and sectors in the Nile Basin »

« Climate change poses serious risks to the social, economic, and environmental systems of the Nile Basin »

« Rainfed agriculture is most vulnerable to climate change and least prepared to cope with its impacts »

« Pastoralism has been generally resilient to climate variability but it is vulnerable to extreme droughts that could lead to conflicts over land and water »

« The energy sector is better prepared for the impacts of climate change due to the mix of energy sources and power trade »

« To mitigate the impacts of climate change, the scaling up of no-regret measures is a sensible course of action »

« Multilateral cooperation promises more benefits and rewards than ever before »

are also inadequate. No measures are in place for improved land management, herd management, or post-drought herd reconstitution. It could compromise the economic viability of the pastoralist lifestyle and encourage rural–urban migration, since economic opportunities outside the pastoralist sector are generally poor in the dryland zone.

The irrigated agricultural sector is unprepared for a scenario in which Nile flows decrease. In the case of bulk water deficits, no mechanisms exist to utilize or manage the remaining water resources over the existing schemes in an equitable and reasonable manner and through a negotiated process, or to systematically reduce the water requirements of irrigation.

Climate resilience in some sectors has improved in recent years. Progress has been made in protecting people and ecosystems in the Main Nile valley and Blue Nile valley against flooding, while the dependency on Nile waters for energy supply will progressively decrease in the longer term with the expected diversification of the energy production mixes, in combination with the establishment of functional regional power markets.

A sensible course of action in an environment with high uncertainty – caused by the unpredictability of the future rainfall and hydrologic regime – is to focus on so-called measures of 'no-regret' that strengthen climate-change resilience while simultaneously contributing to overall development objectives. Robust no-regret measures are effective in a wide range of future weather scenarios. Improved land husbandry, soil and water conservation, small-scale supplementary irrigation, increasing water-storage capacity, and protection of wetlands and other water-related ecosystems that can buffer hydrologic variability are prime examples of effective no-regret measures that create resilience to the high natural climate variability in the Nile Basin while strengthening climate resilience.

The challenge is to scale up climate-change adaptation measures quickly enough to make a significant impact. This will be a daunting task in view of the scale of the action required, but also because the extent of future climate change is still uncertain. However, most measures that strengthen climate change resilience are simultaneously contributing to overall development objectives and are part of existing policies and programs. Accelerated implementation of these 'no-regret' measures by the respective technical agencies is a sensible course of action. It will involve setting up incentive mechanisms to motivate individual actors to implement climate adaptation measures.

Transboundary water resources management is a useful and strategic element of climate-change adaptation. While coordinated flood management is being considered by the riparian countries, limited progress has been made in reducing reservoir evaporation losses through coordinated dam operation. Transboundary action is also required for data collection, data and information sharing, flood forecasting, and for drought early warning.

It is emphasised, however, that most measures to strengthen climate resilience need to be implemented at national level.

Failure to adequately strengthen resilience to climate impacts could have potentially large adverse implications for the ecological, economic, and social systems in the Nile Basin.

TRANSBOUNDARY WATER GOVERNANCE

A scarce and shared resource requires careful management. Ensuring water security for all uses and preparing for climate change requires substantial managerial resources. The capacity for water governance in some Nile countries is affected by factors such as insufficient staffing, insufficient funding, inadequate enforcements of water regulations, insufficient data and modelling tools, shortages of funds for investment in water infrastructure, etc. This situation poses a risk to achieving water security and is a matter of concern.

What is promising is that almost all Nile countries have institutionalised most elements of integrated water resources management (IWRM) in order to address the multi-sectoral dimension of water security and avoid fragmentation.

Managing increasing water stress and competing water uses is complicated by the transboundary nature of the Nile water resources. In the absence of agreed-upon mechanisms for sharing water resources – and the associated benefits – there is the potential for conflict among the Nile Riparian States. However, the findings of this report suggest an active and constructive political commitment to transboundary cooperation by all the Riparian States. This is a critical prerequisite to achieving progress on enacting the Nile Basin Cooperative Framework Agreement and thus securing the sustainability of the transboundary water governance arrangements on the Nile.

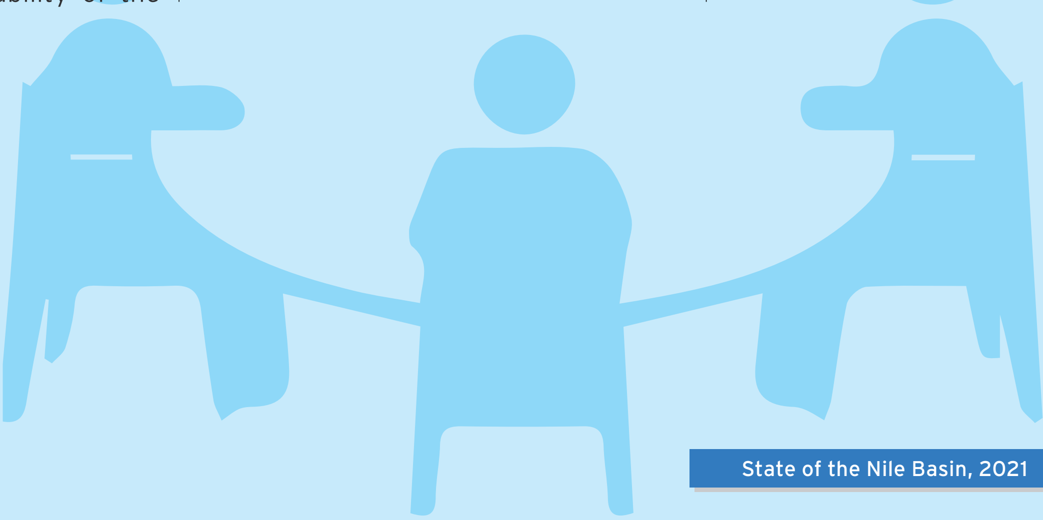
Progress has further been made to strengthen the capacity for transboundary water governance. Functional institutional arrangements are in place in all countries to deal with transboundary water issues. Transboundary water management considerations are, generally, adequately reflected in the policies, laws, strategies, and action plans of individual Riparian States, while a very large number of Nile Basin nationals have been trained in skills required for transboundary cooperation.

Cooperation within the framework of NBI has further enhanced the infrastructure and information that can contribute to achieving water security in the Basin. Identification, development and implementation of transboundary investment projects has resulted in shared benefits and opportunities for further enhancement of trust and cooperation. Additionally, a common and neutral modelling platform – the Nile Basin Decision Support System – has been established that supports policy review and trade-off analysis by the individual states and the NBI policy organs.

The potential is, therefore, immense to consolidate the above-discussed gains towards a permanent transboundary legal framework that will be instrumental in assuring water security in the Nile Basin.

« Business as usual will not deliver the full benefits of transboundary cooperation »

« Effective mechanisms for transboundary water cooperation are emerging and the NBI has played a prominent role in this process »



CONCLUSION

« There are a number of ways of achieving water security in the Nile Basin but not enough progress has been made in implementing these measures »

Relative to the number of people living in the Basin and the size of the catchment area, the Nile is a small river in terms of volume of discharge.

Most of the renewable surface water resources in the Nile Basin are used, predominantly for irrigated agriculture in the Basin. Water use for domestic and industrial purposes is small in comparison, while water used for hydropower production is modest because the primary purpose of the main constructed reservoirs -- is to provide irrigation water. It is probable that water availability is already insufficient for ecosystem protection in the Nile Delta.

Since demand for water continues to rise because of population growth and socio-economic development, water resources in the Nile Basin are under rapidly growing pressure. Additionally, there is considerable risk that fresh water downstream of major urban areas will become heavily polluted – and thus become de facto unusable – because of exponentially increasing volumes of wastewater due to urbanisation and industrialisation.

Nevertheless, the Nile countries are in possession of a considerable set of options to achieve water security. These include, but are not limited to:

- extending the productive use of the large rainwater resources;
- improving irrigation efficiencies;
- importing virtual water through food imports;
- reducing large food losses;
- using non-conventional water sources for M&I supply;
- reducing reservoir operation losses through enhanced cooperation and coordinated reservoir operation; and
- conjunctive use of surface and groundwater.

Thus, while relative water scarcity is real in the Nile Basin, it does not inevitably translate into negative consequences for the diverse ecological, economic, and social systems in the Nile countries.

However, to date there is limited progress in implementing the measures that are available. Specifically, improving water productivity in the critical agricultural sector remains one of the measures that could potentially contribute to water security in the Nile Basin.

INTRODUCTION

Photo: Arne Hoel / World Bank

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INTRODUCTION

Photo credit: istock

Over recent years, several of the Nile Basin countries have been among the fastest-growing economies on the African continent. Across many parts of the Basin, great advances have been made in tackling poverty, malnutrition, health issues, and unemployment. These developments have, to a large extent, depended on the availability of water resources, especially given the important role agriculture plays in the Basin. The river network of the Nile, including the many large wetlands and lakes it sustains, comprises a critical source of water for some riparian countries, especially those that are fully, or to a large extent, situated within the boundaries of the Basin.

However, as in many other regions around the world (WEF, 2019), water-related issues have grown into serious risks in some areas of the Nile Basin. Rising abstractions from rivers and aquifers, rapid land-use change, and heavy pollution have exerted increasing pressures on water resources and the ecosystems that sustain their continuous provision. Driven by growing populations and higher standards of living, there will be an ever-higher demand for food, fibre, and fuel, which, together with the impacts of climate change, will further intensify these pressures in the future. If water security is not placed at the heart of planning and management decisions, water challenges could disrupt development progress in the future. In a transboundary Basin like the Nile, the sustainable management and development of water and natural resources to achieve sustainable development objectives will require cooperation and coordination of the various actors within and across the Basin countries.

THE NILE BASIN INITIATIVE

The Nile Basin Initiative (NBI) is the prime institution involved in facilitating cross-border water management and cooperation. It is a transitional intergovernmental partnership led by 10 Nile Basin countries, namely Burundi, DR Congo, Egypt, Ethiopia, Kenya, Rwanda, South Sudan, Sudan, Tanzania, and Uganda, while Eritrea participates as an observer. The partnership was established on 22 February 1999 and is guided by a SHARED VISION OBJECTIVE

SHARED VISION OBJECTIVE: TO ACHIEVE SUSTAINABLE SOCIO-ECONOMIC DEVELOPMENT THROUGH EQUITABLE UTILISATION OF, AND BENEFIT FROM, THE COMMON NILE BASIN WATER RESOURCES.

NBI CORE FUNCTIONS

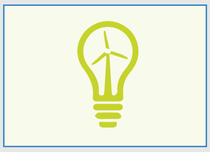
To achieve the Shared Vision Objective, NBI implements three core functions:

- **Basin cooperation:** To facilitate, support and nurture cooperation amongst the Nile Basin countries so as to promote timely and efficient joint actions required for securing benefit from the common Nile Basin water resources.
- **Water resource management:** To assess, manage and safeguard the water resource base that supports the peoples of the Nile Basin by applying the principles of knowledge-based integrated water resources management to water development planning and assessment. The Water Resources Management Program has lined up an array of technical interventions aimed at broadening and deepening understanding of the temporal and spatial variations of the Nile Basin water resources and the interaction between country development goals.
- **Water resource development:** To identify, prepare and facilitate investment in regional/transboundary water development projects and programs, while avoiding negative impacts on the health of the Nile Basin's resources by applying the principles of integrated water resources management.

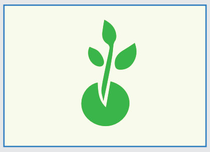
NBI STRATEGY

NBI's work towards achieving the NBI shared vision is guided by the NBI 10-year Strategy (2017–2027), which advocates NBI strategic directions among the NBI partner countries and sets the ambition for delivery of impact on the ground. The 10-year Strategy is implemented through 5-year programs prepared by the three NBI centres: Nile-SEC, ENTRO and NELSA-CU. The 2017–2027 strategy, prepared in consultation with the member states, identified six strategic priorities.

Goal 1
Water security
Enhance availability and sustainable utilisation and management of transboundary water resources of the Nile Basin.



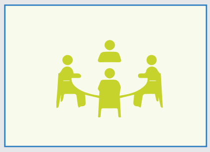
Goal 2
Energy security
Enhance hydropower development in the basin and increase interconnectivity of electric grids and power trade.



Goal 3
Food security
Enhance efficient agricultural water use and promote a basin-wide approach to addressing the linkages between water and food security.

Goal 4
Environmental sustainability
Protect, restore, and promote sustainable use of water-related ecosystems across the basin.

Goal 5
Climate-change adaptation
Improve basin resilience to climate-change impacts.



Goal 6
Transboundary water governance
Strengthen transboundary water governance in the Nile Basin.

PURPOSE OF THE STATE OF THE BASIN REPORT

Photo: iStock

The Nile Basin is starting to experience large-scale developments, guided by the 2017 – 2027 NBI strategy and action plan, but also country-specific national development objectives and master plans, international agreements, and investments. Against this background, there is a need to reflect and monitor some of these developments, assess effects in terms of sustainable utilisation of the basin's water and related resources, and track progress towards overcoming the main basin development challenges.

The objective of this second Nile State of the Basin Report is therefore to:

- Further create a shared understanding of biophysical trends and characteristics of the Nile Basin by providing validated information to riparian states on the phenomena and health of the basin;
- Monitor change and progress towards achieving strategic management objectives in the Nile Basin;
- Provide credible and up-to-date information on and analysis of the basin performance
- Identify and address basin-wide development opportunities and challenges; and
- Highlight regional policy options, potential joint courses of action and strategic measures towards harnessing opportunities and addressing key basin issues and challenges.

This second Nile State of Basin Report present facts, trends, patterns, synthesis, and indicators for both the basin health and multiple biophysical conditions. It also establishes the foundation and structure for basin reporting:

- NBI member states shall build and uphold the process for basin monitoring and reporting.
- Periodic updates of the set of indicators shall be systematically undertaken by the Nile Basin countries through a system to be administered by NBI.
- Basin reporting will be strongly linked with critical assessment of the policies and strategies.

In this way, the report gives policy makers, senior government officials, and the international development community a basis for well-informed decision-making.

The contents and structure of the report are guided by the priorities of the NBI 10-year Strategy (2017–2027), with a special focus on water security for this edition of the Nile State of Basin Report.

WATER SECURITY – CONCEPTUAL FRAMING

The concept of water security has been established as a topic on the international policy agenda since the 2000 Ministerial Declaration of The Hague on Water Security in the 21st Century (World Water Council, 2000). Nile Basin countries have reflected water security in the Nile Basin Cooperative Framework Agreement (CFA), with Article 14 taking water security to mean 'the right of all Nile Basin States to reliable access to, and uses of, the Nile River system for health, agriculture, livelihoods, production, and the environment' (NBI, 2010).

Several conceptual approaches to water security have since been developed. Today, a shared perspective is that water security comprises ensuring water availability and preventing water-related risks for society, economy, and environment.

The discourse on water security in recent years has identified a number of key elements that are necessary to achieving and maintaining water security (see Box 1). There is a common understanding that water security involves tackling complex and interconnected resource challenges in an integrated way, since water is fundamental to any aspect of human well-being and development, to multiple sectors, from agriculture to energy, as well as to achieving various sustainable development goals. Water security cannot be considered in isolation (Figure 1.1). Achieving water security is directly linked to food security, energy security, protecting and preserving ecosystems, and addressing key vulnerabilities and risks from climate change. It is evident that a scarce resource requires careful management, involving institutions, infrastructure and information. Good water governance – including transboundary cooperation – is a critical feature of any effort to achieve water security. In transboundary Basins, the challenge of reaching water security is compounded by the fact that several sovereign countries share lakes, rivers, or wetlands that cross national boundaries. Mitigating water-related risks, such as water scarcity or pollution, cannot be achieved successfully unless the riparian countries within a Basin join forces. Doing so can create significant opportunities for other political and development goals and spill-over effects for regional cooperation.

A COMMONLY USED DEFINITION FOR WATER SECURITY IS THE ONE BY UN-WATER:
The capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability (UN Water, 2013).

BOX 0.1: KEY ELEMENTS FOR ACHIEVING WATER SECURITY

Core elements necessary to achieving and maintaining water security, as found in a broad range of published definitions:

- Access to safe and sufficient drinking water at an affordable cost in order to meet basic needs, which includes sanitation and hygiene (cf. United Nations General Assembly, 2010), and the safeguarding of health and well-being;
- Protection of livelihoods, human rights, and cultural and recreational values;
- Preservation and protection of ecosystems in water development and management systems in order to maintain their ability to deliver and sustain the functioning of essential ecosystem services;
- Water supplies for socio-economic development and activities (such as energy, transport, industry, tourism);
- Collection and treatment of used water to protect human life and the environment from pollution;
- Collaborative approaches to transboundary water resources management within and between countries to promote freshwater sustainability and cooperation;
- The ability to cope with uncertainties and risks of water-related hazards, such as floods, droughts, and pollution, among others; and,
- Good governance and accountability, and the due consideration of the interests of all stakeholders through: appropriate and effective legal regimes; transparent, participatory, and accountable institutions; properly planned, operated and maintained infrastructure; and capacity development.

(UN-Water, 2013)

HOW THIS REPORT WAS PREPARED

The Nile State of the Basin Report was prepared by NBI, in collaboration with a Regional Working Group (RWG). This group comprises of three members from each NBI member state, including the country representative to the NBI Technical Advisory Committee (TAC). NBI further contracted a consultant (adelphi consult) to provide technical support for preparing the report.

Guided by six strategic priorities identified in the NBI 10-year Strategy (2017–2027), the state of the Basin reporting system was structured along six themes:

- water security
- energy security
- agricultural development and food security
- environmental sustainability
- climate change; and
- transboundary governance.

For each of these themes, the current state, main trends, drivers of change, and management responses have been identified. Based on this analysis a comprehensive set of indicators has been selected, and a logical indicator matrix developed for each of the themes, which allows a structured collection and analysis of relevant data and information to describe the state of the Basin with reference to each theme. The logical indicator matrices form the basis of a Nile Basin Reporting Mechanism that allows an accurate and comprehensive description of the state of the Nile Basin in a comparable manner, which will allow progress and the impacts of development to be assessed through future State of the Basin (SOB) reports.

The Nile State of the Basin Report is based on information collected by NBI as part of the Nile decision support system and strategic water resources assessment, as well as on data in the public domain and other published reports. Data Each step in developing the SOB was validated by the Regional Working Groups.

CHAPTER 1

THE CONTEXT FOR WATER RESOURCES DEVELOPMENT IN THE NILE BASIN

Photo: Arne Hoel / World Bank

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KEY MESSAGES

The Nile is the longest rivers on the planet.
On its way from the equator to the Mediterranean Sea, the topography becomes more even, the climate turns warmer, water resources become scarcer and more variable, and fewer plant and animal species are to be found. These and other factors have determined where and how humans have developed the basin's water and land resources.

Humans are modifying the natural environment of the Nile Basin at an unprecedented rate.
This threatens the diverse and rich water-related ecosystems that millions of people directly depend on for fisheries and fuelwood, and which are the foundation of future economic growth and development in Nile Basin countries.

Population growth rates in the Nile countries remain high
The population of the Nile Basin has enlarged from 238 million people in 2012 to 272 million in 2018.

Urbanisation is on the rise in the basin.
Although the majority of the basin population is rural, by 2050, the percentage that is urban is expected to be twice that in 2010.

Despite strong economic growth and improvements in human development indicators in some basin countries, levels of socio-economic development across the basin remain low.
In the majority of basin countries, reduction in poverty, inequality, and malnutrition, and improved access to basic services still fall largely behind that of the average in other developing regions in the world.

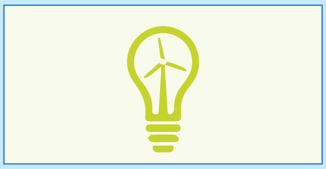
Photo credit: Vivek Bahukhandi

The Nile Basin has great transformative potential for socio-economic development and human prosperity.
Rapidly changing population dynamics will lead to a younger population seeking opportunities in cities. More densely populated urban areas provide the possibility of more cost-efficient water and other infrastructures, including health services and electricity supply.

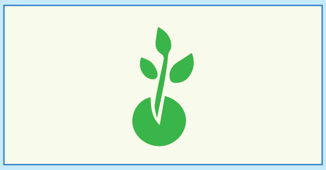
Pressures on the natural environment stem predominantly from land-use change.
This is mainly driven by agriculture, yet increasingly also by expanding urban areas. Populations and cities increase the pressure on sensitive ecosystems through exploitation of natural resources, development of infrastructure, and pollution.

Infrastructures and governance systems are already overwhelmed by the magnitude and pace at which water-related challenges develop.
Rapid population growth and urbanisation require urgent and far-reaching responses in the form of large investments, capacity, and service provision to safeguard the basin's natural resource base, which is essential for achieving water security – and sustainable development at large.

Water security



Energy security



Food security

Environmental sustainability

Climate-change adaptation

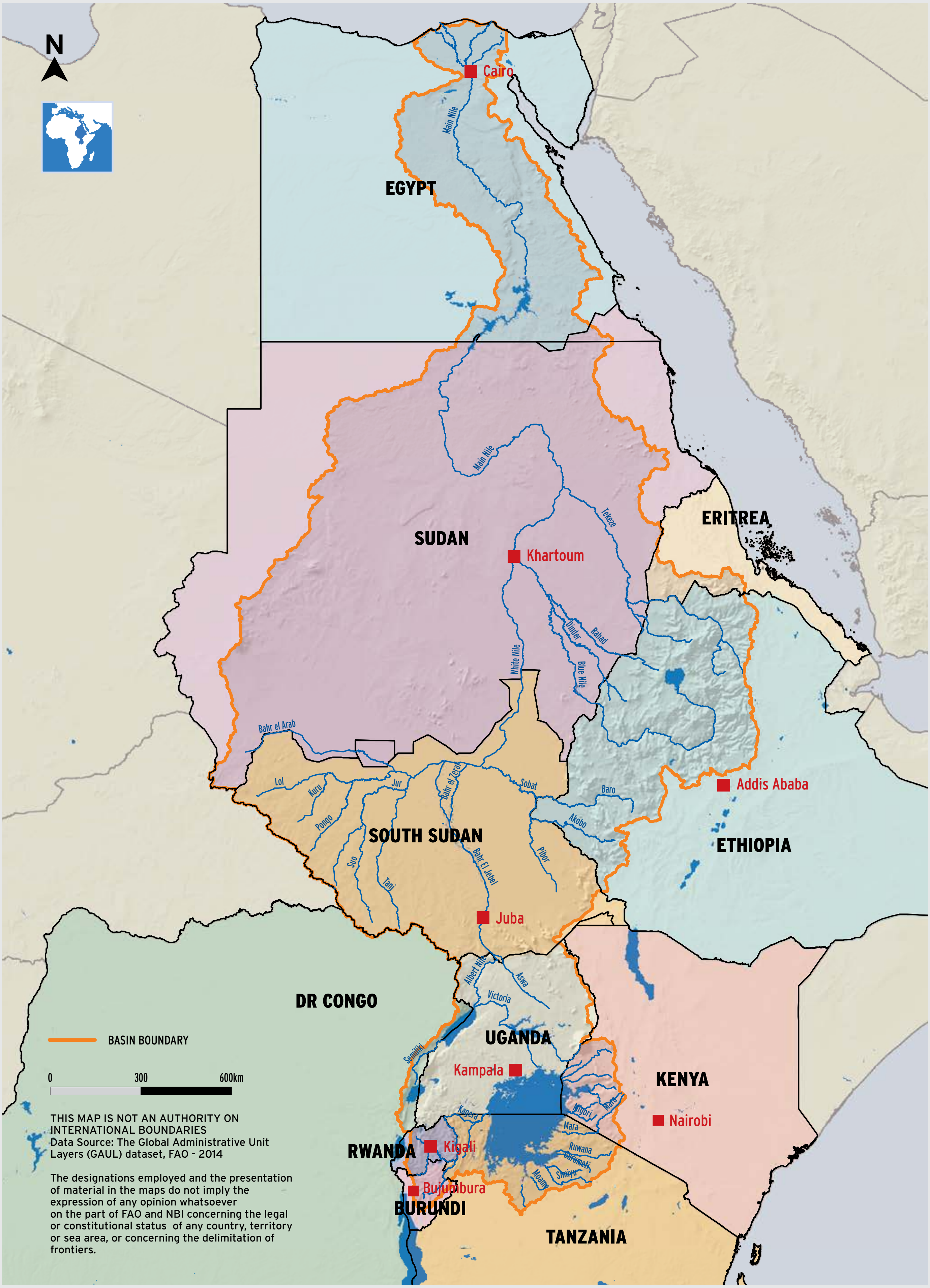
Transboundary water governance

QUICK FACTS ON THE NILE

The Nile is the longest river in the world at 6,695 km, flowing northward through the tropics and the highlands of eastern Africa and draining into the Mediterranean Sea. It flows through eleven countries: Burundi, DR Congo, Egypt, Ethiopia, Eritrea, Kenya, Rwanda, South Sudan, Sudan, Tanzania, and Uganda. The following provides a quick overview of the main facts about the Nile Basin.

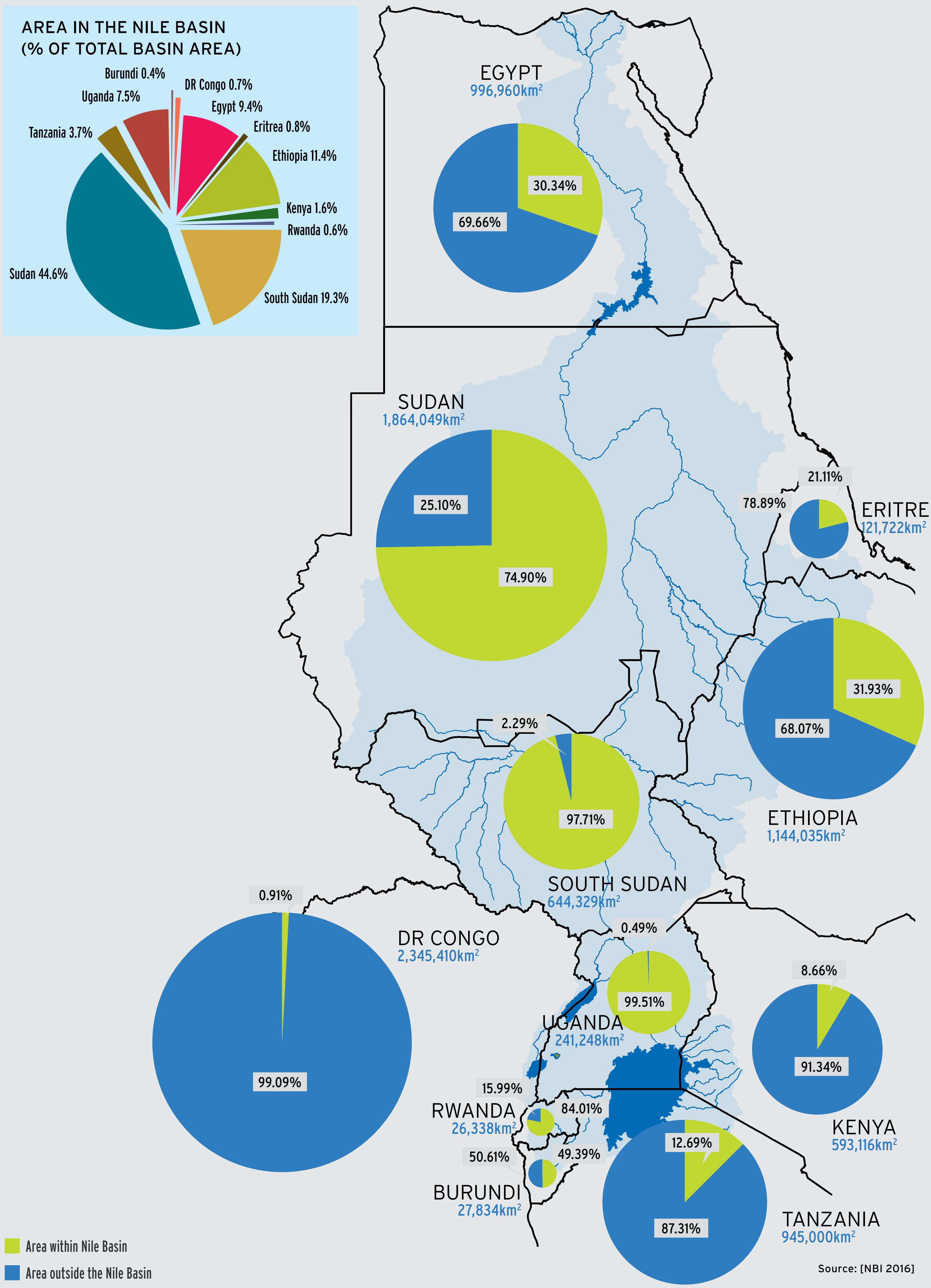
QUICK FACTS ON THE NILE		
	Description	Source of information
Length	6,695 km	NBI (2016a). Nile Basin Water Resources Atlas.
Navigable length	4,149 km	NBI (2012). State of the River Nile Basin.
Basin area	3,200,000 km^2	NBI (2016a)
Location	East Africa and North Africa (Victoria Lake to Mediterranean Sea)	NBI (2016a)
Riparian countries	Burundi, Democratic Republic of Congo, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, South Sudan, Sudan, Tanzania, Uganda	
Estimated mean annual runoff at entrance to the High Aswan Dam (HAD)	84 to 91 BCM (with some estimates even higher)	Various sources
Main tributaries	Kagera, Victoria Nile, Bahr el Jebel, Bahr el Ghazal, Baro-Akobo-Sobat, Blue Nile, Tekeze-Atbara, White Nile, Main Nile	NBI (2016a)
Major natural lakes	Victoria, Kyoga, Albert, Edward, Tana	
Precipitation	Mean annual rainfall: 650 mm	Estimated by NBI based on global data sources (NB Water Resources Atlas, 2016)
Total population of Nile countries	529 million (2018)	UNDESA (2018a)
Population within basin	272 million (2018)	Calculation based on data from Ciesin (2017) & UNDESA (2018a)
Land use	Bare areas (31%); shrub lands (29%); cultivated land (23%); forest (7%); grassland (6%)	NBI (2016). Nile Basin Resources Atlas.
Major dams and regulators with total storage capacity > 1 BCM	Kiira and Nalubale, Chara Chara, Jebel Aulia, Roseires, Sennar, TK-5 (Tekezze). Upper Atbara complex, Merowe, Aswan High, Aswan Low, Grand-Ethiopian-Renaissance-Dam (under construction), Bujagali, Karuma (under construction)	NBI (2016a). (Based on Timmerman 2005, Karyabwite 2000, FAO 2011)

POLITICAL MAP OF THE NILE REGION



Source: [NBI 2016]

FIGURE 1.1: RIPARIAN COUNTRIES AREA WITHIN THE NILE BASIN



Source: [NBI 2016]

PHYSIOGRAPHY OF THE NILE BASIN

The Nile Basin covers about one-tenth of the area of the continent, draining a total land area of 3,200,000 km^2. The Basin is rich with a variety of natural resources (lakes, wetlands, highlands, ecosystem, biodiversity, etc.). It features a very diverse physiography, with varying combinations of characteristic land features such as slope, soils, topography, and vegetation.

Photo credit: Stefan Gara

Photo credit: Vivek Bahukhandi

Photo credit: Vivek Bahukhandi

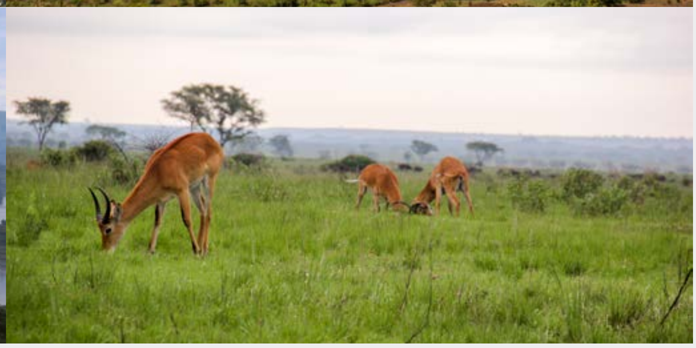


Photo credit: Vivek Bahukhandi

TOPOGRAPHY, GEOLOGY, AND SOILS

The Nile River network evolves from a complex topography. Its geomorphologically distinct tributaries rise in the upper parts of the Basin, the Ethiopian Highlands and East African lakes region. These mountainous areas are characterised by steep slopes prone to high rates of soil erosion, especially in the Ethiopian Highlands and in upper catchments of the Kagera river in Burundi and Rwanda. These areas generate runoff with relatively short time to peak. Along the middle reaches, the Nile tributaries flow across vast plains with gentle slops. Having passed these, the Nile flows through lowland areas for half of its length, stretching from the border of Uganda and South Sudan all the way to the Mediterranean Sea. Only a few isolated eroded mountains and hilltops punctuate these lowlands.

Four hydrogeological systems exist in the Nile Basin: Precambrian crystalline/metamorphic basement rocks, volcanic rocks, unconsolidated sediments, and consolidated sedimentary rocks. Groundwater resources are essentially rich, yet the existence and size of aquifers and their ability to recharge varies strongly by geographical region. In some countries, most notably Egypt and Sudan, the bulk of aquifers are non-renewable, while more permeable geology enables much higher groundwater recharge in areas such as the Ethiopian Highlands.

Rock formations in the Nile Basin are overlain by a variety of soil types, with vertisols, nitisols, ferrasols, and calcisols being most abundant. Their chemical and physical characteristics, including runoff production and moisture-holding capacity, are critical for agricultural productivity. Up to 50% of the Basin area is subject to low soil productivity, yet much of these areas are located in the arid and hyper-arid parts of the lower Basin. Due to expanding land degradation, the area of arable land that is becoming less suitable for agriculture is increasing.

GEOMORPHOLOGY: THREE SUB-SYSTEMS

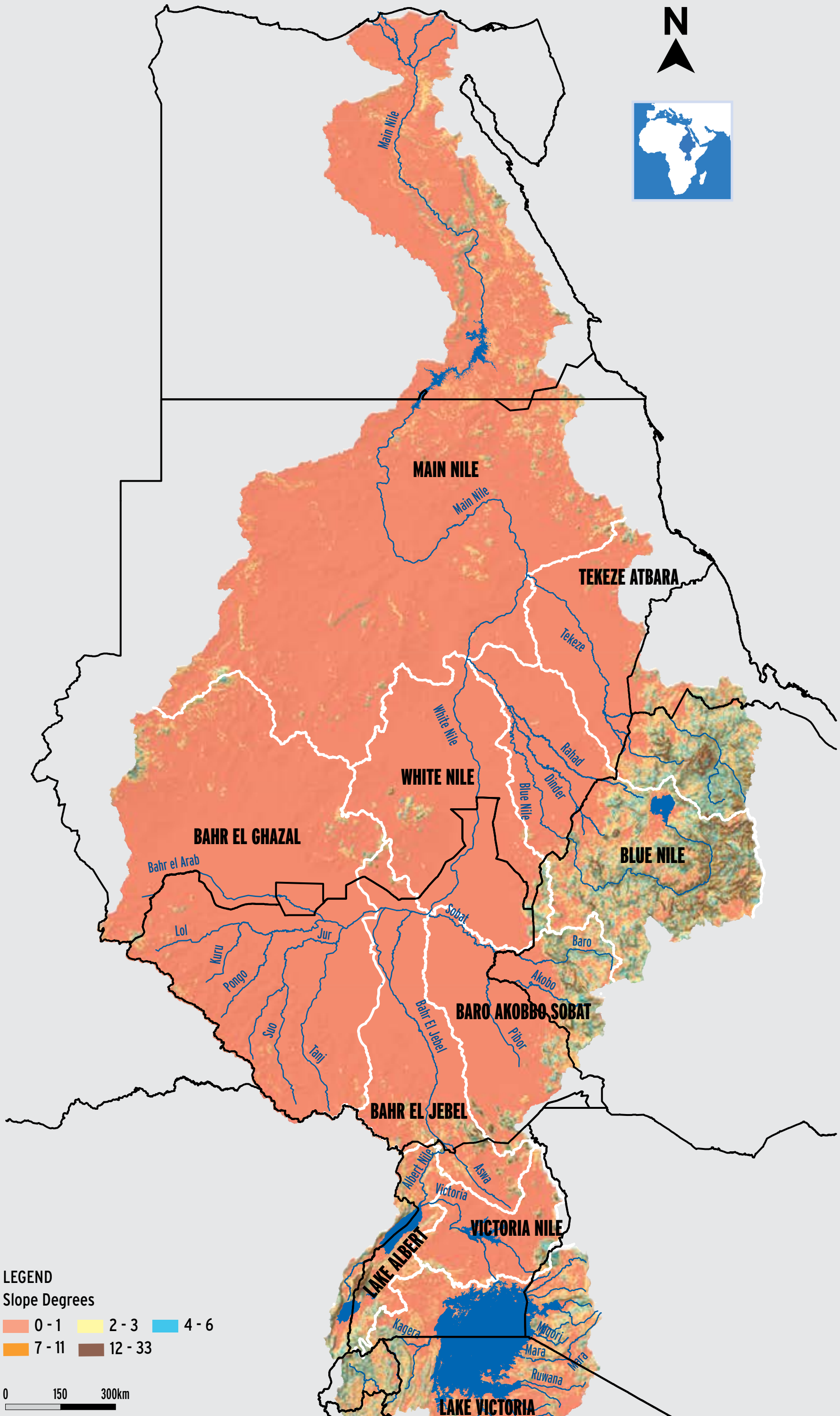
The Nile Basin comprises three sub-systems that have distinctive morphological and hydrological characteristics:

The Eastern Nile sub- system: This covers the catchments of the Blue Nile (Abay), Tekeze-Atbara, and Baro –Akobo-Sobat, which encompass large parts of the Ethiopian Highlands and the plains of the eastern region of South Sudan and Sudan.

The Equatorial Lakes: This covers the entire watershed upstream of the Sobat–White Nile confluence. It includes the Equatorial Lakes region as well as most of South Sudan.

The Main Nile and the Nile Delta: This encompasses the downstream river reach, starting at the Blue–White Nile confluence at Khartoum. The Nile Delta is an extensive wetland system accommodating lakes, freshwater and saline wetlands, and intertidal areas that are intensely cultivated through irrigated agriculture and aquaculture.

FIGURE 1.2: NILE BASIN WITH MAIN SUB-BASINS AND MOST IMPORTANT TRIBUTARIES



(Source of data: SRTM 90-m Digital Elevation Model by NASA) The NBI is not an authority on international boundaries

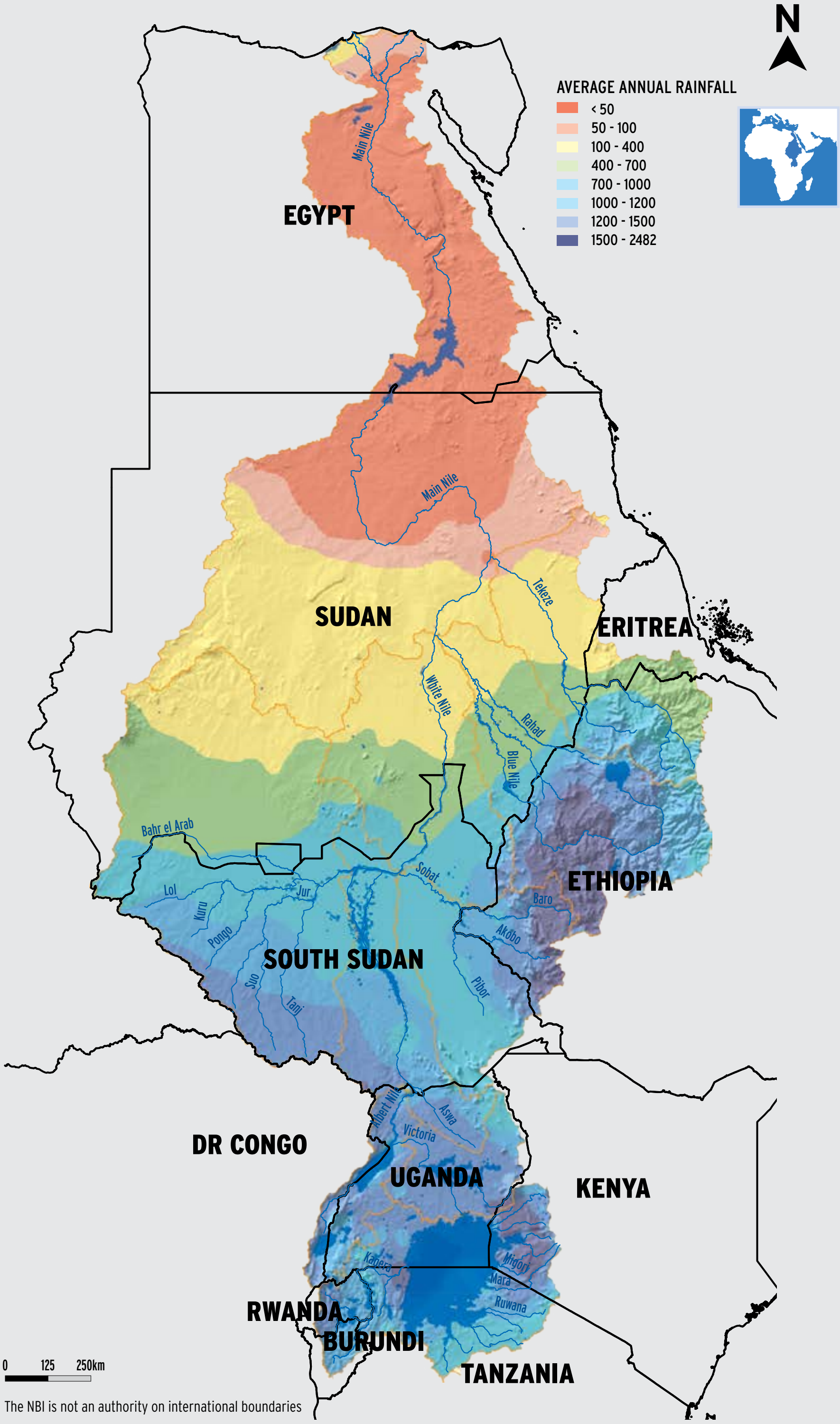
Source: NBI 2016

CLIMATE AND CLIMATE VARIABILITY

The Basin extends across 36 degrees of latitude and encompasses five climate zones, each showing distinctive patterns of precipitation, temperature, and evapotranspiration. Mean annual rainfall steadily decreases from south to north, from over 2,000 mm in some areas around Lake Victoria and the Ethiopian Highlands to less than 50 mm in parts of Egypt and northern Sudan (Figure 1.3). Variability in timing and location of rainfall both between seasons and years has been high throughout recorded history, yet it increases from south to north (Conway, 2017). The unpredictability of water supply presents a serious challenge to important water-dependent economies such as agriculture or the power sector.

Evaporation from soils and vegetation is high in the Basin, ranging from some 3,000 mm/year in northern Sudan to 1,400 mm/year in the Ethiopian Highlands and 1,100 mm/year in the hills of Burundi and Rwanda. This exposes the Basin to a high risk of drought. A significant amount of the Nile's discharge evaporates as the river flows through the semi-arid and arid parts of the Basin, especially in areas where natural flooding occurs or in dam reservoirs. Approximately, over 50% of the flow that enters the Sudd wetlands in South Sudan evaporates (Sutcliffe and Parks, 1999).

FIGURE 1.3: TOTAL RAINFALL (AVERAGE ANNUAL MM)



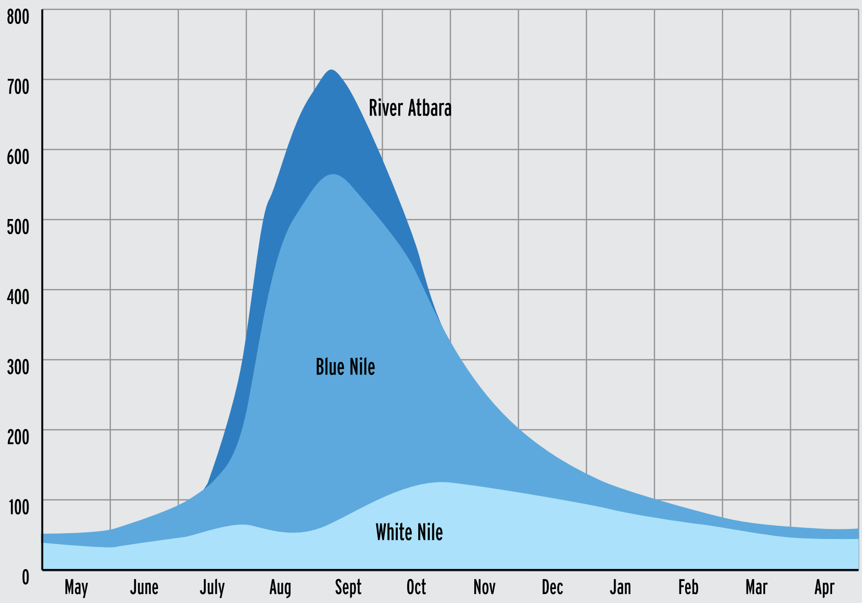
Source: NBI 2016

HYDROLOGY AND FUTURE CLIMATE CHANGE

Despite the large size of the basin's drainage area, the Nile River is relatively small in terms of the volume of its runoff (Awulachew et al., 2012). This is because a huge proportion of the basin, essentially the entire territory of Sudan and Egypt, creates almost no runoff, but features high evaporation rates, especially where rivers are dammed or form extensive wetlands.

Furthermore, the flows of the Main Nile are highly seasonal by nature. The tributaries draining the Ethiopian Highlands contribute 85% of the annual Nile flows. Yet, approximately 70 to 80 percent of this runoff is generated within a single season of four months, as the hydrograph in Figure 1.4 shows. By comparison, the Equatorial Lakes Region, contributes only 15% of the total flows. As a consequence of its regulation by several large lakes and wetlands it crosses, the White Nile provides stable year-round flows. In addition, river flow varies substantially between years, a condition that will intensify markedly under a changing future climate (Siam and Eltahir, 2017).

FIGURE 1.4: INTRA-ANNUAL VARIABILITY AND DISTRIBUTION OF FLOWS IN MILLION CUBIC METRES BY DAY



Source: Cascão, 2019. Based on Sutcliffe and Parks, 1999

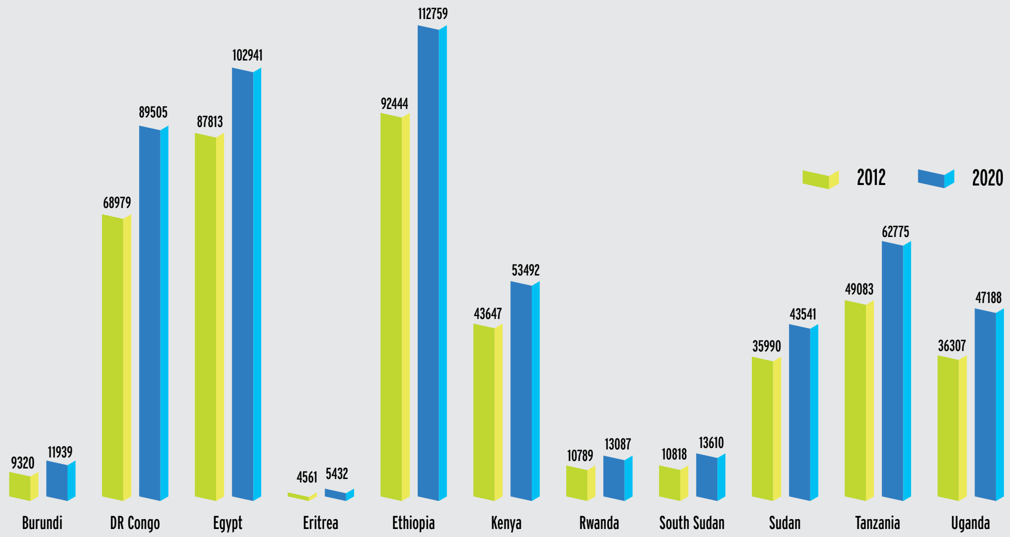
PEOPLE AND LIVELIHOODS

POPULATION DYNAMICS

The Nile Basin accommodates 10% of the population of Africa. Since the first SOB in 2012, population numbers in all Nile countries have continued to rise rapidly (Figure 1.5). Today, the combined population of all Nile Basin countries comprises approximately 556 million (UNDESA, 2018a). This presents an increase of about 20% since 2012 (NBI, 2012a).

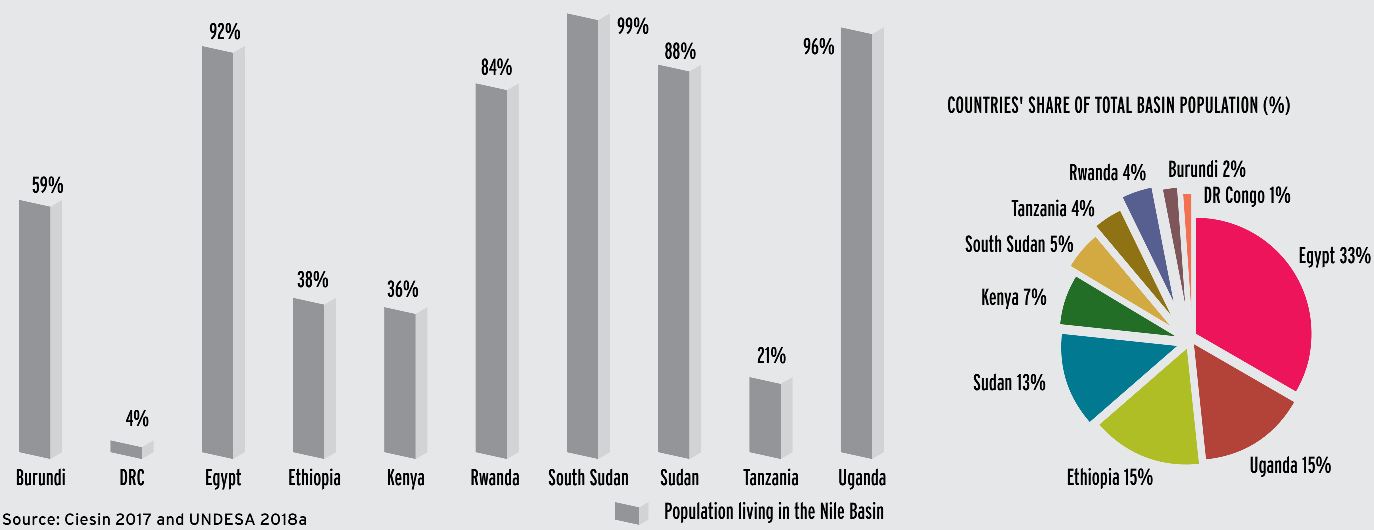
The size of the population living within the Basin has grown from 238 million in 2012 (NBI, 2012a) to 272 million in 2018 (based on UNDESA, 2020). There are vast differences between the Basin countries in regards to the ratio of people living inside and outside the Basin. In five countries – Egypt, Rwanda, South Sudan, Sudan, and Uganda – more than 80% of the population lives within the Nile Basin. Furthermore, Egypt, Ethiopia, Sudan, and Uganda alone account for over 75% of the total Basin population. Notably, only a small share of the large populations of DR Congo and Tanzania live within the Basin.

FIGURE 1.5: TOTAL POPULATION LIVING IN THE NILE BASIN (IN THOUSANDS) COUNTRIES, 2012 & 2020



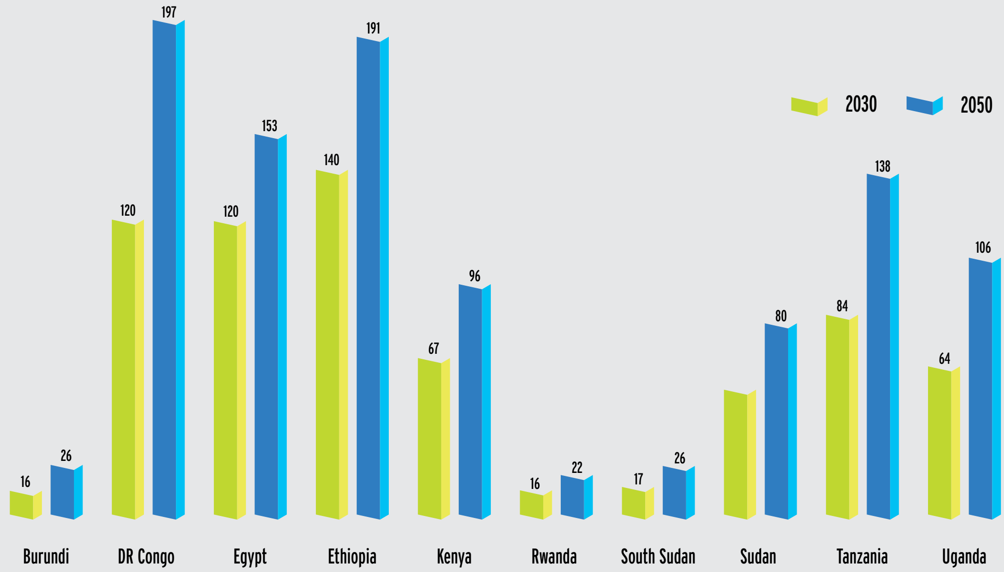
Source: UNDESA 2012 & 2018a

FIGURE 1.6: SHARE OF NILE BASIN COUNTRIES' POPULATION LIVING IN THE BASIN, 2018



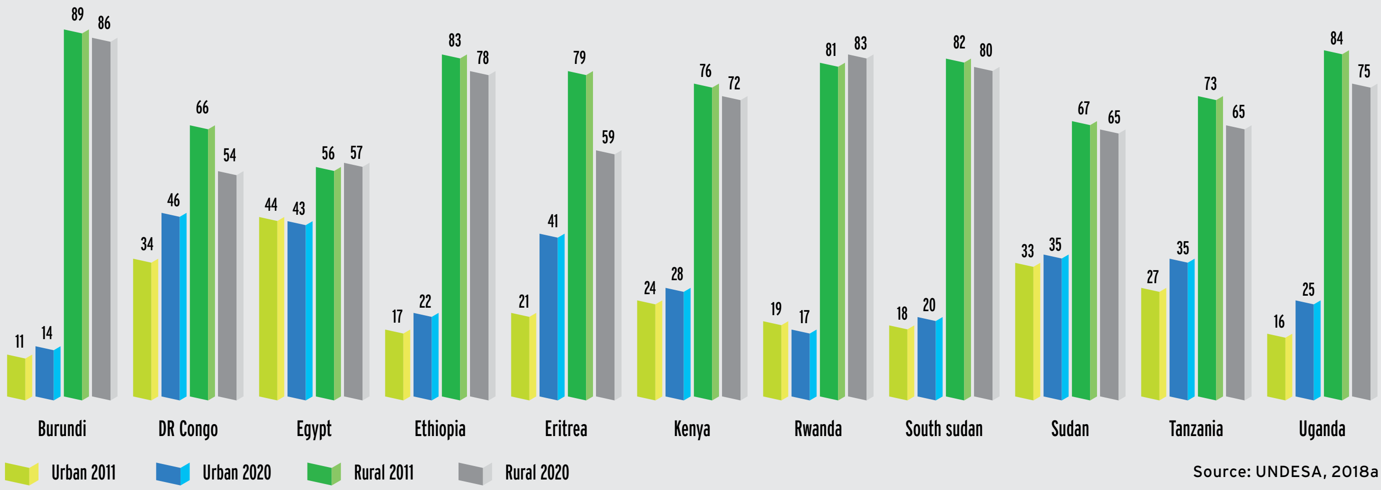
Source: Ciesin 2017 and UNDESA 2018a

FIGURE 1.7: PROJECTED POPULATION IN THE NILE BASIN COUNTRIES (MILLIONS) 2030 & 2050



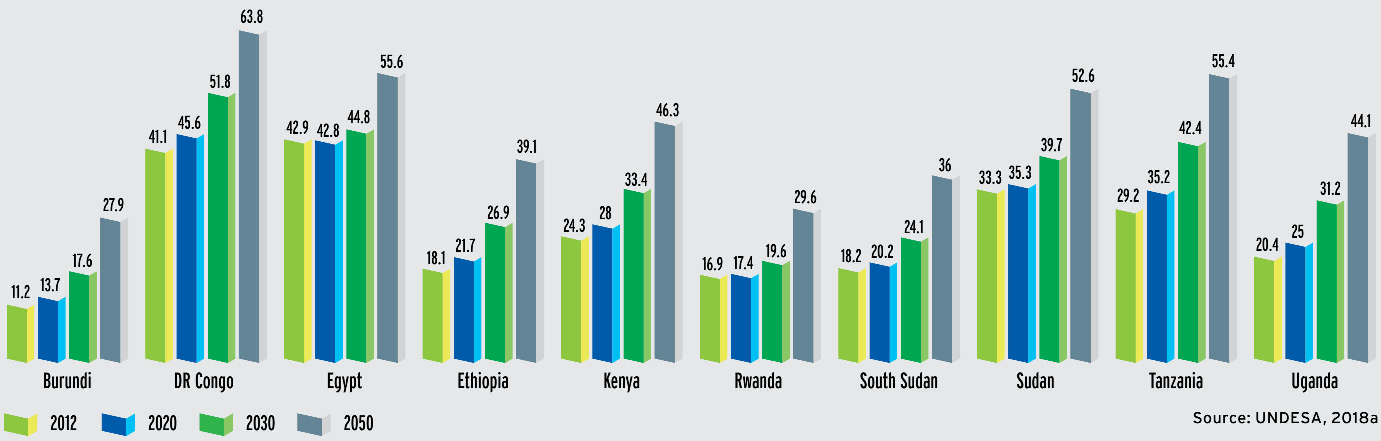
Source: UNDESA 2012 & 2018a

FIGURE 1.8: RURAL POPULATION PER COUNTRY (%) 2012, 2018, 2030 & 2050



Source: UNDESA, 2018a

FIGURE 1.9: URBAN POPULATION PER COUNTRY (%), 2012, 2018, 2030 & 2050



Source: UNDESA, 2018a

DETERMINANTS OF FUTURE POPULATION GROWTH

Population growth rates have been generally declining in the last decades in Egypt, Ethiopia, Sudan, and Kenya, but remain high at above 2% per year. Annual growth rates of around 3% are still witnessed in Burundi, DR Congo, Tanzania, and Uganda. Population growth rates in Eritrea, Rwanda, and South Sudan have been very irregular in the last decades because of political upheaval.

High fertility rates, together with declining mortality rates and rising life expectancy, are key determinants of the persistently high population growth rates in the Nile countries. For instance, between 2012 and 2016, the average life span in the Nile countries increased by 1.6 years, tying in with a trend ongoing for decades. Fertility rates remain high but are steadily declining, apart from in Egypt, where it has been more or less constant for the last 15 years at just above three births per woman. Nevertheless, all Nile countries are characterised by a young age structure, which will maintain the momentum for population growth until the medium-term future and beyond.

PROJECTIONS FOR FUTURE POPULATION GROWTH

Given the persistence of high growth rates, the number of inhabitants is expected to double in all Nile countries apart from Egypt by 2050. The total population of all Nile states will presumably exceed 1 billion by 2050, while the Basin population may climb up to as many as 500 million people (see Figure 1.7).

RURAL-URBAN POPULATION DISTRIBUTION

In 2018, 71% of the basin countries' habitants lived in rural areas, compared to 76% in 2011 (Figure 1.8). Even by 2050, rural populations will remain dominant in five Nile countries: Burundi, Kenya, Rwanda, South Sudan, and Uganda (Figure 1.8). This stands in stark contrast to global developments: slightly more than 50% of the world's population already lives in urban areas today, and this share is expected to increase to 68% by 2050 (UNDESA, 2018a).

Even though the bulk of the population in the Nile Basin is expected to remain rural in the near and medium-term future, urbanisation rates are high. They are mainly driven by high natural population growth in combination with rural-to-urban migration. There is no reliable data on how the extent of cities has changed over the last decades. However, urban land is expected to expand by 600% between the years 2000 and 2030 in Africa. It can be assumed that such growth rates also apply to the Nile Basin (Seto et al., 2012). Generally, urban expansion is occurring unevenly across the basin, with urban growth centres concentrated mainly in three spots: along the Nile River and its delta in Egypt; in the surroundings of Lake Victoria in Kenya and Uganda, as well as in Rwanda and Burundi; and in the greater Addis Ababa region (Güneralp et al., 2017).

Urbanisation in the Nile Basin manifests both in the form of mega cities and smaller cities. By 2030 one of Africa's six mega cities, namely Cairo, will be situated in the Nile Basin, and three within the basin countries (Bello-Schünemann and Aucoin, 2016). As the rapid growth is expected to outpace the capacity of planning institutions, most of the new urban settlements are being developed informally. Today, the proportion of urban inhabitants living in slums is above 50% in all countries except Egypt. Slum development in Africa often unfolds through low-density, low-rise urban sprawl, which is a key driver for the fast spatial expansion of urban areas (Güneralp et al., 2017).

SOCIO-ECONOMIC PROFILE

SLOW BUT STEADY IMPROVEMENTS IN HUMAN DEVELOPMENT

Several of the Nile Basin countries are among the poorest in the world. Eight out of eleven belong to the bottom 50 of the Human Development Index (HDI) (UNDP, 2018), which ranks 189 countries according to indicators of life expectancy, education, and per capita income. Nevertheless, all Basin countries achieved progress on several aspects of human development recently. Kenya has joined Egypt in the Medium Human Development tier, while Tanzania is close to accomplishing this status.

RAPID ECONOMIC DEVELOPMENT

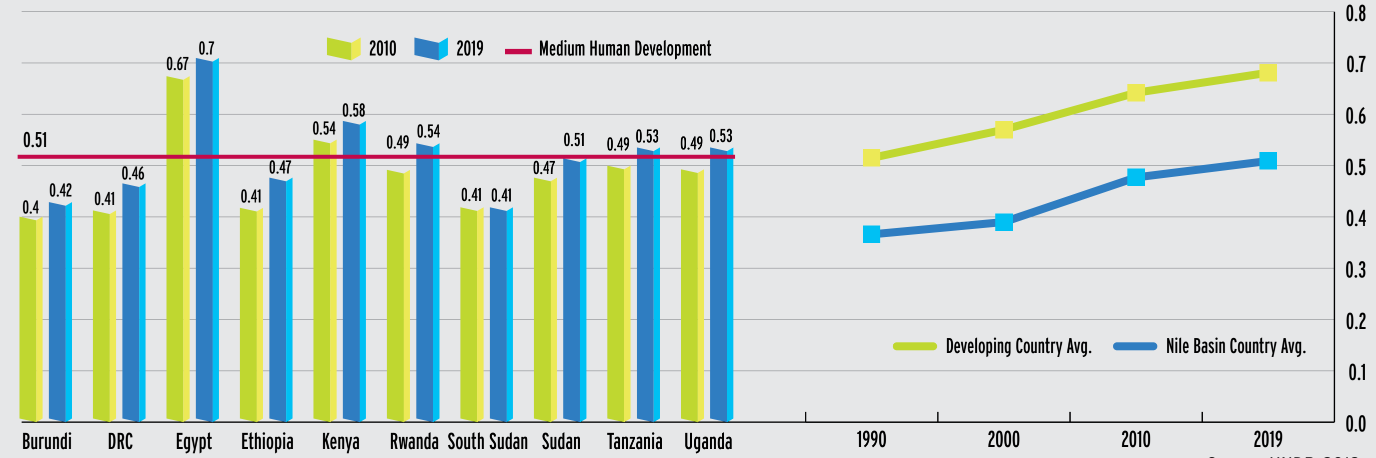
The period between 2012 and 2019 was characterised by economic growth in all countries except for South Sudan (Figure 1.11). Ethiopia, alongside Kenya, Rwanda, and Tanzania, were among the most rapidly expanding economies on the continent, with real growth above 5% (UNECA, 2017). Growth in other countries was more modest, while economic expansion in Burundi came to a standstill in 2017, a situation that still continues.

The COVID-19 pandemic has hit most economies in the Basin hard and is likely to reverse some of the gains recorded over the recent years. While country level analyses are still few, assessments at continental level show that the pandemic will drag African economies into a fall of about 1.4% in GDP, with smaller economies facing contraction of up to 7.8%. The contraction is mainly a result of export adjustments affecting primary com-

FIGURE 1.10:HUMAN DEVELOPMENT INDEX (HDI) IN NILE BASIN COUNTRIES, 2011 & 2019

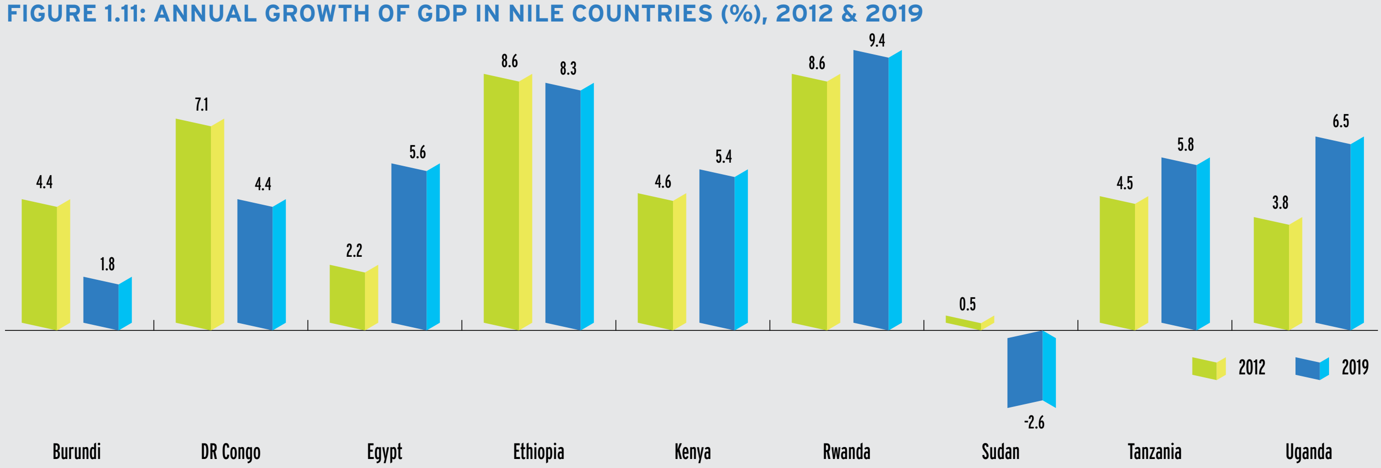
Human Development Index (HDI) per Nile Basin country 2011 & 2019

Average HDI in DEVELOPING AND NILE BASIN COUNTRIES, 1990-2019



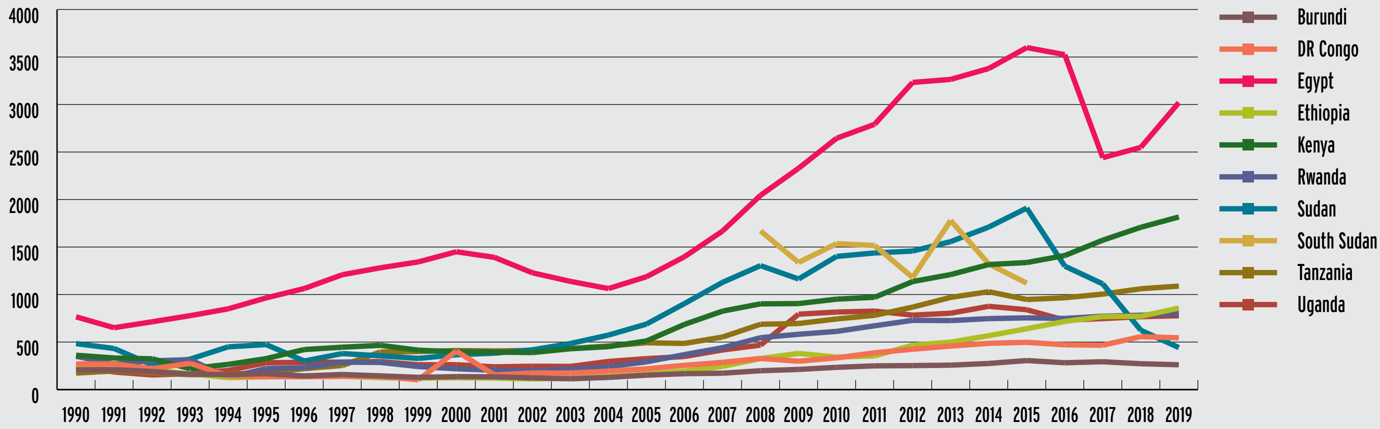
Source: UNDP, 2019

FIGURE 1.11: ANNUAL GROWTH OF GDP IN NILE COUNTRIES (%), 2012 & 2019



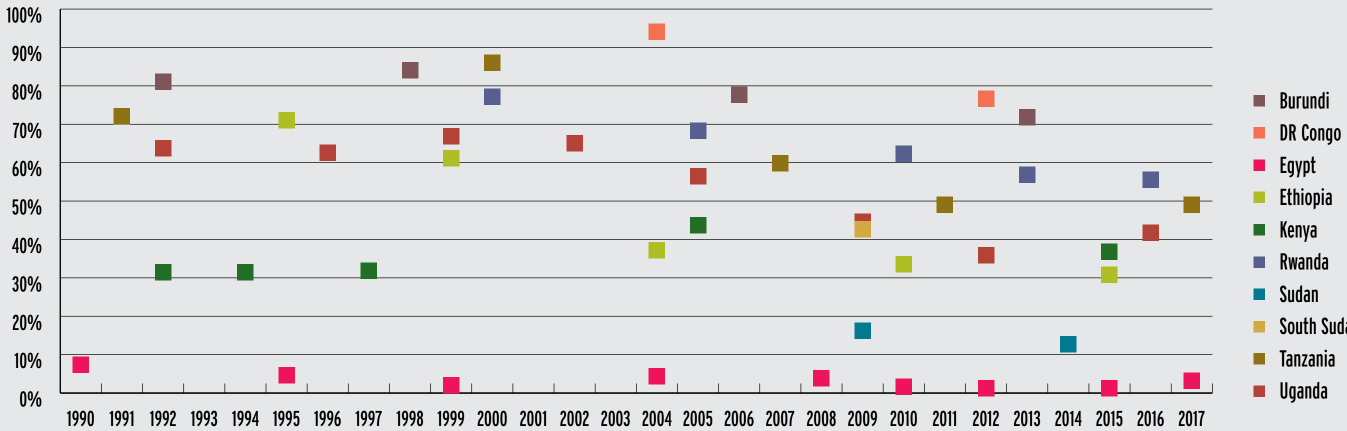
Source: World Bank 2020 / no data available for Eritrea and South Sudan

FIGURE 1.12: ECONOMIC GROWTH: GDP PER CAPITA (CURRENT USD) 1990 - 2019



Source: World Bank 2020

FIGURE 1.13: EXTREME POVERTY: PERCENTAGE OF POPULATION EARNING LESS THAN USD 1.90 PER DAY AT 2011 PURCHASING-POWER PARITY (PPP), 1990-2017



Note: Data availability for poverty is generally fragmented in Africa and makes it difficult to discern reliable trends for some countries.

Source: World Bank 2018

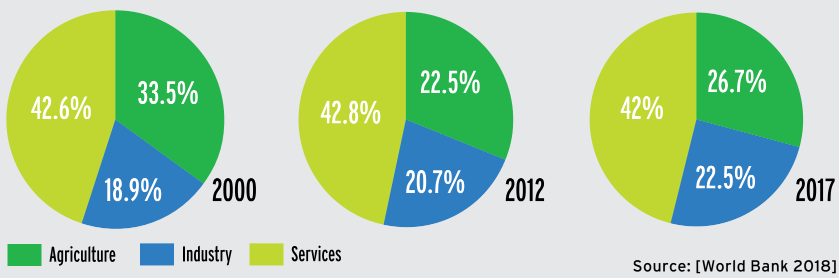
modity exporters, and the attendant losses to tax revenue which reduce the capacity of government to extend public services necessary to respond to the crisis (UNCTAD, 2020).

POVERTY REDUCTION

Figure 1.13 presents the percentage of the population earning less than USD 1.90 per day for the period 1990 to 2014 (at 2011 purchasing power parity). While data is fragmented and not available for all countries, one can observe that the number of people living in extreme poverty has continued to fall. Nevertheless, more than 30% of the population in at least seven Nile Basin countries is still classified as extremely poor.

An important factor that explains the persistence of poverty in the Basin is the slow structural change of the economies (African Development Bank, 2018a). In the Nile Basin, the sectoral make-up of GDP has remained roughly constant since 2000 (Figure 1.14). Consequently, in relative terms, only a fraction of the workforce moves from low-productivity sectors such as agriculture, where wages are low, into highly productive sectors such as manufacturing. While the low-productivity sectors employ the bulk of the Basin's population, their contribution to GDP is comparatively limited. Since low-productivity activities are concentrated in rural areas, poverty reduction in the Nile Basin occurs at a much slower pace in rural than in urban areas.

FIGURE 1.14: ECONOMIC PROFILE: SECTORAL COMPOSITION OF GDP (CURRENT USD) IN NILE BASIN COUNTRIES, 2000-2017



Source: [World Bank 2018]

INCREASING PRESSURES ON THE NATURAL RESOURCE BASE

Photo credit: Shutterstock

Flooding in an encroached wetland

<<As populations are predicted to grow strongly in the future, land-use change is likely to accelerate>>

Growing populations and economies are exerting increasing pressure on the natural environment of the Nile Basin, both in rural areas and around cities. Generally, among the socio-economic forces driving environmental degradation in Africa, population growth and overall economic activity are most critical (Bradshaw and Di Minin, 2019). Evidence drawn upon in this report suggests that the Nile Basin is no exception.

The drivers, which were described in the previous section, manifest themselves as multiple environmental pressures. The main ones selected in this study include:

- land-use change
- unsustainable use of natural resources
- habitat fragmentation
- water pollution.

There are more environmental pressures resulting from changing population dynamics and economic growth. The above four are deemed most critical in regard to their significance in affecting the natural resource base for water security, ecosystem health, hydropower development, food supply, and climate resilience in the Nile Basin.

LAND-USE CHANGE

As populations grow, the demand for land is increasing. As a consequence, water-relevant ecosystems such as riparian woodlands, floodplains, wetlands, and mountain forests are converted to create space for crop production. In a similar vein, increasing livestock populations often lead to overgrazing and bush encroachment in places where fertile grazing land is scarce. In comparison to clear-cutting, pastoralism changes the vegetation cover and plant composition and degrades ecosystems gradually.

Agriculture is by far the greatest driver of land-use change in Africa (Curtis et al., 2018). Although large-scale agriculture projects are on the rise, it is subsistence farming for which most land is cleared (Fisher et al., 2010). The rapid expansion of cities is a less relevant though growing cause of land-use change. Natural habitat is lost not only directly through expanding built-up areas, but also through peri-urban agriculture accompanying it. Importantly, the bulk of urban expansion in Africa is taking place in previously undisturbed locations (Seto et al., 2012).

As populations are predicted to grow strongly in the future, land-use change is likely to accelerate. The loss of wetlands and forests has had visible impacts on ecosystem service provision. For example, shoreline wetlands around Lake Victoria purify wastewater disposed of by adjacent urban areas. As these wetlands are converted into land for settlements, their positive effects on water quality slowly diminish.

UNSUSTAINABLE USE OF WATER AND OTHER NATURAL RESOURCES

A high share of the Basin's population is highly dependent on natural resources. Growing human populations and increasing standards of living are raising the demand for food, fibre, and fuel. The use of natural resources is sustainable if ecosystems are permitted enough time for recovery. However, when the vegetation stock and animal species are over harvested, ecosystems are damaged or collapse. Where human populations are rising, more water resources are required for consumptive purposes, such as irrigation and domestic use. Especially in urban areas, the demand for water supply and sanitation services is growing.

The increasing number of settlements in the vicinity of rivers has caused more tree-cutting for construction and firewood and collection of reeds and grasses for household use, baskets, and matting in floodplains, riparian woodlands, or forested wetlands. An over-exploitation of these resources gradually degrades wetlands and forests, causing increasing levels of soil erosion or the loss of hydrologic functions such as groundwater recharge or flood mitigation. High sediment loadings in rivers, for example, are clogging reservoirs in the Nile Basin and impair the productivity of hydropower dams. The same effects result from livestock populations that overgraze grasslands and shrublands. Natural resources may be further strained by migration, such as the establishment of temporary refugee camps close to protected areas.

HABITAT FRAGMENTATION

New infrastructure developments are a common feature of rapidly growing economies in the Nile Basin. On both land and water, they cause the fragmentation of natural ecosystems, and negatively affect their integrity (e.g. by isolating species populations). Ambitions to elevate electrification, which is still low in most of the Basin countries, have given rise to new hydropower dams across the Basin. Hydropower has affected rivers by disturbing their flood regimes, cutting off sediment transport, or by blocking migratory pathways of fish. The fragmentation of rivers can also have major consequences for wetlands, floodplains, or deltas that are connected to rivers and depend on organic material, sediment, energy, and water carried by them. Economic growth and urban development are also accompanied by an expansion of the road and rail network, often cutting through and fragmenting still intact and wildlife-rich areas. Several major development corridors are planned or under construction in the Nile Basin (Laurance et al., 2015). Once built, deforestation and exploitation of natural resources (e.g. high-value timber and bushmeat) spread out from new transport routes.

WATER POLLUTION

Urbanisation will result in a higher demand for water supply and sanitation. Coverage of these services is still very low in the Nile Basin. The rapid pace at which many cities in the Nile Basin are evolving overwhelms planning authorities; much of the new urban settlements are unplanned and come without basic infrastructure. This is likely to result in increased pollution, not only by domestic and industrial wastewater, but also by solid waste, such as plastic, that ends up in surface water bodies. These challenges are already being witnessed in some urban areas, such as Cairo, Kampala and Khartoum, which are closely located to rivers and lakes. Without adequate sanitation infrastructures, population growth translates into higher volumes of untreated wastewater being disposed of into surface water bodies. Additional sources of pollution stem from increasing application of mineral fertilizer and manure in agriculture. Carried into surface water bodies, they increase the nutrient loading and subsequently eutrophication and associated adverse consequences. Pollution may make water resources no longer appropriate for their previous uses and threaten environmental and human health (see Chapter 5).

« Urbanisation will result in a higher demand for water supply and sanitation. Coverage of these services is still very low in the Nile Basin. The rapid pace at which many cities in the Nile Basin are evolving overwhelms planning authorities »

APPENDIX: POPULATION DYNAMICS

TABLE 1.1: POPULATION GROWTH RATES IN RURAL AND URBAN AREAS FOR ALL NILE BASIN COUNTRIES, 2006-2011 & 2012-2018				
	Urban population growth rate: 6-year average (annual %)		Rural population growth rate: 6-year average (annual %)	
	2006-2011	2012-2018	2006-2011	2012-2018
Burundi	5.8	5.6	3	2.7
DR Congo	4.6	4.6	2.4	2.3
Egypt	1.9	2.0	2.2	1.9
Ethiopia	4.7	4.8	2.3	2.0
Kenya	4.4	4.3	2.2	2.0
Rwanda	2.6	2.7	2.6	2.5
South Sudan	5.1	4.3	4.0	2.8
Sudan	2.4	2.9	2.0	2.1
Tanzania	5.6	5.4	2.2	2.1
Uganda	6.1	5.9	2.8	2.6

Source: UNDESA, 2018a

TABLE 1.2 GDP GROWTH RATES (%) FOR ALL NILE BASIN COUNTRIES, 2000-2019							
	1990	1995	2000	2005	2010	2012	2019
Burundi	3.5	-7.9	-0.9	0.9	5.1	4.4	1.8
DR Congo	-6.6	0.7	-6.9	6.1	7.1	7.1	4.4
Egypt	5.7	4.6	6.4	4.5	5.1	2.2	5.6
Eritrea	n/a	2.9	-3.1	2.6	2.2	n/a	n/a
Ethiopia	2.7	6.1	6.1	11.8	12.6	8.6	8.3
Kenya	4.2	4.4	0.6	5.9	8.4	4.6	5.4
Rwanda	-2.4	35.2	8.4	9.4	7.3	8.6	9.4
South Sudan	n/a	n/a	n/a	n/a	5.5	-46.1	n/a
Sudan	-5.5	6	6.3	7.5	3.5	0.5	-2.6
Tanzania	7	3.6	4.5	7.5	6.3	4.5	5.8
Uganda	6.5	11.5	3.1	6.3	5.6	3.8	6.5

Source: World Bank, 2020

TABLE 1.3: FERTILITY RATES [BIRTH PER WOMEN] FOR ALL NILE BASIN COUNTRIES, 2000-2018							
	1990	1995	2000	2005	2010	2012	2018
Burundi	7.4	7.2	6.9	6.6	6.2	6.0	5.4
DR Congo	6.7	6.8	6.8	6.7	6.5	6.4	5.9
Egypt	4.6	3.8	3.3	3.0	3.2	3.4	3.4
Eritrea	6.5	6.0	5.3	4.9	4.6	4.4	4.1
Ethiopia	7.2	7.0	6.5	5.8	5.1	4.9	4.2
Kenya	6.1	5.5	5.2	4.8	4.4	4.1	3.5
Rwanda	7.2	6.2	5.6	5.1	4.5	4.3	4.0
South Sudan	6.8	6.6	6.2	5.8	5.4	5.2	4.7
Sudan	6.2	5.8	5.5	5.1	4.9	4.8	4.4
Tanzania	6.2	5.9	5.7	5.6	5.4	5.3	4.9

Source: World Bank, 2020

TABLE 1.4: INFANT MORTALITY RATE AND LIFE EXPECTANCY IN NILE BASIN COUNTRIES

	MORTALITY RATE, INFANTS (PER 1,000 LIVE BIRTHS)			LIFE EXPECTANCY AT BIRTH, TOTAL (YEARS)		
	2012	2019	Change 2012-2019	2012	2018	Change 2012-2018
Burundi	53	40	-13	56	61	5
DR Congo	80	66	-14	58	60	2
Egypt	22	17	-5	71	72	1
Ethiopia	50	37	-13	63	66	3
Kenya	38	32	-6	65	66	1
Rwanda	38	26	-12	65	69	4
South Sudan	64	62	-2	55	58	3
Sudan	49	41	-8	63	65	2
Tanzania	45	36	-9	63	65	2
Uganda	45	33	-12	58	63	5
Basin-wide average	48.4	39	-9.4	61.7	64.5	2.8

Source: UNDESA, 2018, UN IGME, 2018

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CHAPTER 2

WATER SECURITY

CONTENTS

KEY MESSAGES

Photo: © Andy Johnstone/Panos Pictures

Ugandan fishermen landing their catch on Lake Victoria

Average annual precipitation over the Nile Basin is estimated to range as 562-660 mm per year for the period 1901 to 2018. Rainfall over the Nile Basin is spatially and temporally highly variable

Egypt and northern Sudan receive insignificant rainfall, but the upstream regions receive quite substantial but highly variable rainfall. The unpredictability of rainfall over most of the Basin poses a formidable challenge for the productive use of these large rainwater resources.

The average runoff coefficient over the Nile Basin is low at around 5%.

The portion of rainfall that does not reach the river system is high. This is partly due to the system of wetlands and lakes in the Equatorial Nile sub-system where large quantify of water leaves the Basin through evaporation and transpiration (through aquatic vegetation). Use of this water for productive purposes would therefore only marginally alter the regional hydrological balances or the Nile flows.

Increasing investments are made in desalination of seawater to augment freshwater supplies:

Egypt is projected to produce 0.25 BCM/year of water by 2022. A desalination plant is under construction in Kenya to generate 0,036 BCM/year while Sudan produces approximately 0.018 BCM/year freshwater from seawater.

Water-storage capacity per capita is generally low.

It actually decreased from the year 2010 to 2015 in all Nile countries apart from Ethiopia; this will adversely impact the productive use of the Nile waters.

The quality of the Nile waters has generally deteriorated.

Population growth and urbanisation, agricultural intensification, and industrial development have had an adverse impact on water quality, especially around urban centres. There is considerable risk that fresh water downstream of major urban areas may become polluted and therefore unusable.

Economic growth and urbanisation will exponentially increase the volume of wastewater across the Basin.

The provision of safe drinking-water facilities and improved sanitation is vital in the fight against water-borne diseases

The high prevalence of water-borne diseases in all countries bar Egypt could result in a vicious cycle of ill health, malnutrition, and poverty, mostly affecting the poorest segments of society.

Irrigated agriculture in the Basin uses the bulk of the renewable Nile flows.

Use of Nile waters for irrigation in most of the Nile riparians is currently very modest. Water productivity in irrigated agriculture in Egypt is high, although improvements are possible.

The development of further full-control irrigation will result in deficits in renewable water resources.

In most countries, plans exist for expanding irrigated agriculture. However, seen Basin-wide, water remains a limiting factor if the current trend of relying on Nile flows continues.

Water productivity is currently low in the rainfed farming systems that cover 87% of arable land in the Nile Basin.

Most of these areas receive substantial but highly variable rainfall, which represents a vital resource if properly distributed over the growing season. A secure water supply in this zone can be achieved through a combination of local and smaller-scale measures, such as supplementary irrigation, primarily focused on extending the productivity of rainwater.

Net evaporation from constructed reservoirs is the second-largest component of the demand function of the renewable Nile waters.

Net evaporation from dams is estimated at 18.8 BCM/year across the basin[2].

A wide range of options still exist to achieve water security.

These include enhancing the productive use of rainwater and irrigated agriculture, improving irrigation efficiency, food imports and reduction of food losses, conjunctive use of groundwater, and use of non-conventional water sources for M&I supply, system-wide optimization of water use, among others. However, further coordinated action needs to be taken in order to implement these measures.

[2] Not including evaporation from regulated lakes

STATE OF THE WATER RESOURCES OF THE NILE

The state of the water resources of the Nile Basin is discussed in four dimensions: water availability, water demands for socio-economic development and the environment, risks from water-related hazards, and pressure on water resources.

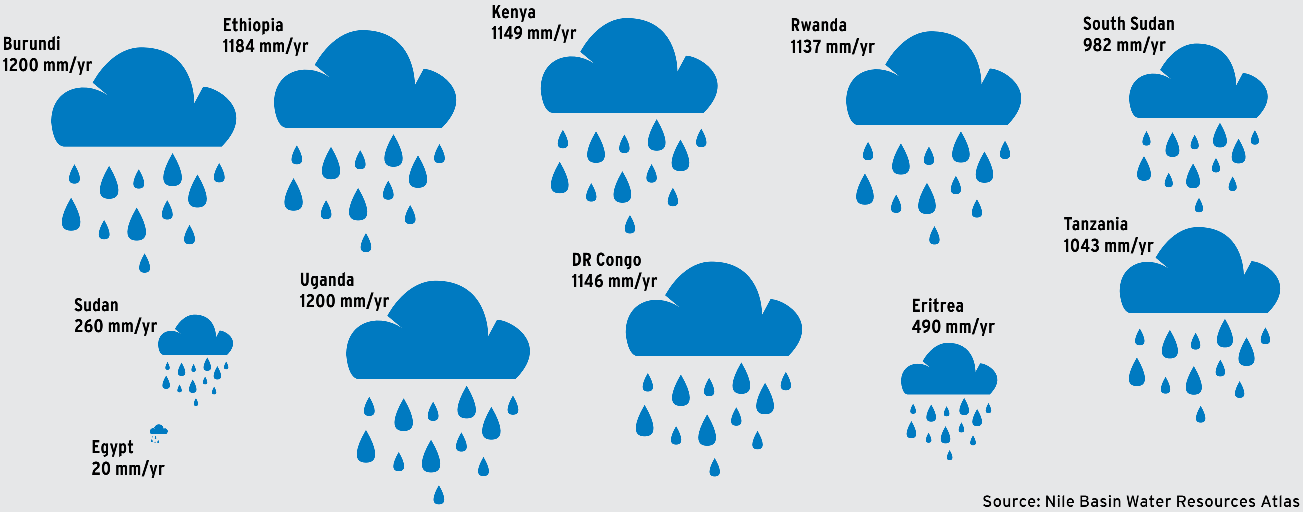
Photo: Arne Hoel / World Bank

WATER AVAILABILITY

RAINFALL

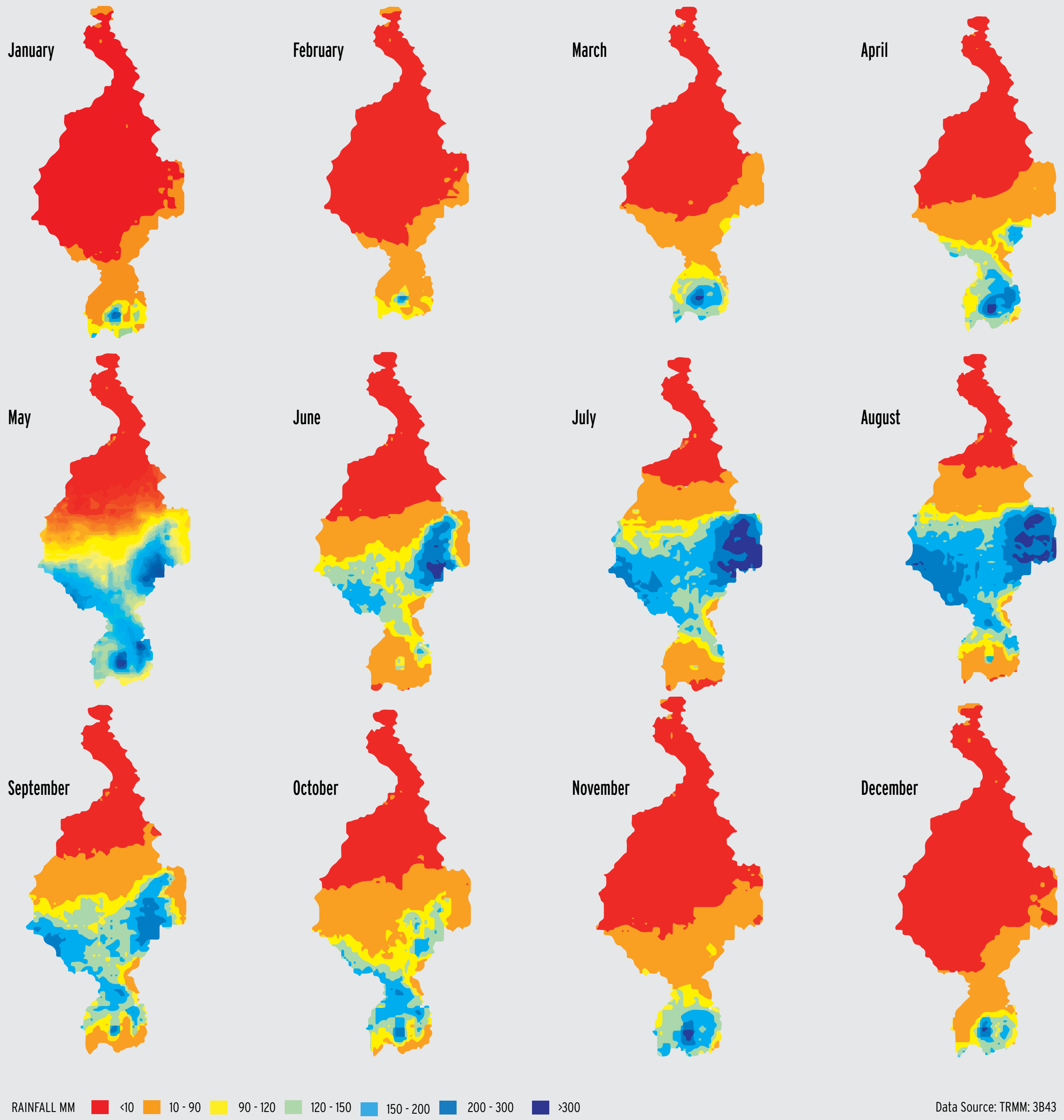
Rainfall over the Nile Basin is highly uneven and differs substantially from country to country. Northern Sudan and Egypt – apart from the latter's Mediterranean coastal area – receive negligible rainfall, while parts of the Equatorial Lakes region and the upper Blue Nile Basin have annual rainfall in excess of 1,000 mm (Figure 2.1). The montane areas such as the Rwenzori Mountains, Mount Elgon, and the Ethiopia Highlands receive over 1,500 mm of rainfall per year and are considered the water towers of the Basin. Figure 2.1 presents rainfall by country.

FIGURE 2.1: AVERAGE RAINFALL BY COUNTRY (MM/YR] (NILE BASIN AREA ONLY)



Source: Nile Basin Water Resources Atlas

FIGURE 2.1A: SPATIAL AND TEMPORAL VARIABILITY OF RAINFALL IN THE NILE BASIN



Source: Nile Basin Water Resources Atlas, 2016

Figure 2.1A shows the monthly rainfall distribution over the Basin. There is a gradual decrease of rainfall from upstream to downstream areas. The seasonal distribution follows the migration of the Inter-Tropical Convergence Zone (ITCZ).

The subtropical zone, with high rainfall, roughly coincides with the areas with high population densities (see Figure 2.1B). By contrast, the semi-arid zone – with mean annual rainfall ranging from 250 to 700 mm – is sparsely populated and generally used for pastoralist activities. Desert areas with annual rainfall below 250 mm are mostly uninhabited, apart from the Nile Valley.

The average annual precipitation over the Basin is estimated to range between 562 – 660 mm/year. Discounting groundwater flow – which in the Nile is generally small compared to the surface flows – the average annual yield of the Nile under naturalised conditions of no abstraction ranges from 84 to as high as 96 BCM at High Aswan Dam for the period 1901 to 2018. It implies that most of the rainfall over the Basin never reaches the river and groundwater system. However, the productive use of this large renewable resource is generally low and adversely affected by the high seasonal and inter-annual variability of rainfall. Not only are there substantial differences between wet and dry years, there are also considerable variations in the timing of the onset of the seasons and distribution of rainfall within the season.

The unpredictability of precipitation causes specific problems. In the subtropical zone, rainfall is generally enough to grow a crop but too unreliable to guarantee the absence of moisture deficits. Farmers, therefore, adopt low-risk strategies that lead to low yields and low rainwater productivity.

Pastoralism in the semi-arid zone is well adapted to unpredictable rainfall and makes good use of rainwater that would otherwise be less productive, because livestock is grazed on arid and semi-arid pastures that utilise water which cannot be used for other activities. Nevertheless, livestock water productivity is low, and there is scope for improving the productive use of the rainwater resources in this zone.

The high seasonal and inter-annual variability of rainfall in the Nile Basin is further illustrated in a series of box plots in Chapter 6, where information is also given on the duration of rainless periods within the crop season for the same stations, which further highlight the high temporal variability of rainfall.

FIGURE 2.1B: AVERAGE ANNUAL RAINFALL FOR THE BASIN

Source: Nile Basin Water Resources Atlas, 2016

RUNOFF COEFFICIENT

Figure 2.2 shows the spatial distribution of this coefficient over the Basin for the period 2009–2014. The runoff coefficient represents the fraction of rainfall that reaches the river system and is available for downstream users.

The runoff coefficient is low (<5%) for large parts of the Nile Basin, with the notable exception of the eastern Nile region in Ethiopia and upper head catchments of the Baro river, where the average runoff coefficient is greater than 20% In the large White Nile sub-Basin, the runoff coefficient is very low. This means that most rainfall over the White Nile Basin never reaches the Nile system. Hence, efforts to capture and store rainwater in this area – with the aim of increasing its productive use, for instance in the large rainfed agricultural sector – will only have limited impacts on the flow in the downstream Nile tributaries. Potential impacts are further attenuated by the regulating effects of the large downstream wetland areas – including the Sudd – and the large buffering capacity of Lake Victoria.

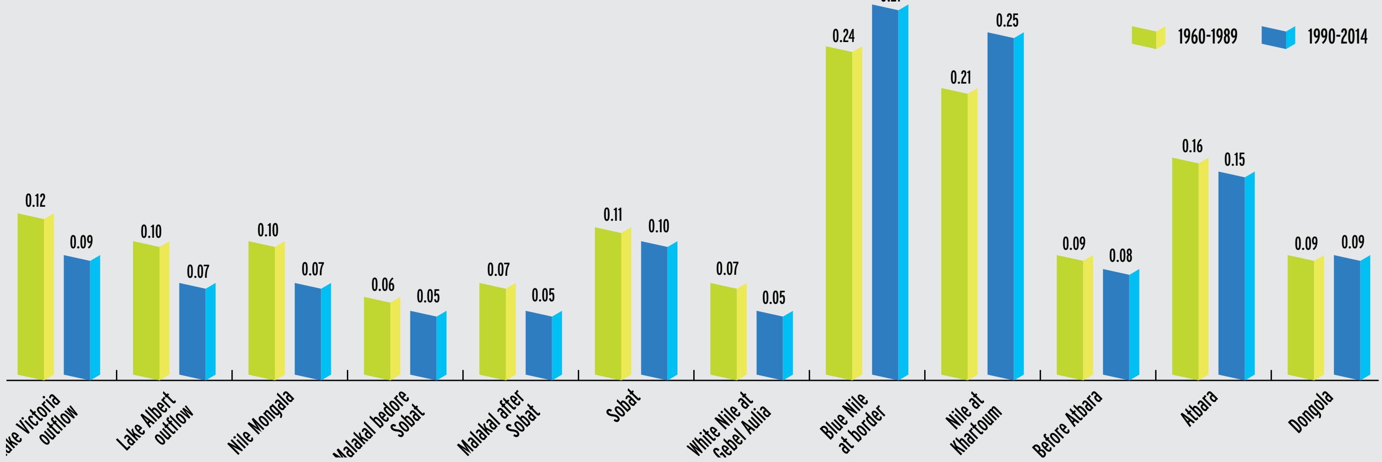
EVAPORATION AND TRANSPIRATION

The generally low runoff coefficient indicates that the portion of rainfall that does not reach the river or groundwater system is substantial. This water – which is not available for use outside its immediate vicinity – is referred to as 'green water'. It is distributed by transpiration and evaporation. Transpiration is the portion of rainfall used to produce biomass; evaporation returns water to the water cycle without productive use. Evaporation losses from lakes (natural and regulated) are given in Table 2.1.

Fig 2.3 shows mean estimated annual evaporation from soils in the Nile Basin for the period 2009 to 2014. It does not include evaporation from canopy interception.
The following observations are made:

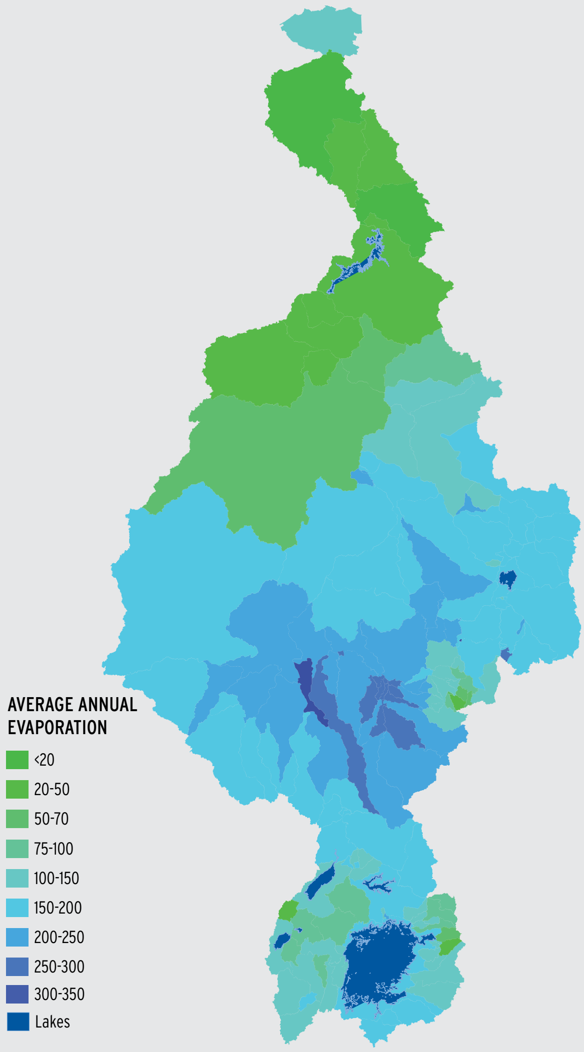
- Evaporation is high in some irrigated areas in Egypt and Sudan, since surface irrigation is vulnerable to evaporation in arid and semi arid zones, where temperatures are very high compared to other regions in the Basin. .
- High evaporation rates in Lakes Victoria, Albert, Kyoga, Tana and Edward.
- High evaporation values in South Sudan extend far beyond the Bahr el Ghazal, Sudd, and Pibor wetlands.
- The zone around the equator in Uganda and Kenya has generally low evaporation values, suggesting permanent vegetation cover throughout the year.
- Evaporation losses are moderate – with only a few exceptions – in the Nile Delta and Nile Valley; nevertheless, evaporation typically exceeds 100 mm/year, which suggests that further improvements in water productivity are possible.

FIGURE 2.2: AVERAGE RUNOFF COEFFICIENT IN THE NILE BASIN



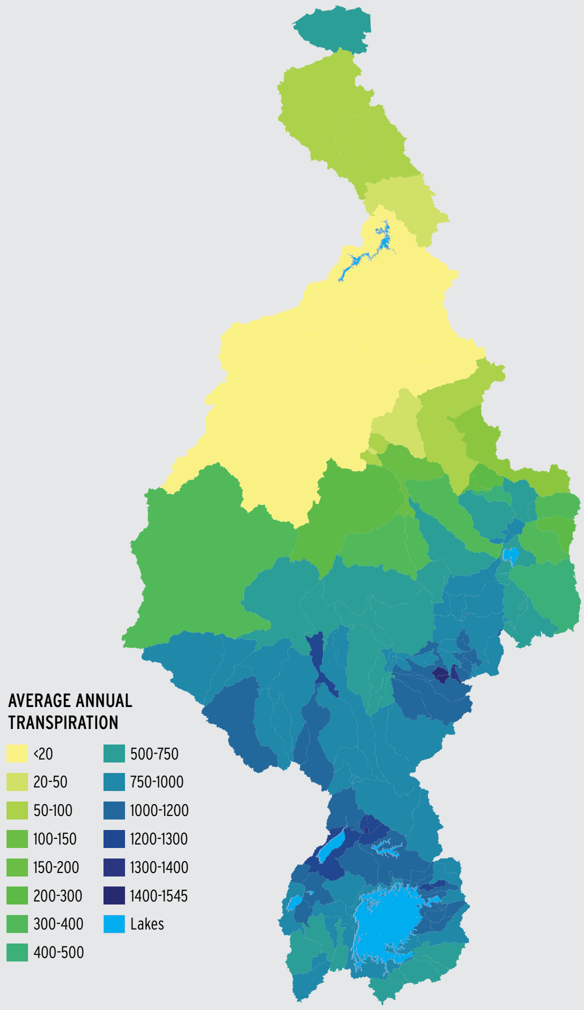
Source: NBI, 2018b

FIGURE 2.3: AVERAGE ANNUAL EVAPORATION IN THE NILE BASIN (MM/YR)



Source: FAO WaPOR

FIGURE 2.4: AVERAGE ANNUAL TRANSPIRATION IN THE NILE BASIN (MM/YR)



Source: FAO WaPOR

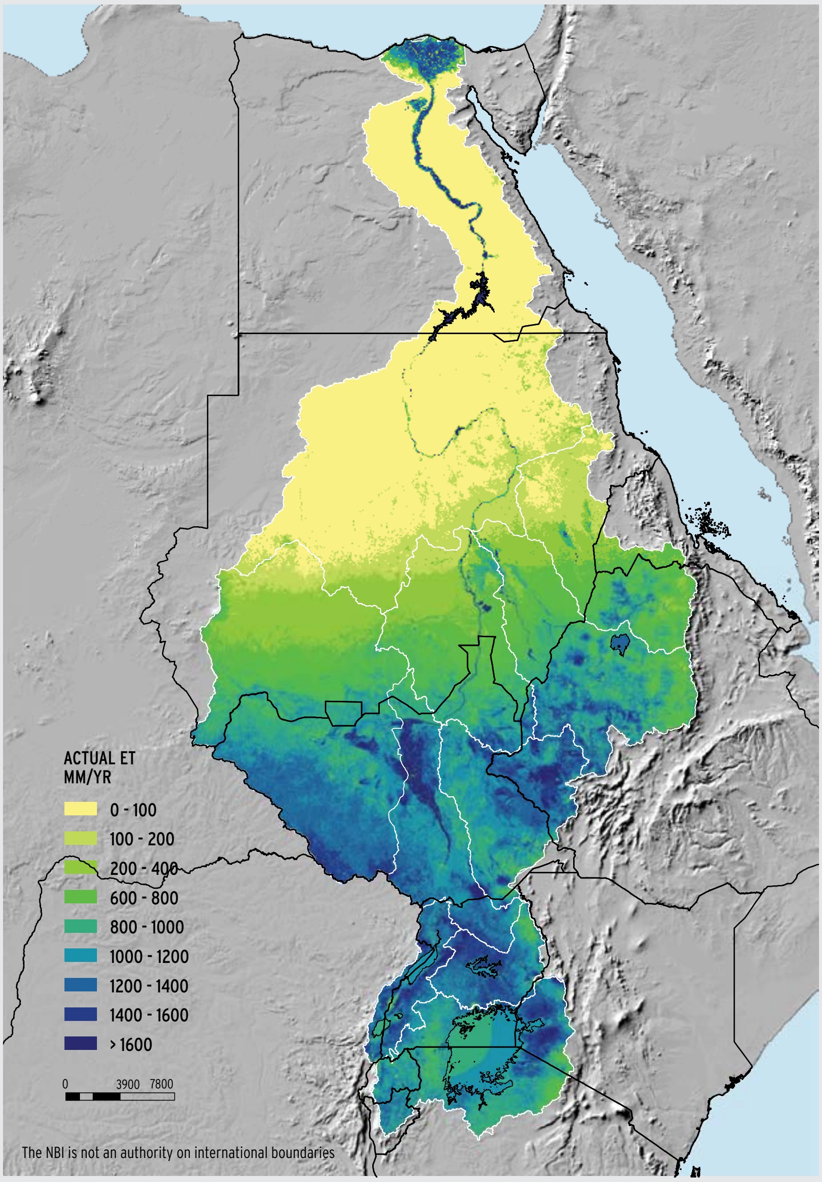
TABLE 2.1 : ESTIMATED NET EVAPORATION FROM LAKES (1950 – 2018)

Lake	EVAPORATION (BCM/ YEAR) (1950-2018)		PRECIPITATION (BCM/ YEAR) (1950-2018)	
	Average	Range	Average	range
Lake Victoria (Regulated)	105	97.5-109.1	115	103-121
Lake Tana (Regulated)	5.2	4.83-5.6	3.7	2.5-5.3
Lake Kyoga	8.2	7.7-8.6	6.3	4.76-7.95
Lake Albert	13.2	11.0- 14.5	6.9	3.2- 7.01

Figure 2.4 presents the estimated mean annual transpiration over the Nile Basin for the period 2009–2014. From a hydrologic perspective, transpiration is evaporation of water from plant leaves. Thus, it represents water that is consumed by plants and could therefore be used for productive agricultural purposes without altering the hydrological balance. Water that is transpired primarily originates from direct rainfall that is stored as soil moisture or that has percolated to the shallow groundwater – except for the riparian zone and wetlands. Thus, increasing the productive use of water that is transpired will not change the flow in the Nile tributaries.

Average annual transpiration is generally above 750 mm for large parts of South Sudan and the Equatorial Nile region, except for some areas that have traditionally been used as rangeland. It is noted that most of the lower White Nile Basin is subject to a un-

FIGURE 2.5: EVAPO-TRANSPIRATION FOR THE BASIN



imodal rainfall regime with one main cropping season.

Average annual transpiration is also high in the Baro Basin and remains substantial in a considerable part of the Blue Nile Basin in Ethiopia.

Evaporation and transpiration are highly pronounced over the wetland areas in the Nile Basin including the Sudd, which stretches from Juba to Malakal in South Sudan. It is the section of the river where more than half of the drainage from the Equatorial Lakes Plateau leaves the Basin through evaporation and transpiration.

The relation between transpiration and biomass production is essentially linear for a given crop, climate, and nutrient status. However, it is recognised that yields are highly variable, and a yield assessment cannot be derived from biomass production because crop production also depends on nutrient status, agricultural practices, and exposure to pests and diseases. Additionally, small moisture deficits at critical points during plant growth can have detrimental impacts on yields. Nevertheless, 750 mm represents a very substantial volume of water, which should be enough to grow a healthy crop provided that occasional small moisture deficits can be taken care of through diverse measures such as water harvesting or supplementary irrigation.

Photo: Shutterstock

RENEWABLE WATER RESOURCES

Renewable water resources are defined as the average annual flow of rivers and recharge of aquifers generated from rainfall. While the Nile Basin is large – measuring over 3 million km2 – the Nile is a modest river in terms of volume of runoff. As discussed above, the estimated annual yield of the Nile Basin ranges between 84–91[4] BCM at Aswan for the period 1901 - 2018[5].

Figure 2.7 presents the seasonal flow patterns and key statistics at the outlet of the major sub-basins. Associated box plots with absolute maximum and minimum recordings provide a measure of flow reliability. The flow regime is further illustrated by the flow duration curve, which shows the percentage of time a specific discharge was exceeded in the historic record. It is noted that the period of record is not identical for the stations presented.

Most of the Nile waters originate on the Ethiopian Highlands. The Blue Nile, Atbara, and Baro contribute approximately 85 of the annual Nile flows but exhibit clear wet and dry spells and are subject to high inter annual variability. In contrast, the White Nile – which is fed by the Baro-Akobo river system from Ethiopia, and the Bibor, and the Bahr el-Jebel that is fed from the Equatorial Plateau, and a small part from Bahr el- Gazal supplies the Main Nile with approximately 28% percent – has a fairly stable discharge throughout the year. Tekeze/Atbara River that originates from the Ethiopian high lands and joins the main Nile at Atbara, provides the Nile with approximately 13%. The downstream river reach, called the main Nile, starting at the Blue–White confluence in Khartoum, generates virtually no runoff.

[4] Some estimates put this figure to more than 96 BCM per year

FIGURE 2.6: MAJOR SUB-BASINS (THE NUMBERS ARE OUTLET LOCATIONS FOR STATISTICS SHOWN IN FIG 2.7)

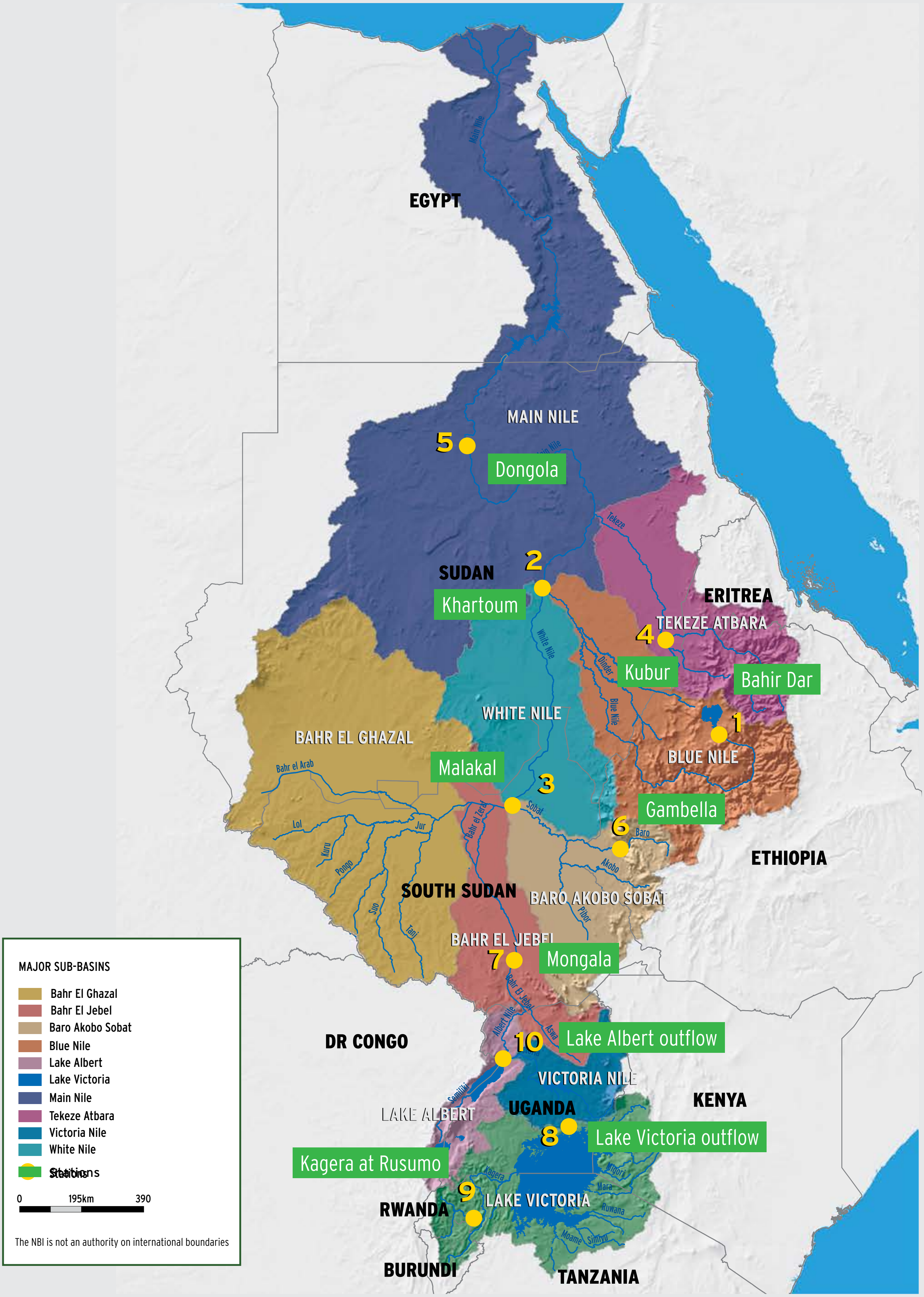
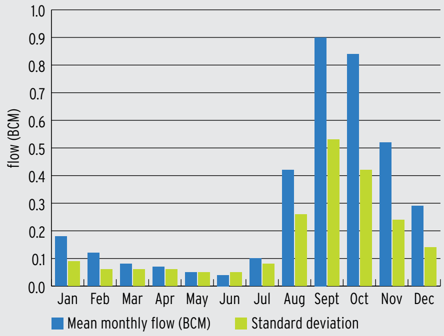


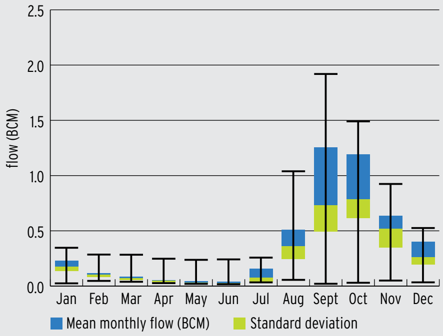
FIGURE 2.7: FLOW STATISTICS AT THE OUTLET OF THE MAJOR SUB-BASINS

1: LAKE TANA OUTFLOW AT BAHIR DAR

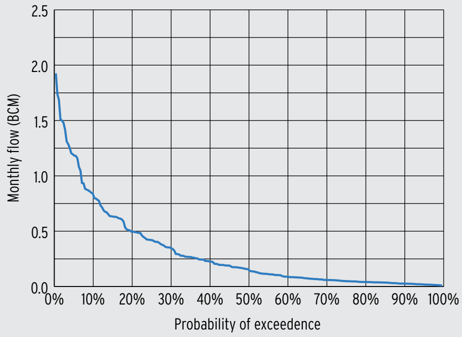
Monthly Flow Distribution



Monthly Flow Statistics

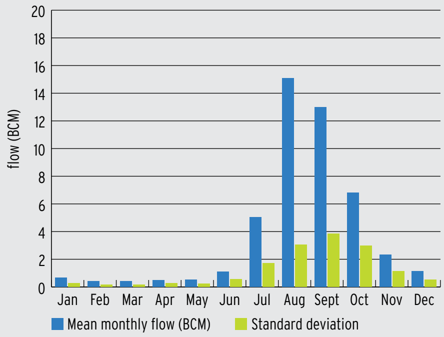


Flow Duration Curve

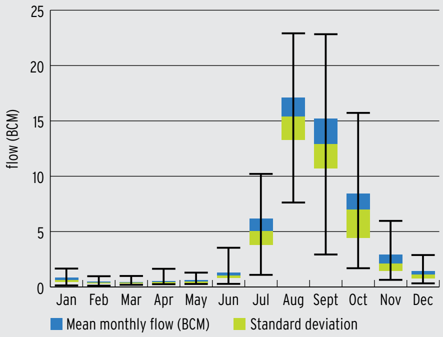


2: BLUE NILE AT KHARTOUM

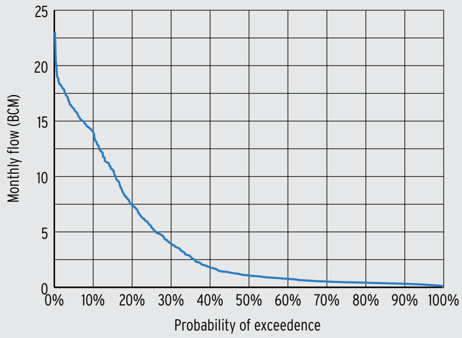
Monthly Flow Distribution



Monthly Flow Statistics

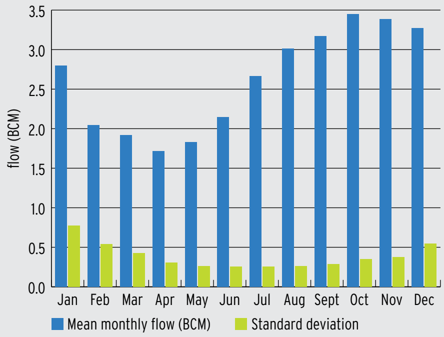


Flow Duration Curve

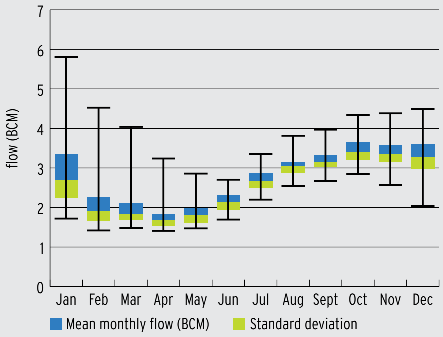


3: WHITE NILE AT MALAKAL

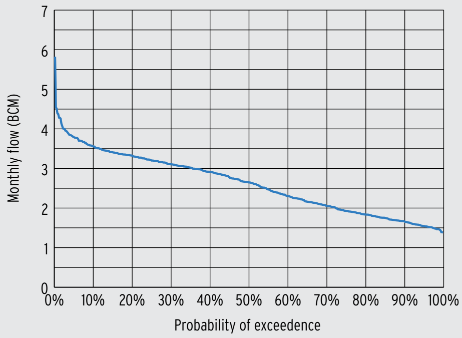
Monthly Flow Distribution



Monthly Flow Statistics

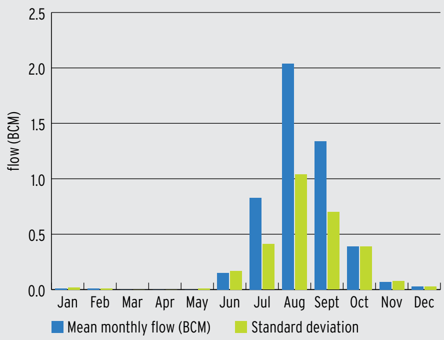


Flow Duration Curve

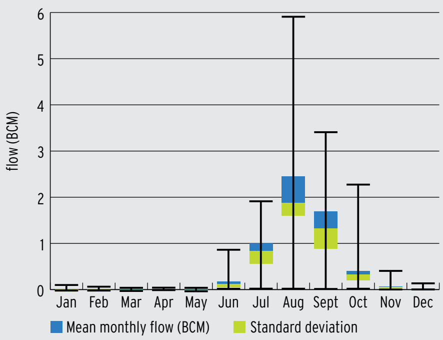


4: TEKEZE-ATBARA AT KUBUR

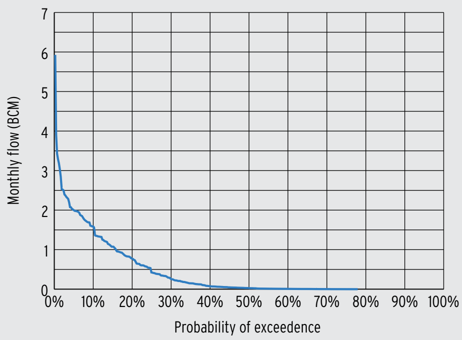
Monthly Flow Distribution



Monthly Flow Statistics



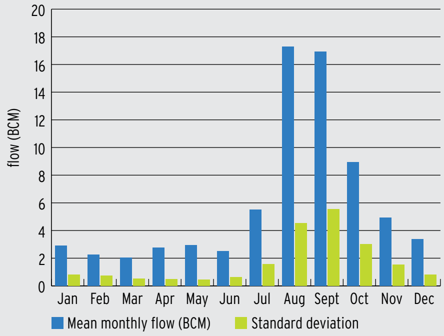
Flow Duration Curve



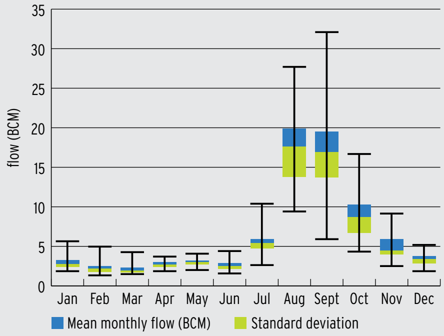
Source: [Nile Basin Water Resources Atlas 2016]

5: MAIN NILE AT DONGOLA

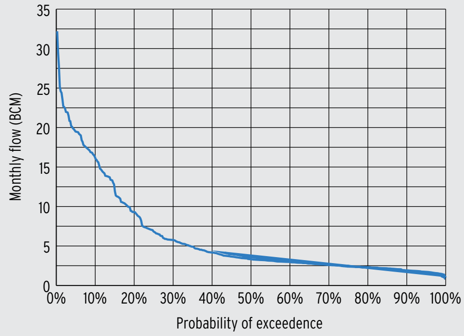
Monthly Flow Distribution



Monthly Flow Statistics

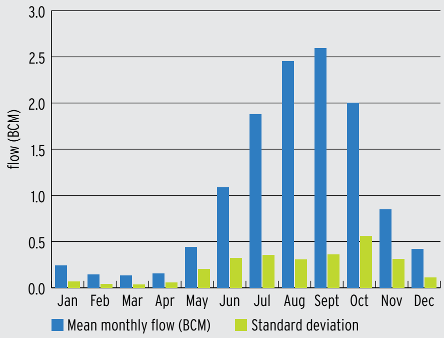


Flow Duration Curve

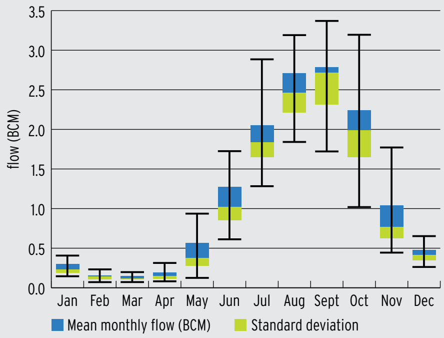


6: BARO NEAR GAMBELLA

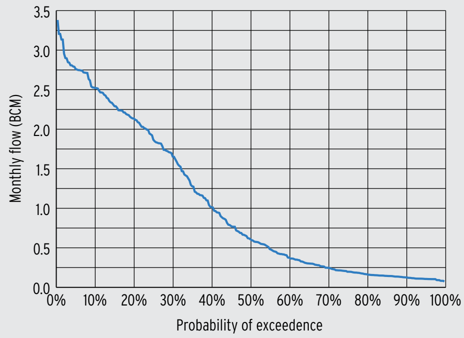
Monthly Flow Distribution



Monthly Flow Statistics

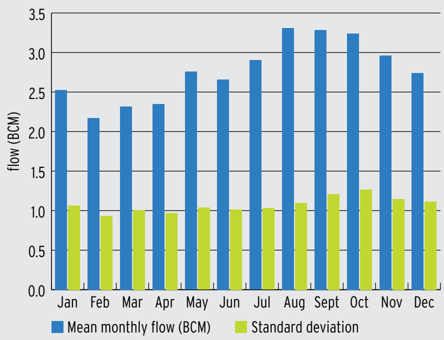


Flow Duration Curve

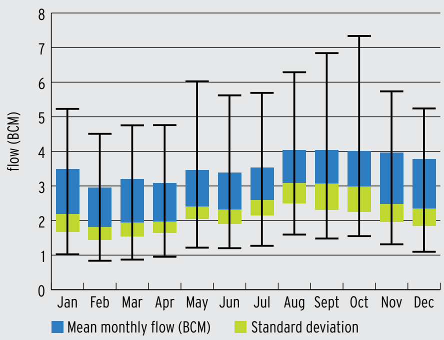


7: BAHR EL JABEL AT MONGALLA

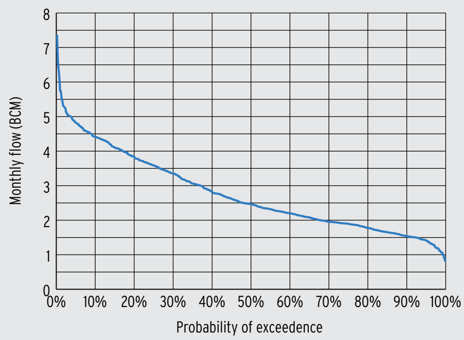
Monthly Flow Distribution



Monthly Flow Statistics

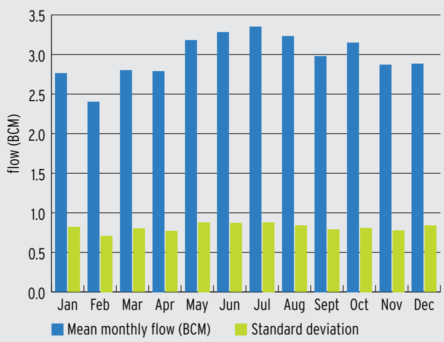


Flow Duration Curve

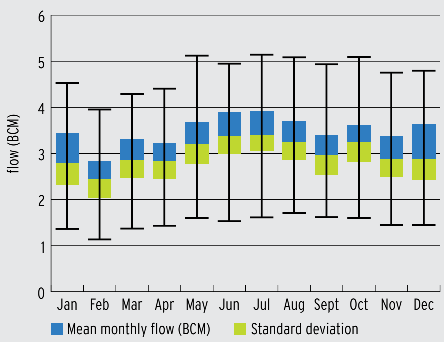


8: VICTORIA NILE AT JINJA

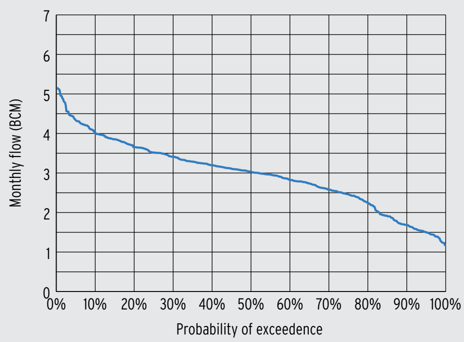
Monthly Flow Distribution



Monthly Flow Statistics



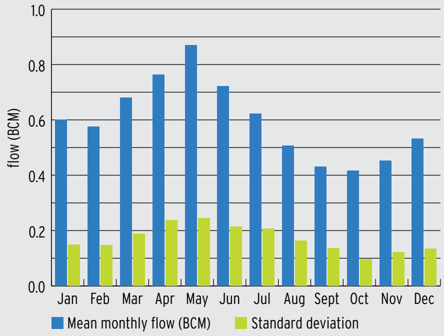
Flow Duration Curve



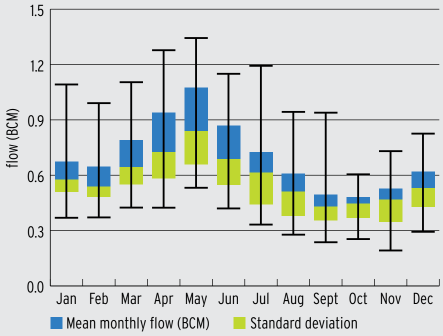
Source: [Nile Basin Water Resources Atlas 2016]

9: KAGERA AT RUSUMO

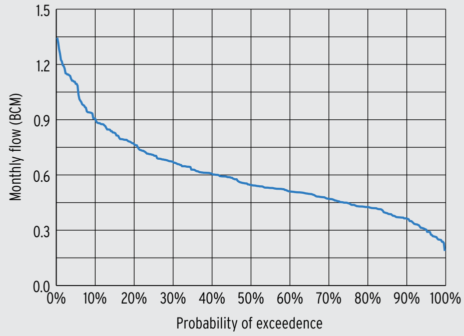
Monthly Flow Distribution



Monthly Flow Statistics

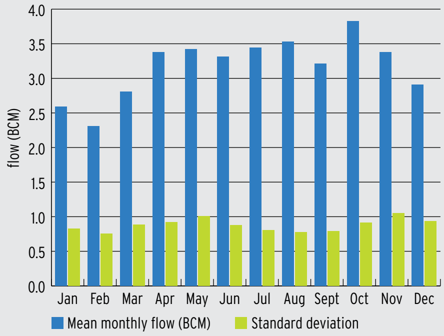


Flow Duration Curve

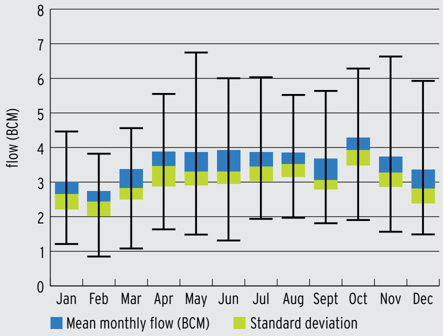


10: LAKE ALBERT OUTFLOW

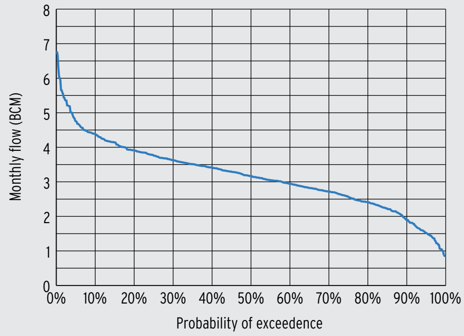
Monthly Flow Distribution



Monthly Flow Statistics



Flow Duration Curve



Source: [Nile Basin Water Resources Atlas 2016]

GROUNDWATER

RENEWABLE GROUNDWATER POTENTIAL

Renewable groundwater resources underlying the Nile Basin occur primarily in shallow aquifers that are actively replenished by rainfall recharge, by seepage from the river and surface water bodies along the watercourse, and from irrigation.

Photo: © Arne Hoel / World Bank

BOX 2.1: LOCAL SCALE GROUNDWATER REPLENISHMENT STUDIES

There have been several regional and local-scale studies employing a variety of methods to arrive at groundwater recharge fluxes in the Nile Basin. An annual groundwater recharge in the order of 200 mm/yr for the 840 km^2 Aroca catchment of the Victoria Nile in central Uganda was determined by Taylor and Howard (1996), using a soil-moisture balance model and isotope data. In several of the upper sub-catchments of the Blue Nile, Ethiopia, recharge was estimated at less than 50 mm/yr in arid plains, and up to 400 mm/yr in the highland areas of north-western Ethiopia, using a conventional water-balance approach and river-discharge analysis, chloride mass balance, soil-water balance methods and river- or channel-flow losses (Ayenew, Kebede, & Alemyahu, 2007). Within southern Sudan (now South Sudan), Abdalla (2010) determined recharge from direct infiltration of rainfall through the soil to be less than 10 mm/yr at distances 20 to 30 km away from the Nile River. Farah et al. (1999) examined the stable isotope composition of the groundwater at the confluence of the Blue and White Nile sub-Basins and determined the contribution of modern rainfall to groundwater recharge to be minimal, with much of the recharge derived from the cooler Holocene period. In the eastern desert region of Egypt, Gheith and Sultan (2002) deduced that around 21% to 31% of the rainfall in high rainfall years (average recurrence interval of 3 to 4 years) is concentrated in wadis that replenish the alluvial aquifers.

Rainfall intensity, more than amount, is often a key determinant of groundwater recharge. In the upper catchments of central Uganda, Taylor and Howard (1996) showed that recharge of groundwater is largely determined by heavy rainfall events, with recharge controlled more by the number of heavy rainfall events (>10 mm/day) during the monsoon, than the total volume of rainfall. This was further supported by the more recent work by Owor et al. (2009).

A reasonably clear picture of the distribution of recharge rates across the Basin is emerging. Using satellite data from the Gravity Recovery and Climate Experiment (GRACE), supported by recharge estimates derived from a distributed recharge model, Bonsor et al. (2010) found values ranging from less than 50 mm/yr in the semi-arid catchments, and a mean of 250 mm/yr in the subtropical upper catchments. Along the thin riparian valley strips, recharge from surface water and irrigation seepage may be up to 400 mm/yr.

The total annual recharge within the Basin has been estimated at about 130 mm. However, it is subject to high spatial variability because of the variability of rainfall and contrasting surface geology. Values derived from the handful of local field studies, used as independent checks, are within this range (0–200 mm/yr). At the African scale, based on a 50 x 50 km grid resolution, Döll and Fiedler (2008) determined recharge to range from 0 to 200 mm/yr across the Nile Basin, further corroborating the above findings.

NON-CONVENTIONAL WATER RESOURCES

Non-conventional water resources include desalinated water, recycling of agricultural drainage water, and treated municipal wastewater.

Some NBI countries have seawater desalination facilities or are embarking on more capabilities. Egypt currently has 58 water desalination plants, representing 440,000 m3/d of capacity. Most of the plants are of relatively small size, e.g., the Dahab plant (at the Gulf of Aqaba) and Hurgada and Sharm El-Sheikh plant (at the Red Sea coast), all of which are seawater desalination plants. In the very near future, Egypt plans to build 35 new desalination facilities, contributing a total of 1,353000 m3/d of capacity [51]. When all these plants are in operation, they can provide 0.5 billion m3 of water per year to the country. As of January 2018, the capacity of Egypt's operating desalination plants

TRANSBOUNDARY AQUIFER SYSTEMS

Extensive regional aquifer systems underlie some parts of the Nile region, as summarised in Table 2.2. Availability of knowledge and information on the aquifers varies with individual riparian states, and strongly correlates with the extent to which the resource is relied upon to meet overall demand.

Photo: © Arne Hoel / World Bank

TABLE 2.2: TRANSBOUNDARY AQUIFERS UNDERLYING THE NILE BASIN				
Aquifer name	Countries	Total aquifer area (km²)	Aquifer area in the Nile Basin (km²)	% area within the Nile Basin
Aquifere du Rift	Democratic Republic of the Congo, South Sudan, Uganda	44,632	30,023	67%
Baggara Basin	Central African Republic, South Sudan, Sudan	239,876	196,127	82%
Coastal Aquifer Basin	Egypt, Israel, Palestinian Territory	23,338	11	0%
Gedaref	Ethiopia, Sudan	57,830	51,369	89%
Kagera Aquifer	Tanzania, Rwanda, Uganda	5,778	5,218	90%
Karoo-Carbonate	Central African Republic, Congo, South Sudan	604,596	120,947	20%
Mereb	Ethiopia, Eritrea	38,752	27,210	70%
Mount Elgon Aquifer	Uganda, Kenya	5,398	4,579	85%
Nubian Sandstone Aquifer System (NSAS Fossil)	Chad, Egypt, Libya, Sudan	2,892,867	567,344	20%
Rift Aquifer	Kenya, Tanzania	21,145	1,780	8%
Sudd Basin	Ethiopia, Kenya, South Sudan	370,647	324,287	87%
Tanganyika	Burundi, Democratic Republic of the Congo, Tanzania	184,594	2,279	1%

Source NBI, 2016a

was reportedly 91 MCM/yr, with plans to build or upgrade facilities to meet a target of 255 MCM/yr by 2021 (desalination.biz, 2018). In Kenya, two contracts were awarded in 2018 by Mombasa County to build two desalination plants [52]: one at a size of 100,000 m3 by day to be built by Almar Water Solutions, a Spanish company; the other at a size of 30,000 m3/day, to be built in Likoni by the Aqua Swiss company. Sudan reported in 2016 a contribution from non-conventional water sources of 18 MCM/yr.

Egypt is the only Nile riparian state that is recycling significant volumes of agricultural drainage water – estimated at 3.5 BCM/yr – and treated municipal wastewater – estimated at 1.4 BCM/yr (Saad, Marwa, Bayoumi, & Zoghdan, 2015). Development of brackish groundwater in the Eastern Desert as well as purification of sea water in the Red Sea coastal areas are used to augment water supply to meet local demands of urban communities and high-value commercial activities. Prioritisation of the technology to contribute to securing the water future of Egypt is currently constrained by the comparatively high costs of treatment, limited know-how of the various technologies, and the environmental challenges of handling the effluent from the plants.

WATER-STORAGE CAPACITY

Several Nile tributaries exhibit clear wet and dry periods. Water storage provides a buffer to attenuate and/or regulate the hydrological variations and make water available in the dry season for productive purposes or environmental flow. Secure access to water resources can significantly increase water productivity, particularly in the agricultural sector. Reservoirs also serve to capture the flood peak and thus mitigate flood risks and damage.

Ongoing expansion of hydro-infra-

FIGURE 2.8: TRANSBOUNDARY AQUIFERS IN THE NILE BASIN

Source: NBI, 2016

TABLE 2.3: STORAGE CAPACITY OF MEDIUM AND LARGE DAMS ON THE NILE AND ITS TRIBUTARIES				
Nile Basin reaches/sub-basins	1999	2012	2018	2020 (including dams under construction)
Equatorial Nile: Lake Victoria basin, Victoria Nile, Albert Nile, Bahr el Jebel	200.75	200.75	200.75	200.75
Eastern Nile: Lake Tana, Blue Nile , Tekeze Atbara, Baro-Akobo-Sobat	15.95	29.15	32.85	106.85
White Nile	3.37	3.37	3.37	
Main Nile	167.4	179.8	179.8	179.8
Lake Albert	13.2	11.0- 14.5	6.9	3.2- 7.01

*Includes Active storage of Lake Victoria

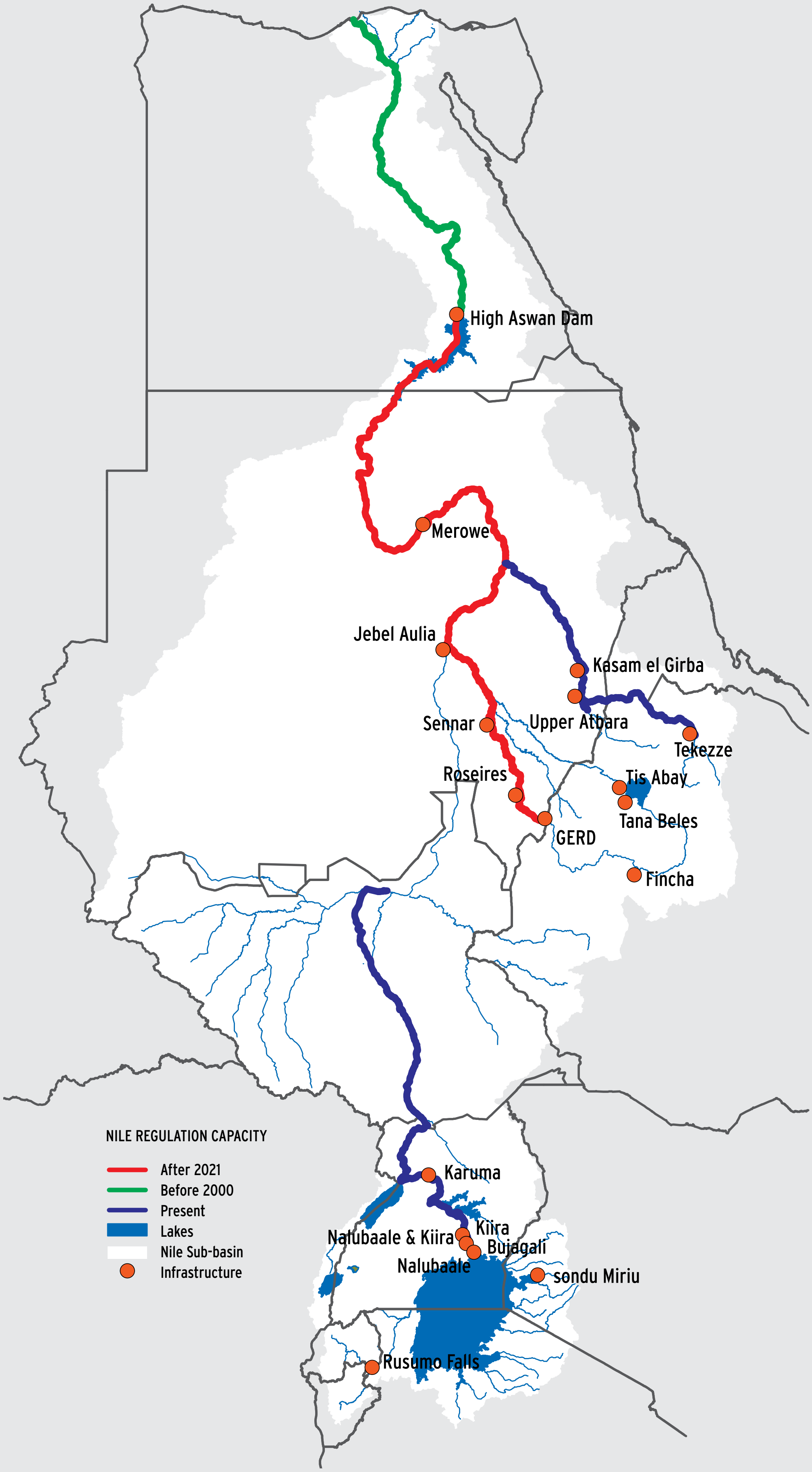
structure in the Nile Basin – combined with infrastructure completed in the last decade – is increasing the capacity to regulate the Nile.

Table 2.3 presents the water-storage capacity in the Nile Basin for three distinct geographic units: the White Nile Basin, the Blue Nile Basin, and the Main Nile upstream of the AHD, and the Main Nile downstream of the AHD. The following observations are made:

- In the last century, only Lake Nasser/ Nubia provided large storage capacity and the ability to fully regulate the River Nile flow; apart from limited seasonal regulation in the small reservoirs, the Nile upstream of the AHD remained a natural river.
- This situation has changed quite dramatically since 2000; several hydro-infrastructure projects have been completed that have increased the capacity to regulate flow (Figure 2.9); after the completion of GERD – the Blue Nile will become a fully regulated river.
- The Victoria Nile is also a regulated river.
- Because of the large expansion of hydro-infrastructure, the benefits accrued to the Nile waters for the upstream riparians have increased dramatically, as illustrated in Table 2.3 for the case of hydropower.

Hence, the Nile River is gradually being transformed from a natural to a regulated river (Figure 2.9). It is noted that many smaller tributaries still follow their natural flow regime, and large tributaries such as the Baro, Pibor, and Akobo – which later join to form the Sobat – remain unregulated. Nevertheless, the increased regulation capacity with enhanced cooperation and coordination can potentially increase the benefits accrued to coordinated management of the shared Nile waters. Potential benefits include flood management, increased hydro-electricity production, agricultural intensification, improved navigation potential, more resilience to prolonged droughts, and reduced evaporation losses.

FIGURE 2.9: RIVER REACHES THAT ARE POTENTIALLY REGULATED



ACTIVE STORAGE

The combined live storage of the two main reservoirs in the Nile system – Lake Nasser/Nubia and Lake Victoria – is reaching near-historic levels at some 350 BCM (Figure 2.10 and Figure 2.11). This represents around 350% of the annual Nile flows. Despite increasing pressure on the Nile waters, live storage has increased by around 127 BCM in the period from 1999 to 2018.

FIGURE 2.10: ACTIVE STORAGE (BCM) FOR LAKE VICTORIA (JAN. 1948 - OCT. 2019)

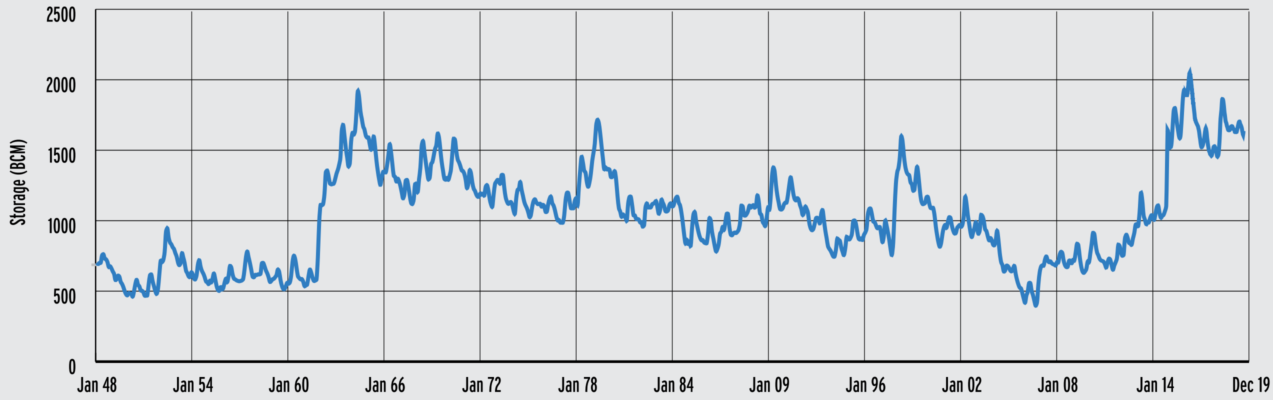
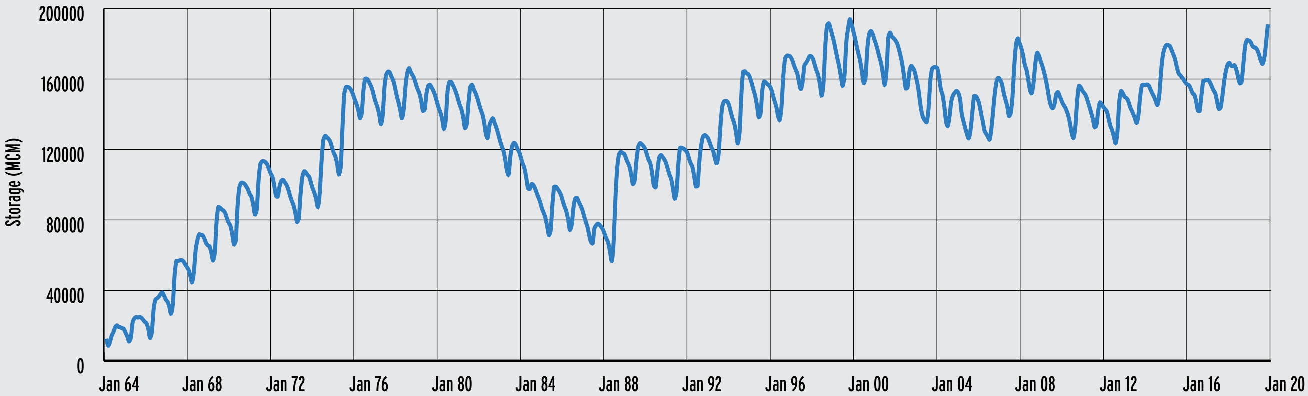


FIGURE 2.11: ACTIVE STORAGE (BCM) FOR ASWAN HIGH DAM (JUN. 1964 - OCT. 2019)



Source: Nile DSS

WATER QUALITY

SURFACE-WATER QUALITY

The quality of a water resource determines if and how it can be used. The quality of the Nile waters has generally deteriorated because of population growth and urbanisation, agricultural intensification, and industrial development. Localised high pollution is experienced mainly around urban centres. Poor water quality has many economic costs associated with it, including degradation of ecosystem services; health-related hazards; impacts on economic activities such as agriculture, industrial production and tourism; increased water treatment costs; and reduced property values. With fresh water projected to become increasingly scarce, the costs associated with addressing water-quality problems is expected to rise.

The observations from The Nile Basin Regional Water Quality Monitoring Baseline Study Report (NBI, 2005a) on the state of water quality in the Nile Basin are provided in Box 2.2 below. Whereas the Nile Transboundary Environmental Action Project achieved consensus among the participating riparian states on the parameters for water-quality monitoring and assessment in the Basin, it also highlighted major differences in protocols, particularly in relation to formats for data collection, capture, processing, storage, consolidation, and update.

GROUNDWATER QUALITY

Information on groundwater quality in the Nile Basin is largely limited to the extent the resource is developed by individual riparian states for improved methods of abstraction, as it is then that relevant parameters are assessed and monitored.

Influencing factors on the quality of groundwater in the Basin include hydrogeology, methods of abstraction,

Fishermen scraping a living on the River Nile in front of modern high rise apartment blocks. The technique involves slapping the water to scare small fish towards the nets.

and human activities in aquifer Basins.

In the Equatorial Lakes Plateau, groundwater quality meets WHO potable water standards. Total dissolved solids are typically around 500 mgl-1, and pH is usually neutral to slightly acidic (BGS, 2018). The main inorganic groundwater quality problems are fluoride, iron and manganese. Fluoride concentrations up to three times the WHO health-based guideline of 1.5 mgl-1 are found in the Albertine Rift and the Mount Elgon catchment areas, while a mean concentration of 3.74 mgl-1 is reported for the Mwanza Region in Tanzania (Malago, Makoba, & Muzuka, 2017). Concentrations of iron and manganese considered above a safe standard have been observed in low-pH groundwater occurring in the considerably mineralised thermal waters of volcanic and tectonic origin in the Albertine Rift (UNESCO, 2004, pp. 227–8), where contamination due to mining activities has also been reported at some sites (Partow, 2011). Aquifers underlying densely populated areas are vulnerable to nitrate and microbial contamination primarily due to sanitation failures. Values up to 26 mg/l (as N) – more than twice the WHO guideline value – and high coliform counts have been reported, particularly in shallow unconsolidated aquifers underlying urban areas in the Lake Victoria Basin (BGS, 2001; 2018).

Mineralisation from reactive rock types, and pollution associated with

Photo: © Andy Johnstone/Panos Pictures

human activities and settlements, are responsible for the pockets of elevated salinity and nitrate pollution reported in the Blue Nile sub-Basin. Higher-than-safe levels of fluoride occur in Ethiopia's Western Highlands and the Rift Valley. Mean fluoride concentrations by groundwater source in Ethiopia are reported as 1.77 (SD ±2.13) for dug wells; 5.87 (SD ±12.87) for boreholes; and 6.76 (SD ±11.73) for cold springs. Thermal wells have a mean concentration of 33.91 (SD ± 18.84) (Malago, Makoba, & Muzuka, 2017). The incidence of fluorosis is known to be high as a result. Nitrate and microbiological pollution from pit latrines, septic and sewerage systems, animal breeding, and fertiliser leachate are major threats to groundwater supplies

BOX 2.2: WATER-QUALITY MANAGEMENT IN THE NILE BASIN

Agricultural runoff, industrial waste and untreated municipal and domestic waste have led to seriously degraded water quality in Lake Victoria over the past few decades (Scheren, Zanting, & Lemmens, 2000). While industrial waste is generally confined to urban areas (Kampala, Mwanza, and Kisumu among others), untreated sewage and agricultural runoff occur all along the heavily populated shoreline. Phosphorus and, to a lesser extent, nitrogen from untreated waste, put excessive nutrients into the water, driving algae blooms and contributing to the water-hyacinth invasion seen in the mid-1990s (Scheren et al., 2000; Williams, Duthie, & Hecky, 2005; Albright, Moorhouse, & McNabb, 2004). In addition, accelerated erosion from deforestation and agricultural conversion of natural areas has led to greatly increased sediment loads being carried into the lake (Machiwa, 2003).

The Nile Basin Regional Water Quality Monitoring Baseline Study Report (NBI, 2005a) indicates that as the river flows through Sudan it picks up some non-point-source agricultural and urban runoff. While water quality has generally been found to be within World Health Organization standards, there are some localised high concentrations of chemical pollution, especially in the Khartoum area (NBI, 2005a). In Egypt, water quality is under pressure from intense population and accompanying agricultural and industrial activity concentrated along the banks of the Nile. In Upper Egypt, this comes primarily from agro-industries, particularly sugar cane (Wahaab & Badawy, 2004). Downstream, where populations are more concentrated, a wide range of industrial pollution and wastewater enters the river from Cairo and Lower Egypt's other urban centres (Wahaab & Badawy, 2004; NBI, 2005b). While Egypt has made significant efforts to construct additional wastewater treatment capacity, population growth has outstripped capacity and considerable domestic wastewater enters the Nile with no treatment (NBI, 2005b). Intense agriculture and some mixing of industrial and domestic wastewater in irrigation-drainage canals make a source of multiple contaminants in Lower Egypt (NBI 2005b).

The Water Quality and Ecosystems Study under Phase I of the Lake Victoria Environmental Management Programme (LVEMP I) identified major point and nonpoint sources of nutrients and estimated the rates of sedimentation into Lake Victoria. The determination of pollution loads from point sources was limited to the biochemical oxygen demand (BOD5), total nitrogen (TN), and total phosphorus (TP). For the nonpoint pollution sources emphasis is given to TN, TP and total suspended solids (TSS); the loads from rivers and atmospheric deposition are also estimated due both to their relevance as quality indicators and their contribution to eutrophication of the lake.

Sedimentation rates in Lake Victoria

Source	TN (t/y)	TP (t/y)
External loading	967,700	50,920
Annual Increase in lake (1960-2000)	30,360	2,760
Permanent burial	107,000	24,000
Outflow through Nile	56,200	3,410
Balance	774,140	20,750

BOX 2.3: OBSERVATIONS ON THE STATE OF WATER QUALITY IN THE NILE BASIN

It is clear that countries all seem to suffer from similar issues:

1. Many are dependent on an agricultural economy, which gives rise to the following problems:
   - i) Non-point nitrate and phosphate pollution from fertilisers;
   - ii) Non-point pollution from pesticides, herbicides, and other complex organic compounds;
   - iii) Over-cultivation by deforestation, resulting in soil erosion and sedimentation.
2. Poor domestic wastewater treatment, resulting in high bacteriological counts from fecal contamination, as well as higher ammonia and chloride concentrations, and high biochemical and chemical oxygen demand (BOD) values. In severe cases they can lower the dissolved oxygen (DO) values, resulting in fish kills.
3. Insufficient treatment of industrial waste waters, which can raise the BOD values and also produce additional pollutants such as heavy metals and complex toxic organic compounds.
4. Tanneries releasing chromium pollution.
5. Problems caused by mining processes releasing acids, heavy metals such as mercury, and toxic compounds such as cyanides.
6. Some countries, particularly those on the Rift Valley, having natural pollutants such as fluoride.

SILTATION

Siltation is arguably one of the worst problems to affect the Nile, particularly that originating in Ethiopia, where soil erosion, which is extensive on the plateau, amounts to 140 million tons per year in the Blue Nile sub-basin, and 85 million tons in the Atbara River causes the dams in Sudan to silt up by an approximate 1% each year. This problem also occurs elsewhere on the White Nile. It causes high turbidity and total suspended solids (TSS) in the rivers, silts up the dams, and erodes the lands, initiating desertification.

One way to reduce soil erosion is by the planting of trees, but the demographic changes caused by the wars and natural disasters has led to the reverse happening, with deforestation prevalent. To prevent this, governments need to be particularly vigilant in managing the land, especially in the river basins.

One possible benefit of siltation is maybe that the silt, which is fertile soil, acts as an absorbent coagulant for certain pollutants.

Research is continuing into siltation-prevention schemes and it would be useful to investigate whether the sediment in the water does actually improve the self-purification of the river and which pollutants are removed. It would also be useful to process the data to investigate if there is a relationship between TSS and turbidity values.

POLLUTION THREATS

The dumping of solid waste is variable in each country and this can only be controlled by good legislation, controls, and designated waste tips. In the developed countries, waste tax and recycling schemes have been established to reduce this pollution load. Countries should list threats to pollution, such as storage of chemicals close to the Nile, or factories that do not produce effluent but could produce a waste problem following a disaster. It is recommended that an inventory of such sites also be made. A hazard assessment study could then be undertaken to produce emergency contingency plans. In developed countries periodic emergency trials are undertaken to ensure all the stakeholders can efficiently deal with such a crisis. This is particularly important in dealing with transboundary pollution control

in the Basin (Ayenew, 2005). Whereas tests have shown salinity levels in the range of 80 to 1800 mgl-1 in the Nubian aquifers, and over 5000 mgl-1 along the margins of the Umm Ruwaba sedimentary formation, the quality of groundwater in Sudan is generally suited for human and irrigation purposes (Ahmed et al., 2000).

In Egypt, groundwater for domestic supplies is abstracted from deep wells because of the high quality of the water, which only has naturally elevated levels of iron and manganese. Groundwater quality in the renewable aquifers varies with proximity to the Nile River. In the Nile Valley margins east and west of the river, salinity is elevated. The same is true for the Nile Delta: salinity increases northwards to the Mediterranean, where it is elevated by seawater intrusion. Anticipated sea-level rise as a consequence of climate change will adversely impact on the quality of the groundwater resources of the Nile Delta. Moreover, contamination from nitrogen compounds and heavy metals in agricultural and industrial effluent, as well as sewer drain seepage, compounds the threat to renewable groundwater availability in both the Nile Valley and the Delta (El Tahlawi & Farrag, 2008)

Photo: © 2004 Arne Hoel/The World Bank

IN SUMMARY

Although Egypt and northern Sudan receive insignificant rainfall, mean annual precipitation over the Nile Basin is substantial. However, the productive use of these large rainwater resources is seriously hampered by the unpredictability of rainfall over most of the Basin.

With a runoff coefficient of just above 4%, only a fraction of the annual rainfall reaches the Nile system. The annual estimated yield of the Basin ranges between 84 - 91[7] BCM.

Extensive aquifer systems holding substantial quantities of groundwater underlie some parts of the Nile region, some of it being fossil water. Groundwater recharge rates range from less than 50 mm/year in the semi-arid catchments to a mean of 250 mm/year in the subtropical upper catchments. Use of fossil groundwater is contingent on the quality and availability of cheap electricity for pumping.

Use of desalinated seawater to augment water supplies is currently practiced in Egypt, Kenya and Sudan.

The quality of the Nile waters has generally deteriorated because of population growth and urbanisation, agricultural intensification, and industrial development. Localised high pollution is experienced mainly around urban centres.

[7]Some estimates put this figure to more than 96 BCM per year

WATER DEMANDS BY SECTOR

This section presents water demands for: municipal and industrial uses, agriculture, hydropower production, and environmental flows; reservoir evaporation is included as a special case of water demand associated with man-made water storage. Insufficient data were available to review water use for fisheries, mining, and navigation. The estimates presented in this section largely are based on NBI Strategic Water Resources Analysis Report (2016).

MUNICIPAL AND INDUSTRIAL WATER USE

It is inevitable that water use for municipal and industrial (M&I) purposes will rise significantly in view of population growth, urbanisation, and socio-economic development.

- No accurate data are available on existing M&I water use in the Nile Basin, but NBI has prepared projections based on various demographic and economic growth scenarios, and the study is still under consideration by NBI. Experience in several water-scarce regions or countries has shown that it is unlikely that future M&I water demands cannot be met provided that adequate infrastructure and policy instruments are in place. The following remarks are made:
- In the many Nile Basin countries, groundwater will probably remain the principal source for community water supply in rural areas and small towns not immediately adjacent to a river.
- Much of the water supplied to houses and industries in urban cities around the Nile tributaries is used for cleaning and removing wastes; most of this water can be returned to the river system after treatment, provided it is collected.
- Hence, the volume of wastewater is anticipated to grow exponentially, and adequate drainage and treatment facilities are required.
- Significant savings in urban water systems are possible by reducing network losses and unaccounted-for-water.
- Significant M&I water savings are possible through diverse water conservation methods, pricing policies for industrial use, and creating awareness about the importance of efficient water use; for instance, mandatory on-site water and wastewater recycling for industries that consume high volumes of water has proved effective in other parts of the world.
- In view of the high value of water for M&I purposes, non-conventional water sources – such as desalinated seawater – can be considered.

AGRICULTURAL WATER DEMAND

In the Nile Basin, agricultural water use far outstrips all other water demands combined. Food security remains a critical concern to all Nile countries due to population growth, economic development, urbanisation, inadequate nutrition levels in all Nile countries bar Egypt (see Chapter 5), and the large rural population that cannot afford imported foods. Hence, further growth of agricultural production is necessary, which is contingent on the availability of adequate water resources.

FULL-CONTROL IRRIGATION

Irrigation uses the largest proporation of water abstracted from Nile and its tributaries.

RAINFED FARMING

Rainfed farming is practised on about 87% of arable land. As discussed in Chapter 5, yields and water productivity are currently low in rainfed farming systems across the Nile region, suggesting large untapped agricultural potential. However, yields will remain low without a secure water supply because of the high temporal variability of rainfall across the Nile Basin and the associated risk of crop failure. Under these conditions, farmers are unwilling to invest in agricultural inputs and improved cultivars that are required for higher yields. Yet the volumes of water required to prevent periodic moisture deficits is typically low. For large rainfed areas in semi-arid environments, however, the additional moisture requirements could be high and may not be supplied from small scale water harvesting procedures.

Small-scale supplementary irrigation based on water harvesting and/or shallow groundwater in combination with improved soil conservation can therefore provide an effective means to prevent moisture deficits in the growing season in most of the rainfed agricultural zone. These interventions primarily aim to supplement and extend the productivity of rainfall, and their overall impact on the downstream river flow is probably low, specifically in the White Nile Basin. From a water-resources perspective, therefore, this approach constitutes a viable strategy to increase agricultural production in the Nile Basin.

WATER USED FOR ENERGY PRODUCTION

Water for energy production in the Nile Basin is mainly concerned with hydro-electricity. In 2018, around 19 percent of the potential capacity had been developed, which will increase to 42% by 2021 when the facilities currently under construction have come into service.

While hydropower generation is called a non-consumptive water use, a considerable amount of water is lost through evaporation in the reservoirs needed to maintain hydraulic head, accommodate power-demand fluctuations, and attenuate seasonal river flows.

However, the major reservoirs in the Nile Basin serve multiple objectives, including flood control, irrigation, maintaining environmental flows, and power production. For instance, the principal function of Lake Nasser/Nubia is to provide water for irrigation, flood control and power production. However by time and due to high annual rate of power demand, the installed power capacity at the AHD now represents less than 5% of the total installed power capacity in Egypt.

Developing the remaining potential hydropower capacity will require retention of extra surface water, leading to evaporation losses. However, the storage capacity on the Blue Nile will enable most new facilities to operate in run-of-river mode – with associated low storage and evaporation losses – provided that good cooperatioin and coordinated reservoir operation policies can be agreed upon by all stakeholders.

Power trade and renewable technologies such as solar and wind could reduce the need to build new hydropower facilities that are less financially attractive or entail considerable negative consequences.

« While hydropower generation is a non-consumptive water use, water is lost through evaporation in the reservoirs »

ENVIRONMENTAL FLOWS

Ongoing and prospective water resources development in the Nile Basin and other stressors – including climate change and agricultural intensification – may alter the quality, quantity, and timing of river flow, which could adversely impact ecosystem services and riverine biodiversity and may affect the livelihood of riparian communities.

Environmental flow requirements determine the flow regime of a river reach that is needed to maintain riverine and floodplain ecosystems. It is a function of the aspired environmental integrity and differs per river reach. Very little information is available on environmental flow estimates. The NBI has developed an Environmental Flow Management Strategy, which was approved by the

Terrace farming

Nile-COM. Further, estimates of environmental flows have been made for selected river reaches.

RESERVOIR EVAPORATION LOSSES

The aggregated net evaporation losses from dams is estimated at 18.8 BCM per. In addition, net evaporation losses from regulated lakes as a result of the additional storage due to the regularion are not included.

The following observations are made:

- Upon completion of GERD, coordinated operation of the hydropower facilities on the Blue and Main Nile could reduce evaporation losses of the reservoirs at Roseires, Sennar, and Merowe, provided that hydraulic head can be maintained through enhanced cooperation and coordination.

IN SUMMARY

Key components of the water-demand function show an upward trend. The projected increase in water demand differs per sector.

Water use for municipal and industrial purposes is subject to exponential growth, but the actual increase in terms of volume of extra surface water required is relatively modest, provided adequate water conservation and recycling measures are taken, ground and surface water sources are used conjunctively, and non-conventional water resources are being developed whenever possible.

Supplementary irrigation to extend rainfall productivity in the large rainfed agricultural sector will only marginally impact on the renewable Nile water resources.

Developing the remaining potential hydropower capacity will require retention of extra surface water, leading to more evaporation losses. About 20% of the renewable Nile flows is already lost through reservoir evaporation. However, the over-year storage capacity on the Blue Nile will enable most new facilities, if any, to operate in run-of-river mode – with associated low storage and evaporation losses – provided that coordinated reservoir operation policies can be agreed upon by the three countries (Egypt, Ethiopia and Sudan). Reduction of costs for alternative power sources such as solar and wind could reduce the need to develop all remaining hydropower potential.

RISKS FROM WATER-RELATED HAZARDS

Common water-related hazards in the Nile countries include floods, mud/landslides, heat waves, droughts, waterborne diseases, dam breaks, and coastal flooding. Loss and damage because of water-related hazards are caused by direct impacts – e.g. damage to buildings, crops and infrastructure, and loss of life and property – and indirect impacts, e.g. losses in productivity and livelihoods, increased investment risk, indebtedness, human health impacts, population displacement, and related conflicts (WWAP, 2012).

Climate change will probably increase the risk of water hazards. However, losses due to water-related disasters are also aggravated by the increase in the value of exposed assets and the growing number of people residing in areas at risk, such as flood plains or steep slopes.

FLOODING

Floods are natural events that occur quite often on virtually every unregulated river unaffected by hydraulic modifications. Nevertheless, the impacts of floods can be dramatic and very damaging. No exhaustive inventory exists of extreme flood events in the Nile Basin, but flood risks are concentrated in the low-lying lands at the foothills of Mount Elgon and the Rwenzori mountains, around the shores of lakes and major wetlands potentially affected by backwater effect – such as the Sudd and the areas upstream of Lake Kyoga – and in the eastern Nile region. The severity of floods is frequently aggravated by deforestation, inappropriate agricultural practices, land degradation, or wetland destruction. Direct flood impacts include loss of life, loss of livestock, destruction of infrastructure such as bridges and roads, crop loss, destruction of properties, as well as potential outbreaks of water-borne diseases such as cholera.

The gentle terrain of floodplains is commonly an attractive site for agriculture, and diverse economic activities, and flood damage risks in the Nile Basin are steadily increasing because of economic development in this zone. This trend will likely continue because of ongoing population growth and increasing pressure on land. Although flooding of the floodplain is a natural event, water managers are nevertheless tasked with protecting people and their belongings in this zone.

The extensive wetland areas in the upstream Nile Basin have a mitigating effect on flood damage. Flood volumes collect in the seasonal and permanent wetlands, causing water levels to rise slowly. Even very large floods do not extend far beyond the wetland margins. The slow rise of water levels enables people and livestock to evacuate the floodplain safely, but crops are lost, and flood waters typically disperse human waste from latrines. Loss of life occurs but is accidental. Human encroachment of wetlands contributes to the severity of the floods.

The flood mechanism is different in the eastern Nile region. Rainfall is concentrated in the period between July and September. Heavy rainfall on steep and often deforested upstream catchments cause a rapid runoff response that exceeds the capacity of the river channel and inundates the densely populated floodplains in the Blue Nile valley in Sudan and Ethiopia, and Main Nile valley in Sudan. In particular, the area around Khartoum is vulnerable. Floods cause property damage, disrupt productive activities, cause livestock and agricultural losses, and lead to water-related diseases and associated health risks.

Hydro-infrastructure development is gradually increasing the capacity to mitigate flood damage. For instance, the forthcoming completion of the Grand Ethiopian Renaissance Dam (GERD) on the Blue Nile will greatly increase the capacity to manage floods in the Blue Nile valley and Main Nile valley in Sudan through enhanced cooperation and coordination. On the Atbara River, the storage capacity of the Tekeze reservoir may help to regulate this highly variable riv-

« Common water-related hazards in the Nile countries include floods, mud/landslides, heat waves, droughts, waterborne diseases, dam breaks, and coastal flooding »

FIGURE 2.12 ELEVATION

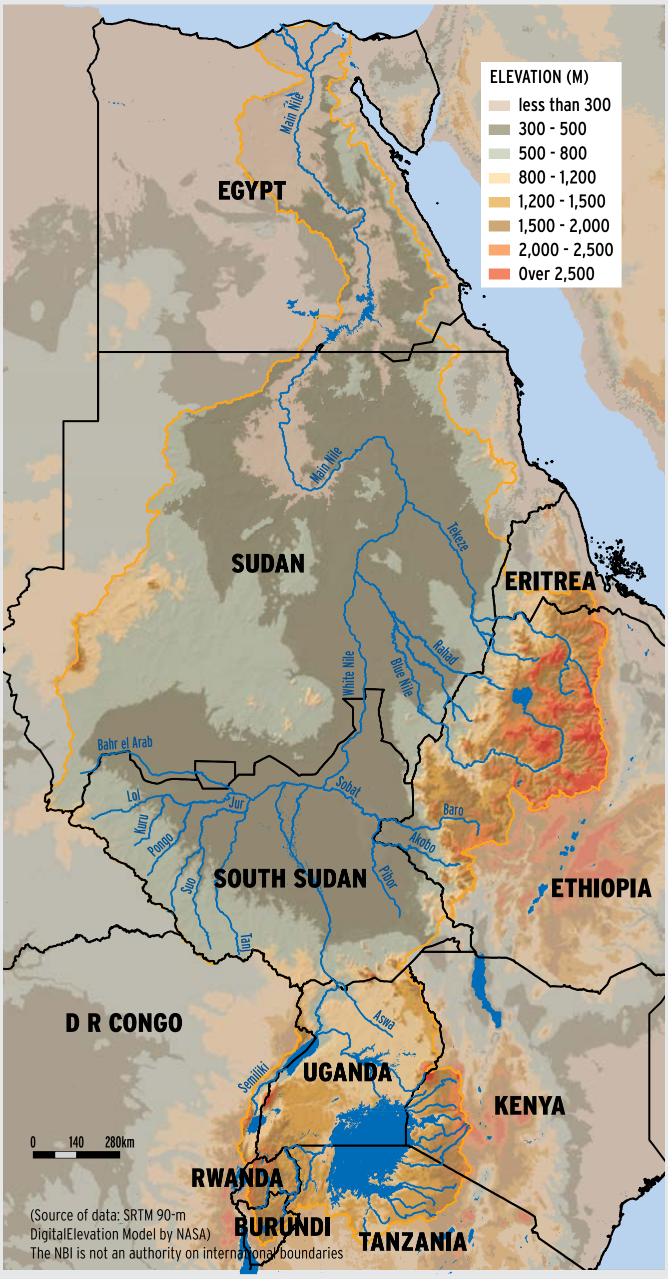


FIGURE 2.13: SLOPE RANGE

Source NBI 2016

er and mitigate flood risk in the downstream river reaches. Furthermore, the Eastern Nile Technical Regional Office (ENTRO) has implemented the Flood Preparedness and Early Warning (FPEW) project to increase the capacity to respond to flood events in the flood-prone areas, including along the Blue and Main Nile. This subject is further discussed in Chapter 6.

Apart from the eastern Nile region, floods in the Nile Basin are predominantly a sub-national or local issue, with largely contained adverse socio-economic consequences. By contrast, floods in the Main Nile valley and Blue Nile valley can have major negative implications for Sudan and Ethiopia, and flood management and mitigation on the Blue Nile, Main Nile, and Atbara in Sudan clearly have a transboundary dimension.

MUD/LANDSLIDES

The Nile's water towers – the Ethiopian Highlands, the Rwenzori Mountains, and Mount Elgon – are in zones classified as highly susceptible to landslides. This is illustrated by Figure 2.12 and Figure 2.13, presenting the topography and slope-range in the Basin.

Mount Elgon is deeply weathered, and severe landslides – in the wettest season of March to October – are a major hazard on some of the lower slopes. Yet the zone around the base of the mountain is densely populated, with rural communities farming the nutrient-rich volcanic soils.

In the Rwenzori Mountains, and indeed the western branch of the East African Rift valley, high rainfall coupled with a large number of faults, increasing population densities, land-use changes, deforestation, and high poverty levels have been determined as the dominant trigger for recent landslides (Monsieurs, et al., 2018). Maki Mateso and Dewitte (2014) mapped more than 600 landslides in this region, although owing to lack of temporal information on their occurrence, only 143 landslide events with known location and date over a span of 48 years from 1968 to 2016 could be captured by Monsieurs et al (2018) in their Landslides Inventory for the central section of the Western branch of the East African Rift (LIWEAR). Casualties are increasing because of higher population densities and encroachment on steeper slopes.

While landslides have devastating consequences at local level – including loss of life – they do not pose a systemic risk to socio-economic development in the Nile Basin.

WATER-BORNE DISEASES

Information on outbreaks of water-borne and other water-related diseases can provide vital pointers regarding access to safe drinking water and the availability of improved sanitation facilities. Figure 2.14 presents statistics for 2016 of children affected by water-borne diseases. Apart from Egypt, incidences of water-borne diseases are affecting a very large percentage of children in the Nile Basin. It points to major shortcomings in meeting targets for improved water and sanitation.

DAM BREAKS

No incidences of failure of medium-size or large dams have been reported. Nevertheless, the ongoing expansion of hydro-infrastructure in the Nile Basin points to the imperative of ensuring dam safety.

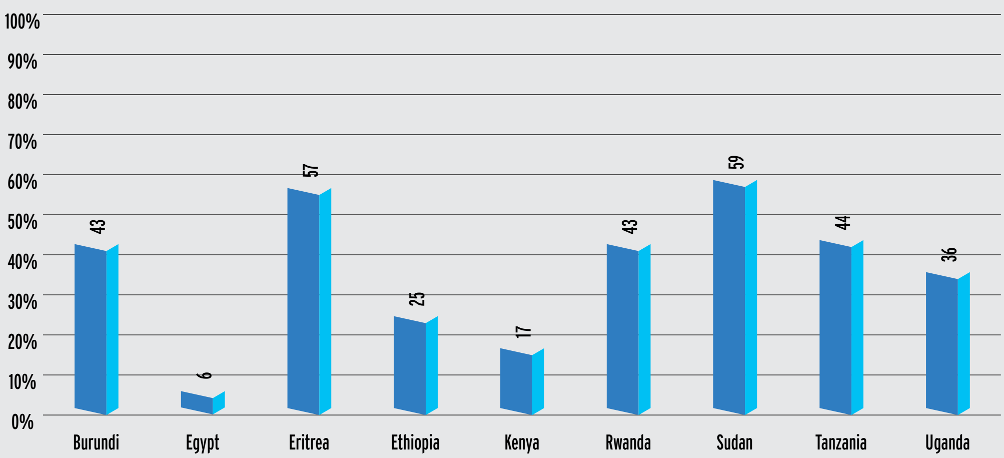
For this report, whereas information was available on prior-notification arrangements for major infrastructure developments, it was not discernible whether a similarly agreed policy framework exists for Basin-wide coordinated dam operation and ensuring dam safety. Collaboration among all riparian states to gather, manage, and share data on dam safety and incidences of dam failure, as well as associated loss and damage is required to both monitor effectiveness of, and inform interventions to enhance, water-related disaster preparedness and capabilities.

COASTAL FLOODING

The only area in the Nile Basin susceptible to coastal flooding is the low-lying Nile Delta in Egypt. The rich arable lands make an

« Climate change and population growth increase the risk of landslides »

FIGURE 2.14: CHILDREN AFFECTED BY WATERBORNE DISEASES REPORTED 2016 (% OF CHILDREN)



Source: [AUC-AMCOW, 2016], no data available for DR Congo and South Sudan important contribution to Egypt's agricultural production, while the area is densely populated and home to about one-third of the country's population.

Sea-level rise will seriously threaten the delta. This threat is compounded by the weakening of the protective offshore sand belt because of reduced silt supply from the Nile after the construction of the Aswan High Dam (AHD), and by land subsidence because of increased groundwater extraction.

IN SUMMARY

Most water-related hazards in the Nile Basin are predominantly local and small scale, and do not pose a systemic risk to socio-economic development and environmental integrity in the Nile countries. However, there are three exceptions.

The high prevalence of water-borne diseases in all countries bar Egypt suggests profound health implications that result in a vicious cycle of ill health, malnutrition, and poverty, mostly affecting the poorest segments of society. It points to the importance of providing safe drinking-water facilities and improved sanitation.

The second major issue is the flooding of the Main Nile valley in Sudan and the Blue Nile valley in Sudan and Ethiopia. It affects a densely populated area with high economic relevance.

The third key water-related hazard is the increased risk of flooding in the Nile Delta because of sea-level rise and land subsidence.

The third key water-related hazard is the increased risk of flooding in the Nile Delta because of sea-level rise and land subsidence.

PRESSURE ON WATER RESOURCES

« Pressure on water resources in the Nile Basin is very much related to food security in the arid zone »

It is evident that the water resources in the Nile Basin are under rapidly growing pressure. The finite and modest Nile waters are now fully utilised for various productive and environmental purposes, while water demand continues to rise due to population growth and socio-economic development. Additionally, climate change and environmental degradation may adversely impact on long-term water availability.

Two components currently dominate the water-demand function. Irrigated agriculture in the Nile Basin uses most of the Nile flows. It is noted that the bulk of the evaporation losses occur in reservoirs whose primary function is to support irrigated agriculture and hydropower. Hence, pressure on water resources in the Nile Basin is very much related to food and power security in the arid zone.

Water-resource deficits were identified in all irrigation development scenarios analysed. Nevertheless, water savings are possible if losses in existing irrigation schemes can be reduced.

While projected M&I water demand shows exponential growth, it is generally low as a proportion of overall water demand, except for Egypt, where projected M&I water demand in 2050 will exceed 18 BCM/year. However, most of this water can be returned to the river system if collected and well treated. It is noted that Egypt is already recycling an estimated 1.4 BCM/year of municipal wastewater.

Given the high value of water for M&I purposes, non-conventional water sources – such as desalinated seawater – can be considered, while significant water savings are possible through diverse water-conservation methods, pricing policies for industrial use, and creating awareness about the importance of efficient water use. Economic growth and urbanisation will exponentially increase the volume of wastewater across the Basin. While most of this water can be reused in principle, it will require large investments in drainage infrastructure and treatment facilities.

Thus, it is unlikely that future M&I water use will lead to unsustainable water deficits provided that diverse efficiency measures are put in place, adequate treatment facilities are established, and reasonable alternatives are developed. However, there is considerable risk that fresh water downstream of major urban areas may become polluted and become de facto unusable.

Water productivity is currently low in rainfed farming across the Nile region – which covers 87% of arable land – suggesting large untapped agricultural and water resources potential. Most of these areas receive substantial but highly variable rainfall. It implies that a secure water supply can be achieved with a relatively small volume of water. Measures should primarily focus on extending the productivity of rainfall, and include supplementary irrigation from either surface or groundwater, land and water conservation, and water harvesting. Groundwater recharge rates in the sub-tropical zone are subject to high spatial variability, but average 250 mm/year. The water resources implications of these measures at Nile Basin scale are relatively small because of the low runoff coefficient experienced in most of the Equatorial Nile region. The huge practical difficulties in extending the productivity of these water resources – mostly rainwater – are acknowledged.

Given the high annual flow target of the Main Nile at Dongola – immediately upstream of Lake Nasser/Nubia – environmental flow requirements for low and drought flows can be met and do not conflict with hydropower production or irrigation. By contrast, it is probable that water scarcity will impact on ecosystem functions downstream of AHD.

Thus, while pressure on water resources in the Nile Basin is increasing, a wide range of options still exist to achieve water security.

« While pressure on water resources in the Nile Basin is increasing, a wide range of options still exist to achieve water security »

RESPONDING TO THE CHALLENGE

THE STATUS OF MEASURES TO ASSURE WATER SECURITY

Measures to assure water security are being implemented at both national and Basin level. They are broad in scope and include actions taken in the water sector, but also in other water-related sectors such as agriculture and energy.

FIGURE 2.15: PERCENTAGE OF RURAL AND URBAN POPULATION USING IMPROVED DRINKING-WATER SOURCES

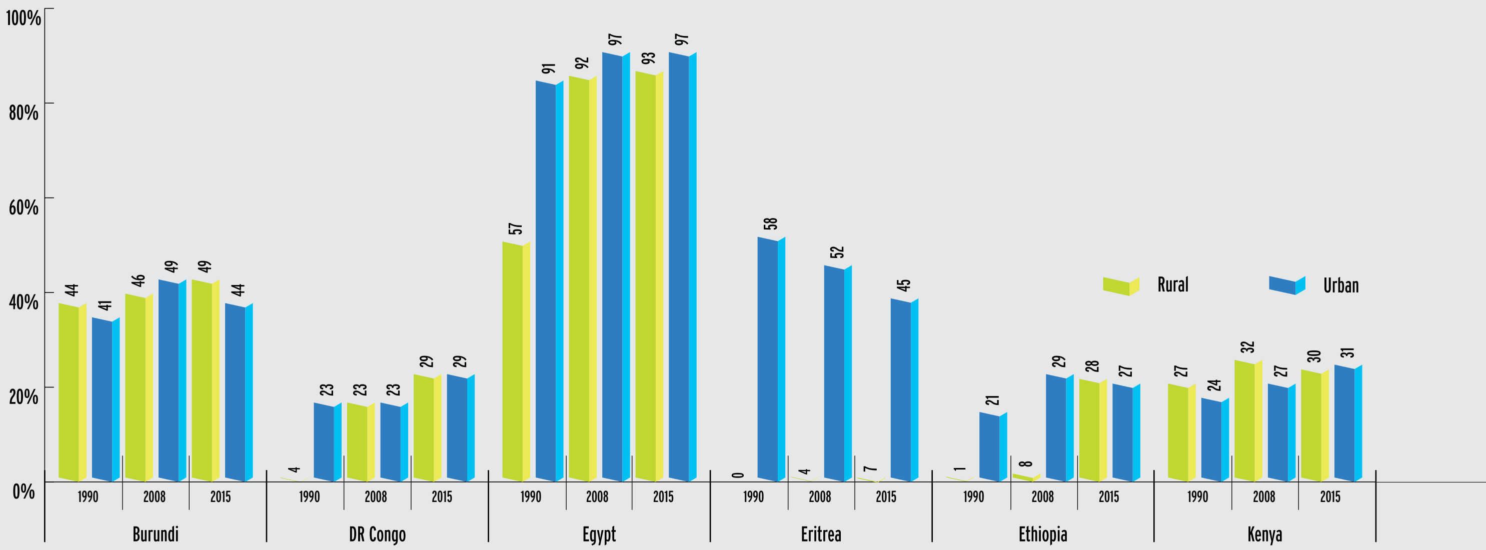
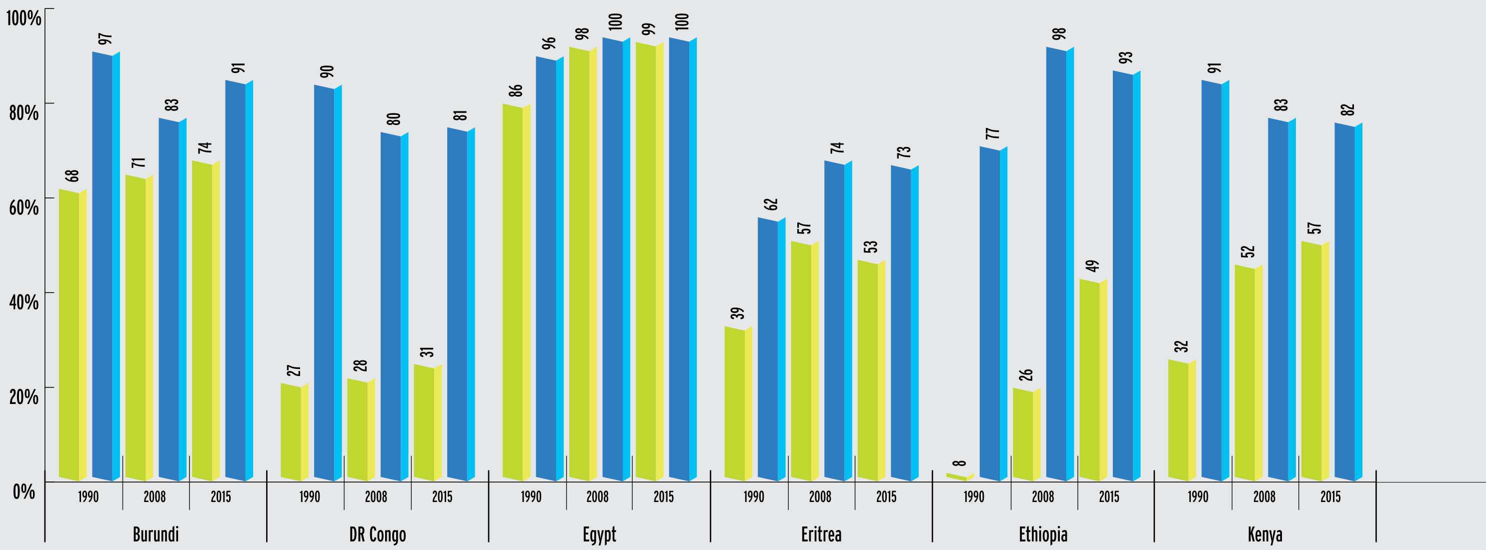


FIGURE 2.16: PERCENTAGE OF RURAL AND URBAN POPULATION USING IMPROVED SANITATION

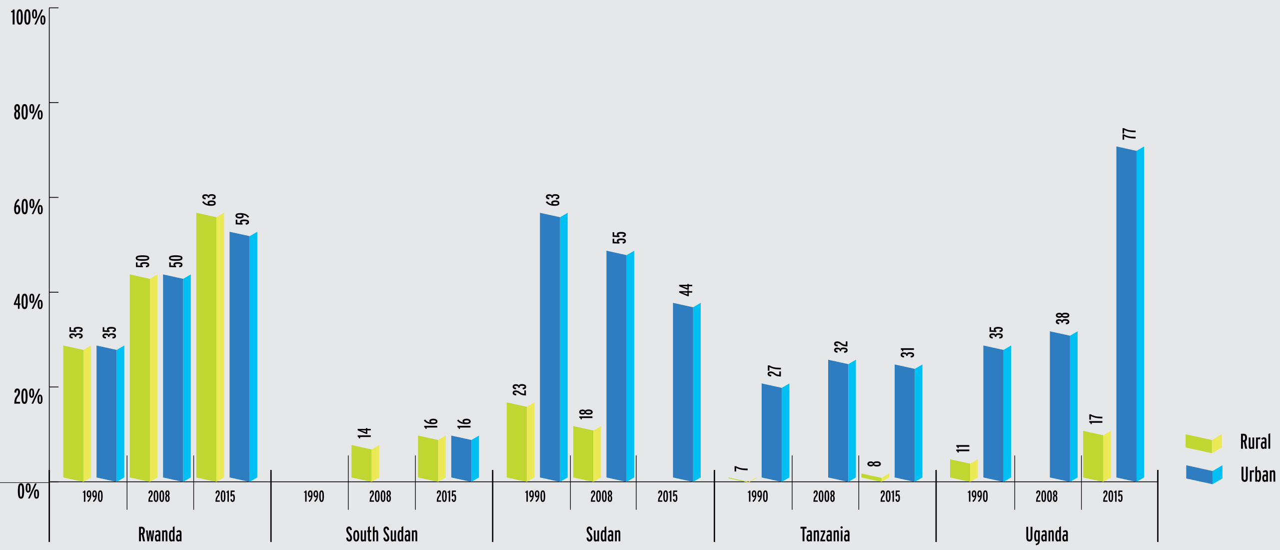


INCREASING ACCESS TO SAFE DRINKING WATER AND BASIC SANITATION

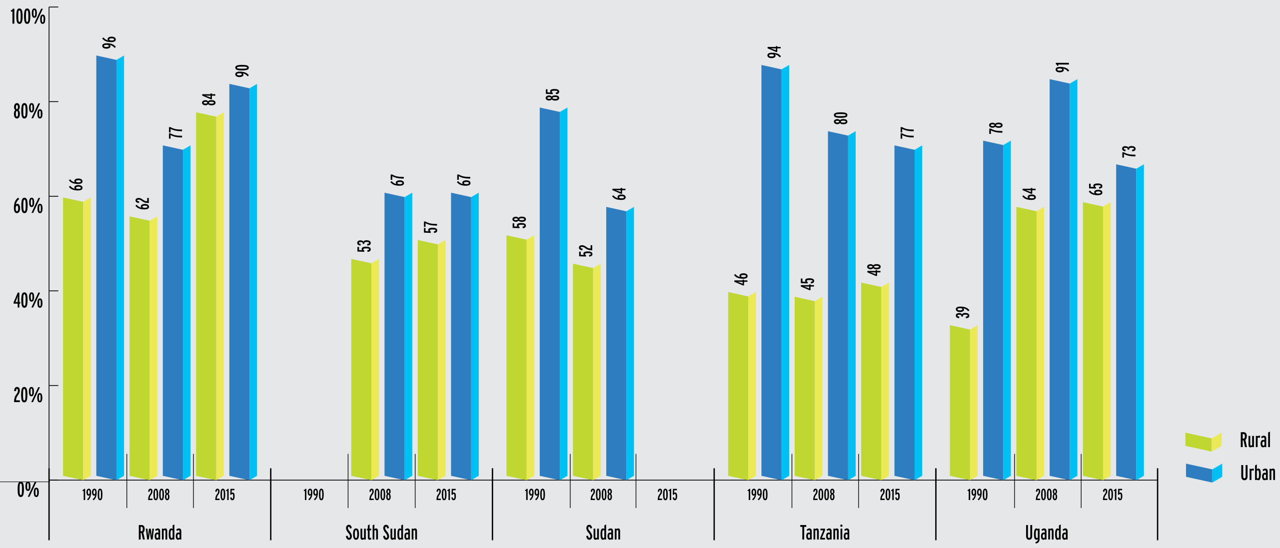
Access to clean and safe water is a prerequisite for a healthy population and has a direct impact on the quality of life, labour productivity, and economic development of a country. Figure 2.15 present the percentage of the rural and urban population with access to improved drinking-water sources. Figure 2.16 show the percentage of the population using improved sanitation.

The following observations are made:

- Only Egypt has near-universal access to safe drinking-water sources in rural and



Source: SOB 2012 (WHO/UNICEF 2010) for 1990; Nile Basin Water Resources Atlas (UNDP) for 2008 & 2015



Source: SOB 2012 (WHO/UNICEF 2010) for 1990; Nile Basin Water Resources Atlas (UNDP) for 2008 & 2015 urban areas.

- Access to improved sanitation facilities is high in urban and rural areas in Egypt; it will enable reuse of treated wastewater for other productive purposes including irrigation.
- General improvements are witnessed in rural areas in the Nile countries, although many people still have no access to safe drinking water; additionally, less than 30% of the rural population in seven Basin countries has access to improved sanitation.
- While a high percentage of the urban population is using improved drinking water facilities, many riparians are evidently struggling to keep up with high population growth in urban areas; access rates are stagnating or even declining in several riparians.
- Access rates to improved sanitation facilities in urban areas remain low in several riparians; this is of concern given the anticipated high growth of wastewater in urban areas and the need to reuse part of it after treatment.

ENSURING WATER QUALITY AND ENVIRONMENTAL INTEGRITY

« Interventions to ensure water quality and environmental integrity should focus on reducing pollution at source and improving watershed management activities »

The inadequate levels of coverage and access to water supply and sanitation services, coupled with incommensurate operation and maintenance arrangements for existing systems, are some of the key factors underlying the reported widespread Nile watershed degradation, water pollution and more frequent outbreaks of water-borne diseases. Sanitation failures, especially inadequate services provision and unsafe practices; raw sewage discharge; disposal of solid waste into rivers and storm drainage systems; leachate from refuse dumps; and, to an extent, mining and industrial effluent pollution, pose a major hazard to water availability and threaten efforts to achieve water security in the Basin.

These pollution sources affect the use of river water for both drinking and irrigation purposes and damage the aquatic life. For example, aquatic organisms can accumulate heavy metals to much higher concentrations than those present in Nile river water, and the subsequent consumption can lead to adverse health effects.

In keeping with the consensus reached on related goals under the African Water Resources Management Priority Action Programme 2016–2025 (see AUC-AMCOW, 2016), interventions to ensure water quality and environmental integrity should focus on reducing pollution at source and improving watershed management activities.

Reducing pollutants at source

These types of interventions seek to avoid unnecessary application of fertilizer and pesticides in farming and to reduce the amount of untreated or poorly treated wastewater that enters surface waters. Reducing the amounts of fertilizer and pesticides is achieved through establishing strict regulations on environmental pollution. Additionally, educational and awareness programmes may be required to equip farmers with more sustainable methods to control pests and weeds and to use fertilizer carefully.

Increasing still low rates of wastewater treatment and appropriate disposal of sludge is fundamental to avoiding uncontrolled inflows of sewage into surface waters. The processed wastewater can be reused for other purposes, such as agriculture with lower water-quality requirements, as is already being done in Egypt for example. In addition, the sludge can be used as a fertilizer or for energy production.

Managing pollutants in the watershed

Landscape structures, vegetation cover, and sustainable land-use practices prevent pollutants, carried by runoff, from entering surface waters. Vegetated field margins, especially on slopes, as well as the avoidance of over-grazing, can help reduce soil erosion and subsequent sedimentation of lakes, rivers, and wetlands. When greened with shrubs and grassed, they also lower the formation of highly concentrated runoff and flash floods that mobilise pollutants and carry them into surface waters. Vegetated buffer zones around lakes, rivers, and wetlands can hold back nutrients, pesticides, and sediments that would otherwise run into these surface waters. Moreover, freshwater plants and animals, for example those of wetlands fringing lakes, filter out pollutants from wastewater discharged by adjacent urban areas.

Chapter 5 takes a more detailed look at actions that have been taken both by the NBI and the Nile Basin countries concerning these pathways to avoid water pollution.

Facilitating the development and adoption of minimum effluent quality standards

These standards should apply to discharge into the Nile, its tributaries and underlying aquifers, as well as standardising regulations for wastewater treatment, environmental flows, and water-quality management in the Basin.

Promoting sustainable wastewater management and reuse

There is need to strengthen the legal, policy and institutional frameworks for the collection and treatment of wastewater to a minimum water-quality standard before it is reused or returned to nature. This can be done through promoting the implementation of an integrated urban water management approach to ensure closing the water loop and allocating water to different users, depending on the quality.

Enhancing use of wastewater and sludge, as appropriate and acceptable, in agricultural and other sectors

Experiences on planned reuse and the technologies applied to assure safety of effluent for return to the environment in African Union (AU) member states, including South Africa, Tunisia and Namibia, should be studied and used to inform replication – to the extent it is possible – in all Nile Basin riparian states. Activities in this regard should be centred on: a) instituting tariff systems targeted towards better cost recovery in wastewater collection and treatment, while at the same time safeguarding affordability; and, b) facilitating safe use of wastewater in urban farming.

MANAGE DEMAND AND INCREASE WATER PRODUCTIVITY

Attempts to manage demand and increase water productivity will, by definition, alleviate pressure on the Nile resources. There is a huge scope to increase water productivity in the Nile Basin. Because agriculture is the dominant water user and agricultural water productivity is generally low, measures to improve the productive use of water in the sector – both in irrigated and rainfed agriculture – can be highly effective. Reducing the water footprint of industrial processes is feasible because of the generally high-value nature of industrial water use, which offers the potential to improve water productivity through a change in practices or technology. Pricing mechanisms could manage excessive municipal demand. Excessive reservoir evaporation could be addressed by enhanced cooperation and coordinated management of storage reservoirs.

« Reducing water demand and increasing water productivity is vital in view of the limited scope for increasing the water supply in the Basin »

INCREASE AGRICULTURAL WATER PRODUCTIVITY

There is significant scope to increase water productivity in the agricultural sector in the Nile Basin. While agricultural modernisation has been earmarked as a priority area in most Nile countries, progress has been modest to slow.

Rainfed sector

The very low water productivity in the rainfed sector is directly related to low yields. It is recognised that high yields cannot be obtained without a secure water supply that eliminates moisture deficits at critical stages during plant growth and also the capacity to produce drought resistant/tolerant varieties. Practices to secure a water supply are focused on extending the productive use of rainwater, and include supplementary irrigation, water harvesting, and soil and water conservation. An in-depth discussion on this topic is provided in Chapter 4.

Programs to support these practices exist in most Nile countries but are small in scope

Photo: Shutter stock

Centre pivot irrigation system

and generally not very effective. The large-scale adaptation of these practices – which are proven and well-established – are contingent on improving the economic viability of agriculture, including small-holder farming, and on providing adequate support in terms of extension services, rural electrification and roads, establishment of value chains, agricultural research, farm commercialisation, etc. It is emphasised that providing secure water supply alone will not automatically translate into higher yields and production. Rather, all constraining factors in the agricultural production system need to be addressed simultaneously. Currently, little progress is being made in the Nile countries to provide the all-encompassing enabling environment for agricultural modernisation.

Irrigated agriculture

As presented earlier, irrigation consumes most of the water withdrawn from the Nile and its tributaries. This is currently so in the lower part of the Basin than in upstream water source regions because of limited or no rain in the arid and semi arid regions. Given the substantial irrigation development planned by all member states, water saving in the irrigation sector can have considerable positive impact in the overall water balance of the Nile Basin. In addition to enhancing productivity of the rainfed sector, improving the performance of the irrigation sector (current and planned), would a long distance towards producing more from available water resources.

REDUCE RESERVOIR EVAPORATION

Evaporation from reservoirs constructed in the Nile Basin is estimated at 18.7 BCM/year. Most of the available lakes and reservoirs have unfavourable geometry – with high surface-to-volume ratios – and are located in a hot and arid zone with high evaporation rates. Enhancing cooperation and coordination of dam operation among the eastern Nile countries would result in considerable net water savings. The following is observed:

- At present, the strategy described above is only possible on the Atbara; coordinated operation of Tekeze reservoir with downstream facilities could reduce evaporation but is not yet being pursued.
- Net water savings is expected to increase with the completion of GERD if enhanced cooperation and coordination

policies are in place.

- The practical implication of this water-saving option is relatively straightforward as it involves only a handful of well-established technical agencies; it is acknowledged that the political aspects are more complex.

DEVELOPING WATER-STORAGE CAPACITY AND INFRASTRUCTURE

In view of the seasonal variability of rainfall in the Nile Basin, increasing storage capacity (micro, small, medium and large storages) that buffers occasional water deficits and watershed management can make an important contribution to improving (agricultural) water productivity, securing municipal and industrial water supply, and maintaining environmental flows. Non-conventional water development and utilisation

Non-conventional water resources include desalinated water, recycling of agricultural drainage water, and treated municipal wastewater. The status of non-conventional water utilisation is reported below:

- Egypt invested in operational desalination capacity, measuring 91 MCM/year in 2018; targeted capacity in 2021 is 255 MCM/year; this represents just over 1% of the projected M&I water demand in Egypt in 2050; because of the comparatively high costs of desalinated water, it is primarily destined for high-value water uses. Significant volumes of agricultural drainage water – estimated at 3.5 BCM/yr – and treated municipal wastewater – estimated at 1.4 BCM/yr (Saad et al., 2015) are reported in Egypt; it is noted that this water originates from the renewable Nile waters and does not represent additional water resources.

REDUCING VULNERABILITY TO WATER-RELATED HAZARDS

The principal water-related hazards in the Nile Basin are related to flooding and water-borne diseases. While important progress is being made in mitigating flood risks on the Main Nile valley in Sudan and Blue Nile valley in Ethiopia and Sudan, there is inadequate progress in providing safe drinking-water facilities and improved sanitation facilities, both in rural and urban areas. In fact, statistics indicate that urban managers are having difficulty keeping up with high urbanisation rates.

STRENGTHENING WATER RESOURCES MANAGEMENT CAPACITY

A scarce and shared resource requires careful management. Adapting to water scarcity and preparing for climate change requires substantial managerial resources. The capacity for water governance in some Nile countries is affected by factors such as insufficient staffing, insufficient funding, inadequate enforcements of water regulations, insufficient data and modelling tools, shortages of funds for investment in water infrastructure, etc. This situation poses a risk to achieving water security and is a matter of concern.

It is promising that almost all Nile countries have institutionalised most elements of integrated water resources management (IWRM) in order to address the multi-sectoral dimension of water security and avoid fragmentation.

This topic is discussed in detail in Chapter 7.

« There is inadequate progress in providing safe drinking-water facilities and improved sanitation facilities, both in rural and urban areas »

CONCLUSION

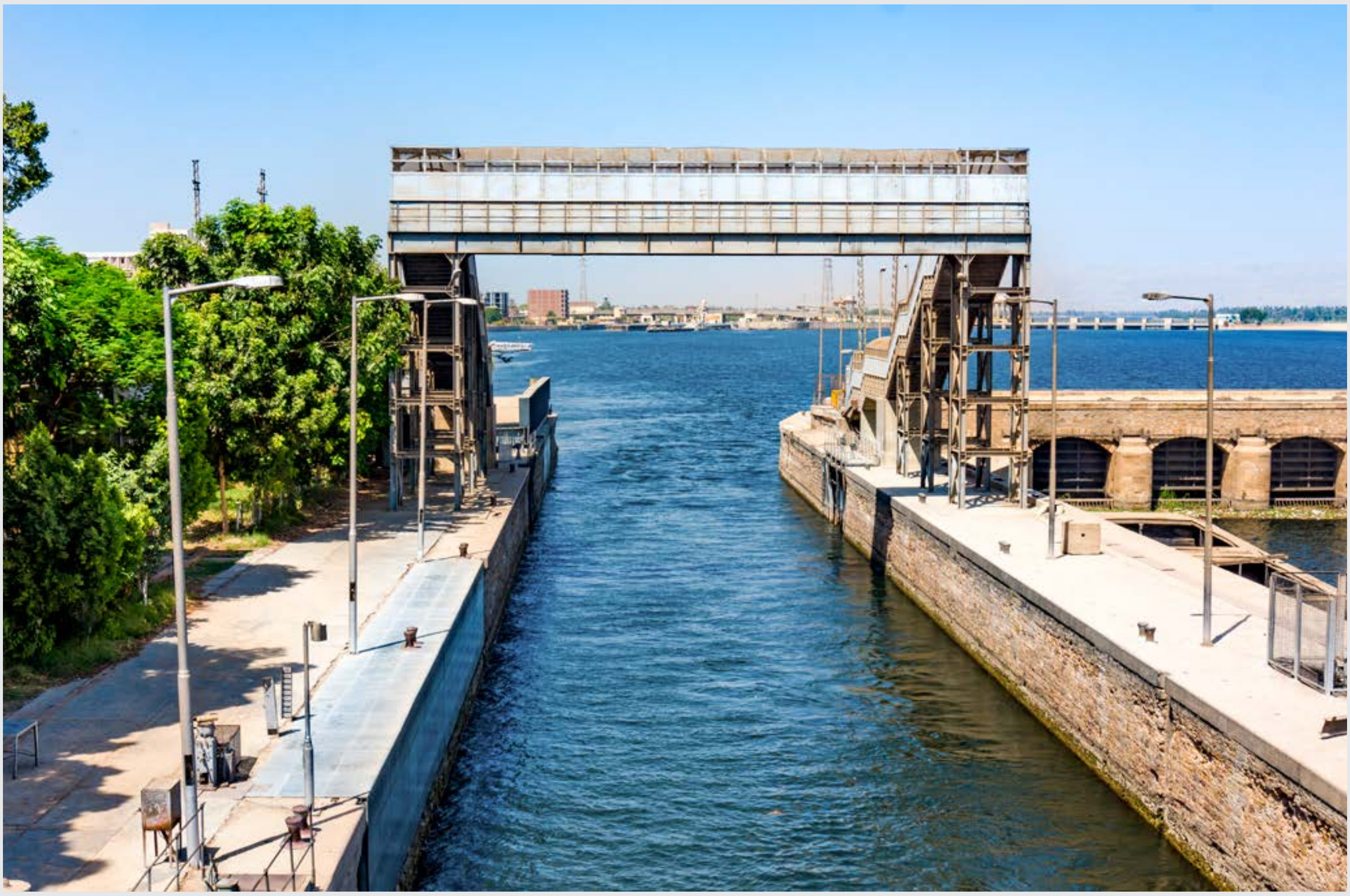


Photo: Shutter stock

The renewable surface-water resources in the Nile Basin are now fully used, predominantly for irrigated agriculture in the Basin. Consumptive water use for domestic and industrial purposes is small in comparison, while water used for hydropower production is modest because the primary purpose of the main constructed reservoirs – except for Merowe, GERD and Tekeze – is to provide irrigation water. It is probable that water availability is already insufficient for ecosystem protection in the Nile Delta.

Since demand for water continues to rise because of population growth and socio-economic development, water resources in the Nile Basin are under rapidly growing pressure. In addition, there is considerable risk that fresh water downstream of major urban areas will become heavily polluted – and thus become de facto unusable – because of exponentially increasing volumes of wastewater due to urbanisation and industrialisation.

Nevertheless, the Nile countries are in possession of a considerable set of options to achieve water security. These include, but are not limited to, extending the productive use of the large rainwater resources, improving irrigation efficiencies, importing of virtual water through food imports, reduction of the large food losses, use of non-conventional water sources for M&I supply, reduction of reservoir evaporation losses through enhanced cooperation and coordinated reservoir operation, use of fossil groundwater, etc.

However, to date there is limited progress in implementing the measures that are available. Specifically, there is insufficient progress in improving water productivity in the critical agricultural sector.

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CHAPTER 3

ENERGY SECURITY

CONTENTS

KEY MESSAGES

Electricity consumption in most Nile countries is still among the lowest in the world.
Electricity supply in most Nile countries continues to be inadequate, unreliable, and expensive. Power is generally too expensive for many low- and middle-income consumers.

In the long term, demand for electricity in the Nile countries is set to increase rapidly.
This is because of demographic trends and increasing access to electricity, as countries endeavour to achieve economic development and meet SDG 7: universal access to modern energy by 2030.

Urban areas have significantly better electrification than rural areas.
Although rural electrification has made substantial gains since 2012 in some Nile countries the negative impacts on the environment of the rural population's dependence on biomass energy sources are still of major concern.

The Nile countries are endowed with substantial energy resources.
These include hydropower potential, natural gas, oil, geothermal energy, coal, peat, biomass (including biogas and waste-to-energy), solar, and wind.

Hydropower potential is vast and hydro-electricity is most attractive because of its long economic life and low per unit energy costs.
The hydropower potential in the Nile Basin is estimated at 31,000 MW, and in 2018 about 19% of it had been developed. This figure will likely rise to 42% by 2021 when new hydropower plants come into service. Most of the hydropower capacity added in 2018–2021 is in Ethiopia and Uganda.

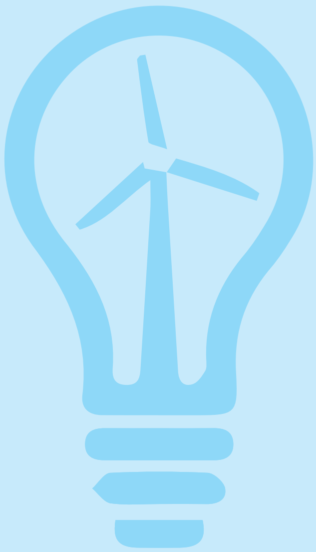
Other renewable technologies are reducing in price.
The lower cost of geothermal, wind, and solar technologies leaves them poised to claim a higher proportion in the optimal power generation mixes of some riparians. Natural gas, used in gas-to-power (GTP) facilities, could serve as the transition fuel as renewable solutions are progressively introduced, and to meet power demand when solar, hydro, or wind are not available.


Photo credit: shutterstock

Nalubaale Dam, Jinja Uganda

The Nile Basin is the only region in Africa without a functional regional power grid but this is expected to change with the forthcoming completion of several transmission lines.
Although most of the regional power transmission lines described in the SOB 2012 have still not been commissioned, and only an insignificant volume of power is traded amongst Nile countries. This is expected to change with the forthcoming completion of several transmission lines between Kenya and neighbouring countries, and as a result of the Grand Ethiopia Renaissance Dam (GERD) coming into service.

Large investments in power generation, transmission and on-grid distribution are required for a sustained period to meet the region's long-term power demand and improve the reliability of grid electricity.



Off-grid and mini-grid systems offer a viable and cost-effective alternative for electricity access in rural areas and could encourage a shift towards decentralised systems.

Significant investments are needed in these systems, particularly in home solar power. While the bulk of investment in transmission and distribution has been made by the public sector, there will be increasing need to attract private-sector investment.

The NBI continues to contribute to the transformation of the region's power sector by providing a forum for joint planning and cooperative development of hydropower generation and transmission options, and by promoting power pooling amongst the Nile countries.

The NBI has developed analytical tools, such as the Nile-DSS, to quantify costs, benefits, and trade-offs in power options, and avoid adversely impacting existing water uses, including the environment.

It may be necessary to better define the mandates and activities of the NBI programs and the East Africa Power Pool (EAPP), to eliminate or minimise duplication of efforts.

While NBI institutions derive their mandates from the Council of Ministers in charge of water, EAPP's mandate is derived from the Council of Ministers in charge of energy. Inter-sector linkages or consultations may currently be inadequate, especially in countries where water and energy portfolios fall under different ministries.

INTRODUCTION – DRIVERS OF DEMAND FOR ENERGY

Photo: istock

A large portion of the population has no access to electricity

VERY LOW POWER CONSUMPTION

Access to cheap and reliable energy is a precondition for economic growth. For a wide range of purposes, electricity is the preferred modern form of energy because of its versatility and low cost of transmission over great distances once the transmission infrastructure is in place.

The Nile Basin offers vast potential for hydro-electric power generation. The powershed – which is conceptualised as the principal power market for a hydropower facility – does not necessarily coincide with the watershed that supplies the water resources for energy generation. Hence, energy statistics in this chapter – including demand for electricity – are considered for the entire nation rather than for the Nile Basin part only.

Figure 3.1 presents annual electric power consumption per capita in the Nile Basin. Consumption of electricity is a basic indicator of the size of an economy and its level of development. The world per capita average is about 3,000 kWh/yr, while per capita electricity consumption commonly exceeds 10,000 kWh/yr in the industrialised world. Electricity consumption in most of the Nile countries is very low compared to the rest of the world. While a positive trend is wit-

« The rural population's continued dependence on biomass energy sources is of major concern » nessed in Ethiopia, Kenya, Sudan, and Tanzania, current power consumption rates are grossly inadequate to support socio-economic development and achieve the middle-income status that is aspired by many Nile countries. Because of low per capita power consumption, use of firewood and charcoal is still widespread in large parts of the Nile Basin, with serious adverse environmental consequences in terms of deforestation and land degradation.

The principal reasons for the very low electricity consumption in the Nile states are threefold: 1) power supply is inadequate, 2) the price of electricity is high given the income of low-income consumers, who form a large percentage of the total number of consumers, and 3) a large portion of the population has no access to electricity.

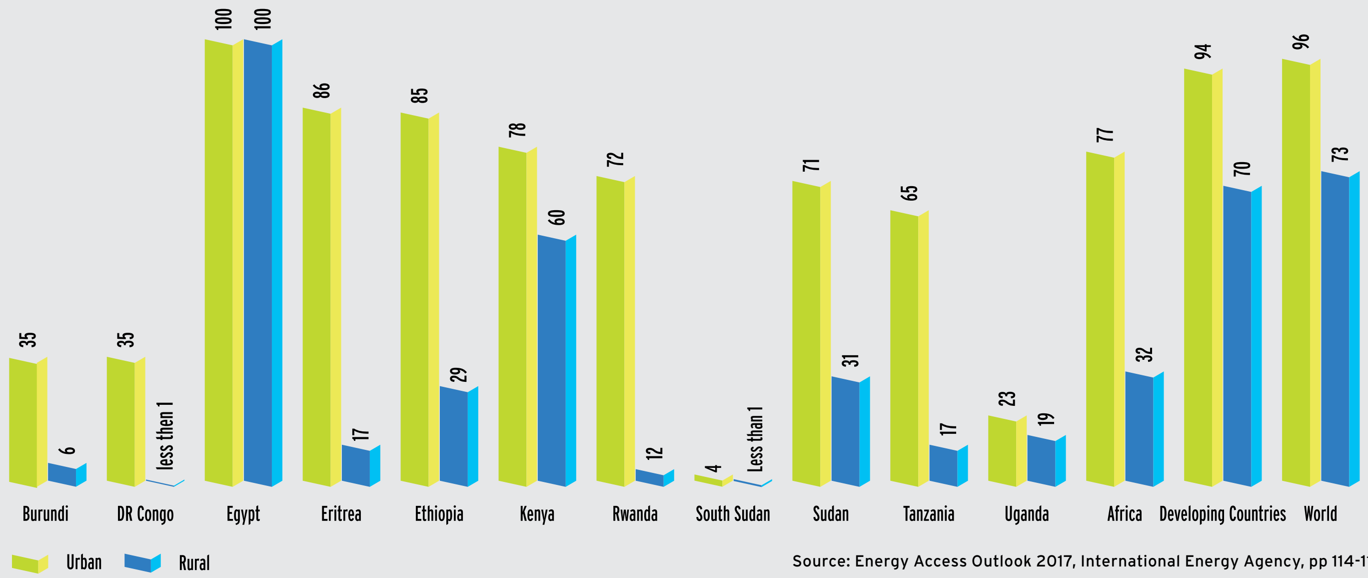
Access to electricity is illustrated in Figure 3.2, for the Nile Basin countries in 2000–2018. Electrification rates remain low in Burundi, DR Congo, South Sudan, and Uganda, although progress has generally been made in increasing access to electric power. Several countries, including Ethiopia, Kenya, Rwanda, Sudan, and Tanzania, have made significant achievements in the 2010–2018 timeframe. A substantial percentage of the urban population in these countries is now supplied with grid electricity (Figure 3.3), but rural electrification rates remain generally low.

Several Nile countries are aiming to achieve 100% (universal) access by 2030 in order to meet the Sustainable Development Goal 7.1 goal of ensuring universal access to affordable, reliable, and modern energy sources by 2030.

FIGURE 3.1: ANNUAL ELECTRIC POWER CONSUMPTION PER CAPITA (KWH), 2012 & 2014

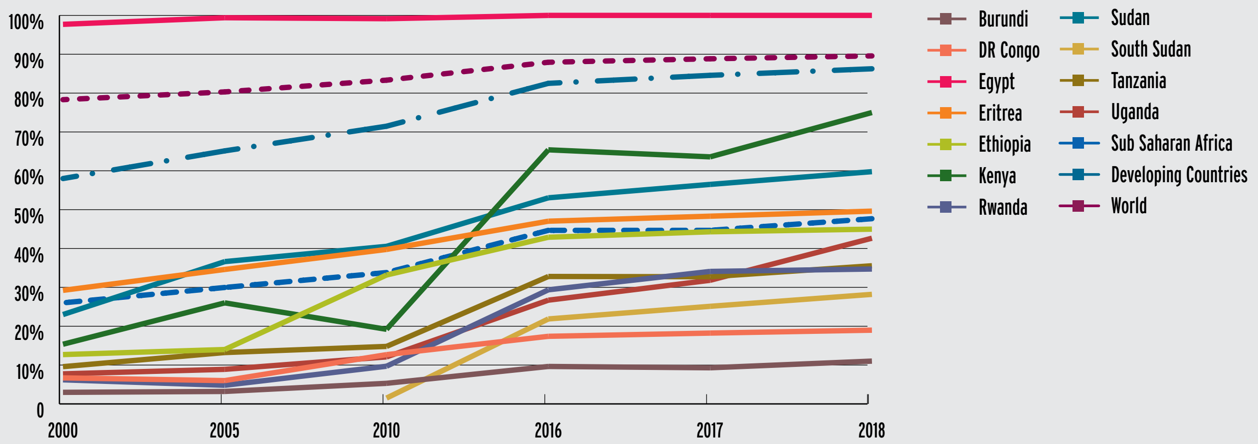
Source: World Bank, n.d. b, no data available for Burundi, Eritrea, Ethiopia, Rwanda, Uganda

FIGURE 3.2: PERCENTAGE OF RURAL/URBAN POPULATION WITH ACCESS TO ELECTRICITY, 2016



Source: Energy Access Outlook 2017, International Energy Agency, pp 114-115

FIGURE 3.3: PERCENTAGE OF TOTAL POPULATION WITH ACCESS TO ELECTRICITY IN NILE BASIN COUNTRIES, 2000-2018



Source: World Bank World Development Indicators, 2020

FAST-RISING DEMAND FOR ENERGY

Demographic trends, increasing rates of electricity access, urbanisation, and economic development all point to rapidly rising demand for electricity in the coming decades.

Populations in all Nile countries continue to grow, and future demand for energy will grow accordingly. Annual population growth rates ranged from 1.7% in Kenya to 3.3% in Burundi in 2017 and suggest a doubling of populations in some countries in the coming 25 years or earlier.

Many Nile countries are making a concerted effort to achieve universal access to electricity in the coming decade. This implies over 100 million new electricity consumers in the Nile Basin in the next 10 to 15 years.

Urban populations continue to grow rapidly in all Nile countries (4% to 6% per annum). Electricity consumption per capita in rural and even peri-urban areas is quite low, since people mostly use charcoal or firewood for cooking, and electricity (if avail-

« The rural population's continued dependence on biomass energy sources is of major concern » able) only for lighting and basic domestic amenities. Additionally, the rural economy is typically labour intensive, with low energy intensity. Urban areas generally have higher electrification rates and a lifestyle with higher electricity consumption. Furthermore, urbanisation permits economies of scale in production that require considerable energy inputs.

All Nile countries aspire to middle-income status in the near or medium-term future, while some have already achieved this status. Economic growth is associated with industrialisation, automation, further development of the service sector, and diverse economic activities with high energy intensity. Power consumption will grow accordingly.

Furthermore, with household income set to rise because of economic growth, many people will switch to modern forms of energy – predominantly electricity – if this improves their lives and enables them to become more productive.

Considering the above, power-demand scenarios show that significant additional power-generation capacity is required to satisfy future electricity demand.

LOWER-THAN-EXPECTED SHORT-TERM GROWTH IN POWER DEMAND

« Power is generally too expensive for many low-income and middle-income consumers »

Despite fast-rising domestic demand for electricity in the long term, growth in demand in recent years has been slower than anticipated in some countries since projected industrial and commercial demands have not fully materialised, and low-income power consumers continue to use less electricity than expected. Electricity supply continues to be expensive and unreliable, and beyond the financial means of many prospective consumers. Even middle-class urban consumers in some Nile countries continue to use charcoal for cooking rather than expensive electricity, and the average rate of access to clean cooking remains low and substantially below access to electricity.

Application of off-grid and mini-grid systems offer an increasingly viable and cost-effective alternative for rural areas and will encourage a shift towards decentralised systems. It may transform the energy access landscape, and new grid connections, therefore, may be slower than anticipated and result in slower growth of the required centralised generation capacity. While the energy transition towards more decentralised systems is promising and ongoing, its trajectory and speed of implementation is yet unclear and cannot be predicted with any degree of certainty. This complicates decision-making regarding investments in power-generation capacity.

Because several transmission projects to create transnational power grids and connections to alternative markets have been delayed for diverse reasons (discussed in detail later in this chapter), there may in the short term be costly surpluses of generation capacity in some countries, concurrent with capacity deficits as well as costly generation mixes in other countries.

Against the shifting power-distribution model – specifically for rural areas – and lower than expected short-term growth in demand for electricity, additional generation capacity needs to be scheduled carefully and investment decisions should take into consideration connection and affordability issues, power-trade constraints, and anticipated developments in non-hydro renewable energy and power storage.

STATE OF ENERGY

ENERGY RESOURCES IN NILE BASIN COUNTRIES

The Nile countries are endowed with substantial energy resources that include hydropower potential, natural gas, oil, geothermal energy, coal, peat, biomass (including biogas and waste-to-energy), solar, and wind, as can be noted from Table 3.1 for renewable energy and Table 3.2 for proven reserves of indigenous fossil energy resources.

TABLE 3.1: NILE BASIN COUNTRIES' INDIGENOUS RENEWABLE ENERGY RESOURCES OVERVIEW, 2017

Country	Solar	Wind	Geothermal	Hydro		Biogas
	Radiation (kWh/m²/ day)	Speed (m/sec)	Potential (MW)	Potential (MW)	Energy annual average (GWh)	Potential (MW)
Burundi	4 to 5	1 to 2.5	n/a	40	n/a	n/a
Ethiopia	5 to 7	6 to 8 at 10 m	10,000	20,000	n/a	n/a
Kenya	4 to 6	9 at 50 m	10,000	6,000	n/a	n/a
Rwanda	4 to 5.4	n/a	170 to 340	313	n/a	n/a
South Sudan	436 (W/m²/yr) (solar potential)	285 - 380 (W/m²) (wind power density)	n/a	2,927	11,852	n/a
Sudan	6.1	3 to 6 at 10 m	400	4,860	24,132	n/a
Tanzania	4 to 7	1.8 to 6.6	300	38,000	1,90,000	n/a
Uganda	5.1	n/a	450	2,000	n/a	n/a

Source: Regional Power Sector Outlook and Diagnostic Report For Eastern Africa, Africa Development Bank, September 2018 – Table 6, pp19. Originally extracted from Energypedia and also various web-based renewable energy sites and press announcements
no data available for DR Congo and Egypt

TABLE 3.2: PROVEN RESERVES OF INDIGENOUS FOSSIL ENERGY RESOURCES, 2017

Country	Crude Oil (billion barrels)	Natural Gas (billion cubic feet)	Coal (billion tons)	Peat (million tons)
Burundi	-	-	-	100 to 150
DR Congo	180	35,000		
Egypt	4.4	77,198	-	-
Ethiopia		4,700	0.3	-
Kenya	0.8	-	0.44	-
Rwanda	-	35	-	55
South Sudan	3.8	3,000	-	-
Sudan	5	3,000	-	-
Tanzania	-	55,080	5	-
Uganda	6.5	-	-	800
Total	200.4	1,78,013	5.7	955-1,005

Source: Regional Power Sector Outlook and Diagnostic Report for Eastern Africa, Africa Development Bank, September 2018 - Table 4, pp 17; World Factbook

While hydropower potential is vast, and hydro-electricity is the most attractive to several riparians because of its long economic life and low per unit energy costs, the reduction in costs of other renewable technologies – such as geothermal, wind, and solar – and vulnerability of hydropower to vagaries of weather have already led to these technologies claiming a higher proportion in the optimal power generation mixes of some riparians. The mix of generation capacity in Nile Basin countries is illustrated in Table 3.3. DR Congo, Ethiopia, Uganda, and Burundi have the highest proportions of hydro at 95%, 89%, 77% and 69% respectively.

Table 3.2 shows that very significant natural gas resources are available in DR Congo, Egypt, and Tanzania. African Energy (2019) argues that natural gas – used in gas-to-power (GTP) schemes – could serve as the transition fuel able to balance the energy mix as renewable solutions are progressively introduced, and to meet power demand when solar or wind are not available.

Photo: Dana Smillie / World Bank

INSTALLED POWER CAPACITY AND FUTURE OUTLOOK

Photo: Shutterstock

The installed power capacities of the Nile Basin countries in 2017 are shown in Table 3.3. The total capacity stood at 60,644 MW, of which 13,333 MW, equivalent to 22%, was hydropower, while other renewable energy technologies totaled 2,119 MW (3.5%), and thermal technologies (including off-grid) provided the balance of 45,192 MW (74.5%). Some of the hydro capacity listed in Table 3.3 is situated outside the Nile Basin.

Since 2017, various renewable-energy technologies have been brought into service, including:

- Lake Turkana Wind Power (Kenya) – 310 MW
- Garissa Solar PV (Kenya) – 55 MW
- Small hydro and off-grid thermal (Kenya) – 5 MW

Table 3.4 lists the installed hydropower facilities in the Nile Basin and Table 3.5 shows the hydro-electric projects currently under construction.

TABLE 3.3: INSTALLED GENERATION CAPACITY IN THE NILE BASIN COUNTRIES (MW), 2019

Country	Hydro	Thermal	Geo-thermal	Solar & wind	Biomass	Off grid	Total	Hydro as % of total
Burundi	48	21	0		0	1.52	70	68.7
DR Congo	2,542	135					2,677	95.0
Egypt	2,800	41,321		887.0			45,008	6.2
Ethiopia	3,816	97	7.3	324.0	60.0	8.2	4,312	88.5
Kenya	826	776	652.0	25.5	28.0	27.4	2,335	35.4
Rwanda	105	97		8.8		0.4	212	49.7
South Sudan		32				2.8	34	0.0
Sudan	1,900	1,745					912	52.1
Tanzania	568	745			10.5	81.9	1,406	40.4
Uganda	1,004	100		18.9	97.1	1.6	1,222	82.2
TOTAL	13,333	45,069	659.3	1,264.2	195.6	123.9	60,644	22.0

Source: African Development Bank, 2018b - Table 7, pp20; and CIA, n.d.

TABLE 3.4: INSTALLED HYDRO-ELECTRICITY CAPACITY IN THE NILE BASIN			
Facility	Country	Installed Capacity (MW)	Year of establishment
Assuit	Egypt	32	1902
Nagaa Hammdi	Egypt	64	early 1900s; 2008
Esna	Egypt	85.7	1906; 1990s
High Aswan Dam	Egypt	2100	1971
Fincha	Ethiopia	128	1973
Tis Abay I	Ethiopia	74	2001
Tis Abbay II	Ethiopia	12	2001
Tekezze (TK5)	Ethiopia	300	2009
Tana Beles	Ethiopia	460	2010
Amerti-Neshe	Ethiopia	97	2011
Gogo Falls	Kenya	2	1956
Sondu Miriu	Kenya	60	2007
Sangoro	Kenya	21	2013
Sennar*	Sudan	15	1961
Jebel Aulia**	Sudan	30	2003
Kashm el Girba	Sudan	17	1964
Roseires***	Sudan	280	1966
Merowe	Sudan	1250	2009
Upper Atbara	Sudan	320	2018
Kikagati	Tanzania	16	2014
Nalubaale	Uganda	180	1954
Kiira	Uganda	200	2000
Bujagali	Uganda	250	2012
Isimba	Uganda	183	2019
Achwa II	Uganda	42	2019
Mubuku I, II, and III	Uganda	27.9	1956
Ishasha	Uganda	6.4	2011
EMS Mpanga	Uganda	18	2011
Buseruka	Uganda	9	2012
Siti I & 2	Uganda	21.5	2017
Muvumba	Uganda	6.5	2017
Rwimi Hydro	Uganda	5.54	2017
Nyamwamba Hydro	Uganda	9.2	2018
Nyagak 1	Uganda	3.5	2012
Lubilia	Uganda	5.4	2018
Nkusi	Uganda	9.6	2018
Mahoma Hydro	Uganda	2.7	2018
Waki HPP	Uganda	4.8	2018
Sindila (Butama)	Uganda	5.25	2019
Ziba - Kyambura	Uganda	7.6	2019
Ndugutu	Uganda	5.9	2019

* Constructed in 1925 but hydro power capacity installed in 1961
** Constructed in 1937 but hydro power capacity installed in 2003
***the heightening of Roseires has increased power produced but not the capacity installed

TABLE 3.5: HYDROPOWER PROJECTS CURRENTLY UNDER CONSTRUCTION IN THE NILE BASIN			
Facility	Country	Installed Capacity [MW]	Year of Establishment
Rusumo Falls	Burundi/Rwanda/ Tanzania	80	under construction
GERD	Ethiopia	6,450	under construction
Karuma	Uganda	600	under construction
Muzizi	Uganda	45	under construction
Achwa I	Uganda	41	under construction
Nyagak III	Uganda	7	under construction
Nyamagasani I	Uganda	6	under construction
Nyamagasani II	Uganda	15	under construction
Kakaka	Uganda	5	under construction
Kikagati	Uganda	16	under construction
	Sub Total:	7,264	

Source: NBI

In the 35-year period since 1971 – since the Aswan High Dam was commissioned – to the end of the 20th century, only a few, mostly small, hydro-electricity projects were completed, except for the Kiira facility at the outlet of Lake Victoria in Uganda (Table 3.4). This situation started to change in the first decade of the 21st century, and hydro-electric generation capacity has expanded quite dramatically in the last decade. Nevertheless, since 2012 – when the last SOB was published – only 320 MW of hydropower had been commissioned, while the heightening of Roseires has increased power produced but not the capacity installed. However, significant hydro-electric capacity, exceeding 7,000 MW (Table 3.5), is under construction and should come into service in the next few years (Table 3.5). Isimba Hydroelectric Power Plant in Uganda was commissioned in 2019.Table 3.5Table 3.5: Hydropower projects currently under construction in the Nile Basin.

In 2018, around 19 percent of the potential hydropower capacity in the Nile Basin had been developed (Table 3.6). This figure will likely increase to 42% by 2021, when GERD, Rusumo Falls, and the run-of-river facilities on the White Nile in Uganda have come into service. The remaining undeveloped hydropower capacity approximates 18 GW. This potential may not be fully exploited as some potential schemes are probably less financially attractive or entail considerable negative consequences. For instance, the potential hydro facilities on the Main Nile – such as Shereiq, Kajbar, and Dal – are now going to be redesigned as run of the river dams, provided that the three countries put in place enhanced cooperation and coordination policies on the GERD, while Murchison Falls on the White Nile would lead to loss of important scenic and environmental value.

The unexploited hydropower potential – while substantial – is not enough in the longer term to achieve regional energy security, given the anticipated demand scenarios, higher costs of the unexploited hydro potential, and susceptibility of hydro to drought; alternative power generation and/or power trade options need to be explored.

BOX 3.1: ESTIMATING HYDROPOWER POTENTIAL

It is noted that estimates of hydropower potential in the Nile Basin slightly differ, depending on the data source – see for instance Table 3.1 and Table 3.6.

Hydropower potential is a function of river discharge, hydraulic head, and component efficiencies. None of these three variables can be established a priori with precision. Head, for instance, depends on the design of the facility while turbine and generator efficiencies are a function of the type and make of the equipment. Future discharge is also subject to uncertainties, both regarding climate and landscape parameters, upstream water use, and water allocation agreements. Hence, hydropower potential is estimated rather than determined with exact precision.

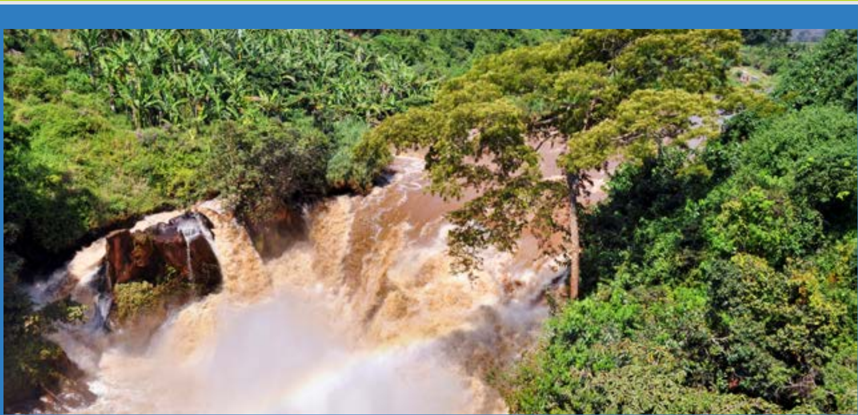
Photo:NBI

The 80 MW Regional Rusumo Falls Hydroelectric Project, jointly owned and financed by Burundi, Rwanda and Tanzania

TABLE 3.6: INSTALLED VERSUS POTENTIAL HYDROPOWER CAPACITY IN THE NILE BASIN					
Country	Estimated Potential Capacity [MW][1]	Installed Capacity 2019 [MW][2]	Installed as percentage of potential capacity 2019	Estimated installed capacity 2021 [MW][3]	Installed as percentage of potential capacity 2021
Burundi	27	0	0%	27	100%
DR Congo	78	0	0%	0	0%
Egypt	2,320	2,282	98%	2,282	98%
Eritrea	NA	NA			
Ethiopia	16,000	1,071	7%	7,071	44%
Kenya	216	83	38%	83	38%
Rwanda	47	0	0%	27	57%
South Sudan	2,570	0	0%	0	0%
Sudan	4,873	1,727	35%	1,727	35%
Tanzania	280	16	6%	43	15%
Uganda	4,723	1,004	21%	1,738	37%
	31,134	6,183	20%	12,998	42%

[1]estimates based on Nile SOB 2012 and data updates from countries
[2]from Table 3.4
[3]from Table 3.4 and Table 3.5; scheduled date of completion has been estimated
Source: NBI, 2012a

BOX 3.2: RUSUMO HYDROPOWER PROJECT



Initial studies on this project were carried out under the auspices of the Kagera Basin Organisation (KBO) in the mid-1980s up to detailed design stage, but due to the political situation in the region, the project could not progress further, and KBO became defunct. With the establishment of the NBI, the Rusumo Hydropower project was re-initiated. A 2003 Strategic/Sectoral Social and Environment Assessment study in the region recommended the project as a regional least-cost option. Between 2006 and 2008, the Nile Basin Trust Fund (NBTF) and African Development Bank (AfDB) funded a number of feasibility studies for the project. However, the studies experienced delays and budget constraints, as a result of which the transmission line studies became obsolete and required updating. Additional funding sought from NBTF for completing the feasibility studies became available in September 2010.

The project is coordinated by NELSAP-CU. When the SOB of 2012 was being prepared, this 80 MW hydropower project, owned equally by Burundi, Rwanda and Tanzania, was projected to reach financial close in 2013, commence construction in 2014, and be commissioned in 2016. The power plant is being funded by the World Bank and the transmission lines to the three countries by the AfDB. The implementation of the power plant was however substantially delayed at the tendering and contracting stages and the initial contractual completion date is February 2020. This date may, however, not be achieved due to ongoing challenges – related to contractor's initial financial and managerial weaknesses – and there is a risk, according to NELSAP, of completion being delayed by up to one year, to February 2021.

The construction of the transmission lines from Rusumo to Bujumbura, Kigali, and Nyakanazi (Tanzania) has been initiated but, though underfunded, needs to be managed so that the lines come into service before or at the same time as the power plant.

POWER PRODUCTION CAPACITY, SOURCES AND COSTS

A large increase in power generation capacity is needed. As mentioned previously, power generation sources in the Nile countries include hydropower, natural gas, oil, solar, wind, coal, geothermal, peat, methane and biomass (including biogas and waste to energy). Power import – either from facilities inside or outside the Nile Basin – can supplement national power generation capacity.

Average unit costs of electricity generation differ greatly among power sources, with hydropower being typically the cheapest option, while heavy fuel-oil is among the most expensive. If household income rises, or the cost of electricity drops, people typically switch to modern fuels such as electricity. Countries have committed to increasing the share of renewable energy in their national energy mix, and renewable energy in the Nile countries comes from, among others, water, geothermal steam, solar, and wind.

Measures are being taken to increase power production and provide access to electricity in rural areas. The measures should simultaneously aim to increase generation capacity, reduce the costs of electricity, and improve the reliability of the power supply (e.g. reduce power outages and voltage fluctuation).

The cost of electricity generated by wind and solar technologies is falling rapidly. Bulk solar can be paired with hydropower (e.g. for the cascade of hydro facilities on the Victoria Nile). Unit costs of geothermal power production are typically low. The current and projected generation mixes of many Nile countries therefore include other (non-hydro) clean and cheap power sources.

Thermal-based power is generally expensive – with the possible exception of natural gas – but may be necessary when power demand is projected to outstrip supply, to provide reserve capacity for intermittent renewables (solar PV and wind) or to supplement hydro capacity during times of drought. Several Nile countries (e.g. Tanzania) have abundant natural gas reserves that can be used for electricity generation.

STATUS OF ESTABLISHING REGIONAL POWER MARKETS

Interconnecting national power grids and creating regional power markets aims to secure reliable and cheap energy provision by diversifying energy sources and pooling capacity. Establishing a large power market reduces the capacity for peak load each individual country needs to maintain, facilitates the conditions to achieve economies of scale for power generation options, lowers the overall capital investment requirement, replaces high-cost energy with lower-cost electricity, and facilitates short-term energy trade in case of emergency supply shocks. Hence, it results in cheaper and more reliable power. Additionally, power trade plays an important role in promoting regional integration.

The Eastern Africa Power Pool (EAPP) is the main regional power market for the Nile Basin countries. Some of the countries are however connected to, or are members of, other power Pools. Egypt is connected to EAPP through Sudan but is also connected to the Comité Maghrébin de L'electricité (COMELEC) – the pool for the North African countries. DR Congo is a member of the Southern African Power Pool (SAPP) and the Central African Power Pool (CAPP), while Tanzania is a member, though not yet connected, of SAPP. Establishing power pools requires developing grid interconnections, additional generating capacity that creates surplus power in some countries or at some facilities, and power-trade frameworks and associated legal and regulatory frameworks. The EAPP is the youngest of the African power pools and is still not yet fully operational as a pool due to delay in completion of several interconnecting transmission lines. In the meantime, EAPP is building the capacity of its institutions and preparing trading rules and tariff methodologies, among other soft issues. Once Tanzania is connected to Zambia through the proposed Tanzania–Zambia interconnection, the Nile Basin countries will be able to trade power not only among themselves but also with SAPP, CAPP and COMELEC members.

Creating regional power markets has been a longstanding goal of the Nile Basin Initiative and the NBI's subsidiary action programs (SAPs), NELSAP and ENSAP, and they have been actively supporting the construction of power transmission projects.

Table 3.7 on next page shows the lines implemented or being implemented by the SAPs.

Several regional generation and transmission lines were in progress in 2012, and studies or other preparations for new projects have since started (Table 3.7). Details on these projects are provided in Section 3.6 Appendix. Most interconnection projects have encountered delays for diverse reasons, and the Nile region is still the only one in Africa without a functional regional power grid and market. However, real progress has been made in establishing a regional power market. In Ethiopia very substantial power generation capacity – including the GERD – is scheduled to come into service in the near future, while transmission facilities have been completed to Sudan and Djibouti, and should be completed shortly to Kenya. Transmission lines are nearing completion (Kenya–Uganda, Uganda–Rwanda) or are under construction (Ethiopia–Kenya, Kenya–Tanzania). Work has started to link the emerging Eastern Africa Power Pool (EAPP) to the Southern African Power Pool (SAPP) through the regional Transmission Corridor Development project. Significant power generation capacity is coming into service in Uganda in the coming years, while Tanzania has advanced plans to boost power generation capacity from around 1,500 MW currently to 5,000MW over the next three years by building new gas-fired and hydroelectric plants, including the 2100 MW facility at Stiegler's Gorge on the Lower Rufiji – which is outside the Nile Basin.

Thus, while activities are generally behind schedule, the elements that compose a functional regional power market are steadily being created. It is noted that DR Congo and South Sudan – countries that have low ur-

TABLE 3.7: STATUS OF INTERCONNECTION PROJECTS AMONG NILE COUNTRIES AND SOME OF THEIR NEIGHBORS

Interconnection project	Capacity MW	Voltage kV	Status
Ethiopia-Djibouti	180	220	Completed in 2011
Ethiopia-Kenya	2,000	500 DC	Nearing completion, expected to be in service by mid-2020.
Ethiopia-Sudan	300	220	Completed in 2013
Kenya-Tanzania	1,520	400	Funding secured; ongoing; scheduled for completion by 2021
Kenya-Uganda	360	400/220	Nearing completion, expected by mid-2020
Rwanda-Burundi-DR Congo	360	220	Funds mobilisation ongoing, completion expected by 2021
Rwanda-Burundi	360	220	Funding for Rwandan part secured; funds mobilisation of Burundian part ongoing, expected by 2020
Sudan-Egypt	300	220	In the final stage of implementation
Tanzania-Zambia	-	-	Funding partly secured; ongoing; scheduled for completion by 2023
Uganda-DR Congo			Funds mobilisation ongoing, expected by 2023
Uganda-Rwanda	360	220	Completed or nearing completion, expected by 2020
Uganda-South Sudan	-	400	Funds mobilisation ongoing

Source: own compilation

ban and rural electrification rates – are not connected, and interconnection projects to link these countries to the emerging Eastern Africa Power Pool have not yet reached the construction phase.

The delays in implementing the power-interconnection projects are due to various challenges, including:

- Non-performing and bankrupt contractors, which has led to termination of some contracts and court injunctions in some countries;
- Outstanding cases of unresolved right of way (ROW) – for instance in Kenya and Uganda, often related to lack of funds for compensation;
- Aging loans/grants that were cancelled and necessitated gap funding to complete the project;
- Damaged material that required replacement;
- Threat of vandalism, which will require deployment of security;
- Inadequate technical and institutional capacity;
- Delays and/or difficulties in securing funding for some projects.

EXCESS CAPACITY CONCURRENT WITH SHORTFALLS AND HIGH COSTS

Table 3.8 shows the electricity supply-demand balances of the Nile Basin countries in 2017. Though the reserve margins look healthy, except for Sudan, some of the countries that have significant hydro capacity can experience capacity and energy shortfalls during seasons of drought. Moreover, some countries that have much thermal capacity, such as Egypt, Rwanda and Sudan, will benefit from importing less costly renewable electricity from other countries if the regional transmission lines are in place.

Because of the aforementioned delayed transmission projects, and since projected industrial and commercial demands have not fully materialised, there may, in the short term, be costly surpluses of generation capacity in some countries at the same time as capacity shortfalls or high generation costs in others.

There is therefore a need for decisive and urgent action to accelerate or unblock the implementation of the stalled transmission lines, by addressing the challenges listed under Table 3.7 above so as to facilitate transfer of cleaner or cheaper energy to areas or countries with costly thermal sources, with heavy carbon footprints, or with capacity/energy shortfalls during the drought seasons. The power transfer capacity should improve further when the Eastern Africa Power Pool (EAPP) and the Southern African Power Pool (EAPP) are interconnected through the planned Tanzania–Zambia interconnection project.

TABLE 3.8: ELECTRICITY SUPPLY-DEMAND BALANCES OF NILE BASIN COUNTRIES, 2017

Country	Installed capacity (MW)	Peak demand (MW)	Reserve (%)	Energy demand, incl. import & export (GWh)
Burundi	70	53.4	31.7	
DR Congo	2,677			
Egypt	45,008	29,400	53.1	
Ethiopia	4,312	2,482.50	73.7	11,451
Kenya	2,335	1,770	31.9	10,256
Rwanda	212	133.94	58.3	534.6
South Sudan	34.3			310.3
Sudan	3,645	3,180	14.6	14,640
Tanzania	1,406	1,051.27	33.7	7,113.57
Uganda	945	625.27	51.1	3,583.49
TOTAL	60,644	38,696	56.1	47,889

Source: African Development Bank, 2018b - Table pp 21; and CIA, n.d.

RESPONSES TO INCREASE IN ELECTRICITY DEMAND AND THE NEED FOR ACCELERATING ELECTRICITY ACCESS

NEED FOR PRIVATE INVESTMENT IN TRANSMISSION AND DISTRIBUTION

« Investments of tens of billions of dollars are required for a sustained period to meet the region's long-term power demand and improve the reliability of grid electricity »

« There is increasing need to attract private-sector investment in power transmission and distribution »

Very large investments in power generation, transmission and on-grid distribution – in the range of tens of billions of dollars – are required for a sustained period to meet the region's long-term power demand. Moreover, in the run up to achieving universal access to electricity, significant investments are also needed in mini-grids and off-grid technologies, particularly in solar home systems. While to date the bulk of investment in transmission and distribution (T&D) has been made by the public sector, going forward there will be increasing need to attract private-sector investment in the two power-supply-chain segments.

Governments, wishing to keep retail electricity tariffs low have concerns about utilising more costly private-sector financing in T&D. Governments with aggressive targets for achieving universal access to electricity are then confronted with the dilemma of using private-sector funding to accelerate universal access at the risk of raising retail tariffs or of keeping tariffs low and not achieving access targets. It may be possible, however, to achieve the target without increasing tariffs if the opening of these business segments to private-sector financing is accompanied by measures to reduce aggregate power-system losses and to improve utility operational efficiency.

Attracting private-sector financing may also require improvement in the enabling environment in the power sectors of several Nile Basin countries, such as is indicated in Table 3.9, which presents the status of the pertinent factors in these countries. Countries that already have private-sector investment in power generation stand better chances of attracting investment also in T&D. This is the case in all countries except DR Congo and South Sudan. Moreover, some countries are ahead of others in already demonstrating private participation or interest in transmission, distribution or rural electrification. These countries include Kenya, South Sudan, Tanzania, and Uganda.

To attract private-sector investment in T&D, the following improvements to the enabling environment would be helpful:

- Enhancing the security situation in some countries.
- Removing legal or regulatory barriers to private investment in T&D.
- Making retail electricity tariffs cost reflective.
- Separating generation, transmission, and distribution accounts of the utilities for more transparency of costs.
- Separating generation, transmission and distribution accounts of the utilities for more transparency of costs.

TABLE 3.9: FACTORS AFFECTING PRIVATE-SECTOR PARTICIPATION

Item	Burundi	DR Congo	Egypt	Ethiopia	Kenya	Rwanda	South Sudan	Sudan	Tanzania	Uganda
Country Credit Risk	N/A	N/A	N/A	B1	B+	B2	N/A	C	B	B+
Security situation favorable to private Investments?	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Government committed?	N/A	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Legal or regulatory barriers?	N/A	No	No	N/A	No	No	No	No	No	No
Private participation in Generation?	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Private participation in Transmission?	No	No	No	No	Yes	No	N/A	No	No	Yes
Private participation in distribution?	No	No	No	No	Yes	No	Yes	No	No	No
Private participation in rural Electrification?	No	No	No	No	Yes	No	Yes	No	Yes	Yes
Private interest in renewables?	N/A	N/A	Yes	Yes	Yes	Yes	N/A	Yes	Yes	Yes
Tariffs Cost Reflective?	N/A	No	N/A	No	Yes	Yes	Yes	No	Yes	Yes
Collection rates adequate? Above 90%?	N/A	N/A	N/A	No	Yes	Yes	Yes	Proba-bly	Yes	Yes
Experience in contracts negotiation?	Yes	No	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Experience in auctions?	No	No	No	No	No	No	No	No	No	No
Separate Generation / Transmission / Distribution Accounts?	No	No	No	Yes	Yes	Yes	No	No	No	Yes
Are there PPAs, PPPs or IPPs?	Yes	No	Yes	No	Yes	Yes	Yes	No	Yes	Yes

Source: African Development Bank, 2018b - Table 3, pp16; and CIA, n.d.

NBI CAN CONTRIBUTE MORE ENERGY TO POWER SECTOR

The NBI continues to contribute to the transformation of the region's power sector by providing a forum for joint planning and cooperative development of hydropower generation and transmission options, and by promoting power pooling amongst the Nile countries. The NBI has developed analytical tools, such as the Nile-DSS, that make it possible to quantify costs, benefits, and trade-offs in power options, and allow for avoidance of impacts to existing water uses, including to the environment. NBI has also prepared guidelines and policies covering different aspects of transboundary water resources management and development.

NEED TO IMPROVE COOPERATION BETWEEN NBI AND EAPP

« The Nile Decision Support System developed by the NBI is used to investigate trade-offs among competing water uses in the Nile Basin and has contributed to optimising hydropower production »

The NBI subsidiary action programs NELSAP and ENSAP and member countries have been planning and implementing major regional power interconnections prior to and since the establishment of the Eastern Africa Power Pool (EAPP) in 2005. Now, EAPP is directed by their Conference of Ministers responsible for energy affairs to oversee the implementation of regional power assets, facilitation of increased power trading, and development of appropriate market structures. NBI, on the other hand, though involved in and implementing energy projects, is directed by Council of Ministers in charge of water affairs, and inter-sector linkages or consultations may currently be lacking or inadequate, especially in countries where energy and water portfolios are in different ministries.

The EAPP, however, has little or no experience in implementing and managing major power infrastructure projects compared to NBI. There is therefore a need for better coordination between NBI and EAPP in regional planning activities, especially in joint planning of major regional power projects. This would eliminate or minimise duplication of efforts and costs.

CONCLUSIONS

This chapter has analysed the status of energy security in the Nile Basin. It has observed that electricity supply in the Nile countries – except for Egypt – continues to be inadequate, unreliable, and expensive, and that a large proportion of the rural and urban population is still not connected to the national grid, with the attendant negative impacts on the environment because of the continued dependence on biomass energy sources. Power consumption is among the lowest in the world and grossly inadequate for the attainment of the middle-income status aspired to by all riparians. Yet demand for electricity is set to increase rapidly. Energy security in the Nile Basin, therefore, is concerned with a) increasing power generation capacity, b) reducing the cost of power, c) achieving universal access in urban and rural areas, and d) increasing the reliability of power supply.

The Nile countries are endowed with substantial energy resources that include hydropower potential, natural gas, oil, geothermal energy, biomass (including biogas and waste-to-energy), solar, and wind. By 2021, some 42% of potential hydropower capacity will be in service. Hydro-electricity is the most attractive to several riparians because of its long economic life and low per unit energy costs, but the reduction in costs of other renewable technologies – such as geothermal, wind, and solar – have already led to these technologies claiming a higher proportion in the optimal power-generation mixes of some riparians. Additionally, very significant natural gas resources are available and gas-to-power (GTP) schemes could serve to balance the energy mix as renewable solutions are progressively introduced, and to meet power demand when solar, hydro, or wind are not available.

Application of off-grid and mini-grid systems offers an increasingly viable and cost-effective alternative for electricity access in (remote) rural areas and could encourage a shift towards decentralised systems.

While the implementation of most of the regional power transmission lines has been delayed due to various challenges, the East Africa Power Pool is steadily emerging, and anticipated power trade will reduce power costs and increase the reliability of supply. Most Nile countries should be interconnected by 2021, except for DR Congo and South Sudan.

Very large investments in power generation, transmission and on-grid distribution are required for a sustained period to meet the region's long-term power demand, achieve universal access, specifically in rural areas, and improve the reliability of the power distribution system. Attracting private-sector investment in transmission and distribution should be encouraged.

APPENDIX

ONGOING AND PLANNED INTERCONNECTION PROJECTS IN THE NILE REGION

INTERCONNECTION OF ELECTRIC GRIDS OF NILE EQUATORIAL LAKES COUNTRIES: BURUNDI, DR CONGO, KENYA, RWANDA, AND UGANDA

The project, which is at the construction stage, comprises in total 931.5 km of overhead transmission lines (OHTL) and 17 associated substations as follows:

220 AND 400 KV UGANDA (BUJAGALI)-KENYA (LESSOS) INTERCONNECTION – 260.5 KM AND ASSOCIATED SUBSTATIONS (SS]

Tororo–Lessos – 400 kV, 132.5 km

- Status and issues: contract was terminated in April 2016, with progress at 50%; arbitration began in April 2018 and joint verification audit was completed in May 2018;
- Action items: liaise with Attorney General to lift court stay order; conduct technical and legal analysis prior to procuring new contractor
- Target completion date: December 2019.

Tororo–Bujagali

- Status and issues: construction works at 87.7%; 7% material supply outstanding; terminated contract as at June 2018; new contractor engaged in Nov 2018;
- Action Items: complete procurement of new contractor aiming to start works in November 2018;
- Target completion date: June 2019.

220 KV UGANDA- RWANDA INTERCONNECTION -164 KM AND ASSOCIATED SS

Mbarara–Mirama – 66 km

- Status and issues: Completed and commissioned
- Action items: Monitor and manage defects liability period.

Mirama–Shango – 98 km – Completed and in operation

RWANDA-BURUNDI – DR CONGO (EASTERN PART) INTERCONNECTIONS AND ASSOCIATED SS

Ruzizi–Bujumbura – 78 km
Goma–Buhandahanda (Bukavu) – 93km
Kibuye–Gisenyi-Goma-Kigali – 193 km

- Goma–Gisenyi (13 km]
- Kibuye–Gisenyi–Birembo (180 km]

Rwanda (Kigoma) – Burundi (Gitega) interconnection – 143 km

- Status and issues: Procurement for Rwanda scope completed. Contract signed and design works commenced. Burundi Scope still suspended by KfW. Funds mobilisation under way led by AfDB (central)
- Action items: Conclude mobilisation of funds with AfDB
- Target completion date: February 2020 (Rwanda), TBD (Burundi]

REGIONAL POWER INTERCONNECTION PROJECTS SUPPORTED BY NELSAP

Uganda–DR Congo Interconnection Project
This project comprises a total of 352.2 km OHTL and 3 High Voltage Substations

Overhead transmission lines:
Nkenda–border – 72.5 km
Border–Beni – 65.5 km
Beni–Butembo – 46.9 km
Beni–Bunia – 167.3 km

Substation:
Extension of Nkenda Substation to 220kV (or 400 KV) – Uganda
New high-voltage substations at Beni, Butembo and Bunia – DR Congo

Rural electrification:
Only in DR Congo to the tune of USD 3.0m

Progress:
Feasibility studies ESIA and RAP completed 2012
Inter-country MOU signed in August 2017

Funds mobilisation ongoing for USD 165M:
- AfDB interested in funding DR Congo under NEPAD IPP
- KfW and AFD are interested funding Uganda

REGIONAL POWER INTERCONNECTION PROJECTS SUPPORTED BY NELSAP

TANZANIA-ZAMBIA INTERCONNECTION

This project is part of the development of the Southern African Power Pool and should connect the SSAP with the EAP. Project components comprise:

Overhead Transmission Lines
(Mbeya-Tunduma)–Zambia (Nakonde–Kasama–Mpika–Pensulo–Mkushi–Kabwe) approximately 735.4 km-long, of which 110 km will be in Tanzania and 625 km in Zambia, comprising of:
- a 400 kV double-circuit line between Mbeya and Tunduma;
- a 400 kV double-circuit line from Tunduma to the border (but will be operated at 330kV);
- a second 330 kV, single-circuit Nakonde-Kasama-Mpika-Pensulo

Substations:
New substation in Uyole near Mbeya (Tanzania]
New substation in Nakonde (Zambia]
A 400/330 kV substation in Tunduma;
Upgrades existing substations in Kasama, Mpika and Pensulo (Zambia);

Progress:
Feasibility study completed October 2017
Financier's conference held 1 December 2017
For Tanzania Scope: Funding secured from WB for (Mbeya–Tunduma) in-

cluding the section Tunduma–Sumbawanga including all associated substation – USD 455m
For Zambia Scope:

- The World Bank has advanced in approving the financing of the Pensulo–Nakonde segment – USD 220m
- Funding mobilisation in progress for two sections: Kabwe–Pensulo and Kasama–Nakonde.

Challenge: Feasibility study findings showed that the anticipated capacity at commissioning of the project of 1000MW could not be met due to network constraints (only up to about 500MW could be exchanged). To overcome this, NELSAP has secured a mandate from the two countries to undertake additional studies through letters that will be followed by singing of MOU currently under review.

REGIONAL POWER INTERCONNECTION PROJECTS SUPPORTED BY NELSAP

UGANDA-SOUTH SUDAN INTERCONNECTION

Progress:

- MOU in place since November 2015
- 5% country contribution (required under NEPAD-IPPF) received
- Appraisal under NEPAD-IPPF completed in October 2016
- South Sudan has written to AfDB to use Country allocation under ADF 14 to the tune of USD 1.5m
- Mobilisation of funds (USD 1.5m) for Uganda continue; AFD and NEPAD-IPPF interested

REGIONAL POWER INTERCONNECTION PROJECTS SUPPORTED BY ENSAP

Gondar–Gedarif – 321 km, 220kV line and substations connecting Ethiopia and Sudan was under construction in 2012, was completed and came into service in 2013
Dire Dawa–Djibouti – 283 km, 220kV line and substations connecting Ethiopia and Djibouti, came into service in 2012
Ethiopia–Sudan–Egypt: The detailed design for this 2,220 km, AC/DC 500/±600-kV, 3,200-MW line and substations had been completed in 2012 and the project was awaiting funding/investor interest.

REGIONAL POWER INTERCONNECTION PROJECTS - MISCELLANEOUS

ETHIOPIA-KENYA INTERCONNECTION

The project concerns a 1,068 km of 500 kV high-voltage direct current (HVDC) electricity highway between Ethiopia and Kenya, with a power transfer capacity of up to 2,000 MW.
Progress:

- Nearing completion; as of April 2018, 95% of the work completed (ESI Africa, April 2018]

KENYA-TANZANIA INTERCONNECTOR

This project comprises a high voltage alternating current (HVAC) 400 kV transmission line (T-line) with a total length of 507.5 km, which starts in Mbeya city in south-west Tanzania and finishes in Isinya town, located 58 km southwards from Kenya's capital Nairobi

Progress:

- Funding secured through $258.82m loan from the African Development Bank and the Japanese International Co-operation Agency;
- Deadline for completion set to end 2020/early 2021

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CHAPTER 4

FOOD SECURITY AND AGRICULTURAL DEVELOPMENT

Photo: Shutterstock

CONTENTS

KEY MESSAGES

Food security remains a critical concern for governments in all Nile countries.
The average daily caloric intake in all Nile countries except Egypt is insufficient. Undernourishment is growing in several countries, implying that the combined food production and imports are not keeping pace with population growth. A large increase in demand for food is anticipated in all Nile countries.

Agricultural trade can play a role in alleviating local and sub-regional food shortages.
All Nile countries are net food importers and likely to remain so for the coming decade. Intra-Basin agricultural trade cannot therefore provide food security for the Nile region in the medium-term future. In the absence of infrastructure for bulk transport between the upper and lower Nile regions, food security in the Equatorial Plateau will largely be based on domestic and sub-regional production.

Development of large irrigation schemes alone is not a viable solution to achieving food security in the Nile Basin.
A deficit in water resources was projected in all scenarios analysed; variables included future climate, expansion of large-scale irrigation areas, and improvements in irrigation efficiency.

Improving yields in underperforming farming systems is a central tenet of a strategy to achieve food security in the Nile Basin.
Yields and associated water productivity are currently low in rainfed farming (which covers 87% of arable land in the Basin) and in some irrigation schemes in Sudan. Hence, there is large untapped agricultural production potential.

A huge effort is required to reduce the substantial food losses experienced across the Basin.

Photo: © Stephan Gladieu / World Bank

Food loss reduces the overall profitability of agriculture, and directly translates into poor agricultural water productivity.

Lack of a secure water supply leads to low yields because of the high temporal variability of rainfall across the Nile Basin and the associated risk of crop failure.
Under these conditions, farmers are unwilling to invest in agricultural inputs and improved cultivars that are required for higher yields. However, the moisture deficits in the zone under rainfed farming are typically low, implying that storage of relatively small volumes of water will avoid moisture stress during plant growth.

Small-scale supplementary irrigation can provide an effective means to prevent moisture deficits in the growing season in large parts of the rainfed agricultural zone.
This can be based on water harvesting and/or shallow groundwater, in combination with improved soil conservation, thereby supplementing and extending the productivity of rainfall.

Low farm-gate prices and high costs for agricultural inputs compromise the economic viability of agriculture.
They remove incentives for good land husbandry and investment in small-scale

supplementary irrigation and water-conservation measures.

In order for a transformation of agricultural to take place, it needs to become more profitable.
Smallholders need to be explicitly included in any effort to improve the economic viability of agriculture.

The private sector is critical in the development of agriculture in the Nile Basin countries, but governments also need to play an active role.
For instance, governments are critical in establishing effective tenure security, providing physical infrastructure, regulating markets to enhance farm profitability, providing extension services, encouraging agricultural research, stimulating the provision of agro-processing and storage facilities, supporting farm commercialisation, etc.

Government investment is needed for the development of rural economies.
Rural economies cannot develop without improved infrastructure and electrification to support agro-processing and storage, credit facilities, and training. Agricultural investment is needed in soil improvement and soil degradation control, water-control infrastructure and irrigation facilities, and in animal health management.

The dominance of rural populations will persist until 2030 and beyond, despite high rural–urban migration.
Large-scale poverty reduction in the Nile Basin is therefore unlikely to occur in the absence of an agricultural growth that also includes smallholders.

Most Nile Basin countries do not prioritise the agricultural sector in budget allocation.
Despite the importance of agricultural modernisation to achieve food security, rural development, and poverty alleviation, the agricultural sector attracts relatively little public funding.

INTRODUCTION: THE IMPORTANCE OF THE AGRICULTURAL SECTOR

Photo: © 2006 Arne Hoel, World Bank

The context for this chapter is described in Chapter 1, and is provided by a) the ongoing population growth in all Nile countries, b) economic development that leads to dietary changes and higher calorie intake per capita, and c) rapid urbanisation. Combined, these three factors result in a rapidly growing demand for food in the Nile Basin and more pressure on finite land and water resources.

Most of the Nile Basin is generally less urbanised, more dominated by smallholder agriculture, less connected to global markets because of high transport costs, and far more dependent on domestic agricultural produce for local food supply. In these circumstances, the performance of the agricultural sector is critical to food security, rural development, and poverty alleviation.

FOOD SECURITY: A MIXED BUT DISTURBING PICTURE

Securing a reliable and affordable supply of food is a key responsibility of government. A large increase in demand for food is anticipated in the Nile Basin because of population growth and economic development. Failure to meet this demand will likely lead to a rise in undernourishment and poverty and could jeopardies the gradual but steady gains in socio-economic development observed in all Nile Basin countries.

The term 'undernourishment' is used to describe the status of people whose food intake does not provide enough calories to meet their physiological requirements on a continuing basis (FAO 2003). Average calorie availability below 3000 kcal per person per day typically indicates structural undernourishment in a nation.

Most of the Nile Basin countries can currently provide adequate nutrition to its population (Table 4.1), although average calorie supply per person is rising in all countries for which data are available, except Uganda. Accordingly, the prevalence of undernourishment (Figure 4.1) is high in most countries. While the situation is improving in Ethiopia and Tanzania, it is deteriorating in Kenya, Rwanda, and Uganda. No recent data are available for Burundi, DR Congo, and Eritrea, but the very low per capita calorie supply in 2005 to 2007 suggests persistent high levels of undernourishment.

Thus, the current supply of food in the Nile

« Undernourishment is an issue in all Nile countries except for Egypt »

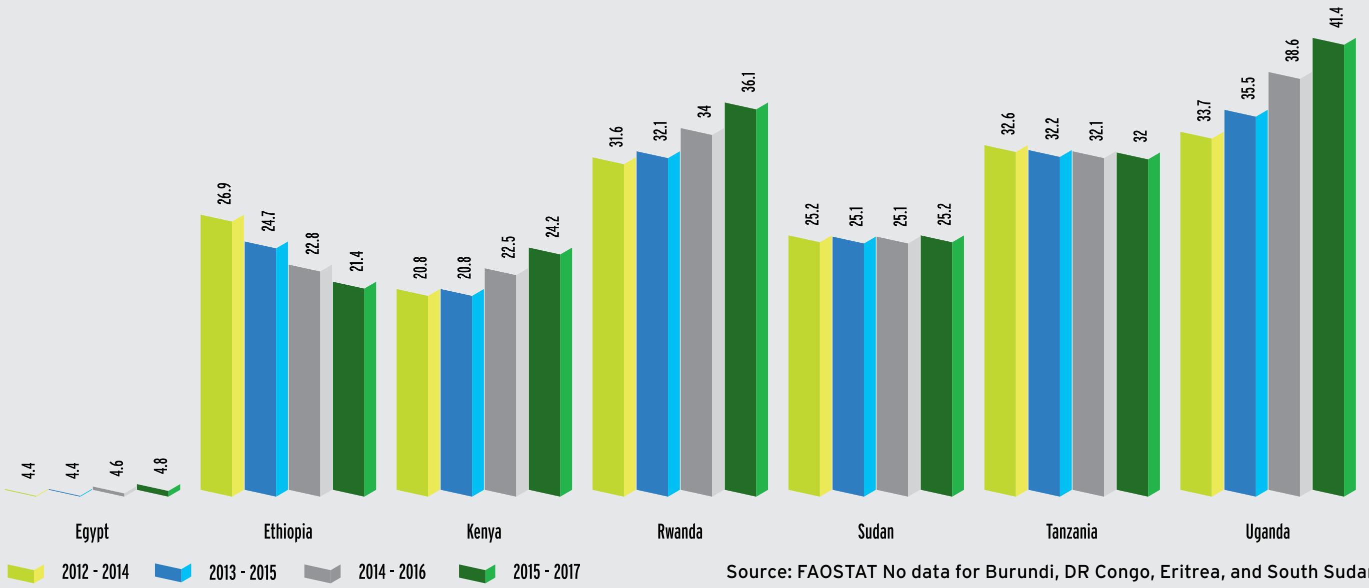
TABLE 4.1: DAILY CALORIE SUPPLY PER PERSON IN NILE BASIN COUNTRIES, 2005-2007, 2013		
	2005-2007	2013
Burundi	1680	
DR Congo	1590	
Egypt	3160	3522
Eritrea	1590	
Ethiopia	1950	2131
Kenya	2060	2206
Rwanda	2050	2228
Sudan	2270	2336
Tanzania	2020	2208
Uganda	2250	2130

Source: FAOSTAT

Basin is generally inadequate. Undernourishment is associated with multiple negative impacts that affect economic growth and public health, while being socially and morally unacceptable.

Additionally, the urban population in small towns and the large rural population mainly consume domestically produced food that is cheaper than imports. In fact, most rural and urban poor are unable to afford imported food. Increasing domestic agricultural production, therefore, is of vital importance to provide food security.

FIG 4.1: PREVALENCE OF UNDERNOURISHED IN NILE BASIN COUNTRIES (PERCENTAGE) IN 2012-2017 - 3YRS AVERAGE



Source: FAOSTAT No data for Burundi, DR Congo, Eritrea, and South Sudan

RURAL DEVELOPMENT

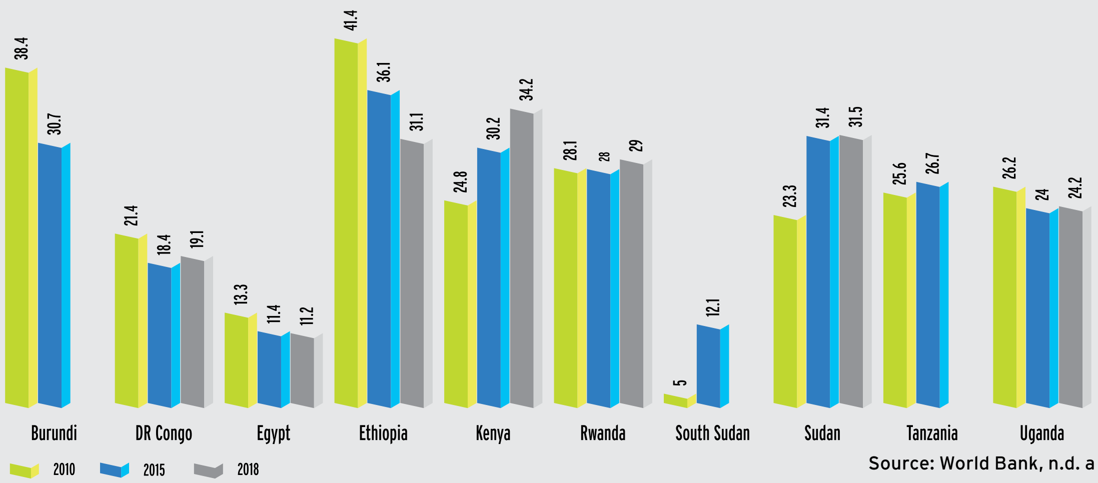
« Dominance of rural population will persist beyond 2030 despite high rural-urban migration »

Most of the population in the Nile countries resides in rural areas (see Chapter 1). This is reflected in the high contribution to GDP of the agricultural sector in most Nile Basin countries (Figure 4.2).

Despite high rural–urban migration, the dominance of the rural populations will persist until 2030 and beyond. Even by 2050 the rural population will remain substantial in many countries. The large rural population remains effectively insulated from global food markets and depends crucially on agriculture for its livelihood and food supply. Therefore, large-scale poverty reduction in the Nile Basin is unlikely to occur in the absence of inclusive agricultural growth. Increasing agricultural production will create opportunities for the development of agro-related services such as processing, storage, and trade – predominantly focused on domestic markets. It will also promote economic growth in terms of domestically produced non-agricultural goods and services.

It is noted that the upstream riparians are keen to attract agro-investments by national and international actors. However, only a few projects are being implemented, most at a relatively modest scale. Delays in project implementation are caused by a combination of three main constraining factors: sovereign risk, the absence of sizable areas of farmland with secure and uncontested tenure in regions with adequate rainfall, and poor infrastructure. It implies that large-scale commercial agriculture is still limited in the Nile riparians and that agricultural transformation must include smallholders.

FIGURE 4.2: CONTRIBUTION OF AGRICULTURE TO GDP IN THE NILE BASIN COUNTRIES, 2017



Source: World Bank, n.d. a

THE ROLE OF THE AGRICULTURAL SECTOR IN EGYPT AND SUDAN

The Egyptian economy is less dependent on the agricultural sector than is those of the other Nile riparians (Figure 4.3). Additionally, due to its concentrated population and effective transport links with international markets, food imports can reach most segments of the populace. Food imports already account for a large percentage of the food supply, with a virtual water component evaluated at some 25 BCM per year. Nevertheless, the agricultural sector remains an important source of employment (as discussed later in this chapter; Figure 4.5), food supply, and revenue.

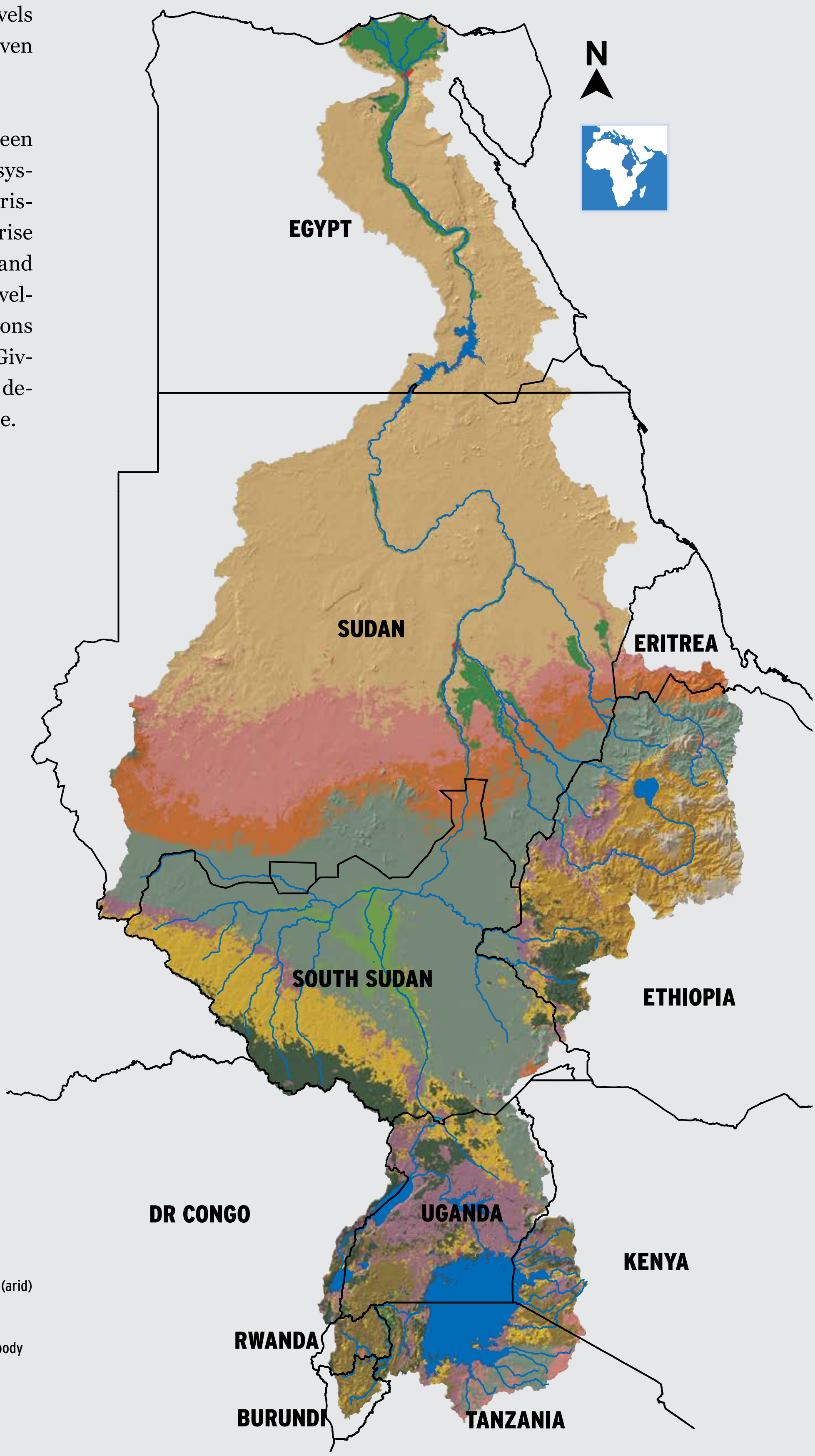
Sudan – like the upstream riparians – has a large number of smallholders that are currently under performing and depend on rainfed agriculture for their livelihood. However, the potential of large-scale commercial agriculture that could produce for export is much larger in Sudan than in the other riparians because of its large available arable land and proximity to Middle Eastern markets as well as the availability of a transport network. Additionally, the large tracts of land that are virtually uninhabited and where development is not really contested, is another factor that could enable agricultural schemes in the country. While Sudan is currently food deficient, it is a probable candidate to become a surplus producer, given its large agricultural potential.

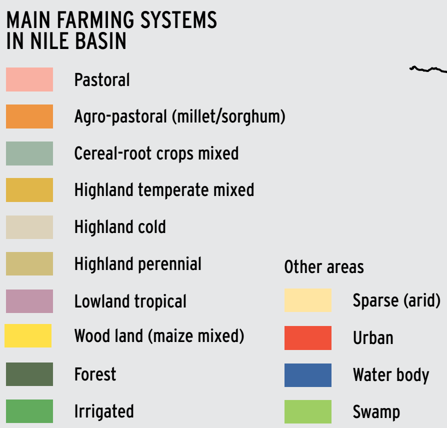
<< Sudan could become a surplus food producer in the future, given its large agricultural potential >>

The Nile Basin exhibits a wide spectrum of agro-climatic zones, human-settlement patterns, and levels of economic development. It has given rise to a diverse agricultural sector.

Ten main farming systems have been identified (Figure 4.4). A farming system has broadly similar characteristics – such as resource base, enterprise pattern, and household livelihoods and constraints – for which similar development strategies and interventions would be appropriate (FAO 2011). Given the size of the Nile Basin, some degree of generalisation is unavoidable.

FIGURE 4.3: MAIN FARMING SYSTEMS IN THE NILE BASIN





The NBI is not an authority on international boundaries

Source: NBI 2012

AGRICULTURAL PRODUCTION FACTORS

The main agricultural production factors are land, water, labour, and capital.

LAND

Land is the principal production factor in the region dominated by rainfed farming. Agricultural land includes arable land, grazing areas, and land used for orchards and other permanent crops. Expansion of agricultural land in the 2012–2016 time frame was negligible (Table 4.1), despite increasing demand for agricultural produce. It suggests that most prime agricultural land is already in use. Prime agricultural land is defined as land with the best soils, physical properties (e.g. flat), and rainfall. Exceptions are Sudan, South Sudan, and possibly Ethiopia, which still have large areas of underused fertile crop land. However, it is noted that: some of these areas are probably used and/or claimed by somebody, and they are likely to be subject to major obstacles to agricultural development, such as inaccessibility to markets, fragmented land holdings, or security concerns.

Further expansion of agricultural land in the other upstream countries is mainly possible through deforestation, wetland encroachment, use of marginal lands, or a decline in fallow land. In some cases, productive land is lost to urban development. Population pressure also leads to shrinking median farm sizes – many of which are too small to generate surplus production. The above implies that area expansion is not an appropriate strategy for agricultural growth in the Nile countries, except for in South Sudan, Sudan, and possibly Ethiopia. Rather, production increases will mainly come from sustainable intensification.

Table 4.1 points to the importance of the livestock sector in many Nile riparians. Most of the pastures are unimproved rangelands that lie in semi-arid and savannah zones. The agricultural production systems in the Nile Basin countries also include fisheries and aquaculture.

WATER

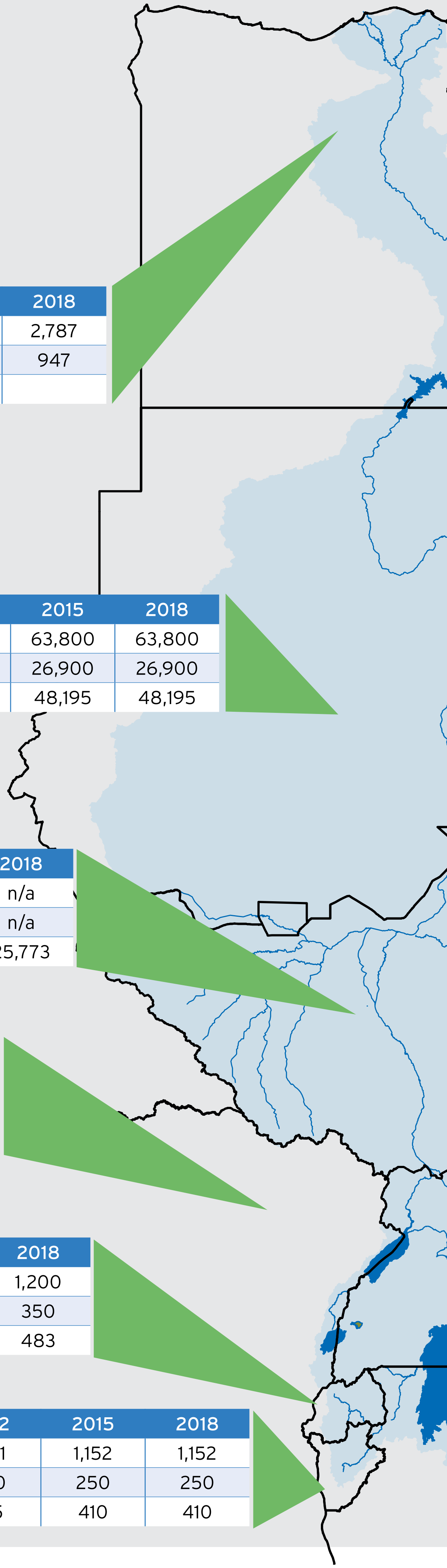
Water is a critical input factor in agricultural production and an obvious constraint for agricultural activities in arid and semi-arid regions.

In the Nile Basin countries, the total area equipped for irrigation is about 5.4 million hectares, while the cropped area is estimated at 6.4 million hectares (Table 4.2). The area equipped for irrigation has increased since 2012. In most Nile Basin countries, the cropped area is smaller than the area equipped for irrigation – except for Egypt and Ethiopia, where two or more crops are grown in some schemes. The bulk of water resources in the Nile Basin are currently used for irrigation (see Chapter 2).

Irrigated agriculture is by far the largest consumer of the Nile waters. Hence, it is evident that further large-scale expansion of irrigated areas supplied by Nile waters will be subject to water constraints. However, irrigated agriculture is insufficient to provide for food security in the Nile Basin. Rainfed agriculture if supported with measures for supplementing soil moisture in times of drought and dry spells could substantially narrow the gap in food security in the Nile Basin.

Despite the prominent role of irrigation, the overall majority (over 87%) of cultivated land in the Nile Basin is under rainfed agriculture. Moisture deficits at critical points during plant growth and latest growth stages adversely impact on yields and can expose farmers to big losses. Hence, yields will remain low without a secure moisture supply, given the high natural variability of the climate in most of the Nile Basin. Rainwater harvesting – which typically involves relatively small volumes of water – is an effective means to achieve higher and more stable yields, lower risk of crop failure, and significantly higher water productivity.

FIGURE 4.4: AGRICULTURAL LAND IN THE NILE BASIN, 2012, 2015 & 2018



EGYPT	2012	2015	2018
Arable land ['000 ha]	2,829	2,867	2,787
Permanent crops ['000 ha]	867	924	947
Permanent meadows ['000 ha]			

SUDAN*	2012	2015	2018
Arable land ['000 ha]	63,800	63,800	63,800
Permanent crops ['000 ha]	26,900	26,900	26,900
Permanent meadows ['000 ha]	48,195	48,195	48,195

SOUTH SUDAN	2012	2015	2018
Arable land ['000 ha]	n/a	n/a	n/a
Permanent crops ['000 ha]	n/a	n/a	n/a
Permanent meadows ['000 ha]	25,773	25,773	25,773

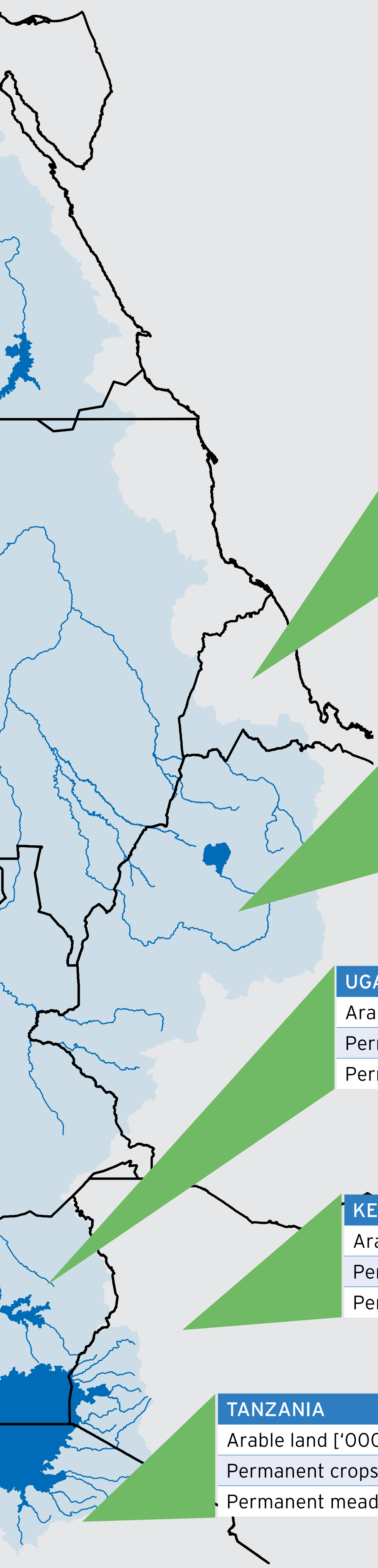
DR CONGO	2012	2015	2018
Arable land ['000 ha]	11,476	12,500	11,800
Permanent crops ['000 ha]	1,100	1,500	1,500
Permanent meadows ['000 ha]	18,200	18,200	18,200

BURUNDI	2012	2015	2018
Arable land ['000 ha]	1,100	1,200	1,200
Permanent crops ['000 ha]	350	350	350
Permanent meadows ['000 ha]	483	483	483

RWANDA	2012	2015	2018
Arable land ['000 ha]	1,151	1,152	1,152
Permanent crops ['000 ha]	250	250	250
Permanent meadows ['000 ha]	415	410	410

Source: FAOSTAT, n.d.

*For the Sudan, the figures are given by the country



ERITREA	2012	2015	2018
Arable land ['000 ha]	690	690	690
Permanent crops ['000 ha]	2	2	2
Permanent meadows ['000 ha]	6,900	6,900	6,900

ETHIOPIA	2012		2018
Arable land ['000 ha]	15,346	15,721	16,187
Permanent crops ['000 ha]	1,142	1,400	1,715
Permanent meadows ['000 ha]	20,000	20,000	20,000

UGANDA	2012	2015	2018
Arable land ['000 ha]	6,900	6,900	6,900
Permanent crops ['000 ha]	2,200	2,200	2,200
Permanent meadows ['000 ha]	5,315	5,315	5,315

KENYA	2012	2015	2018
Arable land ['000 ha]	5,900	5,800	5,800
Permanent crops ['000 ha]	530	530	530
Permanent meadows ['000 ha]	21,300	21,300	21,300

TANZANIA	2012	2015	2018
Arable land ['000 ha]	13,600	13,500	13,500
Permanent crops ['000 ha]	2,100	2,150	2,150
Permanent meadows ['000 ha]	24,000	24,000	24,000

TABLE 4.2: LAND UNDER IRRIGATION IN THE NILE BASIN, 2014/15 & 2018				
Country	Irrigation equipped ('000 ha)		Cropped area ('000 ha)	
	2014/15	2018	2014/15	2018
Burundi	8.7	8.8	15.0	14.9
DR Congo	-	-	-	-
Egypt[8]	3,447	3,823.7	5,021	6,529.6
Eritrea	-	-	-	-
Ethiopia	91	547.4	134	455.4
Kenya	47.8	61.3	20	33.2
Rwanda	7	8.9	7	7.7
South Sudan	0.5	111.3	0.2	111.3
Sudan	1,764.6	2,023.8	1,146.7	1,381.3
Tanzania	19.8	33.4	6	32.1
Uganda	9.7	21.2	9.7	14.7
Total	5,396.1	6,639.8	6,359.5	8,580.2

Source: Compiled from various sources shown in 'Benchmarking Irrigation Performance and Projection of Irrigation Water Demand in the Nile Basin, 2019'

LABOUR

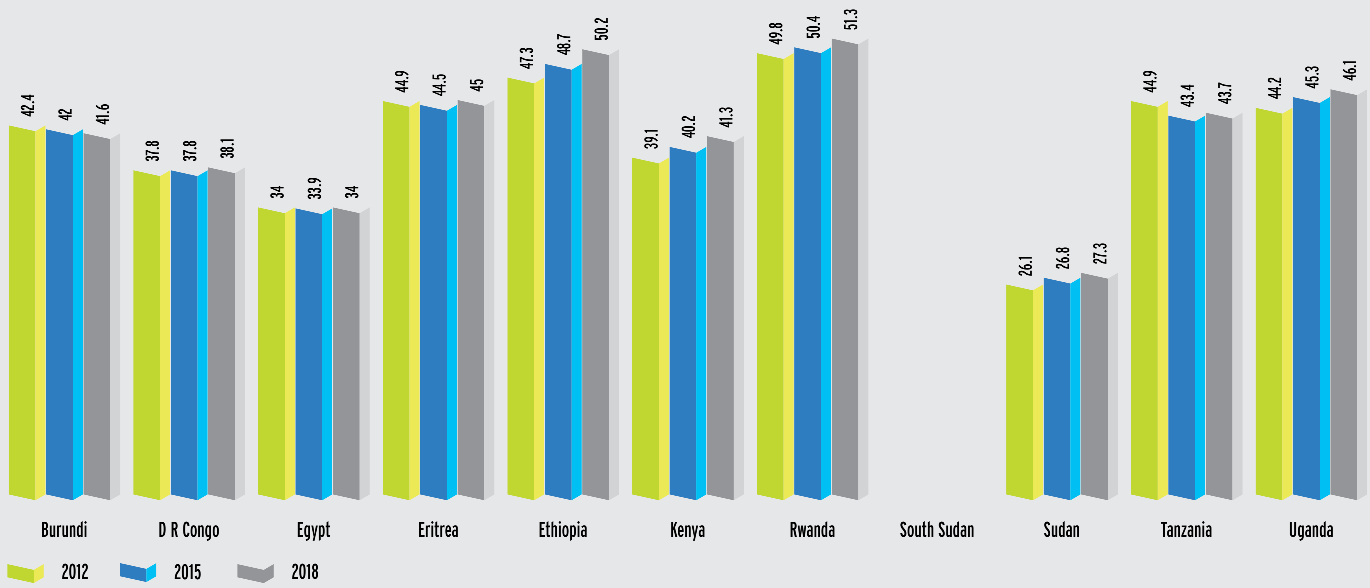
Agricultural production in the Nile Basin is dominated by smallholders. A large percentage of workers remain engaged in agricultural work – although it is recognised that a large portion of agricultural work is seasonal or part-time. In addition, a high percentage of the female population works in agriculture. Despite the large rural population, labour shortages have been reported during land preparation and harvesting. Hence labour constraints need to be considered when adopting modernisation policies that rely on labour-intensive approaches for fertilizer application, irrigation management, and soil and water conservation, etc.

The work in the agricultural sector is predominantly low-wage or non-remunerative. Nevertheless, the proportion of the workforce engaged in agricultural work is rising in most Nile Basin countries, suggesting that the broader economy has been unable to absorb the rapidly rising rural population.

It is noted that successful agricultural production is increasingly becoming more knowledge intensive. Making effective use of scarce and/or expensive inputs requires knowledge of plant physiology, soil characteristics, land conservation practices, and diverse pests and diseases, etc.

[8]While data for other countries were supplied by the respective countries, the data for Egypt has been taken from earlier NBI study (under ENTRO) cross-checked against data in the public domain

FIGURE 4.5: PERCENTAGE OF LABOUR-FORCE PARTICIPATING IN THE AGRICULTURAL SECTOR, 2018



Source: http://dataportal.opendataforafrica.org/bbkawjf/afdb-socio-economic-database-1960-2019?country=1000970-nile-basin-countries-nbc

Photo: © A'Melody Lee; World Bank

CAPITAL

Investment requirements for modernising the agricultural sector in the Nile Basin countries are huge. At farm level, funds required for procuring fertilizer, improved seeds, pesticides, irrigation technology, and machinery, etc. are beyond the means of most smallholders or not justified by the value of the crop. Public investment is required in rural infrastructure, agricultural research, extension services, and water management, etc.

Socio-economic sectors compete over limited national funds. Attracting funding from internal and/or external parties will require an enabling environment. Mobilising funding from external sources is adversely affected by perceived disharmony among the Nile Basin countries. Similarly, at individual country levels, investment policies that are conducive must be in place not only for external funding but also for internal funding.

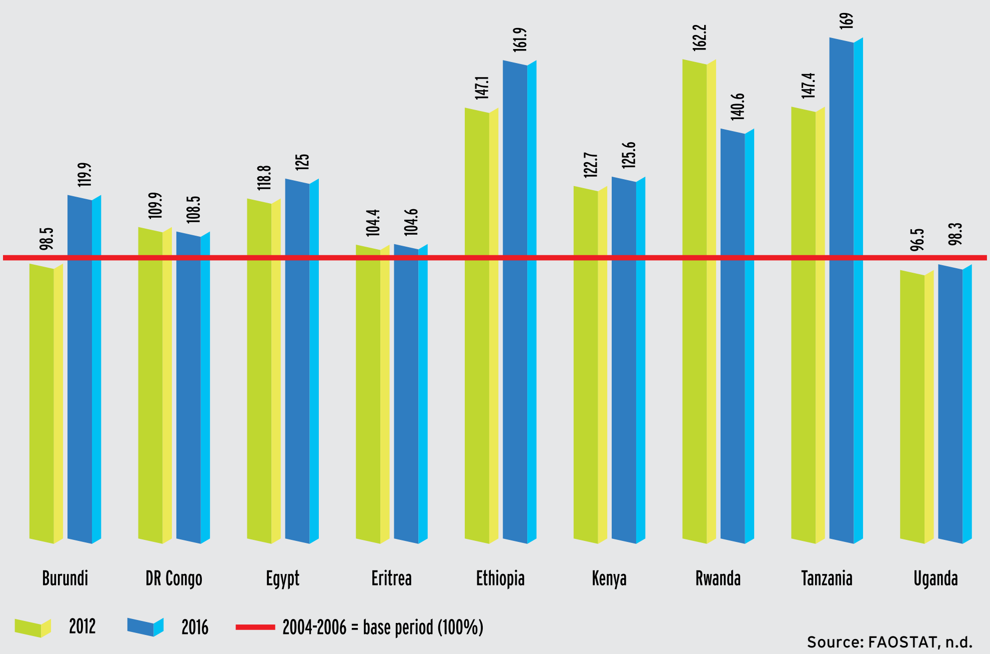
AGRICULTURAL PRODUCTION

Figure 4.6 presents the food production index for the Nile Basin countries for 2012 to 2016. The food production index shows the relative level of the aggregate volume of agricultural production compared to the base period 2004–2006. The index includes all edible agricultural products that contain nutrients; hence coffee and tea, for instance, are excluded. Figure 4.7 and Figure 4.8 present similar indexes for the crop and livestock components.

Figure 4.7 shows a mixed picture for the Nile Region. Positive trends are witnessed in Ethiopia and Tanzania, there is a slow but gradual rise in Egypt, stagnation in DR Congo, Kenya, and Uganda, and high volatility in Burundi, while food production is declining in Rwanda. For many countries, food production has not kept pace with population increase in recent years, which explains the rising level of undernourishment (Figure 4.1) that has been experienced in the 2012–2017 time frame.

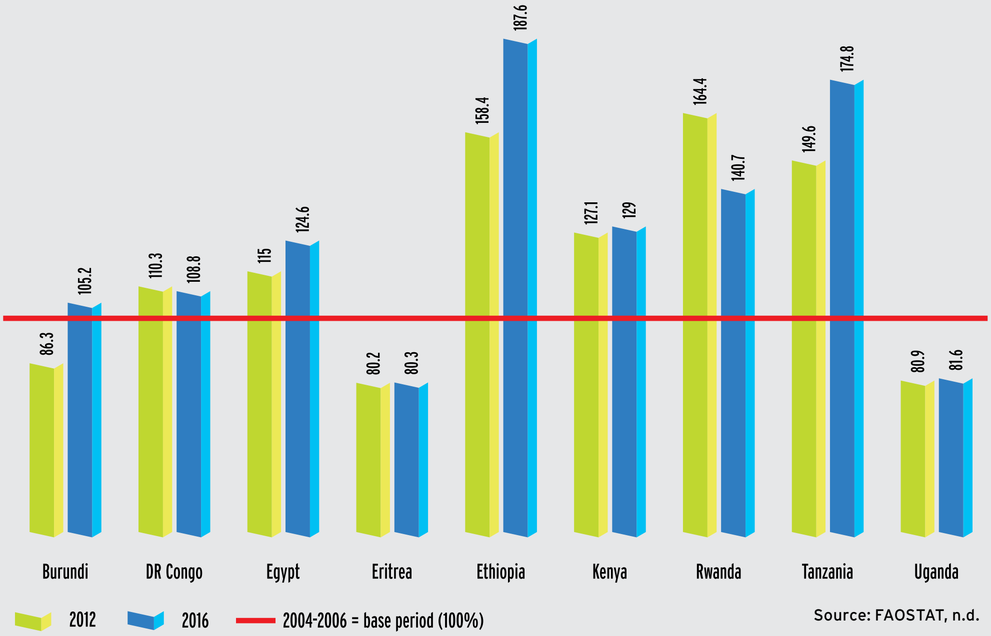
Potential yield is the yield of a crop cultivar when grown with unlimited water and nutrients and biotic stress effectively controlled (van Ittersum, 2013). It is a function of agro-climatic and soil parameters and serves as a benchmark for crop production. The yield gap is defined as the difference

FIGURE 4.6: FOOD PRODUCTION INDEX [2004-2006 = BASE PERIOD), 2012-2016



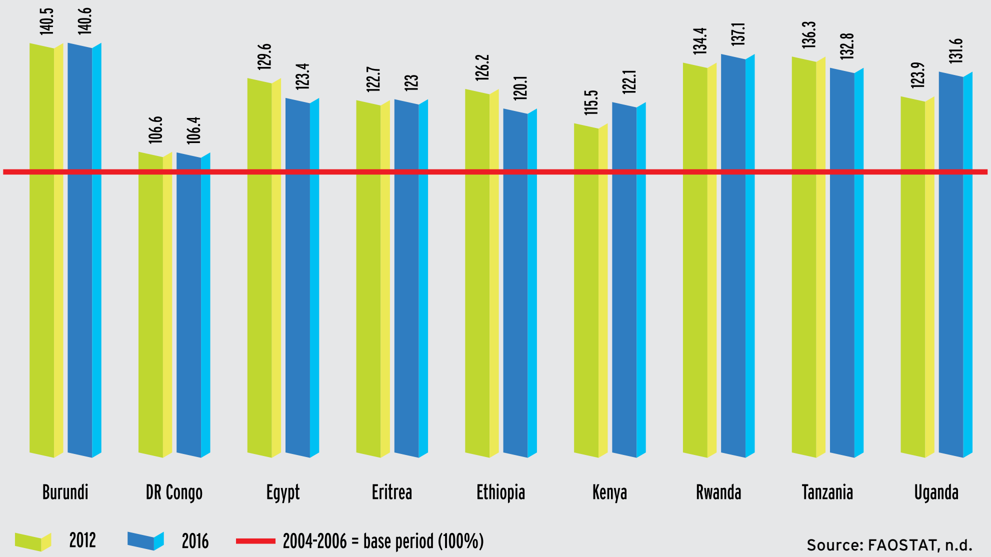
Source: FAOSTAT, n.d.

FIGURE 4.7: CROP PRODUCTION INDEX [2004-2006 = BASE PERIOD), 2012-2016



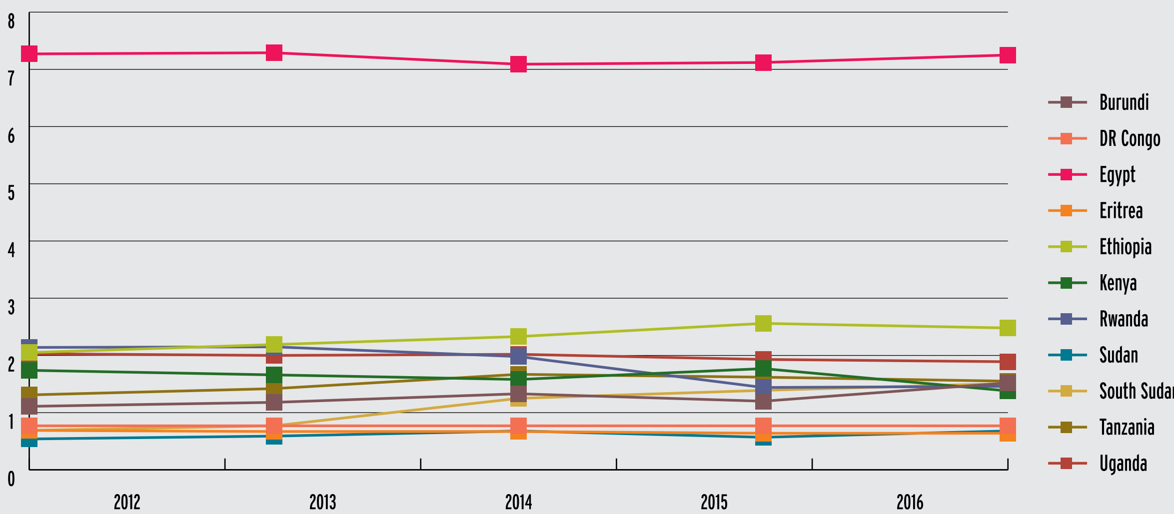
Source: FAOSTAT, n.d.

FIGURE 4.8: LIVESTOCK PRODUCTION INDEX [2004-2006 = BASE PERIOD], 2012-2016



Source: FAOSTAT, n.d.

FIGURE 4.9: CEREAL YIELD (KG/HA) IN THE NILE BASIN, 2012- 2016



Source: Worldbank, n.d.a

TABLE 4.3: AQUACULTURE PRODUCTION IN TONNES/YEAR, 2010, 2013, 2016

Country	Aquaculture production (tonnes per year)		
	2010	2013	2016
Burundi	17.3	165	1,330
DR Congo	2,970	2,869	3,161
Egypt	919,585	1,097,544	1,370,660
Eritrea	n/a	n/a	n/a
Ethiopia	25	45.3	95
Kenya	12,194	23,901	15,360
Rwanda	100	1,165	1,580
South Sudan		20	20
Sudan	2,000	2,500	4,500
Tanzania	7,339	10,166	12,547
Uganda	95,000	98,063	118,051

Source: World Bank, n.d.a

between theoretical yields and actual yields achieved by farmers. Given the high spatial variability of soils and climate, potential yields vary significantly in the Nile Basin. They also differ substantially for rainfed and irrigated agriculture. The yield gap provides an estimate of the untapped crop production potential on existing farmland.

Since the 1960s, cereal yields worldwide have shown an upward trend, increasing from some 1.5 ton/ha to about 4 ton/ha (World Bank). Effective farmers can produce 7 ton/ha or more. It is evident that the yield gap in most Nile Basin countries is substantial and that the region has large untapped agricultural production potential.

Cereal yields (Figure 4.10) can be used as a proxy for measuring the efficiency of agriculture in the respective Nile countries. Apart from Egypt, yields are low to very low, and significantly below potential yields. While a positive trend is witnessed in Burundi, Ethiopia, South Sudan, and Tanzania, reductions are experienced in Egypt, Kenya, Rwanda, and Uganda. Cereal yields are very low in the extensive rainfed dry land areas in Sudan, with low rainfall and high subsequent water stress.

Fisheries and aquaculture are an important component of agricultural production. It is an important source of protein and provides a livelihood to a significant segment of the rural population. Nile Basin fisheries are mainly freshwater lakes, rivers, wetlands, and aquaculture. Fish production statistics comprise captured fisheries and aquaculture. The potential for aquaculture is high and largely untapped.

Aquaculture production is rising rapidly in most Nile countries (Table 4.3). In particular Burundi and Rwanda have seen dramatic increases in the period from 2010 to 2016. Aquaculture is prominent in Egypt and Uganda, substantial in Kenya and Tanzania, and growing in all other countries, albeit starting from a low base.

The Lake Victoria countries and South Sudan have large untapped potential for the development of aquaculture and fish production because of conducive climatic conditions and natural features such as vast gently sloping land, reliable sources of water that include springs, wetlands, rivers, water reservoirs, and the temporary water bodies and soil resources that favour the cultivation of a wide variety of species. However, the development of aquaculture in most of the Nile Basin countries is faced with numerous challenges, including weak institutions, poor access to finance, and a heavy reliance on inadequate government extension services and seed production (Omiti et al., 2009).

WATER PRODUCTIVITY IN AGRICULTURE

Photo: © 2006 Arne Hoel, World Bank

Because of generally high potential evaporation rates across the Nile region, water scarcity is evidently a principal constraining factor in agricultural development almost everywhere in the Basin, even in areas that receive good amounts of rainfall. Improving the productive use of water resources, therefore, is key to agricultural growth and a primary policy objective in most agricultural development strategies.

Water productivity is a measure of the amount of yield produced per unit of water. In areas with good connectivity to regional and international markets it can also be expressed in monetary value generated per unit of water.

The most prevailing farming system in the Nile Basin is the pastoralist system, covering about 45 percent of the land area (Karimi et al., 2012). Livestock water productivity is low. However, most livestock are grazed on arid and semi-arid pastures that utilise water that cannot be used for crop production and would otherwise have been depleted through evapotranspiration before it could reach groundwater or surface water bodies. Karimi et al. (2012) therefore conclude that livestock are efficient in making productive use of water that is of low value for other sectors. Hence, improving livestock water productivity is primarily concerned with animal management strategies rather than with improved land or water management. The scope for improving water productivity is highest in crop production.

« Pastoralism is the farming system best adapted to arid and semi-arid zones and is the largest sector in the Basin, although there is still scope to increase its productivity »

WATER PRODUCTIVITY IN IRRIGATION

Water productivity in the Nile Basin is generally high in the irrigated areas in the Nile Delta and Nile Valley (Karimi et al., 2012). This zone is characterised by intensive irrigation, high yields, and high-value crops. Further incremental improvements are possible through diverse measures that include cropping patterns that produce higher economic returns, the introduction of more water-efficient crops, a reduction in unproductive water losses, interventions that promote aquaculture mixed with crops, and assorted technological and farm management advancements, etc. However, caution on the scope for gains in high water productivity areas is warranted (Molden et al., 2010).

Water productivity is moderate to low in the zones where rainfall is generally sufficient to grow a crop but is highly variable, and random moisture deficits adversely affect yields and discourage farmers from investing in agricultural inputs. This zone comprises large parts of the Equatorial Plateau, South Sudan, and the eastern part of the Nile Basin, mainly in Ethiopia. Low yields are the principal cause for low (or moderate) water productivity. Hence, the prospects for improvement of water productivity are substantial through the implementation of parallel strategies, which may include (Karimi et al., 2011):

- Improving farm water management through rainwater harvesting, soil conservation techniques, and small-scale supplementary irrigation; and
- Promoting irrigated agriculture, which will require investment in storage infrastructure and water-control infrastructure, as well as establishing irrigation scheduling protocols that involve large number of farmers. In areas with a low runoff coefficient, small-scale approaches, including rainwater harvesting, supplementary irrigation from small-scale storage or groundwater, and soil conservation techniques, are unlikely to significantly reduce downstream water availability.

The lowest water productivity values are

Photo: Shutterstock

encountered in the zone that covers the central part of the Nile Basin (Karimi et al., 2012). Agriculture in this zone is rainfed but receives low amounts of rainfall. In most years, crops suffer from moisture stress, and improvements are contingent on establishing full irrigation.

There is substantial scope to improve water productivity in both irrigated and rainfed agriculture, especially where yield gaps are large. In the rainfed sector, increasing physical water productivity is directly related to increasing yields. Relatively small volumes of water are required to avoid moisture stress during plant growth in the zone with substantial rainfall. However, taking away water stress will only improve productivity if other stresses – such as nutrient deficits, weeds, or diseases – are also removed (Descheemaeker, 2013). It has been observed that farmers who are unable to use rainwater effectively are unlikely to use irrigation water effectively. Supplementary irrigation planning, therefore, should be preceded by efforts to maximize the use of direct rainfall through management of soil fertility, reduced tillage operations, soil moisture conservation, and the use of drought- and disease-resistant crops.

Governments in the Nile Basin have introduced technologies that can improve water productivity in the irrigated sector, notably irrigation sprinklers, drip-irrigation systems and, more recently, the system of rice intensification (SRI). SRI is now widely used in Kenya and Tanzania, and there is room for expansion in other countries of the Nile Basin.

« Farmers that are unable to use rainwater effectively are unlikely to use irrigation water effectively »

LIVESTOCK WATER PRODUCTIVITY

The Nile Basin countries host a huge livestock population, including cattle, sheep, goats, and camels. However, livestock water productivity (LWP) is very low – less than 0.1 USD/m3 – with only a few countries showing LWP values of 0.5 USD/m3 and above (van Breugel et al., 2010). Exceptions are the Nile Delta, the Kenyan Highlands, and some isolated areas in Sudan, where milk and meat production are considerably higher, with corresponding higher LWP. Livestock water productivity is defined as the ratio of the sum of the net benefits derived from animal products and services to the amount of water that is depleted or used in the process of producing these goods and services. Livestock provide multiple benefits, such as meat, milk, hides, traction power, manure, insurance against drought, a preferred means of storing wealth, and cultural values (van Breugel, et al., 2010). According to van Breugel et al., (2010), among the greatest opportunities for increasing agricultural water productivity in the Nile Basin countries are the mixed production systems that combine rainfed agriculture and livestock, together with value-added marketing. This facilitates productive use of green water while protecting the land, and providing opportunities for crop and livestock production. Such action would increase the productive use of green water without competing with demands for the Nile's blue water.

Among the constraining factors within the Nile Basin countries to improving the livestock sector is the sectoral planning process, whereby individual sectors are unaware of the actions and plans of other sectors. Integration is therefore required. Furthermore, new institutional arrangements and policies are required to foster inclusion of livestock options within water development planning and water options (beyond provision of drinking water). Integrating livestock, crop and water development will lead to higher agricultural water productivity and more effective and environmentally sustainable human development than the current sector-specific approaches.

« Greatest opportunities for increasing agricultural water productivity in the Nile Basin are mixed production systems »

NEED FOR IMPROVED LAND HUSBANDRY

Photo: A'Melody Lee; World Bank

Rice paddies in the swamps and marshes maximise arable land, yielding food and economic security during the growing season.

Land degradation processes, including soil erosion, salination, compaction, and acidification are a major threat to agricultural production. Interactions between soils, vegetation, rainfall, and evaporation affect how much water enters the land surface and is stored in the soil. Additionally, loss of nutrient-rich topsoil through wind and water erosion often far outpaces the natural cycle of soil formation. Hence, poor management and conservation of agricultural and pastoral land results in declining soil fertility and soil-moisture storage capacity – which are among the root causes of low yields and low water productivity.

Land degradation is widespread throughout the Nile Basin. Yet there are substantial differences in the total land area affected by land degradation between countries. Tanzania, Ethiopia, and Kenya, in particular, accommodate vast areas of severely degraded land (Kirui and Mirzabaev, 2014). Of the sediments that end up in the Main Nile, 97% come from the Ethiopian Highlands, where rates of topsoil loss are very high (Mekonnen, Keesstra, Baartman, Ritsema, & Melesse, 2015). While it is difficult to discern long-term trends on land degradation due to a dearth of data, growing human pressures, such as growing livestock populations or climate-change induced droughts, indicate that the situation is likely to get worse in the future.

In highly eroded lands, simply conserving soils is not an adequate solution for most farmers because it brings no immediate return for the extra work required. Most of these lands are so poor and degraded that even if erosion losses are curbed, the productivity of both land and labour will be mediocre.

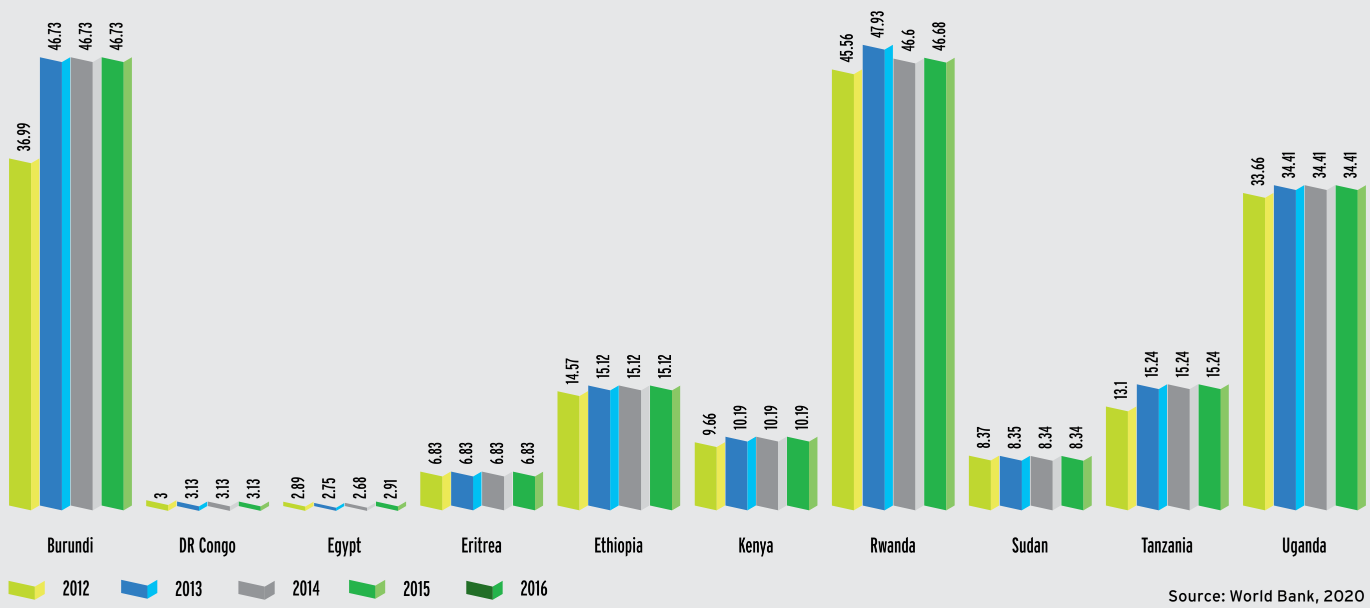
Therefore, good land husbandry practices, coupled with increased soil fertility, are required in order to restore and allow a satisfactory and early return on the labour invested. In pursuit of this aim, land husbandry improves the management of water, organic matter, and nutrients in order to create intensification points for production and for development of the rural environment through animal husbandry (manure being one of the keys to productivity on tropical soils incapable of storing much water or nutrients, agroforestry, and off-season crops).

Improved land husbandry through good farming practices further focuses on building organic matter, increasing the water-storing capacity of the soil and infiltration of rainwater, and preventing loss of top soil. Good soil management can create resilience to the high natural variability of the climate in the Nile Basin countries as well as to climate change, achieving higher yields, reducing fertilizer needs, and improving overall farm profitability. Furthermore, it will increase the capital value of the land.

Farmers have primary responsibility for managing the soil, water and vegetation on their land. In the Nile Basin, the dominance of smallholder farming in the rainfed sector will continue in the foreseeable future. It is acknowledged that improved land husbandry requires secure land tenure. No current statistics are available for the Nile Basin countries on the percentage of people with ownership or secure rights over agricultural land (SDG 5.a.1). Nevertheless, land tenure issues have been reported in several Nile Basin countries.

Governments in the Nile Basin have been at the forefront in promoting sustainable land use. The efforts include various projects and programmes such as the Lake Victoria Environmental Management Project (LVEMP I & II). LVEMP concerns a comprehensive regional development programme that covers the whole of Lake Victoria and its catchment areas in Kenya, Uganda and Tanzania. Examples in Ethiopia include the Sustainable Land Management (SLM) interventions introduced by the government – especially in the Ethiopian Highlands, where land degradation is very severe. However, while the Ethiopian SLM program focused on reversing land degradation, it paid insufficient attention to the goal of enhancing the productivity of rainwater (Merrey and Gebreselassie, 2011).

FIGURE 4.10: ARABLE LAND AS A PERCENTAGE OF TOTAL LAND AREA IN NILE BASIN COUNTRIES, 2010-2015



Source: World Bank, 2020

POLICIES AND ROLE OF GOVERNMENT

Photo: A'Melody Lee; World Bank

In the Nile Basin countries, governments are responsible for providing a commercially sustainable and conducive environment for farmers and the private sector to engage in productive agriculture. In order to achieve this, governments enact policies, legislation, and strategies that are supportive in the promotion of effective and productive utilisation of land and water resources for agricultural production. To this effect, the role of government is critical in establishing effective tenure security, providing physical infrastructure, regulating markets to enhance farm profitability, providing extension services, encouraging agricultural research, stimulating the provision of agro-processing and storage facilities, and supporting farm commercialization.

Secure land tenure is key to addressing land degradation, encouraging more effective use of rainwater, and increasing soil fertility. A farmer or herder will not invest in careful land stewardship or environmental repair without secure tenure and the belief that long-term benefits will accrue from current action or investment, for instance in improved water and soil conservation.

Different countries in the Nile Basin have a variety of land tenure regimes that constrain productive and efficient use of land and therefore food-production capacity. Ownership of land may be secured through inheritance or purchase. Land may also be leased from the government or private owners. The government also grants types of land to private individuals and entities, for example through reclamation projects or in some cases through granting rights to squatters.

Appropriate policies that promote security of land tenure, especially for women, are a pre-requisite for enhancing food-production capacity as well as fostering efficient land markets that can trigger structural transformation processes, attract investments and protect economic livelihoods in most countries to raise agricultural productivity.

AGRICULTURAL ECONOMY

Photo: Shutterstock

LOW FARM INCOME

Increasing the profitability of smallholder farming is a pre-condition for agricultural modernisation. At present, low farm-gate prices compromise the economic viability of farming, while simultaneously removing incentives for good land husbandry. Consequently, much of the agricultural sector is not commercially oriented and continues to be characterised by small landholdings, low inputs use, and low crop yields.

Agricultural productivity is very low in most Nile Basin countries Agricultural productivity is moderate in Kenya and much higher in Egypt. A positive trend is witnessed in Egypt, Ethiopia, Kenya, and Rwanda, but in other countries, productivity is stagnant or declining.

The low agricultural productivity reflects the inefficient state of much of the agricultural sector in many Nile Basin countries. This discourages investments in water-efficient practices and agricultural modernisation in general. Hence, few smallholder farmers currently invest in inputs such as fertilizer and improved seeds – as reflected by the low fertilizer use in many Nile Basin countries (Table 4.4 and Figure 4.12).

In most of the Nile Basin countries, soils are generally deficient in critical nutrients to sustain high crop yields. Soil fertility can further decrease due to poor land husbandry and bad agricultural practices. Nevertheless, few farmers use external inputs such as inorganic fertilizers and herbicides (Table 4.4 and Table 4.5), and the application of synthetic fertilizer in the Nile region remains far below that of other developing regions. Among the reasons for the very low fertilizer application rates in this region is the widespread dependency on rainfed agriculture and the associated risk of crop failure – exacerbated by ineffective soil and water conservation – and inadequate profitability in the good years. Farmers are typically risk averse, as crop failure can have severe financial consequences.

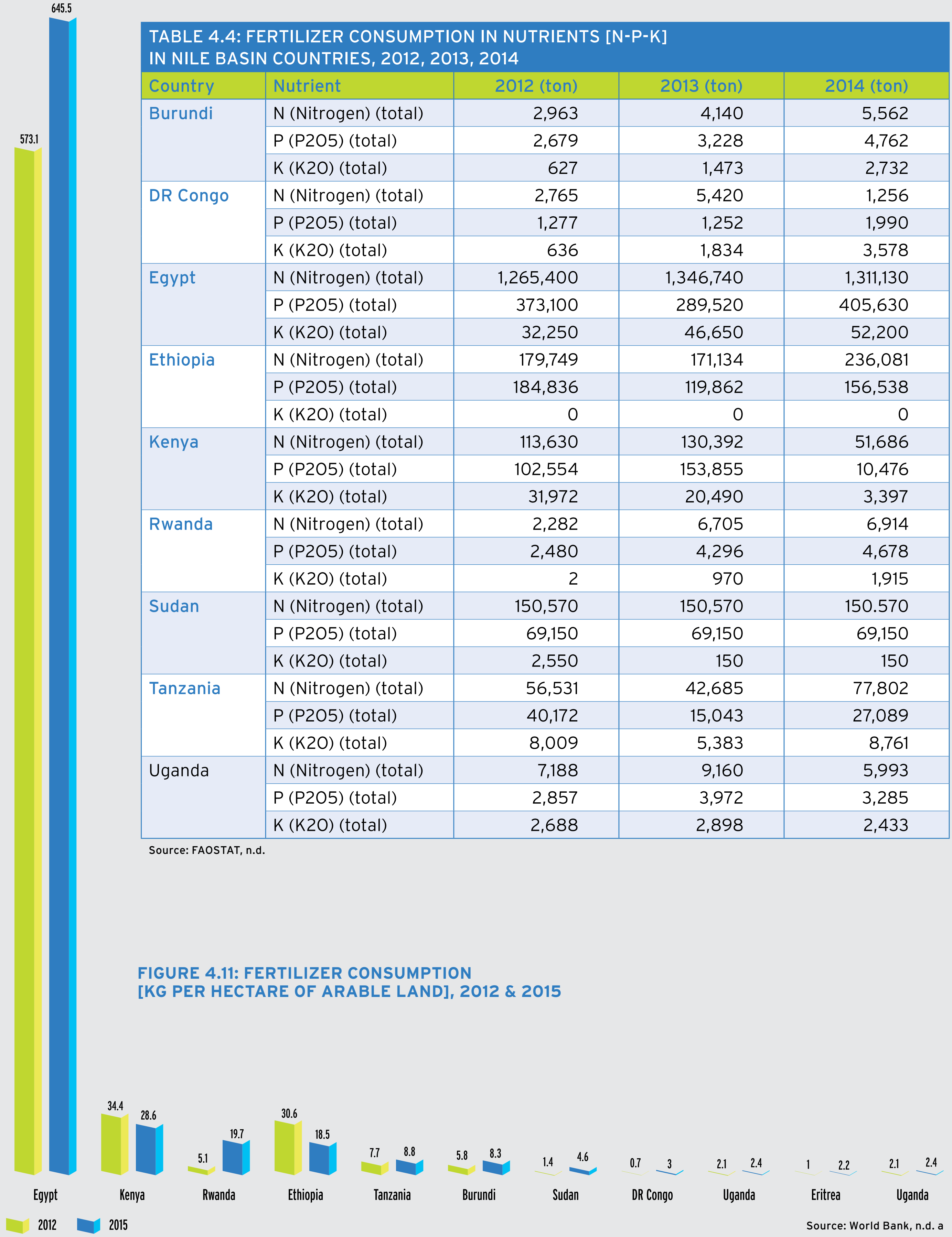
Of the Nile Basin countries, Egypt – with full water control – is currently the only one with high use of fertilizers. It is noted that fertilizer application on the irrigated lands in Sudan is probably higher than suggested in Table 4.4 because the very large rainfed dryland area under cereal production is included in the area statistics.

TABLE 4.4: FERTILIZER CONSUMPTION IN NUTRIENTS [N-P-K] IN NILE BASIN COUNTRIES, 2012, 2013, 2014

Country	Nutrient	2012 (ton)	2013 (ton)	2014 (ton)
Burundi	N (Nitrogen) (total)	2,963	4,140	5,562
	P (P2O5) (total)	2,679	3,228	4,762
	K (K2O) (total)	627	1,473	2,732
DR Congo	N (Nitrogen) (total)	2,765	5,420	1,256
	P (P2O5) (total)	1,277	1,252	1,990
	K (K2O) (total)	636	1,834	3,578
Egypt	N (Nitrogen) (total)	1,265,400	1,346,740	1,311,130
	P (P2O5) (total)	373,100	289,520	405,630
	K (K2O) (total)	32,250	46,650	52,200
Ethiopia	N (Nitrogen) (total)	179,749	171,134	236,081
	P (P2O5) (total)	184,836	119,862	156,538
	K (K2O) (total)	0	0	0
Kenya	N (Nitrogen) (total)	113,630	130,392	51,686
	P (P2O5) (total)	102,554	153,855	10,476
	K (K2O) (total)	31,972	20,490	3,397
Rwanda	N (Nitrogen) (total)	2,282	6,705	6,914
	P (P2O5) (total)	2,480	4,296	4,678
	K (K2O) (total)	2	970	1,915
Sudan	N (Nitrogen) (total)	150,570	150,570	150.570
	P (P2O5) (total)	69,150	69,150	69,150
	K (K2O) (total)	2,550	150	150
Tanzania	N (Nitrogen) (total)	56,531	42,685	77,802
	P (P2O5) (total)	40,172	15,043	27,089
	K (K2O) (total)	8,009	5,383	8,761
Uganda	N (Nitrogen) (total)	7,188	9,160	5,993
	P (P2O5) (total)	2,857	3,972	3,285
	K (K2O) (total)	2,688	2,898	2,433

Source: FAOSTAT, n.d.

FIGURE 4.11: FERTILIZER CONSUMPTION [KG PER HECTARE OF ARABLE LAND], 2012 & 2015



Source: World Bank, n.d. a

Photo: A'Melody Lee; World Bank

The Gatsibo Rice Mill in Gatsibo district, Rwanda buys rice from local farmers, and processes it for local consumption. The mill is part of the same government sponsored project that has improved the irrigation infrastructure in the areas to increase productivity.

The low application of external inputs – especially fertilizer – is also caused by increasing costs and conflicting policy interventions to assist farmers. For example, while there is some limited support in accessing fertilizer for maize farming in some countries, the same is not extended to other agricultural commodities which could help improve household food security. Thus, with limited use of yield-enhancing inputs, many farmers generally obtain low yields and are trapped in chronic poverty.

Cash-crops supplement rural incomes. Table 4.5 shows that the production of major cash crops is steadily rising in most Nile Basin countries, with the exception of tobacco.

Other measures to increase rural incomes and provide incentives for agricultural modernisation include linking smallholders to markets, improving value chains, and reducing food waste.

There are various livestock production systems in the Nile Basin countries, including: sustainable crop-livestock, intensive commercial, and pure pastoral systems. In order to improve the productivity of these systems, attention should be focused on animal health, stock quality, and balanced stocking or carrying capacity. Indeed, higher levels of productivity will require policies that provide incentives to livestock keepers and improved processing infrastructure and marketing.

In general, agriculture should be viewed as a business with the potential for making profits. However, in most of the Nile Basin countries, farmers practice agriculture as a means of survival. In order to realise profits, farmers must minimise the cost of necessary inputs and maximize income through higher farm-gate prices and low transport costs. It requires good rural infrastructure, market access, and timely information on production and marketing trends, both in domestic and regional markets. The latter can be achieved through targeted information-delivery services such as mobile phones or radios. It is clear that governments have a role to play in improving the enabling conditions for agricultural production.

TABLE 4.5: PRODUCTION OF MAJOR CASH CROPS (TONNES), 2010 & 2016						
Country	Coffee		Cotton		Sugar Cane	
	2010	2016	2010	2016	2010	2016
Burundi	89,960	13,624	731	854	1,31,730	2,18,115
DR Congo	31,840	29,798	7,500.00	7,000.00	18,27,140	21,91,333
Egypt	n/a	n/a	1,37,000	1,75,000	1,57,08,900	1,55,57,508
Ethiopia	3,70,569	4,69,091	22,400	42,000	24,00,000	14,10,312
Kenya	42,000	46,100	3900	5147	57,09,586	70,94,619
Rwanda	19,319	19,906	n/a	n/a	1,15,304	93,823
Sudan	n/a	n/a	59,300	59,500	75,26,700	55,19,320
Tanzania	40,000	52,982	88,000	67,000	28,00,825	29,98,279
Uganda	1,66,968	2,08,641	25,768	28,300	35,50,000	37,64,666

Source: [FAOSTAT, n.d.]

TABLE 4.5B: PRODUCTION OF MAJOR CASH CROPS (TONNES), 2010 & 2016				
Country	Tea		Tobacco	
	2010	2016	2010	2016
Burundi	37,875	52,701	1,351	1,298
DR Congo	2,791	3,201	3,709	3,783
Egypt	n/a	n/a	n/a	n/a
Ethiopia	7,586	10,253	2,532	2,138
Kenya	3,99,006	4,73,000	14,156	9,974
Rwanda	22,249	25,628	5,375	4,975
Sudan	n/a	n/a	n/a	n/a
Tanzania	33,160	36,561	60,900	1,01,129
Uganda	49,182	62,705	27,138	33,629

Source: [FAOSTAT, n.d.]

NO DATA FOR ERITREA AND SOUTH SUDAN

Photo: istock

ABSENCE OF VALUE CHAIN

Value-chain infrastructure is still virtually absent or in poor condition in many parts of the Nile Basin countries. Lack of a value chain encourages production and/or export of low-value bulk produce rather than high-value processed agro-products, and thus adversely impacts on farm profitability, as well as on the benefits for the respective Nile Basin countries. This is reflected in the low agricultural-value added per worker in some Nile countries (Figure 4.14).

The absence of agro-processing facilities and the consequent low demand for many agricultural commodities discourages surplus production by smallholders and perpetuates rural poverty.

Many governments have embarked on efforts to revamp the rural economy through agro-processing and industrialisation. Among the critical questions to be addressed is why past industries have collapsed, so that past mistakes can be avoided.

HIGH FOOD LOSSES

Rural incomes and the rural economy, as well as food security, are also negatively affected by high food losses. Globally, food losses and waste are estimated at one-third or more of agricultural production. SDG 12.3.1 is designated to monitor food losses in individual countries, but data are currently not available for the Nile Basin countries.

In low-income countries food is mainly lost during the early (harvesting) and middle stages (processing) of the food supply chain. Once it reaches the household, much less food is wasted.

While data are absent, anecdotal evidence suggests high food losses in the upstream Nile Basin countries. When harvesting is slow because of labour shortages, losses can be substantial. Poor access to trunk roads lead to high transport losses, while inadequate storage and processing facilities further increase post-harvest losses.

Food losses represent a waste of scarce natural resources while reducing the overall profitability of agriculture. Additionally, food-losses directly translate into poor agricultural water productivity.

Food losses can be reduced by improving rural infrastructure, enhanced storage and agro-processing facilities, and developing the value chain. Meeting the SGD 12.3 target to halve food waste by 2030 would make a very substantial impact on food security, water security, farm profitability, and rural development in the Nile Basin countries. In order to better target interventions, it is important to identify where, specifically, in the food production chain most losses occur.

NILE BASIN AGRICULTURAL TRADE

Regional agricultural trade can strengthen food security, enhance rural development, generate foreign exchange, and promote regional integration. Agricultural trade volumes among Nile Basin countries are small but growing. They mainly take place among the countries on the Equatorial Plateau that are within regional trading blocks. Trade in agricultural produce between the upper and lower Nile regions is virtually non-existent because of the absence of infrastructure for bulk transport.

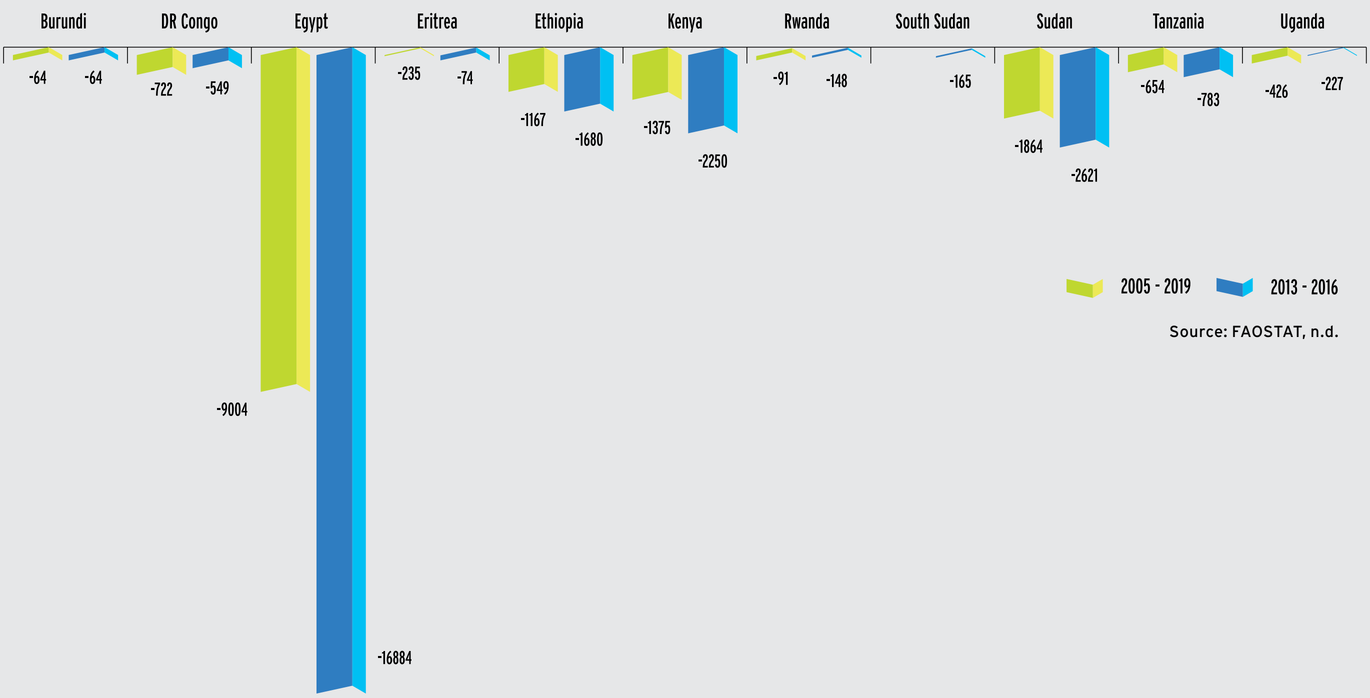
Efforts to promote agricultural trade in the Nile Basin countries are mainstreamed in key policies at national and regional level. For example, COMESA includes nine Nile Basin countries, EAC has six Nile Basin countries, while SADC includes two Nile Basin countries. Nevertheless, local interventions occasionally prohibit export to neighbouring countries, thereby denying farmers good incomes.

While policies are in place to promote agricultural trade, none of the Nile Basin countries is currently a surplus producer of cereals – which are the largest segment of international food trade because they can be readily stored for long periods of time and transported in bulk. In fact, the cereal trade balance is showing a negative trend (Figure 4.12. While improvements have been witnessed in DR Congo, Eritrea, and Uganda, the cereal deficit is growing in Egypt, Ethiopia, Kenya, Rwanda, Sudan, and Tanzania. It is noted that Uganda – where the cereal deficit has decreased – has seen a substantial increase in the level of undernourishment (Figure 4.2), implying that food imports were in fact insufficient.

Figure 4.13 presents the cereal imports and exports from 2013 to 2016. Export volumes were marginal in most countries.

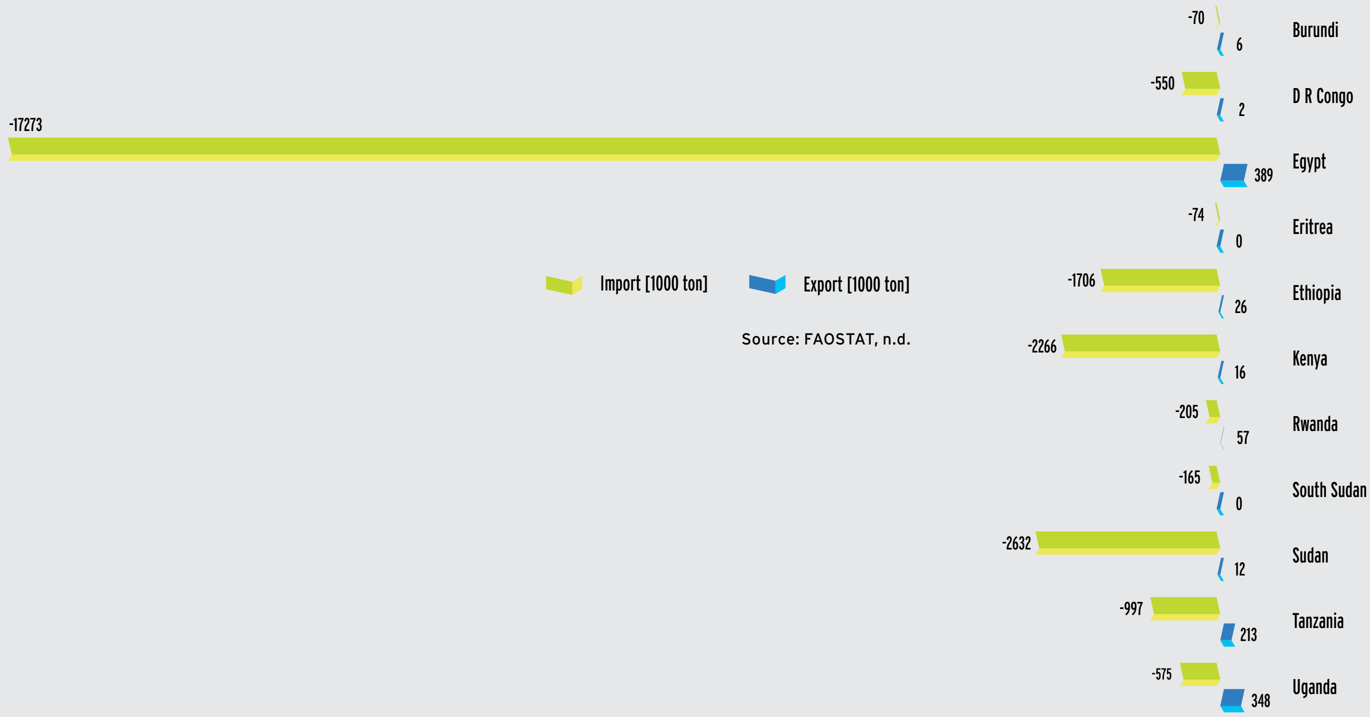
While the potential for agricultural trade among the Nile Basin countries is promising, large-scale trade in the short term is not realistic since all Nile countries are currently food deficient, and many are experiencing substantial levels of undernourishment (Figure 4.1). Sudan is the most likely candidate to become a surplus producer in the

FIGURE 4.12: CEREAL TRADE BALANCE IN THE NILE BASIN, (THOUSAND TONNES) 2005-2009, 2013-2016



Source: FAOSTAT, n.d.

FIGURE 4.13: CEREAL IMPORT AND EXPORTS IN THE NILE BASIN COUNTRIES ('000 TONNES), 2013-2016



Source: FAOSTAT, n.d.

Photo: Shutterstock

medium-term future. It implies that agricultural development through export of staples will only play a limited role in most of the Nile Basin countries in the short- and medium-term future, and that intra-Basin trade is not an effective means to assure general food security until one or more countries produce a consistent and reliable surplus. While cross-border trade can alleviate local food shortages, it is currently not a solution at national or Basin level.

Moreover, the cost of imported food is too high for the large rural population in areas less connected to domestic and global markets. Agricultural trade, therefore, cannot achieve food security for this population segment. Growing domestic demand needs to be met first and foremost by domestic produce.

Basic food production for local markets – rather than for export – offers attractive investment opportunities in many parts of the Nile Basin countries because of rapidly rising demand. Value addition for domestic markets is probably a realistic alternative to agro-processing for export, as it does not necessitate the high-quality standards required for export. When producing for import substitution, high transport costs because of inadequate infrastructure and logistics turn into a comparative advantage.

Nevertheless, opportunities exist to promote intra-regional trade, especially in cereals, pulses, and other less perishable commodities. There are some attractive aspects of promoting intra-regional agricultural trade that hinge on a) stabilizing producer prices in the exporting country while reducing consumer prices in importing countries, and b) promoting regional integration, since there are varying harvesting calendars for different commodities and hence not much competition between countries. Tariffs on imports or exports of agricultural produce among the Nile Basin countries should be reviewed and removed, where possible, because they impede intra-Basin trade.

« Intra-basin agricultural trade is not a viable short-term solution to food insecurity, as all Nile Basin countries are net importers and agricultural trade deficits are increasing »

AGRICULTURAL MODERNISATION: A ROLE FOR GOVERNMENT

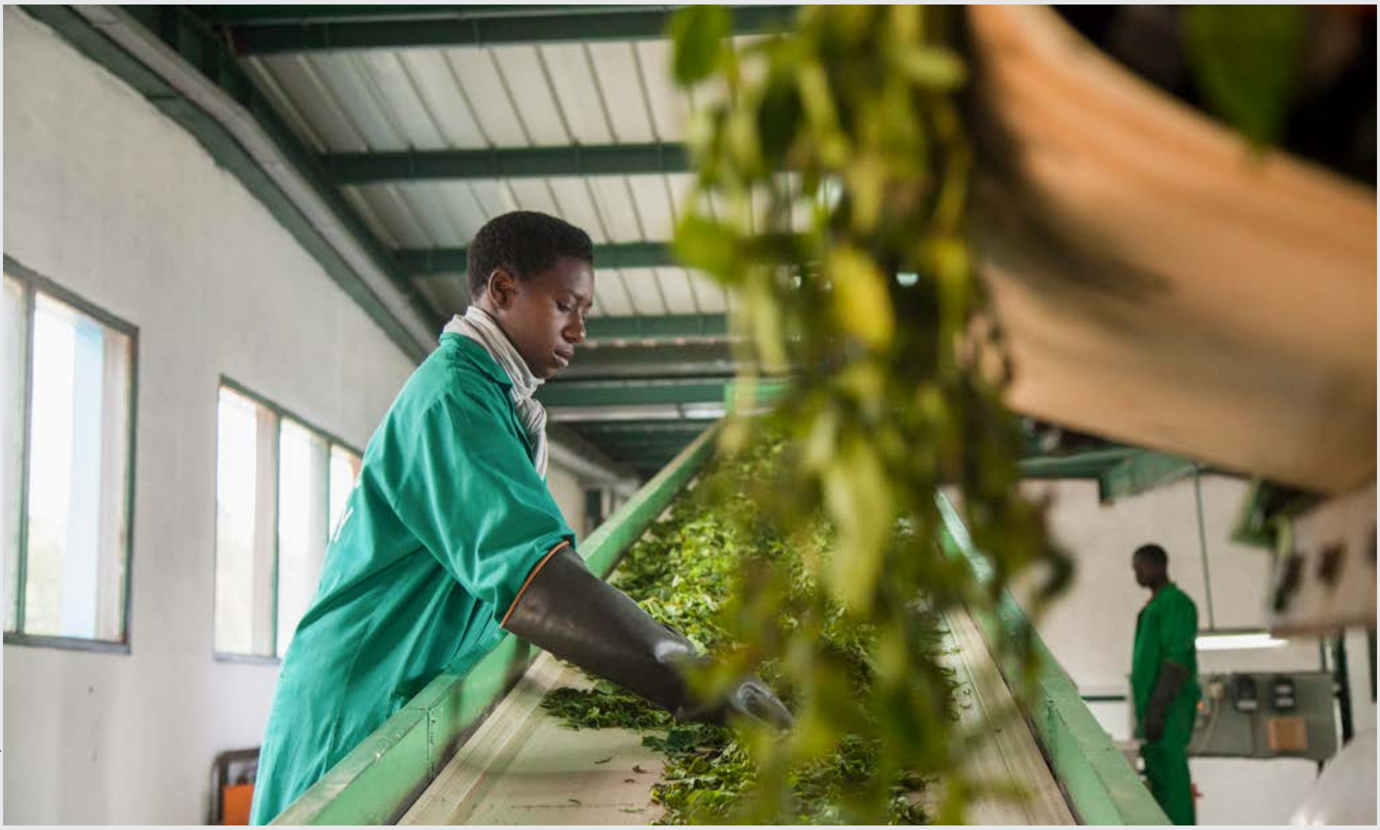


Photo: A'Melody Lee; World Bank

The Kitabi Tea Processing Facility in Kitabi, Rwanda has a capacity of 48 000 tons of green leaf per day. The facility employs 200 people during its peak season and about 70 during the rest of the year.

There is huge scope and need for agricultural modernisation in the Nile Basin countries. While all countries are encouraging the private sector to play a key role in this endeavour, government funding remains essential to support the modernisation process. Government investments are needed for rural infrastructure, extension services, rural electrification to support agro-processing and storage, agricultural research, credit facilities, training, soil improvement and soil-degradation control, water-control infrastructure and irrigation facilities, animal health management, etc.

Table 4.6 presents the Agriculture Orientation Index (AOI) for government expenditure in the Nile Basin countries for the

TABLE 4.6: AGRICULTURE ORIENTATION INDEX [AOI) FOR GOVERNMENT EXPENDITURE, 2012-2016

Country	Agriculture Orientation Index				
	2012	2013	2014	2015	2016
Burundi	0.09	0.07			
DR Congo	0.3	0.21	0.37	0.2	0.35
Egypt	0.19	0.17	0.14	0.13	0.11
Ethiopia	0.35	0.16	0.19	0.2	0.25
Kenya	0.14	0.12	0.1	0.05	0.05
Rwanda	0.16				0.1
Tanzania	0.05	0.07	0.06	0.04	
Uganda	0.13	0.19	0.18	0.16	0.17

Source: FAOSTAT, n.d.] (no data is available for Eritrea, South Sudan, and Sudan period 2012 to 2016. The AOI is defined as the agriculture share of government expenditures, divided by the agriculture share of GDP. It provides a measure of the relative importance of the agricultural sector in overall expenditure by the government.

Table 4.6 shows that the AOI is low for all the Nile Basin countries for which data are available. A value below 1 implies that the flow of public funds to the agricultural sector is smaller than the relative contribution of this sector to the economy. Agriculture contributes between 25% and 40% to GDP for the Nile Basin countries, except for Egypt where it is just above 10% (Figure 4.3). Hence, allocating at least 10% of national budgetary resources to agriculture and rural development would imply AOI values between 0.25 and 0.40, or above. Most of the Nile countries are not achieving this level. It implies that the agricultural sector is not prioritised in terms of budget allocation in the countries. Table 4.6 shows a downward trend in some countries. In view of the high investment needs in the agricultural sector, inadequate government support may jeopardise the objective of agricultural modernisation and growth, which is essential for achieving food security and poverty alleviation in rural areas.

While, in the past, governments invested directly in irrigation schemes – with frequent unsatisfactory outcomes, currently this role has been taken over by the private sector. Private investments have also been directed to high-value export commodities such as vegetables and flowers in some countries.

According to the NBI Strategy 2017–2027, the NBI is committed to supporting Nile Basin countries in identifying and preparing projects to improve the existing irrigation infrastructure, as well as to develop new irrigation areas in order to increase agricultural productivity in the Basin. A similar commitment is made for the modernisation of existing irrigation schemes, with the aim of improving water productivity and water-use efficiency. In this process, the 'tail-to-mouth' approach should be applied, which requires that improvements start at field level to ensure that the available water is efficiently utilised for maximum crop and biomass production.

Additionally, NBI is supporting member states in identifying and preparing bankable investment projects that focus on reversing watershed degradation and reclaiming these areas for productive agriculture. Landscape restoration will be implemented through soil and water conservation measures to enhance effective use of rainwater for crop production and reduce vulnerability to drought shocks.

CONCLUSION

Photo: Salahaldeen Nadir/ World Bank

This chapter has presented the status of food security and agricultural development in the Nile Basin countries. It has observed that food production is currently inadequate, while demand for food is set to increase substantially because of demographic trends and economic developments. However, there is substantial untapped production potential in the Nile Basin both in the livestock, aquaculture, and crop production systems. Improved animal management, soil conservation and improved land husbandry, small-scale supplementary irrigation, and a reduction in food losses are important elements of a viable strategy to achieve food security and rural development in the Nile Basin. Because of the dominance of the rural population in the coming decade and beyond, agricultural transformation needs to include smallholders. Capturing the agricultural potential, however, will require dramatic improvements in the economic viability of farming across the Basin. Government action will play a critical role in the agricultural modernisation process. It is noted that, at present, none of the Nile Basin countries – bar one – is prioritizing the agricultural sector in terms of budget allocation, and trends in agricultural production show a mix picture.

It is noted that intra-Basin agricultural trade can alleviate local food shortages but is not an effective means of providing Basin-wide food security until at least one Nile country becomes a consistent surplus producer. For the short- and medium-term future, therefore, food security will largely be based on domestic and regional production.

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ECOSYSTEMS AND BIODIVERSITY

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CONTENTS

KEY MESSAGES

The Nile Basin is endowed with rich environmental resources and harbours high levels of biodiversity.
Rivers, lakes, wetlands, savannah and forests regulate runoff and moderate floods, filter water, and prevent erosion, and they sustain millions of livelihoods in the basin, which are largely based on subsistence farming and fishing. Water-related ecosystems build the backbone for human water security, food supply, energy generation, and economic growth. It is therefore important to increase awareness that any future development relies on managing them sustainably.

Despite the enormous benefits they provide, numerous water-related ecosystems are in decline, a trend that has intensified since 2012.
Human activities threaten their functioning and integrity as never before through an interplay of rising water withdrawals, pollution from urban, industrial and agricultural sources, development of hydraulic infrastructures, overfishing, invasive species and land-use change. Many of the pressures are driven by agriculture, which is why the sector plays a key role in finding solutions to manage water-related ecosystems.

Biodiversity is declining especially where competition for limited water resources is high.
The main Nile features among the regions in Africa with the highest number of extinct freshwater species. The number of threatened freshwater species is particularly high in Lake Victoria and surrounding wetlands, mostly due to the many fish species that face a high risk of extinction.

The Nile is one of the most regulated large rivers in Africa.
A recent environmental flows assessment conducted by NBI indicated that many river reaches have still ecologically acceptable flow regimes. However, mounting pressure from human activities has fundamentally altered flow conditions in several places, causing notable adverse impacts for water-related ecosystems and human water security.


Photo: © Andy Johnstone/Panos Pictures

There is increased evidence of considerable degradation of wetlands in the Nile Basin over past decades.
A recent study showed that some wetland land cover classes have decreased by approximately 35% between 1985 and 2015.

There is a general decline in basin-wide forest coverage.
Between 1985 and 2015, basin-wide forest area decreased by 29%. The loss has been even greater in some countries while others gained forest area. Also in countries with few forests remaining, such as Ethiopia, deforestation continues. The basin's water towers, have experienced significant forest loss, which has affected the flow conditions of some rivers they source.

NBI has carried out interventions to improve policies and management for water-related ecosystems.
Since 2012, NBI has developed a Wetlands Management Strategy (2013) and an Environmental Flows Strategy (2016) that help guide and complement nation-

al-level measures. It has also undertaken wetland inventory and developed a wetland atlas; and carried out a valuation study of ecosystem services provided by wetlands as well as awareness raising and training for personnel engaged in wetland conservation.

In the Nile Basin, protected areas account for 13% of the total basin area.
DR Congo and Tanzania have protected as much as 40% of their total land area respectively, although not all of the 40% lies within the Nile Basin. Four Nile Basin countries protect less than 10% and thus fall short of reaching officially recommended conservation target (Aichi Target 11). There is a particular need to extend protection for freshwater Key Biodiversity Areas (KBAs), of which one-third are currently covered through protected areas.

Several Nile Basin countries have improved essential elements of wetland management since 2012. More of them conducted inventories and established management plans for Ramsar Sites.
Importantly, NBI has commissioned several baseline studies to assess the state of strategic wetlands in the Nile Basin. No additional Ramsar Site has been designated in the same period. Notably only Uganda and Kenya have wetland policies. Ongoing degradation of wetlands calls for improved wetland protection.

The implementation of measures to provide environmental flow requirements is still at an early stage.
National policies address environmental flows only in Tanzania and Kenya. Recently completed or currently constructed hydropower dams have not been guided by environmental flow assessments. In the backdrop of a projected five-fold increase in hydropower capacity by 2050, environmental flow requirements need to be set across the basin.

The level of protection provided for the basin's water towers varies substantially.
Protected areas cover large areas of the Mau Forest, Mount Elgon, and the Rwenzori Mountains though with varying strictness levels. In contrast, protection coverage for the Ethiopian Highlands is very low. Watershed management projects, including afforestation and sustainable farming, have been encouraged over recent years, both by NBI and on a national level. However, the scope of these programmes is inadequate given that populations are growing rapidly in and around the water towers.

Further assessments and monitoring of the hydrological conditions and the state of freshwater species and ecosystems is needed for more efficient conservation planning and sustainable water management.
There is a need to further extend ongoing efforts, such as baseline assessments of transboundary wetlands or the water-quality monitoring systems. Filling information gaps is especially needed, as the availability of water becomes increasingly unpredictable under a changing climate.

INTRODUCTION

The purpose of this chapter is to describe the basin's water-related ecosystems and the benefits they provide, the key anthropogenic pressures affecting them, changes that have occurred to their state recently, and responses to safeguard them in the future. The focus is set on rivers, wetlands, lakes, and forests in water-source areas, all of which play a prime role in supporting human water security, livelihoods and freshwater biodiversity. This chapter looks at rivers and lakes jointly, given they are both aquatic ecosystems while forests and wetlands are treated separately, given that they are terrestrial or semi-terrestrial ecosystems.

The Nile Basin's ecosystems and associated natural resources are of fundamental importance to the wellbeing of its 257 million inhabitants (NBI, 2016) and comprise the backbone of national economies. They provide myriad benefits referred to as ecosystem services (Costanza et al., 1997). Ecosystem services provided by wetlands and other water-related ecosystems range from replenishing groundwater, controlling floods and providing fish-based diets. In the Nile Basin, as in many other parts of the developing world, a large proportion of people directly depend on these ecosystem goods and services; they constitute most of their day-to-day subsistence and income. If wetlands and other ecosystems lose their capacity to generate these ecosystem goods and services, as a result of habitat degradation and loss, millions of livelihoods are endangered, as well as a large proportion of the Nile Basin countries' combined economic power.

Both biodiversity and sustainable provisions of ecosystem services are clearly at risk in the basin (Vörösmarty et al., 2010). The Nile is no exception to global trends, according to which freshwater species populations have declined by 83% between 1970 and 2014 (Grooten and Almond, 2018). The Nile Basin´s rapidly growing populations and economies have been consuming more and more natural resources over recent decades. These rising needs are inevitably increasing the pressure on ecosystems, many of which have become threatened. Agriculture is the principle driving force behind the loss of wetlands and forests. However, urbanisation, the most defining demographic trend affecting Africa in the 21st century, is fundamentally reshaping human geographies. The growth of cities is determining more and more where wetlands, rivers, and forests will most heavily be put under strain in the future.

Given their immense benefits, it is imperative that the Nile's waters are not developed at the expense of water-related ecosystems. To guarantee human water security for decades to come, the protection of wetlands, rivers, lakes, and forests needs to be at the heart of decisions on water-resource management and development. The cross-border nature of many of the basin wetlands and other water-related ecosystems requires that challenges such as mounting water pollution and over-exploitation of fish are tackled through a transboundary approach. Equally, an integrated, nexus-driven perspective needs to guide decisions over water allocations for agriculture, energy generation and cities in order to balance the tradeoffs and minimize negative impact for ecosystems and associated biodiversity.

« Pressures from human activities in the Nile Basin are greater than ever before, causing the decline of many water-related ecosystems »

WATER-RELATED ECOSYSTEMS AND BIODIVERSITY OF THE NILE BASIN

Photo: Shutterstock

The Nile, the longest river in the world, traverses 16 terrestrial ecoregions from source to sea. An ecoregion is an area containing a geographically distinct assemblage of plants and animals that share similar environmental conditions and interact in such ways as to enhance their collective long-term survival. Wetlands, rivers, lakes, and forests thus exist in versatile forms and types. They have co-evolved with the topography, geomorphology, and climate, all of which change dramatically as the river flows from the Equator through the Sahara to the Mediterranean. Along the upstream–downstream gradation, the water resources become scarcer, which has affected the ways in which humans use water to produce food and other commodities.

BOX 5.1: DEFINITIONS OF UMBRELLA, KEYSTONE AND FLAGSHIP SPECIES

UMBRELLA SPECIES: An umbrella species indirectly protects many other species that make up the ecological community of its habitat.
KEYSTONE SPECIES: A keystone species is a plant or animal that plays a unique and crucial role in the way an ecosystem functions.
FLAGSHIP SPECIES: A flagship species is one selected to act as an ambassador, icon or symbol for a defined habitat, issue, campaign or environmental cause.

The basin harbours outstanding diversity and endemism of species. A number of habitats, such as the Albertine Rift, which stretches across the sub-basins of Lake Albert and Victoria, and the Ethiopian Highlands, are part of the Eastern Afromontane biodiversity hotspot. The Nile Basin also hosts a large number of birds that rely on habitats in the Nile Basin as a stop-over or for over-wintering. Generally, species richness is highest at, and decreases away from, the equator. With respect to freshwater species, areas of lowest richness overlap with arid regions, given the paucity of habitats for water-dependent species. The African aquatic fauna has not been well studied, especially in some areas, such as the swamps of the Sudd. The actual number of existing or threatened species may thus be higher than is currently assumed (Darwall et al., 2011).

The majority of the species richness and endemism exists in a fraction of the basin. The Albertine Rift, for instance, is home to approximately 40% of the mammals, 50% of the birds, 14% of the reptiles, and 19% of the amphibians of Africa. Equally, freshwater biodiversity for several taxonomic

TABLE 5.1: ABSOLUTE NUMBER AND PROPORTION OF SPECIES IN WETLANDS OR WETLAND COMPLEXES WITHIN THE NILE BASIN

Wetland/wetland group	Total number of species	Number of endemic species	Number of keystone and umbrella species	Number of flagship species
Nile Delta	580	9	6	22
Dinder river	592	11	11	27
Lake Tana	521	26	7	22
Baro/Akobo Sobat Wetlands (Machar Marshes)	598	15	11	31
Sudd	695	22	15	32
Bahr el Ghazal	603	9	9	28
Lake Kyoga	768	39	11	30
Semliki	1071	69	13	36
Lake Victoria	1982	226	18	37
Kagera	754	33	11	28
Mara	816	195	10	25
Sio Nzoia Yala Nyando	980	203	12	22
TOTAL	3079			

Source: NBI 2019c

groups (fish, molluscs, and crabs) in Eastern Africa peaks in the Great Lakes and its surrounding shoreline or riverine wetlands. Table 5.1 shows that the basin's wetlands with very high biodiversity and endemism are all located around Lake Victoria, including those of Semliki, Kagera, and Sio Nzoia Yala Nyando. The Nile Delta, Dinder, Lake Tana and the Machar Marshes, being located in the upper part of the basin, have only moderate species richness and endemism in comparison. The same applies to lakes, with Lake Victoria, for example, being home to more than 600 endemic freshwater species alone, most of which are cichlids. Species richness, too, is lower in rivers of the upper Nile Basin. For example, there are fewer than 30 fish species recorded for most of its length while some tributaries, for example in the Ethiopian Highlands, support fewer than five fish species (Darwall et al., 2011). Table 5.1 also shows numbers of umbrella, keystone, and flagship species. When designing future conservation actions, these species should receive major attention, for example because raising support for them may be more effective than for other species.

Freshwater biodiversity directly sustains millions of livelihoods in the Nile Basin. For example, two-thirds of freshwater species are of socio-economic value (Juffe-Bignoli & Darwall, 2012). The wildlife tourism industry, for example in the Virunga National Park or the Serengeti, contributes considerably to the economies of the respective countries. Species abundance and composition are a key determinant for the health of ecosystems. Declining species numbers can translate into fewer ecosystem services, such as fisheries, carbon sequestration, or nutrient cycling, and hence destroy human livelihoods (Chapin, et al., 1998; Gardner et al, 2019).

« The decline of rivers, lakes, wetlands, and forests goes along with the loss of their ecosystem services and goods that are critical to millions of livelihoods and the economies in the riparian states. »

Photo: Vivek Bahukhandi

RIVERS AND LAKES

The Nile's drainage network is comprised of many small and large rivers. Compared to its size, the total runoff is comparatively small because a substantial part of the basin is located in semi-arid and arid areas with very little rainfall. The Nile is mainly supplied by tributaries of the Blue Nile, Atbara, Sobat and Bahr el Jebel. Around 85% of the discharge is generated in the Eastern Nile region, in Ethiopia, which grants the country a high responsibility in managing the flow-dependent ecosystem processes. Yet the flows from the Ethiopian Highlands are highly seasonal, with approximately 75% of their total being generated between July and October. During the dry season, from November to April, the White Nile contributes 70% to 90% of the Nile's total discharge. Despite its overall low discharge contribution compared to the Blue Nile, the flows of the White Nile are thus paramount for the Main Nile's water supply (Sutcliffe and Parks, 1999).

The riverine ecology changes as the Nile flows from south to north. Fast-flowing streams with rocky beds featuring scant vegetation and biodiversity are common in upstream areas, such as those draining Mount Elgon or the Ethiopian Highlands. As the Nile's tributaries meander through lowlands, extensive swamps form in the river channels, while wet-season flows inundate grasslands and woodlands for several months of the year. Papyrus, common reed and perennial grasses fringe the riverine network throughout the basin (Green, 2009). Importantly, many of the large lakes and wetlands are connected to the Nile River and its tributaries. Changes to the flow regime can cause considerable threats to wetlands and lakes and the fish, fuelwood, and other important natural resources they provide to local populations. This augments the necessity to manage and develop the waters of the Nile through a basin-wide and integrated approach.

However, river flows are not only critical for wetlands, lakes and the delta. They form the lifeline for some of the Nile Basin's most iconic terrestrial ecosystems. The Mara River, for example, originates in the Mau Forest in Kenya and flows through the plains of the Serengeti before discharging into Lake Victoria. Around 2 million wildebeest and zebra depend on it as the only dry-season source of water during their migrations. The Sudd wetland in South Sudan, which is one of the most significant wetlands globally, is fed by the Bahr el Jebel . The Sudd, in turn, is part of and sustains the Jonglei plains, Africa's largest remaining intact savannah, the extent of which is three times that of the Serengeti National Park. 1.2 million antelope, among other species, migrate to the floodplains for grazing during the wet season (Furniss, 2010).

The Nile Basin accommodates a large number of lakes and wetlands, which together comprise 10% of the basin's area (Rebelo and McCartney, 2012). Besides Lake Victoria, which is the largest lake in the basin, and in Africa, there are several large lakes in the Equatorial Lakes region, including Lake Albert, Kyoga, Edward and George. In the Eastern Nile, the only large lake is Lake Tana. In the lower reaches of the basin, the reservoirs of the Aswan, Roseries, and Merowi dams, as well as several large lagoons in the Nile Delta, count as the only lakes. Floating papyrus mats, water lilies, and the invasive water hyacinth usually cover open-water habitats. The lakes are of high importance for food security, fishery-based livelihoods and biodiversity. Lake Victoria, and further downstream, Lake Kyoga and Lake Albert, and the Sobat river regulate the flows of the White Nile, while Lake Tana's outflows and the downstream Abay river tributaries become the Blue Nile. Lake Victoria's fisheries alone support 1.2 million livelihoods (Rebelo and McCartney, 2012).

WETLANDS

Wetlands are spread throughout the basin. However, as Table 5.2 shows, the large majority of them is located in the upper parts of the basin around Lake Victoria. While wetlands in the Nile Basin can be distinctive in the habitat they provide, papyrus and perennial grasses dominate many of them. Moreover, it is typical for wetlands in the Nile Basin to fringe the shorelines of lakes, which can become extensive where tributaries enter.

In the Equatorial Lakes Plateau, most of the wetlands can be found in Uganda, and especially along the shores of Lake Victoria. Wetlands also adjoin the Kagera, Semliki, and Simiyu rivers and fringe the shorelines of other large equatorial lakes. While existing throughout Ethiopia, seasonal and permanent lakeshore Lake Tana's swamps form Ethiopia's largest wetland complex. Shortly after having crossed the South Sudanese border, the Bahr el Jebel floods the Sudd swamps, the basin's largest wetland. Its extent is highly variable, depending on year-to-year inflows. In the lower, more arid, region of the basin, wetlands almost exclusively exist in the Nile Delta including Lake Burrulus, where they stretch along 240 km2 of the Mediterranean coastline. Other important arid areas of wetlands exist in the Blue Nile sub-basin including the Back Swamps or Mayas of Sudan.

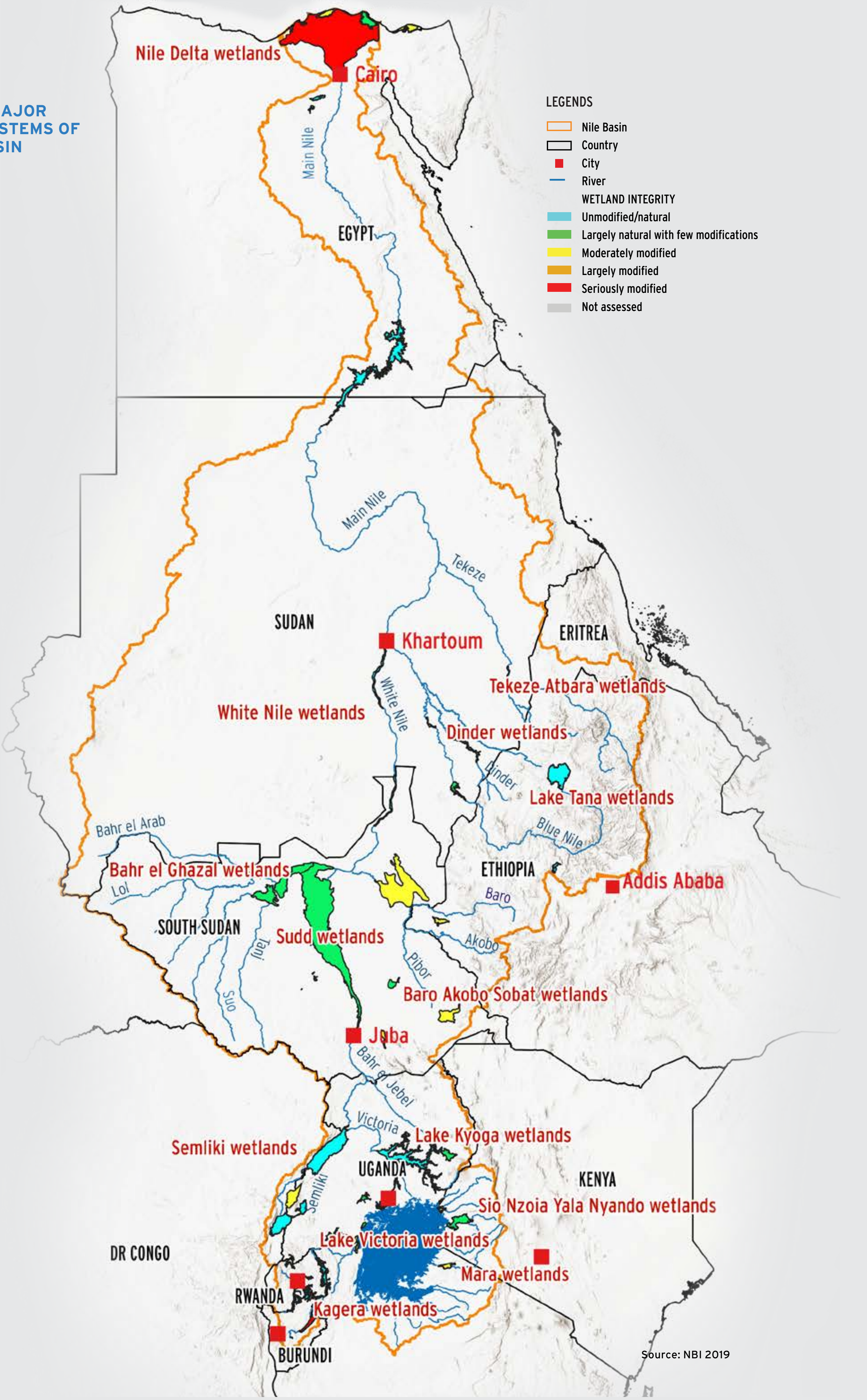
Wetlands are one of the most biologically productive ecosystems. They provide fisheries, fuelwood, and arable land, as well as various hydrologic ecosystem services (Ramsar Convention Secretariat, 2018). They moderate floods, purify water, recharge aquifers, and often supply rare sources of water for livestock or agriculture during the dry season.

TABLE 5.2: WETLAND EXTENT PER SUB-BASIN OF NILE RIVER BASIN

Sub-basin	Area (km^2 2015)	Total wetland extent (km^2)	Total wetland extent (%)	Identified overall wetland extent (km^2)	Permanent overall wetland extent (%)
Main Nile	1,027,806	9,869	1	29,332	28
Bah el Gazal	609,723	5,186	0.9	5,313	7
Blue Nile	313,861	4,320	1.4	4,671	82
White Nile	265,257	1,938	0.7	1,566	64
Lake Victoria	264,040	69,434	27	6,203	52
Tekeze Atbara	240,084	355	0.14	63	82
Baro Akobo Sobat	206,294	1,554	0.8	12,906	4
Bahr el Jebel	186,875	17,108	9	23,719	34
Victoria Nile	85,771	6,351	9	6,337	64
Lake Albert	74,920	8,977	12	10,590	78
TOTAL AREA	3,274,631	125,092	3.82	100,700	

Source: NBI 2019

FIGURE 5.1: MAJOR WETLAND SYSTEMS OF THE NILE BASIN



Source: NBI 2019

BOX 5.2: PEATLANDS

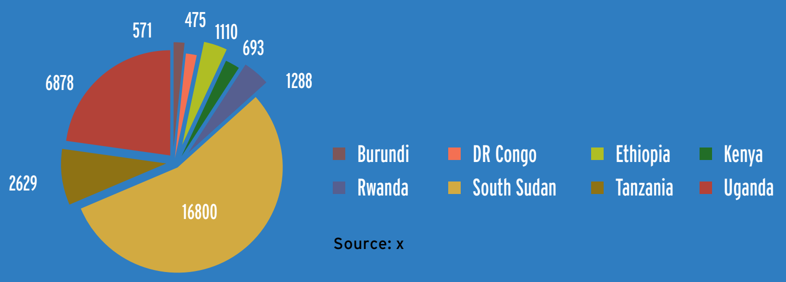
Wetlands, and particularly peatlands, also play a crucial role in the context of global warming. Peatlands are wetlands with a high content of organic soils and a water table close to the surface. While covering only 3% of the global land surface, they store more than double the carbon of all forests globally (Leifeld & Menichietti, 2018). This is why their ongoing degradation – 17 % are either destroyed or degraded globally – accounts for 5% to global anthropogenic GHG emissions (Crump, 2017).

The study "Assessment of Carbon (CO2) Emissions Avoidance Potential from the Nile Basin Peatlands", carried out on behalf of NBI (NBI, 2019c), found that the Nile Basin accommodates 30,445 km2 of estimated peatland area. This size compares to the largest described peatland complex in Amazonia, which stretches across 35,600km2 (Draper et al., 2014).

Importantly, with around 16,000 km2, peatlands in South Sudan comprise more than half of that area, as Figure 5.2 shows. The remainder of peatlands is mostly located in the Equatorial Lakes region, mostly though in Uganda and Tanzania. There are also at least 1100 KM^2 of peat in the Ethiopian part of the Blue Nile Sub-basin.

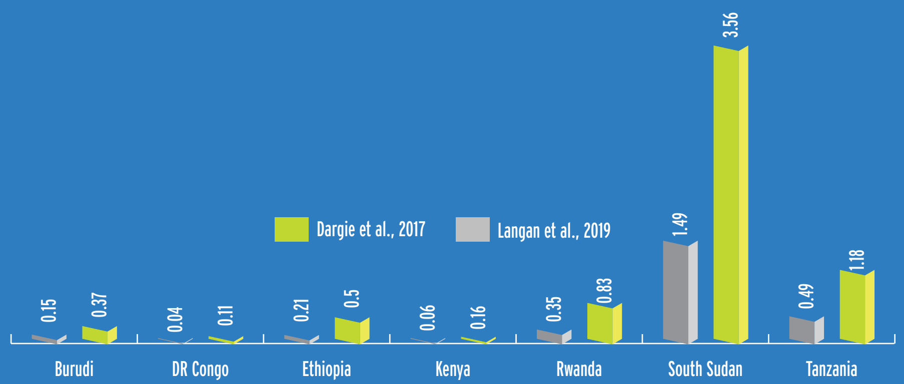
Basin-wide soil carbon stocks range between 4.2Gt and 10Gt. This may equate to 3.5-8.3% of the global tropical peatland carbon stocks (Leifeld and Menichetti, 2018). As Figure 5.2 shows the countries with the largest area also have the highest carbon stock: South Sudan (1.5 - 3.59 GtC), followed by Uganda (1.3 - 3.1 GtC) and Tanzania (0.5 - 1.2 Gt). Given their role for climate mitigation, efforts to safeguard carbon-rich wetlands in the Nile Basin can make use of global climate instruments including climate finance alongside typical conservation and management approaches.

FIGURE 5.2: DISTRIBUTION OF ESTIMATED PEATLAND AREA (KM2) WITHIN THE NILE BASIN COUNTRIES, EXCLUDING EGYPT AND SUDAN [NBI, 2019C]



Source: x

FIGURE 5.3: TOTAL CARBON STOCKS (GTC) OF PEATLANDS IN NILE BASIN COUNTRIES EXCLUDING EGYPT AND SUDAN [NBI, 2019C]. CALCULATIONS ARE BASED ON BULK DENSITY AND CARBON CONTENT VALUES OF DARGIE ET AL., 2017 (GREEN) AND LANGAN ET AL., 2019 (GREY).

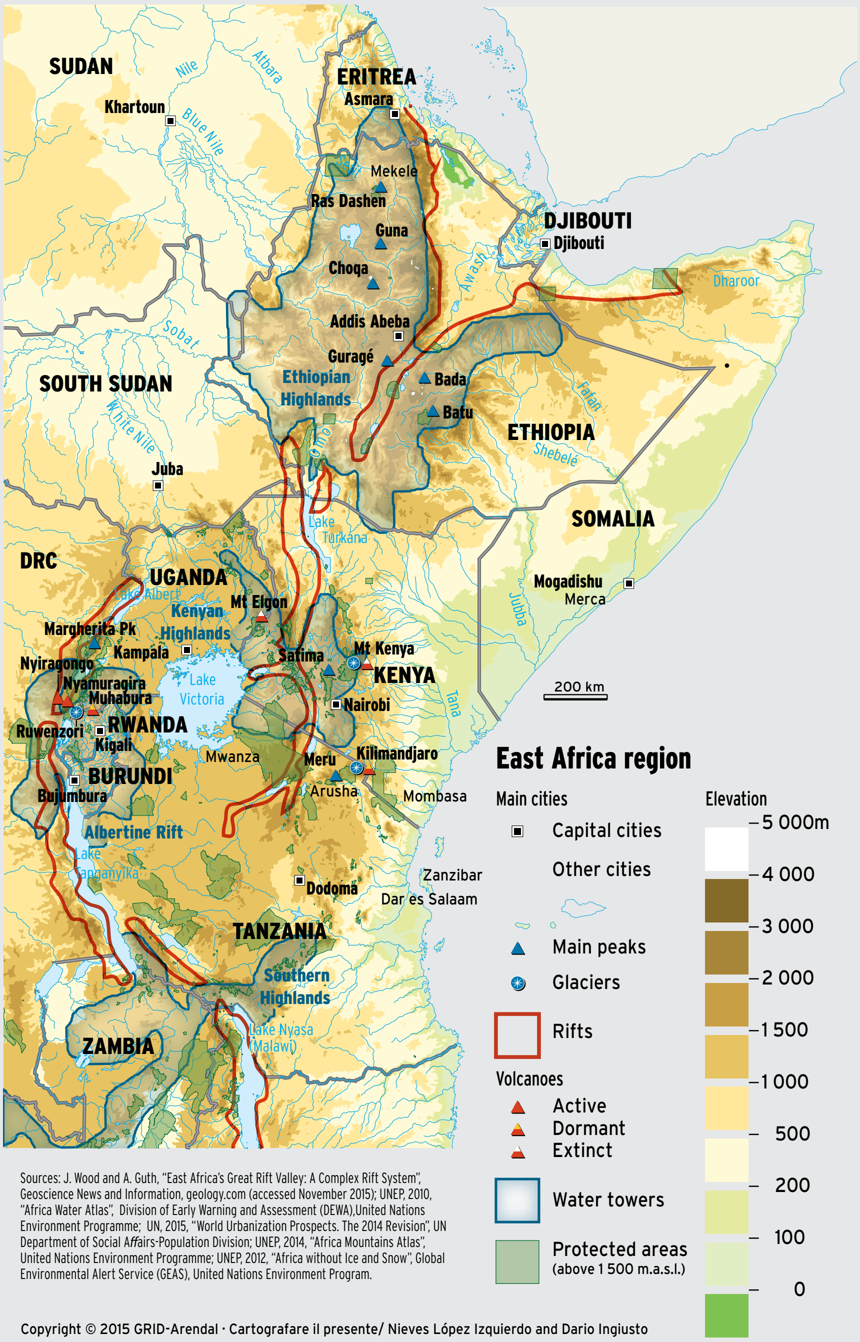


MONTANE FORESTS

Forests cover approximately 7% of the basin territory, yet exist almost exclusively in the upper parts of the basin (NBI, 2016). Montane forests function as the prime 'water towers' in the Nile Basin and East Africa. Water towers are areas in high altitude that provide significant hydrologic services in comparison with lowlands (Viviroli et al., 2007). Although the interdependencies between forests and the water cycle are complex and often misunderstood, water towers tend to generate a significant proportion of basin-wide streamflows and to sustain dry-season flows. They also elevate water quality and reduce sedimentation, moderate peak runoffs and floods, and foster infiltration and groundwater recharge (Ellison et al., 2017).

In the Nile Basin, the most important water towers are the Ethiopian Highlands, the Rwenzori Mountains, the Mau Forest, and Mount Elgon (see Figure 5.1). Given the significant runoff they create, this study focuses on these four, although there are smaller important water- source areas. The Ethiopian Highlands function as the largest water tower, generating 85% of the Nile river flows. The other three water towers are located in the equatorial zone. The Rwenzori Mountains straddle the equator along the border between Uganda and the DR Congo for about 110 km. Mount Elgon, the smallest water tower, is a dormant volcano located on the border of Uganda and Kenya. Besides their hydrologic services, the basin's water towers accommodate high levels of biodiversity and contain remnants of indigenous forest (EAC, UNEP and Grid-Arendal, 2016).

FIGURE 5.4: MAIN WATER TOWERS IN EAST AFRICA



Sources: J. Wood and A. Guth, "East Africa's Great Rift Valley: A Complex Rift System", Geoscience News and Information, geology.com (accessed November 2015); UNEP, 2010, "Africa Water Atlas", Division of Early Warning and Assessment (DEWA),United Nations Environment Programme; UN, 2015, "World Urbanization Prospects. The 2014 Revision", UN Department of Social Affairs-Population Division; UNEP, 2014, "Africa Mountains Atlas", United Nations Environment Programme; UNEP, 2012, "Africa without Ice and Snow", Global Environmental Alert Service (GEAS), United Nations Environment Program.

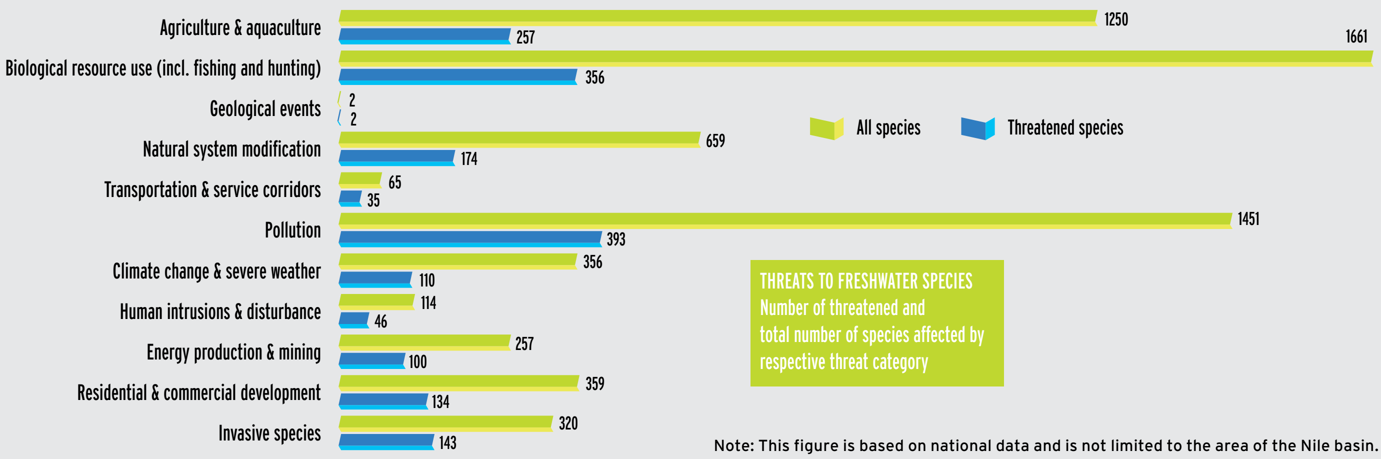
Source: Adapted from EAC, UNEP and GRID-Arendal, 2016

PRESSURES ON WATER-RELATED ECOSYSTEMS

This section will provide an overview of the current use of and pressures on the basin's natural resources, with an emphasis on water-related ecosystems. Rivers, lakes, wetlands, and forests are affected by multiple, often overlapping, pressures, which stem from the drivers described in Chapter 1. The key pressures vary between terrestrial and freshwater ecosystems or different taxonomic groups or even single species. They also change between different regions. Figure 5.5 shows the main pressures to freshwater species in the Nile Basin. This section analyses the effects of water-resource developments, land-use change, natural resource exploitation, water pollution, and invasive species, which have been found to be the main pressures affecting water-related ecosystems in the Nile Basin.

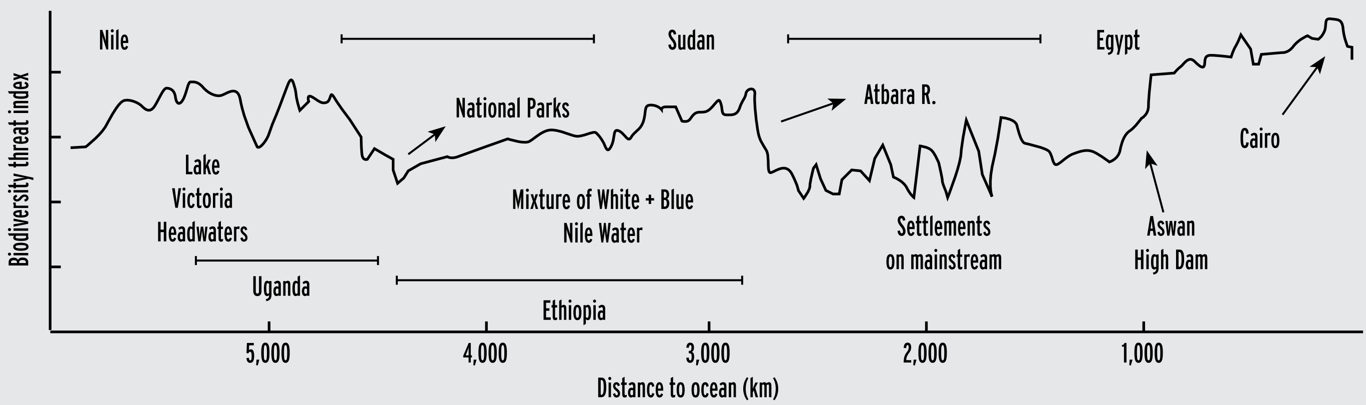
The cumulative impact of these pressures on water-related ecosystems and biodiversity in the Nile Basin tends to increase from source to sea, as depicted in Figure 5.6. Nevertheless, they fluctuate quite strongly, depending on the types and intensity of human activities in the sub-basins. Four key pressures, which have continued to intensify recently, will be analysed in more depth in this chapter. As Chapter 1 concluded, population density and economic activities appear to be the single most important forces. Discerning the relative importance of pressures and their timely development will help identify gaps in research and guide conservation and management actions.

FIGURE 5.5: DIFFERENT THREATS TO FRESHWATER SPECIES. AGGREGATE NUMBER OF SPECIES ASSESSED IN IUCN RED LIST FOR ALL NILE BASIN COUNTRIES, 2018



Note: This figure is based on national data and is not limited to the area of the Nile basin.
Source: IUCN, 2019

FIGURE 5.6: THREATS TO FRESHWATER BIODIVERSITY IN DIFFERENT TRANSECTS FROM THE NILE'S UPSTREAM AREAS TO THE RIVER MOUTH



Source: Used with permission from Springer Nature, Nature 467p 555 - 551 Global threats to human water security and river biodiversity by Vorosmarty et al 2010, Copyright c Springer Nature

WATER-RESOURCE DEVELOPMENTS

Photo: istock

Rivers, lakes, and wetlands depend on sufficient freshwater availability. If too much water is withdrawn from them, through diversions or pumping, they shrink in size or run dry altogether. Over-exploitation has become a more prominent issue in several parts of the Nile. Equally, the integrity of freshwater ecosystems depends on the natural flow dynamics, which are increasingly modified through hydraulic infrastructures.

The chapter 2 on water security demonstrated that demand for water continues to rise because of population growth and socio-economic development. This will magnify the water shortages already experienced by water-related ecosystems in some places, where human dependence on the Nile flows is particularly high. In the most arid areas, high human water demands are closely related to high numbers of threatened freshwater species (Darwall et al., 2011). Nevertheless, irrigation is expected to become more widespread as populations become more dense and require higher food yields from the same land.

The number of dams currently planned and constructed is very high compared to many other river basins in Africa (Zarfl, Lumsdon, Berlekamp, Tydecks, & Tockner, 2014). Installed capacity is forecast to grow fivefold, from 5560 MW in 2014 to 26,000 MW in 2050 (NBI, 2016). Ensuing changes in the flow regime, including fragmentation of riverine habitat and lower and less frequent floods, is an immense threat to freshwater biodiversity, as Section 5.5.1 will discuss. Moreover, dams disturb sediment supply and dynamics. Sediment loads reaching the delta have been reduced drastically compared with predevelopment levels,.

Groundwater and surface-water resources are interconnected hydrologically. Aquifers often source wetlands and rivers that overlay them. These lose key supplies of water if the aquifers become depleted. In rural areas of the Ethiopian Highlands and the Equatorial Lakes Plateau, 70% to 80% of the population is dependent on groundwater (NBI, 2012). The unsustainable groundwater use in some parts of the Main Nile Basin jeopardises freshwater ecosystems and human water security in the long term.

LAND-USE CHANGE AND EXPLOITATION OF NATURAL RESOURCES

Photo: Flore de Preneuf / World Bank

Population growth centres in the Nile Basin overlap strongly with biodiversity hotspots and the prime water towers. Increasing population density is going to further drive conversion of natural habitats into urban and agricultural land and the exploitation of natural resources in adjacent forests, wetlands, rivers and lakes.

Agriculture is one of the most prominent forces propelling the conversion of natural ecosystems in the Nile Basin. On a basin scale, it increased by 34% between 1985 and 2015, as found by a recent inventory study of important wetlands in the Nile Basin. As competition for grazing and arable land increases, people push more frequently onto land that is challenging to cultivate. For example, subsistence farmers increasingly turn to seasonally dried-up shoreline wetlands, while pastoralist herd cattle on ever-steeper slopes. The overuse of land is a prime cause for land degradation, making soils more prone to erosion and causing damage to the flora and fauna of wetlands (Rebelo and McCartney, 2012). Farming and pastoralism occurs across the basin. The density of livestock populations is particularly high in parts of Ethiopia and Kenya.

Urban land is going to expand by 600% in Africa between 2000 and 2030. Three out of Africa's five main urban-growth areas are located in the Nile Basin: the Ethiopian High-

« Agricultural water use is a key factor threatening the availability and quality of water for rivers, lakes, wetlands, and forests. »

TABLE 5.3: LAND-USE AND LAND-COVER-CHANGE STATISTICS FOR THE NILE BASIN, 1985-2015. PERCENTAGE OF TOTAL AREA BASED ON LAND COVER IN 2015

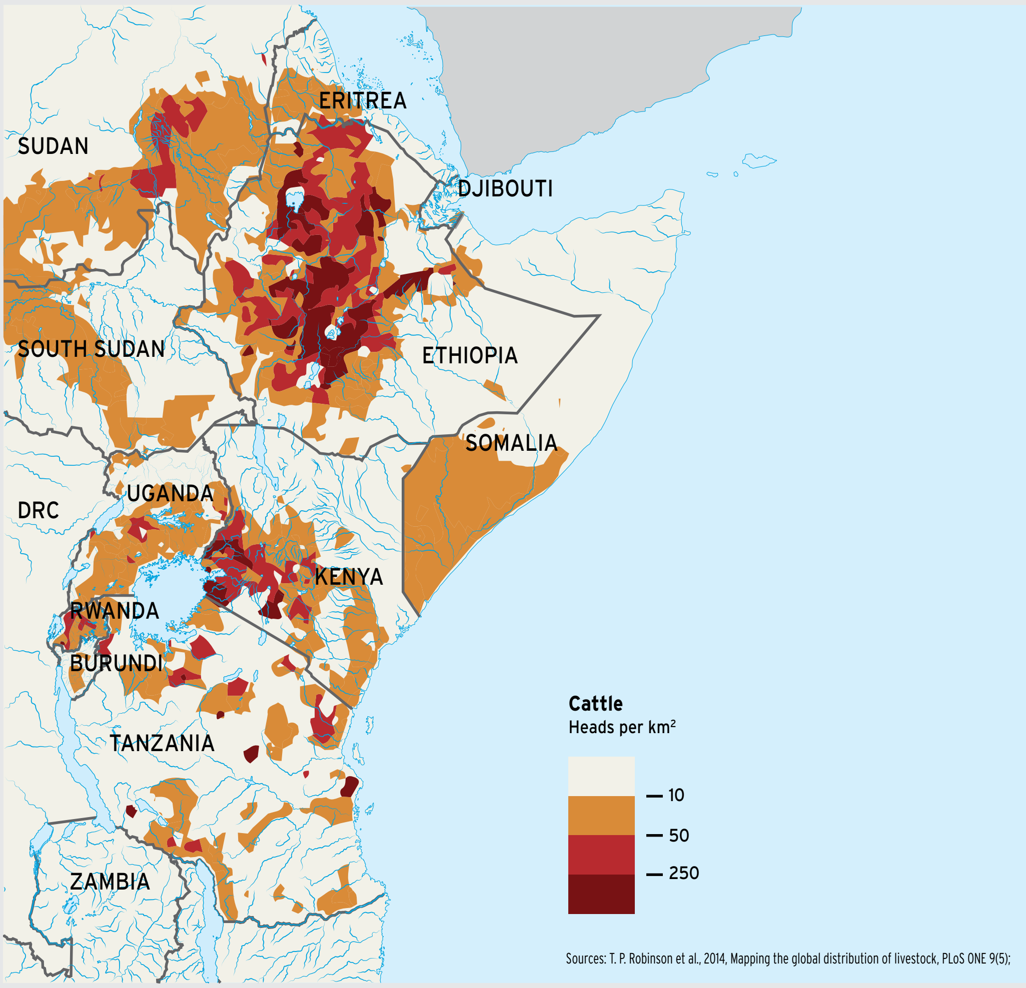
Landcover Class	1985 (km²)	2015 (km²)	Change 1985-2015 (%)	Proportion of total basin area (%)
Water	92,552	95,771	3	3
Papyrus	11,665	5,897	-49	0
Wetland grasses	10,963	8,285	-24	0
Reeds	10,371	17,329	67	1
Shrubland	1,608,712	1,024,495	-36	31
Forest	63,276	45,115	-29	1
Agriculture	527,839	1,115,463	111	34
Desert bare soil	947,307	960,339	1	29
Settlement	1,946	1,945	0[1]	0
TOTAL AREA	3,274,631	3,274,638	0	100

[1]Please note that the study focused on assessing changes in the extent of wetlands in the Nile Basin. The results for other land-uses like urban areas may not be correct, as urban areas throughout Africa are expanding rapidly (see section on urbanisation below).
Source: NBI, 2019

lands, the Nile Delta and Nile Valley, and the Equatorial Lakes Plateau (Seto et al., 2012). These are evolving close to many areas that feature exceptional biodiversity and provide hydrologic ecosystem services. Further encroachment on them is expected to occur rapidly. The urban land within 50 km of protected areas on the Equatorial Lakes Plateau (including the region around Lake Victoria) will increase from 5,425 km2 to 107,110 km^2 between 2000 and 2030 (Güneralp, Shuaib Lwasa, Masundire, Parnell and Seto, 2017). Large-scale infrastructures linking cities will further close in on or criss-cross large numbers of biodiversity hotspots, for example in the Albertine Rift (Laurence, Sloan, Weng and Sayer, 2015).

Population growth is not only resulting in water-related ecosystems being converted to make space for urban areas and farming. More people means increased competition for natural resources such as fish or fuelwood. Overfishing is one of the principal drivers for declines of fisheries in the basin's wetlands and major lakes (Dejen, Anteneh, & Vijverberg, 2017). All water bodies except the Sudd wetlands are subject to overfishing (Rebelo and McCartney, 2012). While rural electrification rates have notably increased, including the period 2012 to 2017, in some areas over 90% of the population still relied on fuelwood. The growing need for fuelwood has led to tree-cutting in riparian woodlands, forested wetlands, and mountain forests. Loss of vegetation can undermine plant productivity and, in turn, the hydrologic services they provide, such as the provision of dry-season flows or groundwater recharge.

FIGURE 5.7: NILE BASIN COUNTRIES WITH A HIGHEST DENSITY OF LIVESTOCK POPULATIONS, 2014



Source: EAC, UNEP and Grid-Arendal, 2016

WATER POLLUTION FROM AGRICULTURAL RUNOFF, WASTEWATER, AND SOIL EROSION

Photo: Shutterstock

Water pollution is increasingly becoming a concern for freshwater ecosystems throughout Africa (Darwall et al., 2011). This is also the case in some parts of the Nile Basin, whereas large sections of it also show relatively good water quality. Although the data availability is generally poor, large stretches of the White Nile between Uganda and Sudan may be in a good condition, too. Given that large parts of the basin exhibit low levels of industrialisation, chemical pollution is a concern in only a few areas, mainly in large urban and industrial centers. The pollution sources with the most severe effects on freshwater ecosystems are nutrients from untreated sewage and fertilizer and sediment carried by runoff.

Rising levels of eutrophication are most prominently observed in major lakes. Eutrophication causes uncontrolled algae growth and depletes oxygen levels, thereby increasing mortality in freshwater organisms, simplification of plant communities, and the spread of invasive species (Sayer et al. 2018). It is most commonly caused through phosphorus and nitrogen, which stem from untreated sewage discharged into open waters around growing urban centres, and agricultural return flows containing fertiliser, trends which are expected to continue. Lake Tana, for example, has gradually moved from moderate to high levels of eutrophication (Goshu, Koelmans, and Klein, 2017). Water quality in Lake Victoria has continued to decline, mainly because of intensifying eutrophication (Njiru, van der Knaap, Kundu, & Nyamweya, 2018).

High sediment loads from degraded lands are being washed with runoff into lakes, rivers, and wetlands. There, they lead to siltation of spawning habitats in lakes, wetlands, and rivers or increased levels of turbidity. For example, the soil loss rate around Lake Tana is high and has substantially increased over recent years (Vijvberg, Sibbing and Dejen, 2009). Many aquatic species have low tolerance to increased turbidity and sedimentation levels, and are suffering population declines as a consequence. In Lake Victoria, for example, soil erosion and sedimentation are a threat to 89% of the freshwater species (Sayer, Maíz-Tomé, and Darwall, 2018).

INVASIVE SPECIES

Invasive species are the second-largest threat to biodiversity globally (Bellard, Cassey, & Blackburn, 2016). In the Nile Basin, they are becoming increasingly common, although some species have been around for several decades. As regional and global trade becomes more globally connected, species spreading outside their natural range will become more pervasive.

Water hyacinth is one of the most prominent examples. It is an exotic free-floating plant from South America now found in the entire Nile Basin. Its thick, floating mats are associated with multiple damages, among them a significant freshwater biodiversity loss and lower fish catches (Howard and Matindi, 2003).

To cope with population declines of native fish triggered by overfishing, several exotic fish species, including the Nile Perch, were introduced to Lake Victoria in the late 1950s. The subsequent spread of the Nile Perch has contributed to the extinction of at least 200 cichlid species (Witte et al., 2007). The species loss in Lake Victoria is the largest to have afflicted any aquatic ecosystem (Sayer, Maíz-Tomé, and Darwall, 2018). Originally, cichlid species accounted for 80% of the catch. Their share has almost entirely been replaced by growing populations of Nile Perch. However, while peaking around 2000, catches of Nile Perch have more than halved since then, due to overfishing. Simultaneously, cichlid populations have started to recover since around 2003 (Njiru et al., 2018).

BOX 5.3: DEFINITION OF INVASIVE SPECIES

Invasive species are plants, animals, and microorganisms that occur outside their natural range. They are introduced intentionally for economic or agricultural purposes, or accidentally, through tourism, travel, or trade. Invasive species may originate from foreign lands or from a different part of the same country or region. Once introduced, invasive species may spread very fast and threaten the survival of native species (NBI, 2012).

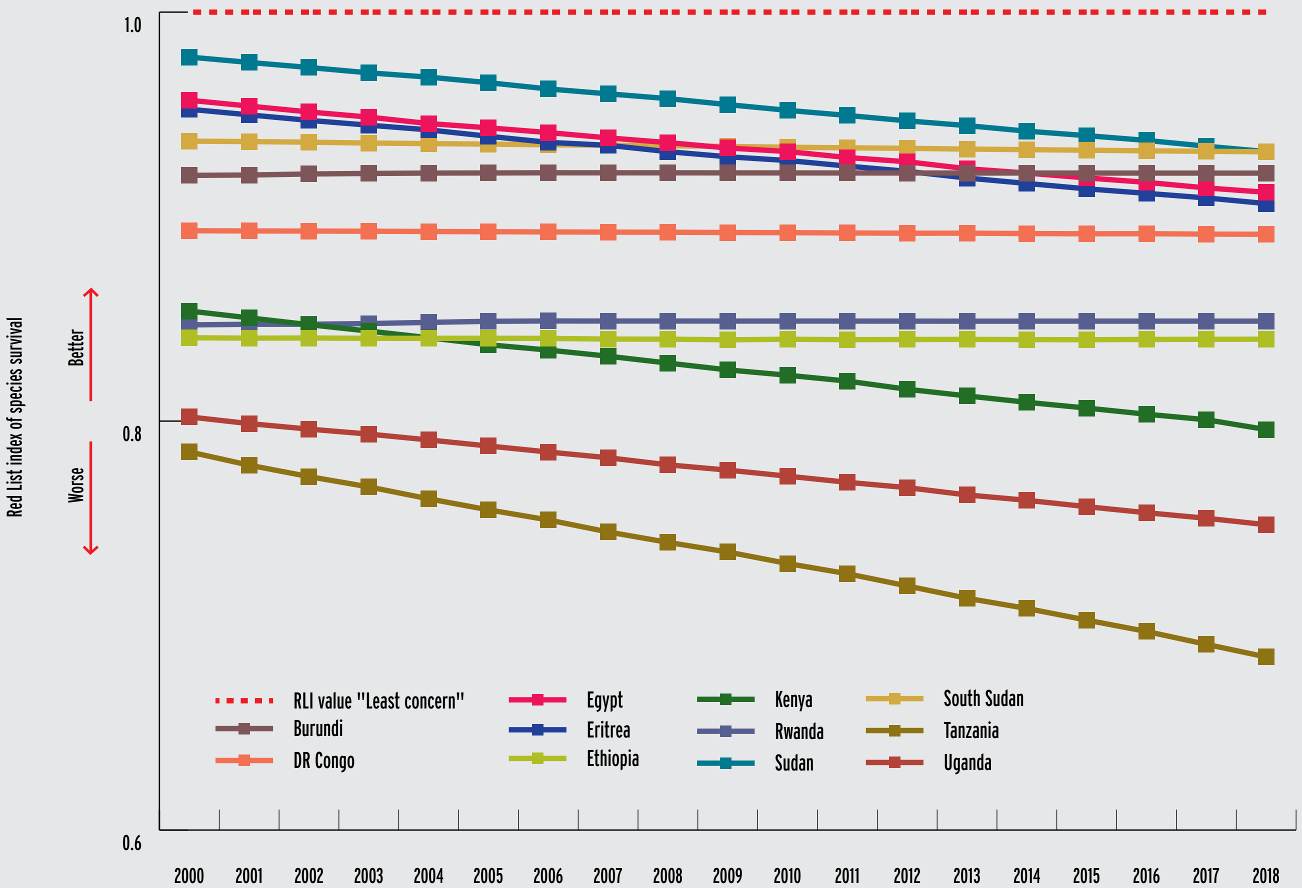
THE STATE OF WATER-RELATED ECOSYSTEMS

Changes in aquatic and terrestrial ecosystems have been apparent since 2012. The general lack of time-series data means that trends can only be measured for a few major ecosystems. In most of those, declines of habitats and species populations due to human activities are evident. Land-cover changes indicate that natural environments are increasingly being turned into urban and agricultural land. The IUCN Red List Index Values in Figure 5.8 shows that the number of threatened species has increased in almost all Nile Basin countries. While national-level data may say little about the state of single lakes or wetlands, it signals that many of them are undergoing serious decline.

Some Nile Basin countries have a particularly high number of threatened species. Most of them are found in Tanzania, followed by Kenya and DR Congo (Section 5.10 Appendix II). This means that a high proportion of species face extinction in these countries. But the equatorial countries also accommodate more species compared to other African countries. The number of threatened freshwater species is particularly driven up by the aforementioned high number of threatened fish species in the Great Lakes (Darwall et al., 2011).

« A lack of data makes it difficult to determine the state of ecosystems, key threats, and effective solutions. »

FIGURE 5.8: RED LIST INDEX FOR FOUR TAXONOMIC GROUPS (BIRDS, MAMMALS, AMPHIBIANS, AND CORALS), 2000-2018



*Note: This figure is based on national data and is not limited to the area of the Nile basin.

Source: IUCN, 2019

« Changes of riverine ecosystems are likely to increase as further dams and irrigation projects are completed. »

Photo: istock

The ecological state of rivers in the Nile Basin varies. A recent environmental flow assessment commissioned by NBI (2019) which is the most comprehensive so far, shows that the flow conditions in nine river reaches across the basin have been modified, yet most of them were still found to be largely natural. That is, they carry roughly the same amount of water at different times of the year like they did before humans started to extract water from them or impounded them through dams. It is important to note that these nine reaches are not representative of the whole river network in the Nile Basin.

In fact, humans have fundamentally altered rivers in several places that are not covered in the above study. These have come to affect freshwater ecosystems, most notably of the lower Main Nile. The flow reaching the delta is only a small fraction of the original volume (Redeker and Kantoush, 2014), while the delta channel network, which once sustained a vast system of wetlands, has decreased substantially (Syvitski et al., 2009). But flow-related impacts caused by water withdrawals or unsustainable land use are also apparent in some rivers in the headwaters. Large-scale deforestation in the Mau Forest, for example, has rendered some rivers in the water tower seasonal, reduced their dry-season flows, and increased floods (Mango et al., 2011).

Already, around the year 2000, the Nile's flow regime was assessed as 'strongly impacted' by dams (Nilsson, Reidy, Dynesius,

BOX 5.4: ENVIRONMENTAL FLOWS

Modifications of the flow regime in the Nile Basin have had considerable impacts on freshwater ecosystems, as demonstrated earlier in this chapter. The term environmental flows is now widely used to describe 'the quantity, timing, and quality of freshwater flows and levels necessary to sustain freshwater ecosystems which, in turn, support human cultures, economies, sustainable livelihoods, and well-being' (Arthington et al., 2018). When implemented, for example as part of a basin-wide water management plan or in the wake of designing and operating dam projects, they can substantially lower damage caused to rivers and wetlands. Furthermore, the establishment of environmental flows is an important prerequisite to enhancing the resilience of freshwater ecosystems and protecting them under a changing climate (LeQuesne et al. 2010).

& Revenga, 2005). At the present time, few of the major tributaries remain free-flowing. Going from south to north dams disrupt river flows more frequently (Grill et al., 2019). Information on dam-based impacts for freshwater ecosystems and biodiversity in the Nile Basin is scarce and fragmented, yet they are known about from other studies (Vörösmarty et al., 2010), and can be expected to have materialised in similar ways in the Nile Basin. For example, an assessment led by García et al. (2010) found that the Main Nile features a very high number of extinct freshwater species, most of which are fish. The Aswan High Dam is viewed to be the main cause of the extinction of these fish species, as it impedes riverine migration routes and reproduction cycles. Moreover, nutrient-rich silt coming down the river was reduced markedly because of the dam and is viewed to have caused a 83% decline in annual sardine harvest in the eastern Mediterranean (McAllister, Craig, Davidson, Delany and Sneddon, 2001).

Changes of riverine ecosystems are likely to increase as further dams and irrigation projects are completed. While the discharge of the headwater tributaries is projected to increase as a consequence of climate change, growing demands could take up a lot of that surplus, eventually further reducing flows of the Main Nile (Siam & Eltahir, 2017). Especially where dams have already disrupted the natural dynamics of flow and sediment, climate change is expected to intensify flow-related effects on freshwater ecosystems (Palmer et al., 2008). The impacts of climate change on the hydrology of the Nile and, in turn, its freshwater ecosystems are analysed in Chapter 6.

Like rivers, many of the basin's lakes face high pressures from human activities including pollution and overexploitation of resources. This is causing a decline of freshwater biodiversity, with the risk of species extinctions continuing to increase. Lake Victoria has the second-highest number of threatened species among Africa's lakes: 20% of its species are threatened, most being fish (Sayer, Maíz-Tomé, and Darwall, 2018). In Lake Tana, the total catch of the three commercially most important fish species dropped from 177 kg/per trip in 1993 to 56 kg/trip in 2010 (Dejen et al., 2017). In Lake Victoria, commercial fisheries have been declining as well (Njiru et al., 2018). As the underlying causes, such as overfishing and eutrophication, are projected to intensify, it has to be assumed that fish stocks will continue to decline, putting more and more livelihoods at risk. The decline of fish populations is raising concern, given their role in the basin's food security. The four Nile Delta lakes provided 35% of Egypt fish catch during the 1970s, which has plummeted to 17% in recent times. 28% of the species fished in Egypt's inland water face the risk of extinction, while three have already become extinct (Juffe-Bignoli & Darwall, 2012).

Photo: istock

WETLANDS

Photo: Shutterstock

Between 1970 and 2015, the extent of wetlands in Africa declined by 42% (Darrah et al., 2019). Many of the Nile Basin's major wetlands have been lost or are under pressure. A recent study showed that some wetland land cover classes have decreased by approximately 35% between 1985 and 2015 (NBI, 2019)[2]. This has been manifested in considerable loss of habitat and declining populations of freshwater species, with negative impacts for fisheries and other human uses. These trends are likely to persist. However, it is important to note that loss and degradation of wetlands has been

TABLE 5.4: WETLANDS OF INTERNATIONAL IMPORTANCE (RAMSAR SITES) IN THE NILE BASIN

Country	Ramsar Site	Area (ha)
DR Congo	Virunga National Park	800,000
Egypt	Lake Burullus	46,200
Rwanda	Rugezi - Bulera- Ruhondo	6,376
South Sudan	Wetland	5,700,000
Sudan	Dinder National Park	1,084,600
Uganda	Lake Bisina System	54,229
	Lake George	5,000
	Lake Mburo- Nakivali System	26,834
	Lake Nabugabo System	22,000
	Lake Nakuwa System	91,150
	Lake Opeta System	68,912
	Lutembe Bay	98
	Mabamba Bay	2,424
	Murchison Falls-Albert Delta	17,293
	Rwenzori Mountains	99,500
	Sango Bay-Musambwa Island-Kagera Wetland System*	55,110

Source: NBI, 2019c

*Tanzania is in the process of enacting Minziro Forest as a Ramsar site and therefore this will become a transboundary Ramsar Site

[2]Wetland extent is comprised of the land cover classes reeds, wetland grasses, and papyrus. While this study represents the first of its kind to provide estimations about changes in the extent of wetlands in the Nile Basin over an extended time period, these trends should be considered with caution due to data gaps as well as certain weaknesses inherent to remote sensing.

much more significant in several places, developments which are often linked to rapidly increasing population density. Uganda, for example, lost 30% of its wetlands between 1994 and 2008. Around Lake Victoria, the loss of wetlands was as high as 50% (MWE, 2016). In urban areas such as Kampala and Entebbe, wetland loss has accelerated in more recent years (Magumba et al., 2014). The size of the Nile Delta's major lagoons was dramatically reduced between 1975 and 2005. Lake Manzala, Egypt's largest lagoon, lost 27% of its open-water habitats and 16% of its wetlands in that period, while the Sinnére and San El-Hagar lagoons lost 99.9% of their original extent (Mediterranean Wetlands Observatory, 2014). Other wetlands, for example the Sudd, have experienced only minor habitat loss (attributed to civil war and political instability so no serious sedentary livelihoods), although agricultural activity has strongly intensified there since 1985 (NBI, 2019).

Clear trends with respect to the condition of the remaining wetlands are hard to derive. A recent study by NBI (2019) has assessed the ecological state of key wetlands in the basin using the Wetland Integrity Score. Its key findings being presented in Table 5.6 (on next page), it concludes that the majority of these wetlands are still in acceptable ecological category (B/C or higher), with only a few wetlands having low integrity scores that are considered ecologically unacceptable (D/E or below). The condition of 12 out 16 that were assessed has improved or remained stable between 1985 and 2018. However, it is important to note that several of these scores it is important to note that although some of these scores seem high, partly due to the spatial data[3], they have been fluctuating strongly but also because they have been fluctuating strongly in the time period under assessment. Studies, for example on the wetlands in Ethiopia (Seid, 2017) or around Lake Victoria (LVBC and Grid-Arendal, 2017), confirm that some wetlands in the Nile Basin are actually under severe pressure from human activities.

TABLE 5.5: ECOLOGICAL STATE OF RAMSAR SITES AND OTHER WETLANDS. DATA RETRIEVED FROM CONFERENCE OF THE PARTIES (COP) REPORTS

		Burundi	DR Congo	Egypt	Eritrea	Ethiopia	Kenya	Rwanda	South Sudan	Sudan	Tanzania	Uganda
COP11 (2009- 2012)	Ramsar sites	↓	↓*	=	n/a	n/a	=	↑	↓*		↓*	↑
	Wetlands generally	=	n/a*	↑	n/a	n/a	↓	↑	n/a*		n/a*	↑
COP12 (2012- 2015)	Ramsar sites	↑	↓	=	n/a	n/a	↑	↑	=	=	↓	↑
	Wetlands generally	↓	↓	↑	n/a	n/a	=	↑	=	=	↓	=
COP13 (2015- 2018)	Ramsar sites	=	↓	↑	n/a	n/a	=	↑	n/a	=	n/a	↑
	Wetlands generally	↓	↓	=	n/a	n/a	=	↑	n/a	↑	n/a	↑

Source: Ramsar Convention of Wetlands, 2018b

Status of Ramsar sites and Wetlands: Improved (↑); No change (=); Deteriorated (↓); No data available (n/a)

Note: In some of the COP 11 reports, data was ambiguous, which is displayed here with *.
No reports were available for Eritrea and Ethiopia as they are not signatories to the Ramsar Convention.

[3]It is known that agriculture, in particular, which largely drives the deterioration of integrity, can be difficult to discern in land use categorisation and is hence often underestimated. This would translate into an inflated integrity score. Nevertheless, this simple integrity score calculation facilitates the relative comparison of different scenarios and how they might affect wetland integrity.

TABLE 5.6: THE WITHIN-WETLAND INTEGRITY SCORES FOR MAJOR NILE BASIN WETLANDS

	Integrity Scores	
Wetland	1985	2018
Bahr el Ghazal	0.79	0.79
Dinder Floodplain	0.80	0.50
Kagera Swamps	0.87	0.96
Kyoga Kwania Swamp Complex	0.92	0.93
Lake Edward	0.98	0.98
Lake George	0.79	0.93
Lake Tana	0.98	0.97
Machar Marshes	0.78	0.78
Mara Wetland	0.74	0.76
Nyando	0.58	0.65
Nzoia River	0.66	0.76
Semliki Valley Wetlands	0.58	0.67
Sio Siteko	0.66	0.40
Sudd	0.86	0.87
The Nile Delta	0.39	0.35
Yala Swamp	0.63	0.78

A	>92-100
A/B	>88 - ≤ 92
B	>82 - ≤ 88
B/C	>78 - ≤ 82
C	>62 - ≤ 78
C/D	>58 - ≤ 62
D	>42 - ≤ 58
D/E	>38 - ≤ 42
E	20 - ≤ 38
F	<20

A Unmodified
B Largely natural with few modifications
C Moderately modifies
D Largely modified
E Seriously modified
F Extremely modified

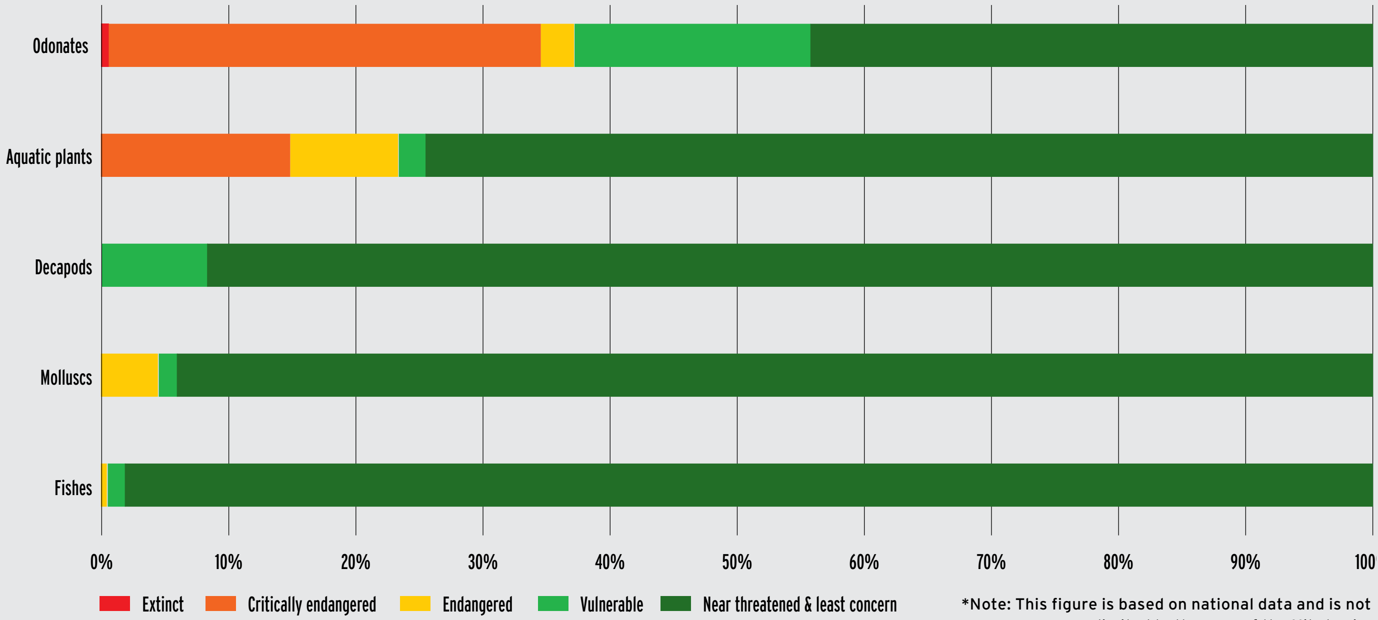
Source: NBI, 2019c

The papyrus wetlands around Lake Tana, the largest wetland complex in Ethiopia, are heavily exploited for fibre and firewood (Vijvberg, Sibbing and Dejen, 2009), as confirmed through reporting made for Ramsar (Table 5.7). The number of non-Ramsar wetlands that have deteriorated has grown over the last three reporting cycles. Trends regarding the state of Ramsar sites are more positive, with steady improvements being reported in Rwanda and Uganda. The Nile Delta, too, is undergoing severe deterioration. Due to the almost entirely reduced sediment supply, the Delta is sinking rapidly, in some areas near the Mediterranean by almost 1 cm a year. Sea-level rise of one metre could absorb 32% of the delta area and jeopardise a major share of the delta's freshwater resources due to seawater intrusion (Bohannon, 2010).

Habitat loss and deterioration of wetlands has noticeable impacts on their biodiversity. As wetlands fringe many rivers and lakes in the Nile Basin, some freshwater species may thrive (and be threatened) in several or all of these ecosystems. A recent study by NBI has assessed critically endangered and endangered species in the basin's most important wetlands, the number of which is highest for those along the Mara River and the Sio Nzoia Yala Nyando (See Table 5.7). This is because in all of them many of their large numbers of fish species are threatened (McKenzie and Harrison, 2019).

FIGURE 5.9: AN ASSESSMENT OF THE EXTINCTION RISK TO 651 FRESHWATER SPECIES IN LAKE VICTORIA, 2018

THREATENED FRESHWATER SPECIES IN LAKE VICTORIA: Of 651 freshwater taxa assessed, the most globally threatened are fish (55%), followed by molluscs (26%), decapods (8%), aquatic plants (6%) and odonates (2%).



*Note: This figure is based on national data and is not limited to the area of the Nile basin.
Source: Sayer, Maíz-Tomé, and Darwall, 2018

TABLE 5.7: THREATENED SPECIES IN MAJOR WETLANDS OF NILE BASIN

Wetland	Critically Endangered	Endangered	Near Threatened	Vulnerable	Conservation Dependent
Bahr el Ghazal	3	5	13	11	5
Baro/Akobo Sobat Wetlands (Machar Marshes)	1	5	17	13	7
Dinder	4	4	16	13	5
Kagera	3	5	19	10	4
Lake Kyoga	3	7	18	9	1
Lake Tana	3	4	15	17	
Lake Victoria	58	20	37	49	5
Mara	47	8	16	31	2
Nile Delta	5	7	19	6	
Semliki	5	13	32	18	4
Sio Nzoia Yala Nyando	50	10	20	36	1
Sudd	4	5	17	15	6

Source: Sayer, Maíz-Tomé, and Darwall, 2018

FORESTS

Photo: Shutterstock

« Between 1985 and 2015, the basin wide forest area decreased by 29%. »

The extent of the remaining forest cover in the Nile Basin countries varies substantially, from less than 1% in Egypt to around 65% in DR Congo (Section 5.9: Appendix I). A similar picture emerges for the basin's three water towers. Less than 3% of the original forest cover remains in the Ethiopian Highlands. There, the bulk of deforestation occurred between 1900 and 1980. During that period, tree cover in relation to the total land area declined from 40% to 3.2% (Eshetu, 2014). Mount Elgon has lost one-fifth of its original forest cover (Mugagga, Kakembo, & Buyinza, 2012).

Between 1985 and 2015, basin-wide forest area decreased by 29%. Deforestation rates are still high in some countries, while half have gained more forest than they lost recently. However, there is evidence of continued forest loss in many parts of the basin[4]. Uganda's forest cover declined from 19% to 7% between 2000 and 2016. This is problematic since the country's forests lie entirely in the basin and are hence important for the regional hydrology (see Section 5.10 Appendix III). DR Congo is considered one of the three most rapidly emerging deforestation hotspots globally, with rates having increased by a factor of 2.5 between 2010 and 2014. New deforestation hotspots in DR Congo also scatter the area along the entire border with Uganda (Harris, Goldman, Gabris, Nordling, & Minnemeyer, 2011), which belongs to the water tower of the Albertine Rift. Population growth will further drive the expansion of agriculture and urban areas, as well as the need for forest products. Even in Ethiopia, where the forest cover is less than 3%, the deforestation rate remains as high as 0.8% a year (Eshetu, 2014).

[4]From the vantage point of forest conservation, it is critical to differentiate between the types of forests that are lost and gained over time. An overall increase of forest cover may be achieved through new forest plantation, while primary or intact forest habitat is lost at the same time.

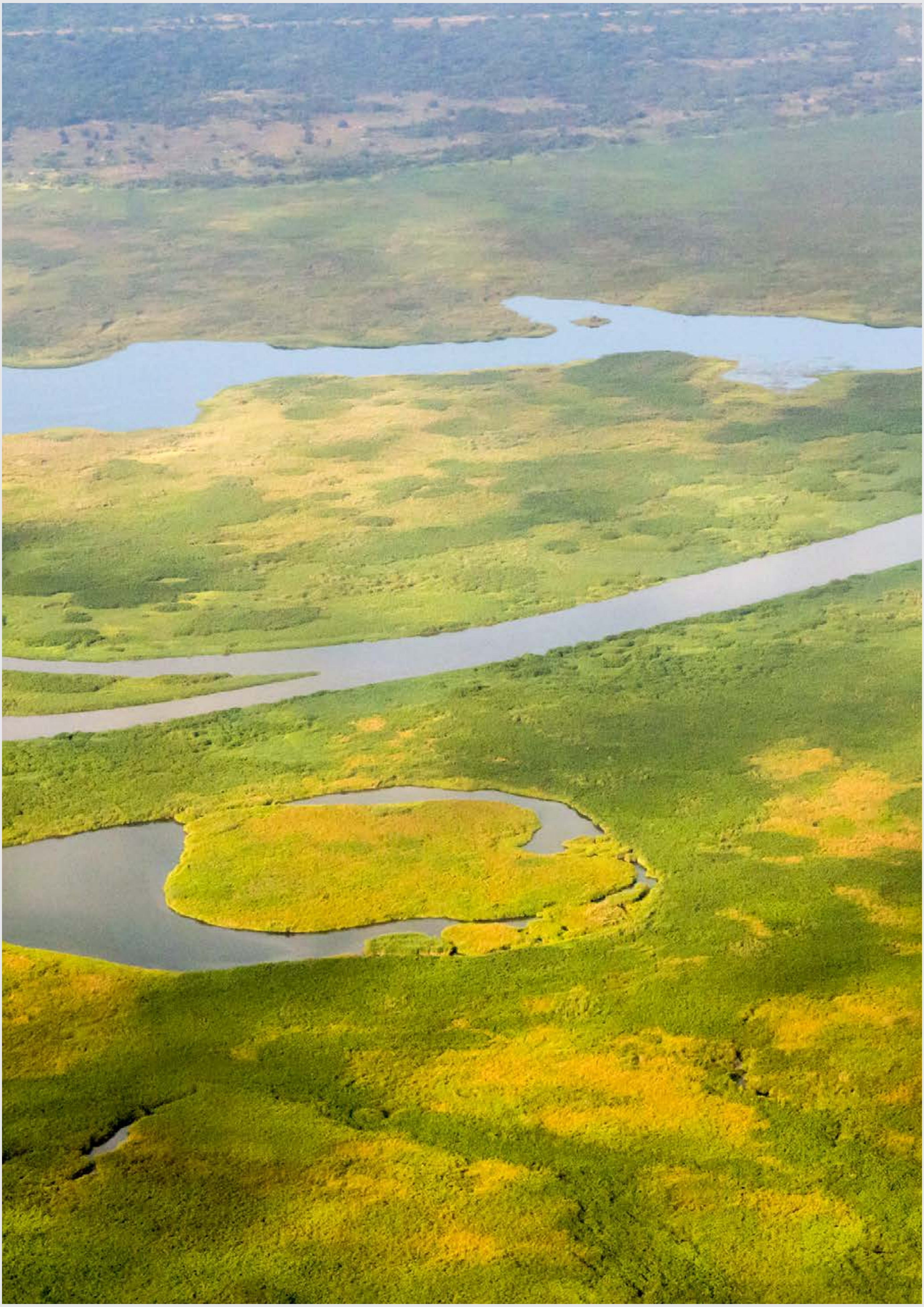
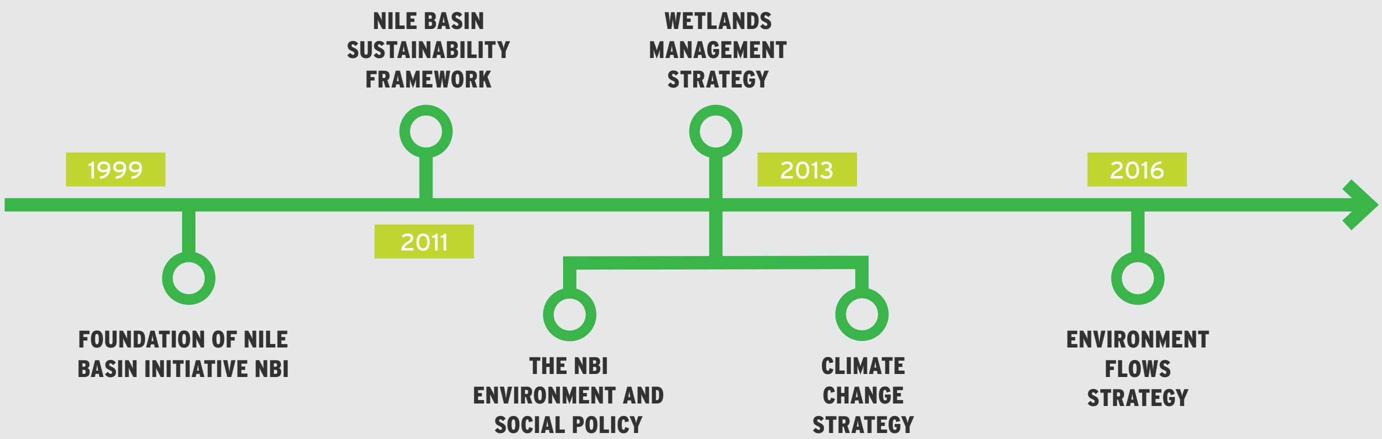


Photo: Shutterstock

RESPONSES

This section evaluates past and current actions taken at the transboundary and national level against the threats facing water-related ecosystems. It considers institutional and governance arrangements, and policies, yet sets emphasis on actions related to conservation and water-resources management.

FIGURE 5.10: TRANSBOUNDARY POLICIES FOR ECOSYSTEM AND NATURAL RESOURCE MANAGEMENT DEVELOPED THROUGH NBI



INSTITUTIONS AND GOVERNANCE MECHANISMS FOR THE PROTECTION OF WATER-RELATED ECOSYSTEMS

Like most transboundary river basins, the Nile Basin's natural resources are not governed by an entity with supranational legal competencies. NBI is a basin-wide institution that coordinates the management and development of water and natural resources. NBI's governance framework and objectives draw on and are complemented by the laws and policies of its member states, and those of other regional institutions. NBI member states, furthermore, have signed and are committed to a range of global conventions and policies.

TRANSBOUNDARY POLICIES OF THE NILE BASIN INITIATIVE

The Nile Basin Sustainability Framework (NBSF) (NBI, 2011) functions as the overarching 'conceptual structure and organisational mechanism for achieving sustainability'. The NBSF defines four Key Strategic Directions (KSD). Each of them proposes interventions (including policies, strategies, and guidelines) for pursuing its broader objectives.

Between 2012 and 2018, the NBI added several key policy documents with respect to safeguarding the basin's water-related ecosystems. The Environment and Social Policy (2013) sets out broad objectives, principles and policy areas for transboundary natural resource management, including those for biodiversity and wetlands. The strategies for wetlands (NBI, 2013) and for environmental flows (NBI, 2016) are much more specific in how broad objectives are to be implemented.

The latest policies mark important achievements to manage the Nile's natural resources and ecosystems cooperatively. They address important topics yet cover only a few areas in need of transboundary policies. Transboundary strategies are required for the management of freshwater ecosystems and biodiversity, and for soil erosion and

Photo: NBI

sedimentation, especially in the water towers. Transboundary strategies, furthermore, need be aligned with national policies and entail implementation frameworks with clearly assigned roles, responsibilities and timeframes, and need to be grounded in the views elicited in multi-stakeholder participation processes.

RELATIONSHIP WITH GLOBAL AND REGIONAL INSTITUTIONS AND POLICIES

With respect to freshwater ecosystems, the Ramsar Convention on Wetlands – the most important international initiative on wetland protection – provides the framework for national action and international cooperation. All Nile Basin states except Ethiopia are currently signatories to the convention. Equally relevant is the Convention on Biological Diversity (CBD), which deals with all matters concerning the preservation of biodiversity. All Nile Basin countries have signed the CBD, with South Sudan ratifying the Convention in 2014. Other important conventions include the World Heritage Convention (WHC), Convention on the Conservation of Migratory Species of Wild Animals and the African Convention on the Conservation of Nature and Natural Resources.

There exist a range of regional governance frameworks. The most important ones include the East African Community (EAC), the Intergovernmental Authority on Development (IGAD), the African Union (AU), and the Lake Victoria Basin Commission (LVBC). NBI is collaborating with these organisations. While their strategic goals and thematic priorities vary, they all deal with natural and water-resource issues. Their policies offer effective vehicles for addressing issues such as wetlands and biodiversity.

Initiatives such as IGAD's Strengthening Transboundary Water Governance or LBVC's Environment Programme have been vital in driving actions to protect the environment (LVBC and Grid-Arendal, 2017). Provisions on specific issues such as wetlands and or water towers are rare, as of yet. Existing policies and initiatives usually lack legal leverage. For example, while the EAC's Protocol on Environment and Natural Resources Management or the Greater Virunga Transboundary Collaboration are promising tools, they have not, or have only partially, been signed. Lacking a legal mandate, they remain ineffective. To unleash the potential of regional governance, it will be crucial to develop and implement policies and governance mechanisms for transboundary ecosystems.

« The future health of water-related ecosystems depends on careful planning and management of water resources and well-designed conservation activities at the basin scale. »

NATIONAL LEGISLATION AND POLICIES

Many Nile Basin countries have policies and legislation for natural-resource management in place, including legislative provisions to carry out environmental impact assessments for water-resource development projects. However, the robustness and comprehensiveness of the policies and laws vary between the Nile Basin countries. The majority of them also have environmental agencies that deal with cross-cutting and inter-sectoral environmental matters (Birdlife International, 2012).

Policy and legal provisions relevant to sustainably managing water-related ecosystems are less common and, if existent, often fragmented. Only Kenya and Tanzania have entrenched environmental flows in national policies and legislation (McClain, 2012). Wetland policies exist only in Uganda and Kenya. However, existing legal and policy provisions, such as for wetlands or mountain forests, generally have substantial weaknesses. They fall into different sectoral laws and policies and different governmental and administrative bodies are responsible for enforcing them. These often have insufficient authority and power or conflicting mandates (EAC, UNEP and GRID-Arendal, 2016; Materu et al., 2018).

Moreover, the enforcement of laws and policies, is often weak, being constrained by a general lack of human and financial resources, data, political instability, or corruption (Osipova et al., 2017). Another cause can be insufficient high-level political support. There are multiple cases where protected areas are not being properly gazetted and therefore lack legal backing (Birdlife International, 2012). In other cases governments neglect environmental policies, for example as environmental objectives collide with interests for developing natural resources in protected areas (Watson, Dudely, Segan, and Hockings, 2014).

REGIONAL AND NATIONAL CONSERVATION AND MANAGEMENT RESPONSES

CONSERVATION OF WATER-RELATED ECOSYSTEMS THROUGH PROTECTED AREAS

Protected areas are a cornerstone strategy for biodiversity conservation. When protected, ecosystems are less likely to suffer from pressures caused by human activities close to or within them (Reis et al, 2017). Their importance as refuges is increasing as many threatened species remain only inside protected areas, including the Nile Basin (McClain, 2012; Watson, Dudely, Segan, and Hockings, 2014). To counteract the rapid global biodiversity decline, the Convention for Biodiversity (CBD), under Aichi Target 11 in its Strategic Plan 2011–2020, encourages its signatories to protect a minimum of 17% of terrestrial and inland waters.

There are multiple protected areas in the Nile Basin, mostly situated in its lower parts. Five countries are close to meeting or even exceeding Aichi Target 11, with DR Congo and Tanzania having protected as much as 40% of their total land area. Six countries are currently not complying with the target value (see Figure 5.8). Simultaneously, the protection coverage for inland waters is much lower than that for terrestrial ecosystems. Only South Sudan exceeds 17% coverage of inland waters, while five countries stay below 5% (Bastin et al., 2019).

Overall, 13% of the Nile Basin is protected (Allan, et al. 2019)[5]. Currently, only 12.88% of Africa's wetlands are protected (Reid et al., 2017). In the Nile Basin, there are 17 Ramsar Sites[6] as of 2019. Table 5.8 demonstrates that a few Ramsar Sites essentially account for the bulk of the wetland area designated under the Convention. It also shows that no new Ramsar Sites have been designated within the basin since 2012 and that some countries have no Ramsar Sites at all or that they are not located within their part of the Nile Basin. In countries such as Tanzania, Ramsar Sites protect only 5.5% of the overall wetland areas (Materu et al., 2018), which highlights the necessity for extending the network of Ramsar sites.

Furthermore, the success of protected areas is reliant on the type of protection offered. World Heritage Sites and National Parks, for example, offer the strictest protection (IUCN category I and II). They are much better able to buffer human pressures than are more weakly protected areas (III-VI). In the majority of countries, less than one-quarter of the protected areas are strictly protected. However, in some countries, the protection type is not known for a large number of protected areas. To provide better protection for certain ecosystems, it can be beneficial to upgrade their strictness level. Generally, this applies particularly to those areas experiencing very high human pressures (Jones et al., 2018).

As resources for conservation are always limited, it is critical to prioritise ecosystems particularly rich in biodiversity and endemism (Myers, Mittermeier, Mittermeier, da Fonseca, & Kent, 2002). Ecosystems designated as Key Biodiversity Areas (KBAs) contribute most significantly to the persistence of global biodiversity, and must hence receive priority in conservation. With regard to KBAs for freshwater species, their coverage in most Nile Basin countries is lower (around one-third are within protected areas) than the global average of 44% (UNEP-WCMC, IUCN and NGS, 2018). Between 2000 and 2012, several countries increased their protection coverage of Freshwater KBAs, yet almost no progress has been made since then, except in Burundi and DR Con-

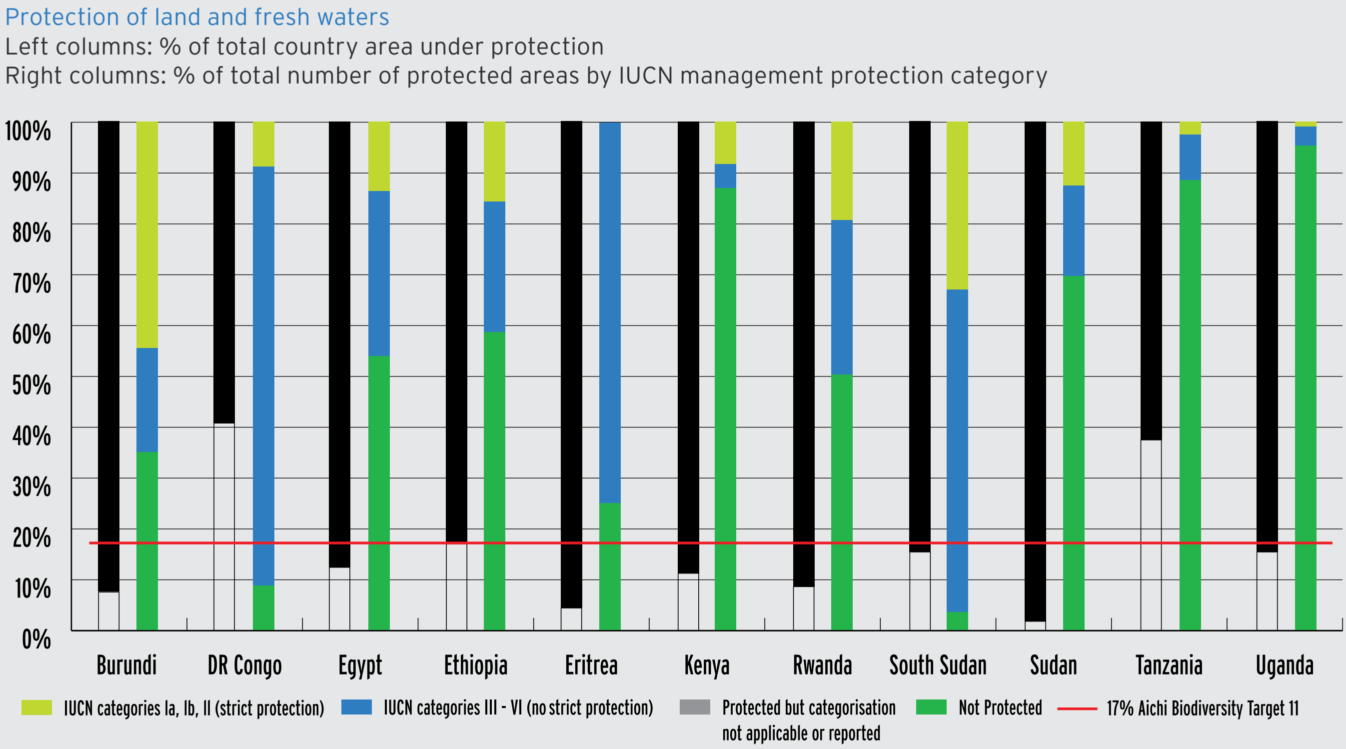
TABLE 5.8: NUMBER AND EXTENT OF RAMSAR SITES WITHIN THE BASIN PART AND IN THE ENTIRE TERRITORY OF NILE BASIN COUNTRIES, 2012 & 2018

	Inside the basin				Outside the basin			
	2012		2018		2012		2018	
Country	No.	Size (ha)	No.	Size (ha)	No.	Size (ha)	No.	Size (ha)
Burundi	0	0	0	0	1	10,673	4	78,515
DR Congo	1	800,000	1	800,000	2	6,635,624	3	11,106,617
Egypt	1	46,200	1	46,200	3	369,332	3	369,332
Eritrea	0	0	0	0	0	0	0	0
Ethiopia	0	0	0	0	0	0	0	0
Kenya	0	0	0	0	6	265,449	6	265,449
Rwanda	1	6,736	1	6,736	0	0	0	0
South Sudan	1	5,700,000	1	5,700,000	0	0	0	0
Sudan	1	1,084,600	1	1,084,600	2	1,405,000	2	1,405,000
Tanzania	0	0	0	0	4	4,868,424	4	4,868,424
Uganda	12	454,303	12	454,303	0	0	0	0

Source: Ramsar Convention Secretariat, 2019

[5]The percentage of protected area in the Nile Basin has been calculated on the basis of data provided in the supplementary material (Table S2 « General geographic and protected area statistics for each of the Nile basin countries ») in Allan et al. 2019.
[6]Ramsar Sites offer no legal protection. However, signatories to the Convention are obliged to conduct ecological inventories and develop management plans, among others. Both are vital elements to inform and guide wetland management and enhance their protection. Ramsar Sites also provide a basis from which to design other, legally binding, types of protection (Roucoux et al., 2014; Darpie et al., 2019).

FIGURE 5.11: PROTECTION OF LAND AND FRESH WATERS



Source: most recent values, retrieved from UNEP-WCMC, 2019

go (Section 5.11 Appendix III). While there are many KBAs awaiting urgent protection, stagnating progress in recent years reflects global trends (Watson, Dudely, Segan, and Hockings, 2014). Another way to prioritise conservation actions geographically is to look at Important Birding Areas (IBAs), which are areas particular important for safeguarding bird species and habitats. Table 5.9 shows that the basin's wetlands rank quite differently in what regards the number and overall size of IBAs, yet those wetlands around Lake Victoria being most important to that end.

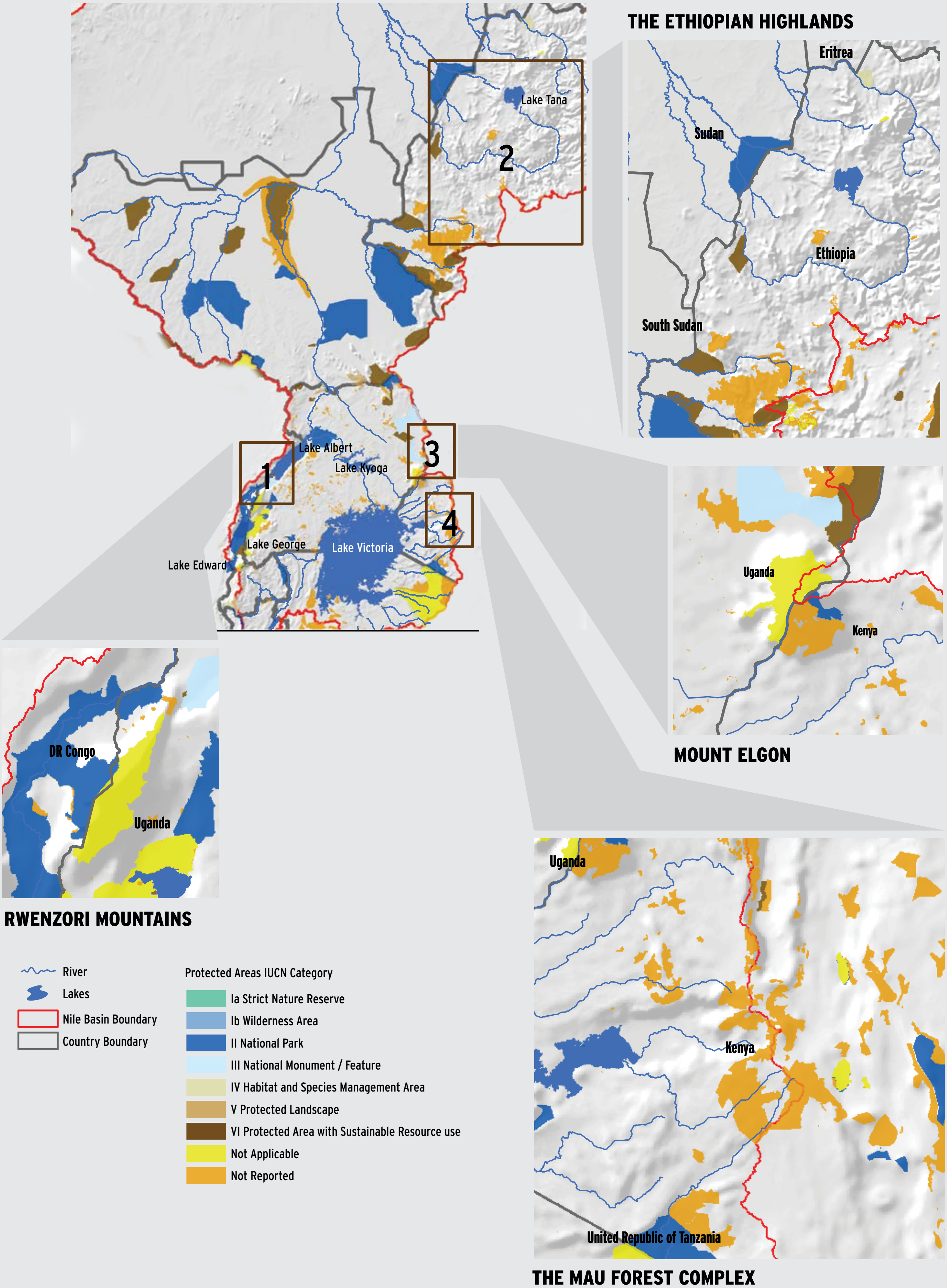
Protected areas are also critical for safeguarding freshwater resources and ensuring human water security (Harrison et al, 2016). The level of protection in the Nile Basin's water towers varies substantially. The protected area coverage of Albertine Rift and Mount Elgon is extensive, with some areas being strictly protected. This is especially true for the Albertine Rift, which accommo-

TABLE 5.9: IMPORTANT BIRD AREAS (IBA) IN MAJOR WETLANDS OF NILE BASIN

Wetland	IBA Count	Rank (Counts)	IBA Area (Ha)	Rank (Area)
Nile Delta	5	0.50	203,889	0.04
Dinder wetlands	2	0.20	2,090,000	0.38
Lake Tana wetlands	1	0.10	400,000	0.07
Baro/Akobo Sobat wetlands (Machar Marshes)	3	0.30	4,544,500	0.83
Sudd (Bahr el Jebel)	1	0.10	5,500,000	1.00
Bahr el Ghazal wetlands	0	0.00	0	0.00
Lake Kyoga wetlands	3	0.30	98,100	0.02
Semliki wetlands incl. Lake Albert / George/ Edward	7	0.70	1,655,100	0.30
Lake Victoria wetlands	10	1.00	53,763	0.10
Kagera wetlands	6	0.60	303,230	0.06
Mara wetlands	1	0.10	50,000	0.01
Sio Nzoia Yala Nyando wetlands	5	0.50	9,100	0.00

Source: NBI, 2019c

FIGURE 5.12: PROTECTED AREAS IN MAIN WATER TOWERS, 2018 [MAPS WITH VARYING RESOLUTIONS CREATED WITH DATA FROM PROTECTED PLANET



dates three of the continent's World Heritage Sites and four Ramsar sites. The protected area coverage of the Ethiopian Highlands is small compared to its extent.

Protecting forests or wetlands is no guarantee of conservation success (Leverington et al. 2010). Without effective governance and management, protected areas are at risk of ending up as 'paper parks'. Ineffective management is a problem in many protected areas and is a key reason why some are subject to serious degradation. This applies even to those with strict protection, such as the Virunga National park (Birdlife International, 2012). Failure of protection is often due to inadequate funding and staff, coupled with a general lack of high-level political support. Provision of resources needs to increase, especially as the immediate surroundings of many protected areas are already densely populated. For example, population density on the slopes of Mount Elgon is as high as 900 people/km2 (EAC, UNEP and GRID-Arendal, 2016).

SUSTAINABLE MANAGEMENT OF WETLANDS

The success of protecting wetlands, too, hinges greatly on how effectively they are

Photo: Arne Hoel / World Bank

managed. National wetland inventories, for example, inform management and policies, and function as a baseline for measuring if these are effective. Six Nile Basin countries state that they conducted inventories in 2018, which is twice the number compared to 2012. Generally, many Ramsar sites lack practical management plans, posing an essential constraint to effective management (Gardner et al., 2015). The majority of Ramsar sites in the Nile Basin have management plans in place,(Rugezi – Bulera- Ruhondo, Lake Nabugabo, Lutembe Bay, Murchison Falls-Albert Delta, Nabajjuzi System, Rwenzori Mountains and Sango Bay), which also seem to be largely implemented. Some are in preparation (Virunga, Lake Bisina, Lake Mburo- Nakivali System, Lake Opeta System, Mabamba Bay, Sango Bay- Musambwa Island, Dinder National Park, Lake Burullus), others are not available yet (Lake George, Lake Nakuwa System, Sudd). Yet limited data availability prohibits the derivation of clear trends. Overall, fewer basin countries reported professionally and some not all in the last reporting cycle. Without diligent reporting, it is difficult to evaluate and improve management.

NBI can play a key role in strengthening efforts to protect the Nile Basin's wetlands,

FIGURE 5.13: WETLANDS OF INTERNATIONAL IMPORTANCE (RAMSAR SITES) IN THE NILE BASIN

SUDD WETLAND (5,700,000 HA, SOUTH SUDAN) One of the largest tropical wetlands in the world. The site is composed of various ecosystems, from open water and submerged vegetation to floating fringe vegetation, seasonally inundated woodland, rain-fed and river-fed grasslands, and floodplain scrubland. It is an important wintering ground for birds, and home to some endemic fish, birds, mammals, and plants. The size of the wetland is variable, consisting of permanent swamps during the dry season (November–March) and seasonal swamps, created by flooding of the Nile (Bahr el Jebel), in the wet season (April until October).

MURCHISON FALLS–ALBERT DELTA (17,293 HA, UGANDA) Stretches from the top of Murchison Falls, where the River Nile flows through a rock cleft some 6m wide, to the delta at its confluence with Lake Albert. The lower parts are important for waterbirds, while the delta is an important spawning and breeding ground for Lake Albert fisheries. Murchison Falls are one of the main tourist attractions and recreation areas in Uganda, and the site is of social and cultural importance to the people of the area.

RWENZORI MOUNTAINS (99,500 HA, UGANDA) The entire Afro-alpine ecosystem (between 1,600 and 5,100 meters above sea level) is unique. High rainfall and melting of snow from the peaks contributes to various wetland types, such as peatlands, freshwater lakes, and tundra. The mountains are known to support numerous species of global conservation concern.

LAKE GEORGE (15,000 HA, UGANDA) A complex of river systems originating in the Rwenzori Mountains supply a system of permanent swamps located on Lake George. The site supports large mammals, including elephants, hippopotamus, and antelope, and is important for numerous species of wintering waterbirds as well as various notable resident birds.

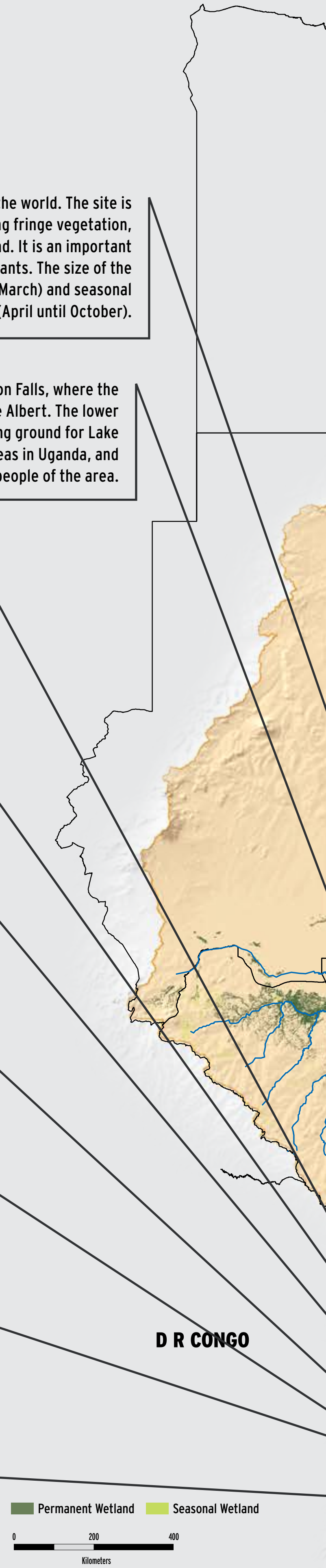
VIRUNGA NATIONAL PARK (800,000 HA, DR CONGO) Lying astride the equator, the site contains most tropical biotopes and boasts some of the most substantial concentrations of wild mammals in Africa. It provides important feeding and wintering grounds to migratory birds and is one of the few places where mountain gorilla can be found in their natural environment.

LAKE MBURO–NAKIVALI SYSTEM (26,834 HA, UGANDA) A system of open and wooded savanna, seasonal and permanent wetlands, and five lakes, of which Lake Mburo is by far the largest. It forms a unique habitat, lying at the convergence of two biological zones, giving it very high biodiversity. The site is also of immense socio-economic value as a source of water for domestic use, livestock, wildlife, pasture for local herds during droughts, fish, and materials for crafts and thatching. The area is a popular tourist destination.

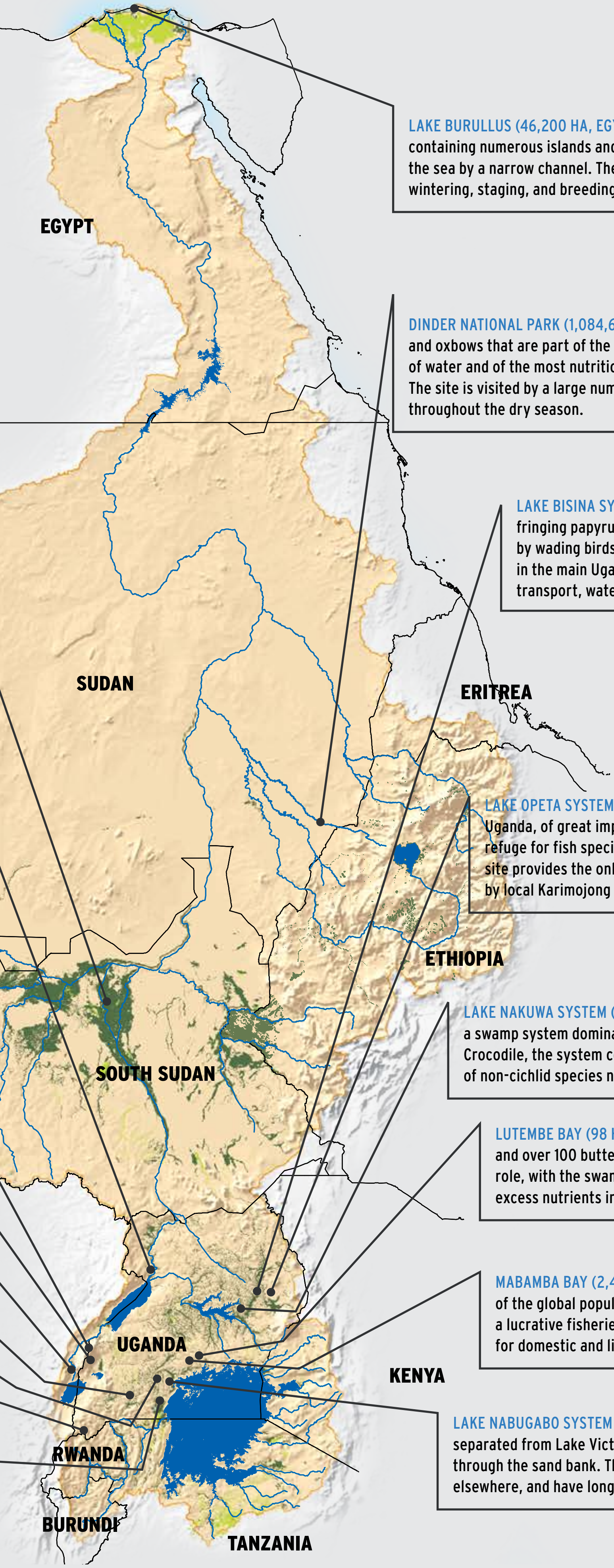
NABAJJUZI SYSTEM (1,753 HA, UGANDA) Provides a spawning ground for mudfish and lungfish, supports globally threatened bird species and the endangered Sitatunga. Certain species are closely associated with cultural traditions of the Buganda Kingdom, especially the totems. Also plays an important role in stabilising the banks of River Nabajjuzi, groundwater recharge, flood control and as a natural filter for silt and sediments in the runoff. It is the source of water for nearby townships and provides fish, clay, papyrus, medicine, and game meat to local communities.

RUGEZI–BULERA–RUHONDO (6,736 HA, RWANDA) Rugezi Marsh is located in a flooded valley near Rwanda's northern border with Uganda at an altitude of 2,050 metres, and feeds Bulera and Ruhondo lakes. The site is a unique and important ecosystem which covers part of an Important Bird Area. The marsh is an important headwater of the Kagera and Nile river systems, and is very significant to the national economy as it enables downstream hydro-electric power generation.

SANGO BAY–MUSAMBWA ISLAND–KAGERA WETLAND SYSTEM (55,110 HA, UGANDA) A mosaic of wetland types including the biggest tract of swamp forest in Uganda, papyrus swamps, herbaceous swamps interspersed with palms and seasonally flooded grasslands, sandy, rocky and forest shores, and three rocky islets. It lies in the transition between the East and West African vegetation zones, resulting in rich biodiversity. The system supports huge congregations of waterbirds, and hosts globally endangered mammals such as elephant, black and white colobus monkey and a subspecies of the blue monkey.



Source: compiled from Rebelo and McCartney 2012, Ramsar Convention Secretariat 2018



LAKE BURULLUS (46,200 HA, EGYPT) A shallow, saline lagoon containing numerous islands and islets connected with the sea by a narrow channel. The area provides important wintering, staging, and breeding habitat for birds.

DINDER NATIONAL PARK (1,084,600 HA, SUDAN) A large complex of about 40 wetlands and pools formed by meanders and oxbows that are part of the seasonal Rahad and Dinder river drainage systems. The wetlands are vital as a source of water and of the most nutritious grasses for herbivores, especially during the most severe part of the dry season. The site is visited by a large number of species of migratory birds, and some of the areas contain quantities of fish throughout the dry season.

LAKE BISINA SYSTEM (54,229 HA, UGANDA) A shallow freshwater lake with a thin strip of fringing papyrus swamp, part of the Lake Kyoga Basin lakes. It is used as a feeding ground by wading birds, and is also important as a refuge for fish species that have gone extinct in the main Ugandan lakes. The lake is important for local communities in terms of fishing, transport, water supply and famine foods.

LAKE OPETA SYSTEM (68,912 HA, UGANDA) Probably the most important wetland marsh in Uganda, of great importance for the conservation of birds. The site is also important as a refuge for fish species that have gone extinct in the main lakes. During the dry season the site provides the only refuge for animals from the Pian-Upe wildlife reserve, and is used by local Karimojong and Pokot for livestock grazing.

LAKE NAKUWA SYSTEM (91,150 HA, UGANDA) A permanent wetland with a number of satellite lakes and a swamp system dominated by dense papyrus. In addition to supporting the Sitatunga and the Nile Crocodile, the system contains the most diverse cichlid species assemblage and is a haven for a number of non-cichlid species no longer found in the large lakes of Kyoga and Victoria.

LUTEMBE BAY (98 HA, UGANDA) Supports globally threatened species of birds, endangered cichlid fish, and over 100 butterfly species, including three rare ones. The system plays an important hydrological role, with the swamps surrounding the Murchison Bay acting as natural filters for silt, sediments, and excess nutrients in surface run-off, wastewaters from industries, and sewage from Kampala City.

MABAMBA BAY (2,424 HA, UGANDA) The site is part of a wetland system that hosts approximately 38% of the global population of the blue swallow and other birds of global conservation concern. It supports a lucrative fisheries activity as well as providing raw material for local crafts, building materials, water for domestic and livestock use, and non-wood products.

LAKE NABUGABO SYSTEM (22,000 HA, UGANDA) A shallow freshwater lake with three smaller lakes, separated from Lake Victoria by a sand bar. There are no surface outflows from the lakes, only seepage through the sand bank. The lakes contain several endemic fish that have become depleted or extinct elsewhere, and have long supplied local communities with fish, water, and handicraft materials.

Photo: Shutterstock

especially those spanning several countries. In addition to identifying and protecting the most important wetlands, it can help member states to follow existing principles and guidelines for designing and managing wetlands, such as those provided by Ramsar, which only a few countries worldwide pursue adequately (Reis et al., 2017). A crucial action will be to encourage countries to improve reporting and deploy new technologies for that purpose (e.g. nascent earth observation methods), and to implement management plans, as well as helping them to find funding and increase investments (Ramsar Convention Secretariat, 2018). Since 2012, NBI has marshalled a suite of interventions that are in line with these generally recommended actions for wetland conservation. Importantly, NBI has commissioned several baseline studies for major transboundary wetlands in the Nile Basin. These studies are intended to mainstream wetland conservation and wise use into basin wide planning processes.

NBI has also commissioned the development of important management tools for the basin's wetlands. For example, the Wetland Management Framework will, on the basis of the above studies, additional data, and existing wetland management plans at the national level, provide a roadmap for sustainably managing the basin's most important transboundary wetlands. In parallel, NBI is developing a Wetland Monitoring Strategy, which will allow it to monitor, compile, and analyse data on wetland extent, indicator species and ecosystem services. It has also supported the development of wetland management plans for a number of transboundary wetlands, such as the Sio–Siteko wetland, which is shared by Kenya and Uganda (NBI, 2009). Additional development of wetlands management plans and conservation investment plans for Semliki (Uganda and DRC), Sango-Bay-Minziro (Uganda and Tanzania) are completed and endorsed by the respective countries (2020).

WATERSHED MANAGEMENT AND REFORESTATION MEASURES IN THE WATER TOWERS

Management of upstream source areas can be a more cost-effective way than deploying engineering solutions to fix degraded watershed services downstream. Watershed man-

TABLE 5.10: STATUS OF ENACTMENT OF WETLANDS POLICY AND MANAGEMENT INSTRUMENTS IN RAMSAR SITES

PROTECTION OF RAMSAR SITES
Different policy and management aspects evaluated for the latest to reporting cycles (COP11, COP12 and COP13)

Legend: **Completed** · **Not Completed** · **Planned** · **Not Available**

	COP Period	Burundi	DR Congo	Egypt	Eritrea	Ethiopia	Kenya	Rwanda	South Sudan	Sudan	Tanzania	Uganda
National Wetland Policy in Place	2009-2012	Completed	Not Completed	Completed	Not Available	Not Available	Planned	Not Completed	Not Completed	Not Completed	Completed	Completed
	2012-2015	Completed	Not Completed	Completed	Not Available	Not Available	Planned	Not Completed	Not Completed	Not Completed	Planned	Completed
	2015-2018	Completed	Not Completed	Completed	Not Available	Not Available	Completed	Not Completed	Not Available	Not Completed	Not Available	Completed
National Wetlands Inventory	2009-2012	Not Completed	Not Completed	Completed	Not Available	Not Available	Planned	Completed	Not Completed	Not Completed	Planned	Completed
	2012-2015	Not Completed	Not Completed	Completed	Not Available	Not Available	Completed	Completed	Not Available	Completed	Not Available	Completed
	2015-2018	Planned	Completed	Completed	Not Available	Not Available	Not Completed	Planned	Not Available	Planned	Not Available	Planned
Management Plan in Place (# of sites)	2009-2012	0	3	3	Not Available	Not Available	2	1	1		11	
	2012-2015	3	3	4	Not Available	Not Available	6	1	0	Not Available	0	12
	2015-2018	3	Not Available	4	Not Available	Not Available	Not Available	1	Not Available	2	Not Available	12
Management Plan Implemented (# of sites)	2009-2012	0	3/3	3/3	Not Available	Not Available	2/2	1/1	Not Available	Not Available	Not Available	8/11
	2012-2015	0	Not Available		Not Available	Not Available	6/6	1/1	0	Not Available	0	12/12
	2015-2018	3/3	Not Available	4/4	Not Available	Not Available	Not Available	1/1	Not Available	1/2	Not Available	>4

Note: The category 'planned' refers to an aggregated group of information, namely 'planned, in progress, and in preparation'. The category 'not available' entails that the COP report did not have data on that specific topic. No reports were available for Eritrea and Ethiopia, as these countries are not part of the Ramsar Convention.
Source: Ramsar Convention Secretariat, 2018

agement aims to maintain various functions, including water quality and water supply for humans and ecosystems. It can therefore also create important synergy effects for biodiversity conservation and water management (Harrison et al., 2016). It is critical to sustain these functions, to address issues such as water pollution, deforestation, floods, or soil erosion. This necessarily involves multiple stakeholders, such as farmers, the forestry and mining sector, and city governments (Postel and Thompson, 2005). Three of the water towers stretch across the territories of several Nile Basin countries, with the Albertine Rift including as many as six countries. To manage them, transboundary cooperation is indispensable. For several years, watershed management has been high on the agenda of NBI. There are 16 management and water-resource development projects under preparation or already underway currently, most of which were started after 2012. An array of projects has been implemented by single countries or through multilateral efforts, such as the Kenya Water Tower Climate Change Resilience Program. Started in 2015, it protects and restores Kenya's five prime water tow-

« The importance of environmental flows – sufficient amounts of water to sustain livelihoods and ecosystems – requires recognition in national policies and planning instruments. »

ers, including Mount Elgon.

While some of the watershed programmes yielded notable successes, interventions need to be replicated at a much larger scale, given the small fraction of the catchment areas they cover. This is especially true for the Ethiopian Highlands, which is densely populated. With its population set to double by 2050, already heavily degraded soils, very low forest cover, and weakly protected ecosystems require much greater efforts. NBI can support basin countries in setting up transboundary governance mechanisms and harmonising policies for different land uses for the water towers that so far only partially exist (EAC, UNEP and GRID-Arendal (2016).

ASSESSMENT AND IMPLEMENTATION OF ENVIRONMENTAL FLOWS

While the implementation of environmental flows in the Nile Basin is just in its infancy, a few important steps have been achieved recently. In 2016, NBI published the Nile Flows Framework Technical Implementation Manual (2016a) that provides general standards and norms for assessing and implementing environmental flows. However, environmental flow assessments (EFAs) have been carried out for only a few rivers, such as for the Mara (NBI 2020, LVBC, and WWF-ESARPO, 2010) and the Blue Nile (Reitberger and McCartney, 2011). In most cases, the EFAs were coarse, desktop-based studies offering rather low-confidence in their findings. There is no evidence that the design and operation of hydropower projects recently completed or currently under construction – Tekeze (2009) and the Grand Ethiopian Renaissance Dam (under construction) in Ethiopia, Bujagali in Uganda (2012), or the Rusumo Falls (under construction) – has been guided by EFAs. Some of them are even implemented without any environmental and social impact assessments, or the assessments are carried out by companies with vested interests (Birdlife International, 2012).

A basin-wide EFA for nine river segments and a more comprehensive study for the Mara River has been completed recently by Nile Basin Initiative (NBI 2019). The coarse basin wide assessment used historical flow data to determine environment flow requirements – hydrological conditions needed to maintain certain qualities of riverine and floodplain ecosystems.

Against the backdrop of a projected five-fold increase in hydropower capacity until 2050 in the Nile Basin, there is an urgent need for advancing initial interventions that take a basin-wide approach to environmental flows. The study by Nile Basin Initiative highlights that the coarse EFA can only serve as a starting point, requiring more detailed EFAs. To do so, it is essential to fill information gaps, especially on the ecological qualities of rivers. In the face of limited resources, future studies should be conducted for rivers with high biodiversity and ecosystem services affected by planned water-resource developments. The findings of such EFAs must make inroads into water allocation planning and into socio-economic impact assessments carried out for hydro-infrastructure projects (King & Brown, 2018). NBI can support these activities at the transboundary scale. However, successful implementation is highly dependent on the enforcement of national legislation and policies, as other examples have shown (Hirji & Davis, 2009).

COMBATING INVASIVE SPECIES

Efforts to control invasive species take place at the national or local scale, with most of them possibly focusing on water hyacinth. There are currently no projects being carried out by NBI. Efforts to control water hyacinth have produced mixed results. In many cases, the plant spread again after elimination intervention. Generally, a combination of biological and mechanical measures have proven most successful.

Many interventions have been undertaken by one or several riparian states, most of which have involved Lake Victoria. For example, during 1999–2016, Uganda and Egypt were cooperating on aquatic weed control (mostly water hyacinth). This endeavour included Lake Victoria, Albert, and Kyoga and extended to the Kagera and Albert rivers. In the White Nile in Sudan, Egypt and Sudan are making concerted efforts to combat water hyacinth and other envasive weeds. In Ethiopia, a concerted effort is underway including the establishment of a dedicated trust fund and an organisation that carries out the control of water hyacinth in Lake Tana. There are some efforts to capitalise on the water hyacinth, such as by using it for crafts, fertilizers, and biogas, although their scale is limited. To combat water hyacinth effectively, it will be necessary to reduce nutrient inflows into waterways. This is because highly productive waters foster the growth of water hyacinth.

Controlling invasive species is an important measure by the Ramsar Convention to protect wetlands. Table 5.11 shows that the Nile Basin countries have made advances in both establishing policies with respect to invasive species and in conducting inventories to monitor invasive species. Between 2012 and 2018, the first three countries, namely Egypt, Kenya, and Uganda, started to include invasive species elements into policies. These three countries, in addition to Rwanda, also reported carrying out inventories of invasive species. Before 2012, only Egypt had done so. Also, a few countries are planning or have now started to assess their programmes to control invasive species in wetlands.

TABLE 5.11: STATUS OF IMPLEMENTATION FOR POLICIES AND MANAGEMENT OF INVASIVE SPECIES IN RAMSAR SITES

INVASIVE SPECIES
Different policy and management aspects evaluated for the latest to reporting cycles (COP11, COP12 and COP13)

Legend: Completed | Not Completed | Planned | Not Available

	COP Period	Burundi	DR Congo	Egypt	Eritrea	Ethiopia	Kenya	Rwanda	South Sudan	Sudan	Tanzania	Uganda
Invasive Species Policy in Place	2009-2012	Not Completed	Not Completed	Planned	Not Available	Not Available	Planned	Not Completed	Not Completed	Not Completed	Not Completed	Not Completed
	2012-2015	Not Completed	Not Completed	Planned	Not Available	Not Available	Completed	Not Completed	Not Completed	Planned	Not Completed	Completed
	2015-2018	Planned	Not Completed	Completed	Not Available	Not Available	Planned	Not Completed	Not Available	Planned	Not Available	Completed
Invasive Species Inventory	2009-2012	Planned	Not Completed	Completed	Not Available	Not Available	Planned	Not Completed	Not Completed	Not Completed	Planned	Planned
	2012-2015	Planned	Not Completed	Completed	Not Available	Not Available	Planned	Planned	Not Completed	Planned	Not Completed	Completed
	2015-2018	Planned	Planned	Completed	Not Available	Not Available	Completed	Completed	Not Available	Planned	Not Available	Completed
Assessment of Control Programmes	2015-2018	Planned	Not Completed	Planned	Not Available	Not Available	Planned	Not Completed	Not Available	Planned	Not Available	Completed

Note: The category 'planned' refers to an aggregated group of information, namely 'planned, in progress, and in preparation'. The category 'not available' implies that the COP report did not offer data on that aspect. No reports were available for Eritrea and Ethiopia, as these countries are not part of the Ramsar Convention.
Source: Ramsar Convention of Wetlands, 2018b

CONCLUSIONS AND RECOMMENDATIONS

The purpose of this chapter is to describe the basin's ecosystems and the benefits they provide, the key human activities that affect them, and changes that materialised recently. The focus is on ecosystems which play a prime role in supporting human water security and freshwater biodiversity, here called water-related ecosystems.

Many water-related ecosystems are under pressure, a trend which has intensified since 2012. Pressures will increase at an unprecedented rate, given that human populations in the Nile Basin and their needs for natural resources will grow faster than ever before. Similarly, the ongoing degradation of ecosystems will make the Nile's rivers, lakes, wetlands, and forests less able to generate the same amount of services as they have done over the last decades.

Great strides have been made in safeguarding the water-related ecosystems and the services they provide to humans, but to keep pace with the growing future challenges even greater efforts will be necessary. To this end, the following interventions are recommended:

- RIVERS AND LAKES: As expected pressures on aquatic ecosystems are slated to grow, it will be critical to maintain and enhance environmental flows and alleviate water quality problems caused by agricultural run-off and uncontrolled wastewater discharge to ensure continued provision of ecosystem services such as fisheries and habit for the diversity of species they support;
- WETLANDS: The substantial loss of wetlands as evidenced in a recent wetlands assessment requires to enhance their sustainable use and the protection to maintain their ecosystem services and biodiversity, their hydrological functions within the river system, and their massive carbon pools, especially those of peatlands;
- FORESTS: In the wake of rapidly growing populations and increased needs for forest products, especially farming land and fuelwood, better protection of forests, and particularly the basin's water towers, will be fundamental to maintain and enhance their various water-related catchment functions such as flood control and groundwater recharge.

There are multiple global river basins that have lost much of their natural capital. The ecosystem services and goods water-related ecosystems once provided to humans now have to be replaced through engineering solutions, often at costs that far outweigh the investments that would have been necessary to protect them in the first place. These calls for nature-based solutions striking a balance between green and grey infrastructure. The Nile's water-related ecosystems are under immense pressures from population increase, agriculture, infrastructure development, urbanization and climate change. Therefore collaborative concerted and urgent efforts are needed now to avoid further degradation in the future in detriment of nature, biodiversity, livelihoods and associated economies.

APPENDIX I

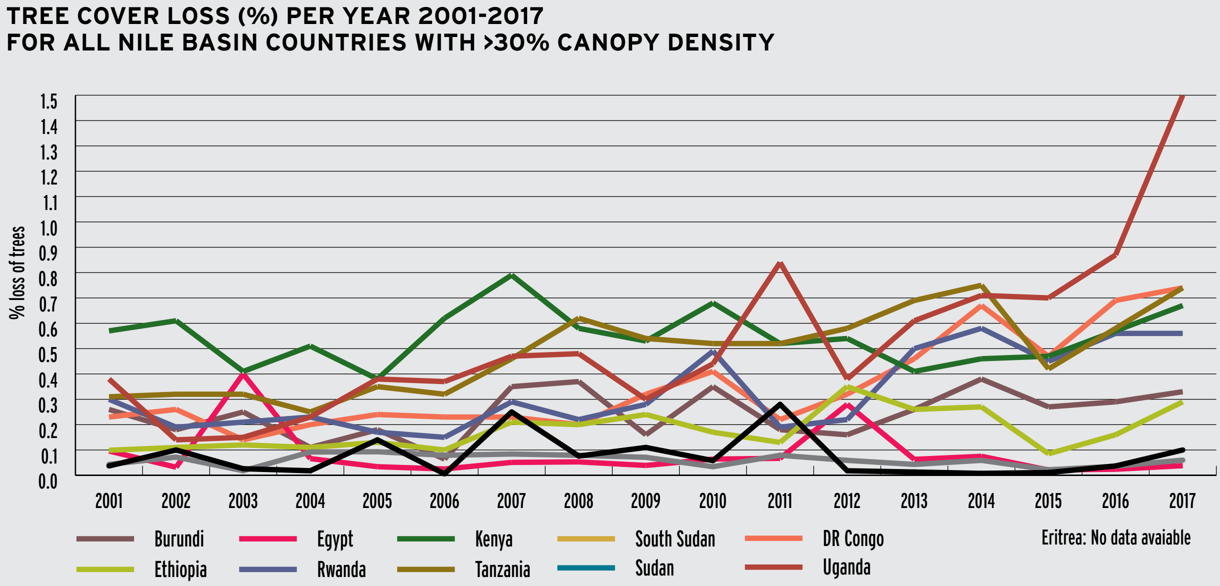
FOREST COVER AND DEFORESTATION RATES

TABLE 5.12: FOREST AREA AS A PERCENTAGE OF TOTAL LAND AREA IN NILE BASIN COUNTRIES

Indicator	Year	Burundi	DR Congo	Ethiopia	Eritrea	Egypt	Kenya	Rwanda	South Sudan	Sudan	Uganda	Tanzania
Forest Area	2000	7.7	69.4	13.7	15.6	0.1	6.2	13.9			19.4	58.6
	2012	9.9	68.0	12.3	15.1	0.1	7.4	18.1			13.7	54.1
	2016	10.9	67.2	12.5	14.9	0.1	7.8	19.7			6.9	51.6

Source: FAO, 2016

FIGURE 5.14: ANNUAL FOREST LOSS RATES FOR NILE BASIN COUNTRIES (PERCENTAGE), 2001-2017



Source: Global Forest Watch 2018

APPENDIX II

BIODIVERSITY

TABLE 5.13: IUCN RED LIST OF THREATENED SPECIES
Not all existing species have been assessed for each taxonomic group, including those that remain unknown. The figures do not therefore present the total numbers of species per country

Country	Mammals	Birds	Reptiles*	Amphibians	Fishes*	Molluscs*	Other Inverts*	Plants*	Fungi & Protists*	Total*
Burundi	14	14	0	1	17	4	3	89	0	142
DR Congo	34	39	9	11	94	45	10	148	0	390
Egypt	18	14	13	0	54	0	56	8	0	163
Eritrea	15	19	7	0	26	1	57	5	0	130
Ethiopia	33	33	3	12	14	4	11	47	0	157
Kenya	30	43	12	11	73	20	67	234	0	490
Rwanda	24	19	0	2	7	0	4	41	0	97
South Sudan	13	19	4	0	0	0	1	16	0	53
Sudan	15	24	6	0	28	0	50	17	0	140
Tanzania	40	49	34	61	176	11	118	632	0	1121
Uganda	30	28	4	2	60	14	16	64	0	218
Nile Basin										3101

Source: IUCN, 2018, accessed July 2018

APPENDIX III

PROTECTION OF KEY BIODIVERSITY AREAS AND FORESTS

TABLE 5.14: COVERAGE OF FRESHWATER AND MOUNTAIN KEY BIODIVERSITY AREAS AND LEGALLY PROTECTED FORESTS

Indicator	Year	Burundi	DR Congo	Ethiopia	Eritrea	Egypt	Kenya	Rwanda	South Sudan	Sudan	Uganda	Tanzania
Freshwater Key Biodiversity Areas	2000	48.8	29.4	16	0.03	28.5	26.5	41.8	45.2	0	40.8	26.8
	2012	44.2	32.1	16.0	0.03	28.5	38.4	47.8	58.8	0	60.8	33.9
	2018	52.3	35.6	16.0	0.03	28.5	38.4	47.8	58.8	0	60.8	33.9
Mountain KBAs	2000		28.9	18.4	14.3	45	42.4	44.5	28.7	0	76.1	55.4
	2012	62.7	28.9	20.1	14.3	45	43.98	49.5	28.7	0	76.7	61.6
	2018	63	28.9	20.1	14.3	45	43.98	49.5	28.7	0	76.7	61.6
Legally Protected Forest (% of total land area)	2000	37.3				26.9	7.14	37.3		16.9	35.2	4.3
	2010	50.6	10.7			26.9	11.8	50.6		24.5	35.2	4.3
	2015	56.4	15.9			26.9	13.2	56.4		24.5	35.2	4.3

Source: UNEP-WCMC and IUCN, 2018

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CHAPTER 6

IMPROVING RESILIENCE TO CLIMATE CHANGE IMPACTS

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CONTENTS

KEY MESSAGES / SUMMARY

Recent climate projections predict that the Nile region is subject to a warming and more variable climate.
The main climate impacts are increased aridity, higher temperatures, more frequent and more severe flooding, more frequent and more intense droughts, and higher variability of rainfall and associated streamflow. The extent of future climate change in the Nile region is yet unclear, and different parts of the Basin will be affected in different ways.

The Nile Basin is highly vulnerable to climate impacts
Factors contributing to this vulnerability are high poverty levels, the expansive and fragile dryland zone, low water-storage capacity, poor farming practices in the large rainfed area, a large and growing rural population that is reliant on the natural resource base for its livelihood and political instability. Additionally, several countries are highly reliant on hydro-electricity for their power supply.

Climate change poses a serious risk to ecological, economic, and social systems in the Nile Basin.
Preparations for climate change within the Basin countries are currently considered inadequate.

The large rainfed agricultural sector is particularly vulnerable to climate impacts.
Farmers are almost totally unprepared to cope with more unpredictable weather and more frequent dry spells. Higher risks of crop failure will impede agricultural modernisation and hamper the crucial objective to improve yields in rainfed farming. It has adverse consequences for rural development, poverty alleviation, food security, land degradation and environmental sustainability, and rural–urban migration.

Preparations for climate change in the pastoralist sector are also inadequate.


Photo: © Andy Johnstone/Panos Pictures

Deforestation leading to climate change

No measures are in place for improved land management, herd management, or post-drought herd reconstitution. It could compromise the economic viability of the pastoralist lifestyle.

The irrigated agricultural sector is unprepared for a scenario in which Nile flows decrease.
In instances of bulk water deficits, no mechanisms exist to manage the remaining water resources over the existing schemes in an equitable reasonable manner, or to systematically reduce irrigation water requirements.

Droughts, floods, and temperature increases are predicted to negatively affect wetlands, rivers, lakes, forests, and other ecosystems throughout the Nile Basin.
This will also affect the services these ecosystems provide to humans and as habitat for the Basin's rich biodiversity. Current levels of degradation already reduce the ability of ecosystems to adapt to changing climate conditions. Knowledge about their general status and vulnerability, current levels of protection, and planned adaptations to buffer ecosystems against climate change are inadequate.

Climate resilience in some sectors has improved in recent years.

Progress has been made in protecting people and ecosystems in the Main Nile and Blue Nile valley against flash and riverine flooding, while the dependency on Nile waters for energy supply will progressively decrease in the longer term with the expected diversification of energy production, in combination with the establishment of functional regional power markets.

The challenge is to scale up climate-change adaptation measures quickly enough to make a significant impact.

This will be a daunting task in view of the scale of the action required. However, most measures that strengthen climate-change resilience are simultaneously contributing to overall development objectives and are part of existing policies and programs. Accelerated implementation of these 'no-regret' measures by the respective technical agencies is a sensible course of action. It will involve setting up incentive mechanisms to motivate individual actors to implement climate-adaptation measures.

Transboundary water resources management is a useful and strategic element of climate-change adaptation.

Enhanced cooperation and coordination of dam operation is a key strategy for reducing reservoir evaporation losses which are likely to be increased due to climate change. However, This require progress in cooperative transboundary management through data and information sharing and joint data collection and assessments. Most measures to strengthen climate resilience need to be implemented at national level.

RESILIENCE TO CLIMATE CHANGE IMPACTS


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Climate change is impacting the water resources in the Nile Basin and could impair the functioning of the economic, livelihood, and natural systems that are reliant on them. Since all climate projections point towards continuing warming, it is important for the Nile countries to strengthen resilience to the stresses and shocks caused by climate impacts in order to meet diverse socio-economic development goals and preserve the progress made so far. In the context of the Nile Basin, strengthening climate resilience will also strengthen resilience to the natural variability of the climate and a broad variety of other climatic, socio-economic, and environmental disturbances. Thus, an integrated socio-ecological understanding is required, and improving Basin resilience to climate impacts will have close links to poverty alleviation, sustainable development, catchment management, and food security, among others.

Climate resilience is defined as: 'the ability of socio-ecological systems to absorb and recover from climate shocks and stresses, while positively adapting and transforming their structures and means for living in the face of long-term change and uncertainty' (adapted from Bindoff et al., 2013). Achieving resilience may require interventions at sub-national, national, and regional level.

BOX 6.1: DEFINITIONS

Absorptive capacity: the ability of a system to prepare for, mitigate, or recover from negative climate impacts using existing responses and coping mechanisms

Adaptive capacity: the ability of a system to adjust, modify, or change its characteristics in order to better respond to existing and anticipated climate shocks and stresses, and to take advantage of opportunities

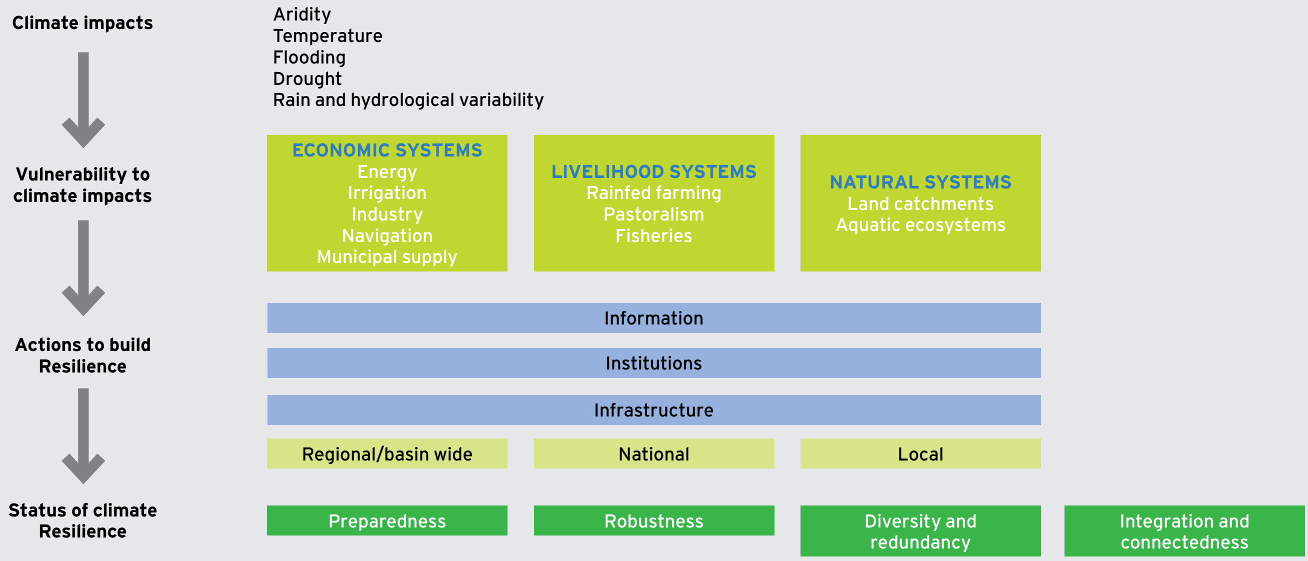
Transformative capacity: the ability of a system to fundamentally change its characteristics when the existing conditions become untenable in the face of climate shocks

Source (GIZ, 2014)

Figure 6.1 presents the conceptual framework that has been adopted in this chapter (adapted from World Bank, 2017).
The main climate impacts in the Nile Basin are manifested in:

- increased aridity
- higher temperatures
- more frequent and more severe flooding

FIGURE 6.1: CONCEPTUAL FRAMEWORK FOR ASSESSING BASIN RESILIENCE TO CLIMATE-CHANGE IMPACTS



Source: Adopted from World Bank, 2017

- more frequent and more intense droughts, and
- higher variability of rainfall and associated streamflow.

The first step in building climate resilience is identifying and analysing the vulnerabilities of the core economic, livelihood, and natural systems to the five major climate impacts listed above. The vulnerability of a system is defined as its tendency or readiness to be adversely affected. Since the extent of future warming is yet uncertain, this analysis is mostly conceptual. Attention should be given to potential positive or negative feedback loops in order to assess the magnitude of potential impacts and identify the most critical adverse consequences of a warming climate. These will differ by sector and location.

Options to strengthen resilience to climate impacts will be reviewed at local, national and regional level, and organised around the three I's: Information, Institutions, and Infrastructure (World Bank, 2017). Information is concerned with trusted and shared data, forecasts, planning tools, optimisation models, etc. Institutions cover issues such as policies, organisations, coordination mechanisms, and laws. Infrastructure deals with physical structures such as storage reservoirs and embankments, but also with catchment management elements, reforestation, and wetland restoration.

Lastly, the status of climate resilience of the core systems will be analysed in terms of preparedness, robustness, diversity and redundancy, and integration and connectedness.

A WARMING AND MORE VARIABLE CLIMATE IN THE NILE REGION

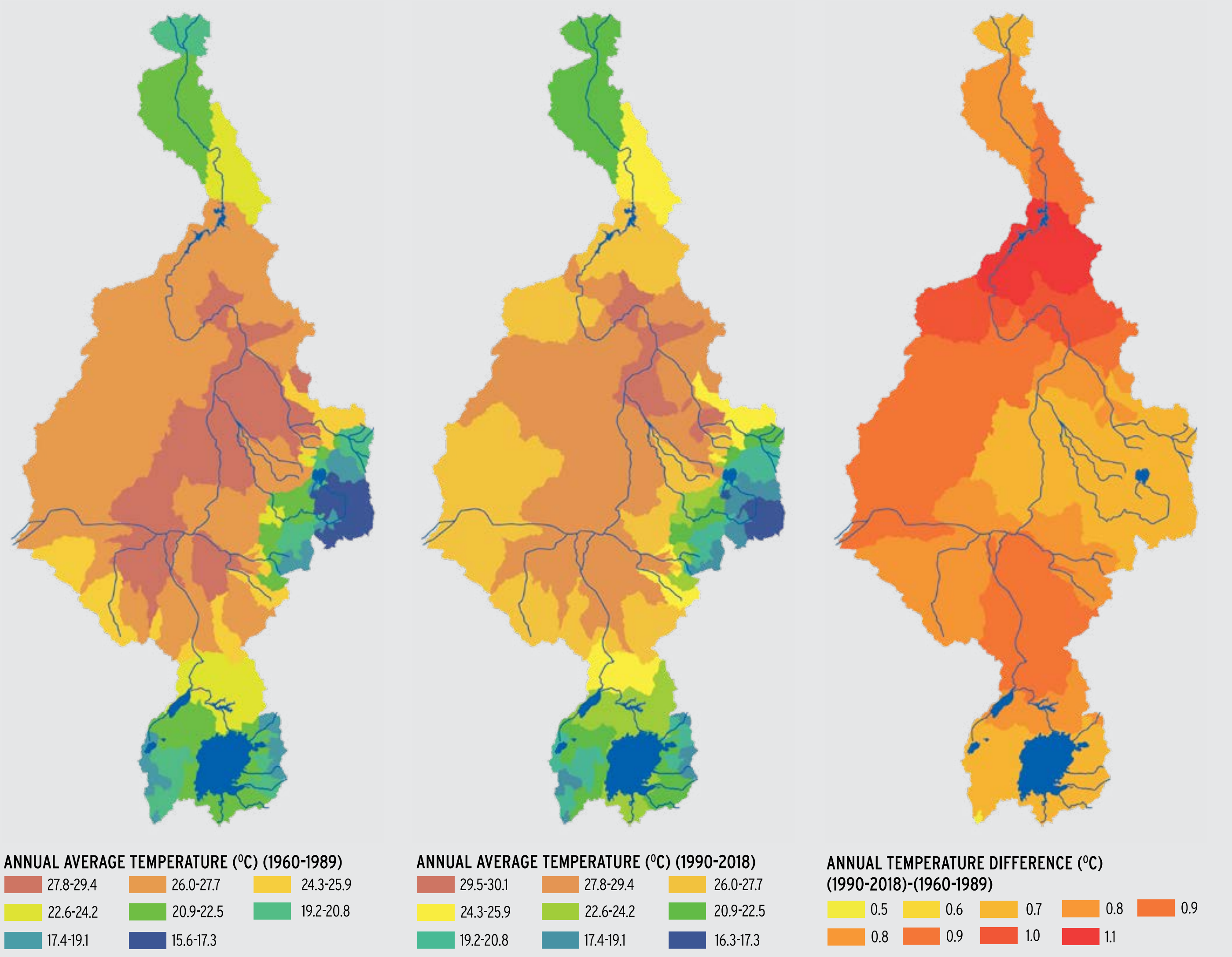
All climate projections point to continuing warming, but the extent of future climate change is uncertain. This section will review the changes in climate that have been observed relative to the reference period 1960-1989.

HIGHER TEMPERATURES

Figure 6.2 shows average annual temperatures in the Nile Basin for 1960–1989 and 1990–2018. The following observations are made:

- Relative to 1960–1989, average annual temperatures have risen in every part of the Nile Basin; the increase ranges from 0.5 to 1.1 degree Celsius.
- The lowest increase was observed in the mountains of Burundi; the highest temperature rise – approaching 1.1 °C – was observed in southern Egypt and northern Sudan.
- The rise in temperature is generally lower at higher altitudes.

FIGURE 6.2: AVERAGE ANNUAL TEMPERATURES, 1960-1989 AND 1990-2018



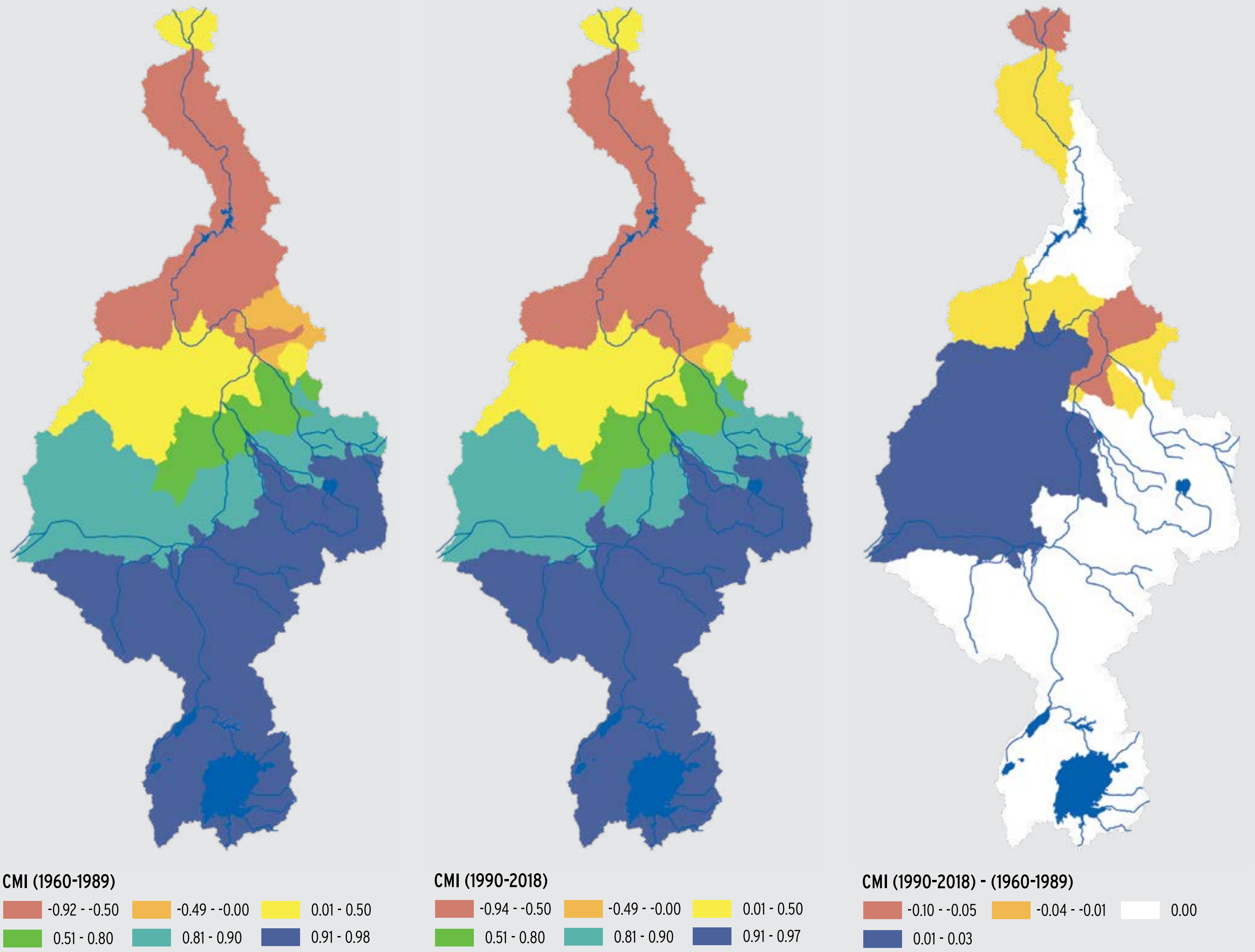
MORE FREQUENT AND MORE INTENSE DROUGHTS

The Climate Moisture Index (CMI) has been used to assess changing drought conditions in the Nile Basin. CMI provides an indicator of moisture available to support plant growth. Hence, it represents an indicator for agricultural drought, which differs from meteorological or hydrological drought. The CMI is based on two parameters: annual precipitation and annual potential evapotranspiration.

Figure 6.3 presents average CMI values for 1960–1989 and 1990–2019. The northern part of the Nile Basin has become slightly drier, while the south-eastern part of Sudan has become somewhat wetter. The observed changes are small. In most of the Nile Basin, however, no meaningful change in CMI values were observed, indicating that the climatic conditions for biomass production and agricultural activities have effectively not changed since the reference period 1960–1989.

FIGURE 6.3: CLIMATE MOISTURE INDEX [CMI), 1960-1989 AND 1990-2018

CMI provides an indicator of moisture available to support plant growth. White indicates, that the average CMI has not changed in between the time periods.



INCREASING VARIABILITY OF RAINFALL

Four indicators – level of rainfall, onset of rains, length of dry spells, and annual rain statistics – have been analysed to assess changes in seasonal and annual rainfall patterns.

AVERAGE ANNUAL RAINFALL

Figure 6.4 compares average annual rainfall for the periods 1960–1989 and 1990–2018. The following is observed:

- There is no uniform signal; rainfall has decreased in some areas while it has increased in others.
- For areas with less rainfall, the maximum observed decrease is about 10%.
- Rainfall has decreased marginally in the northern part of the Nile Basin.
- A rather substantial decrease has been witnessed in the Baro–Akobo–Sobat region; it is noted, however, that large parts of this region are still receiving significant rainfall, exceeding 1,200 mm/year.
- A potentially more consequential decrease in average annual rainfall – in excess of 5% – has been observed in the southern part of the Lake Victoria catchment.
- Rainfall has increased over parts of Uganda and South Sudan.

FIGURE 6.4: AVERAGE ANNUAL RAINFALL, 1960-1989 AND 1990-2018

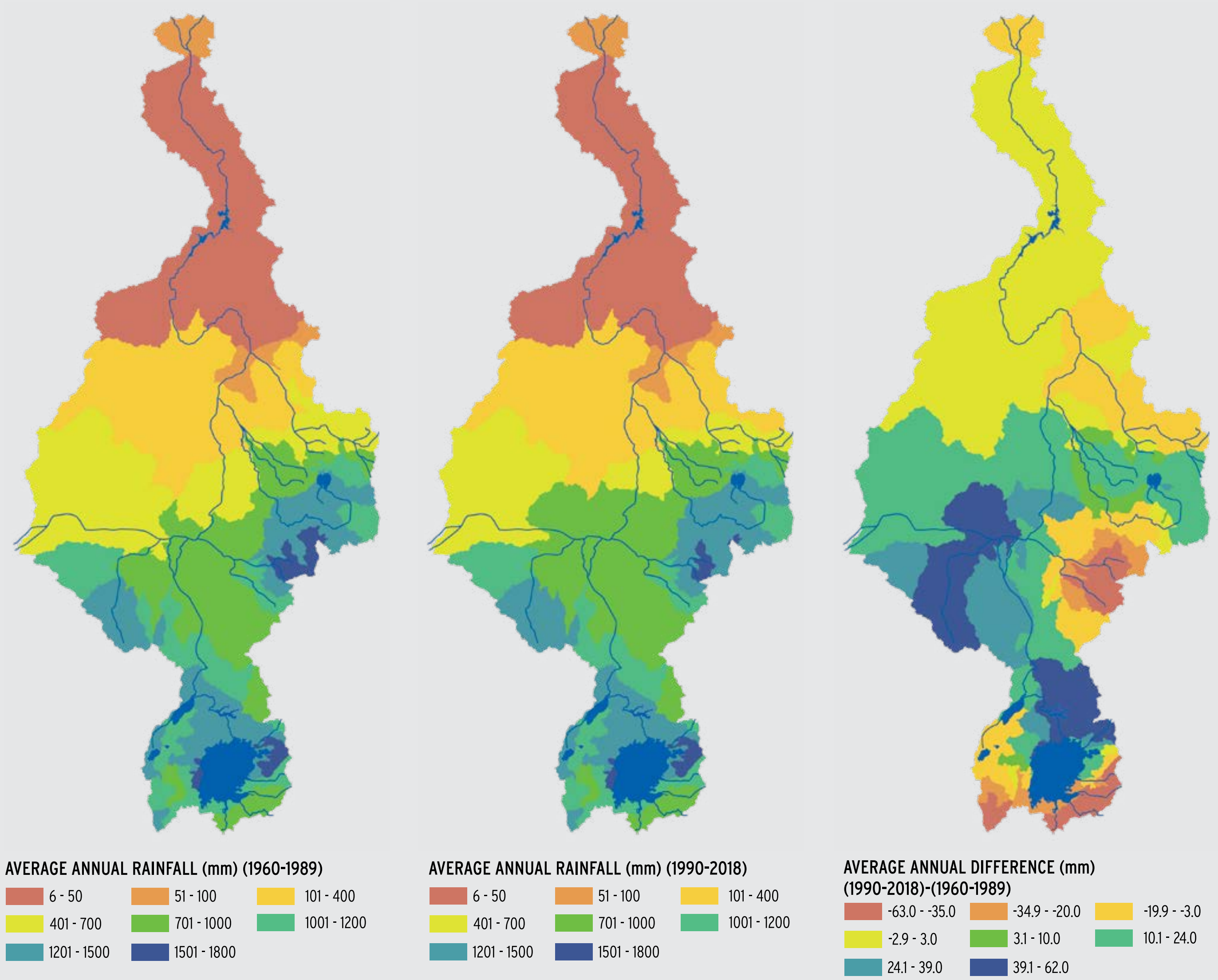


Photo: Shutterstock

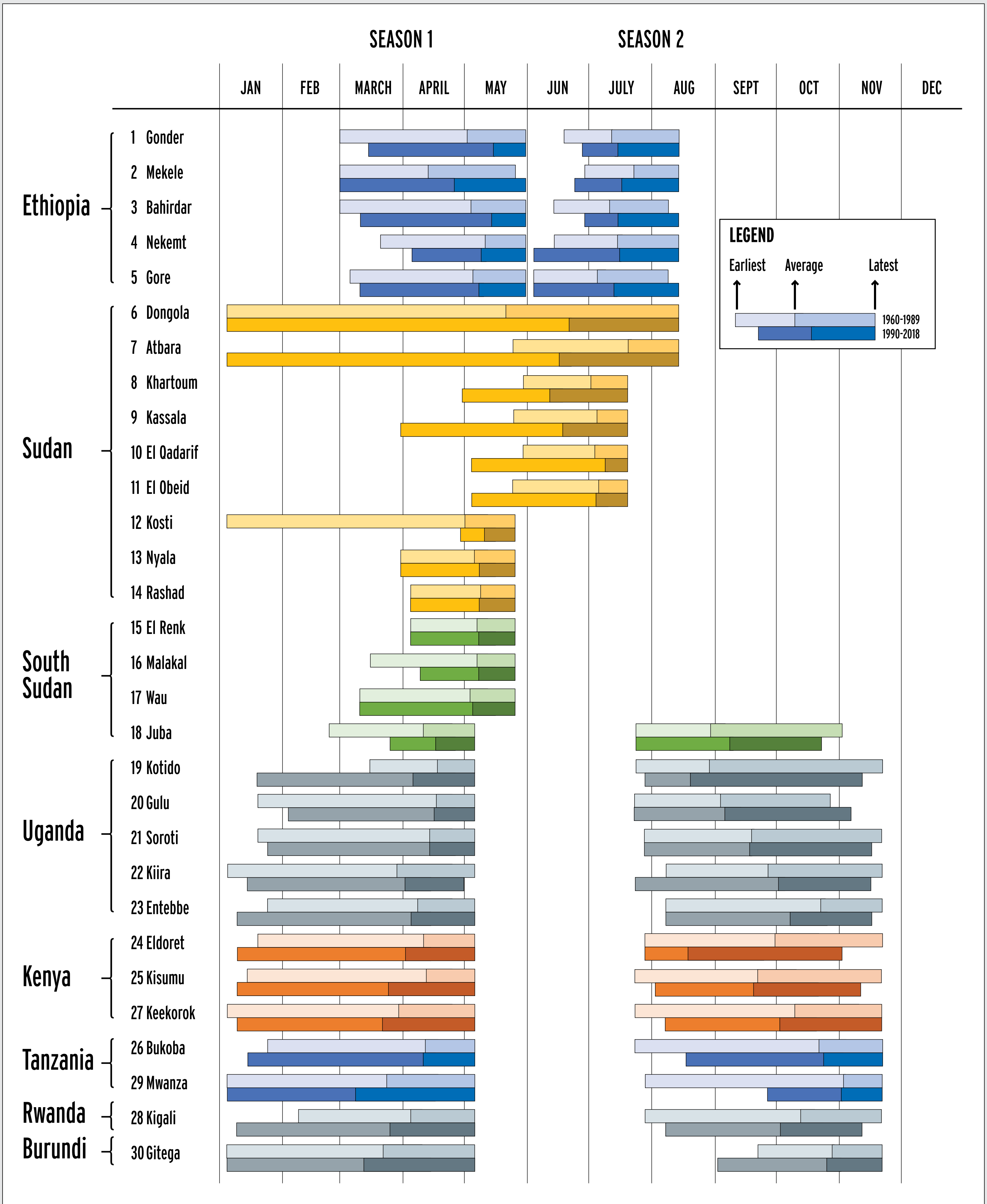
« While it is evident that the onset and duration of the wet season is changing, no uniform trend can be discerned »

ONSET OF THE RAINY SEASON

A measure of predictability in the onset of the rainy season is important for local agricultural planning. Figure 6.5 compares the timing of the first large rain event (> 50 mm) before and after 1990 in the respective wet seasons for 30 rainfall stations across the Nile Basin. Daily rainfall data are obtained from the Princeton Daily Precipitation dataset.

While it is evident that the onset and duration of the wet season is changing, no uniform trend can be discerned. In the eastern Nile Basin, there is some evidence of a shorter and more concentrated rainy season. By contrast, the rains in some stations have generally started earlier, but without evidence of an increase in total rainfall. The signal for the Equatorial Plateau is mixed, with some stations witnessing a shorter wet season and others an earlier and longer one. The 'short rains' – which occur in the second half of the year – have generally become shorter, thereby increasing the risk of crop failure.

FIGURE 6.5: COMPARISON OF TIMING OF FIRST SERIOUS RAIN EVENT [>50 MM) BEFORE AND AFTER 1990 [SHEFFIELD ET AL., 2006]



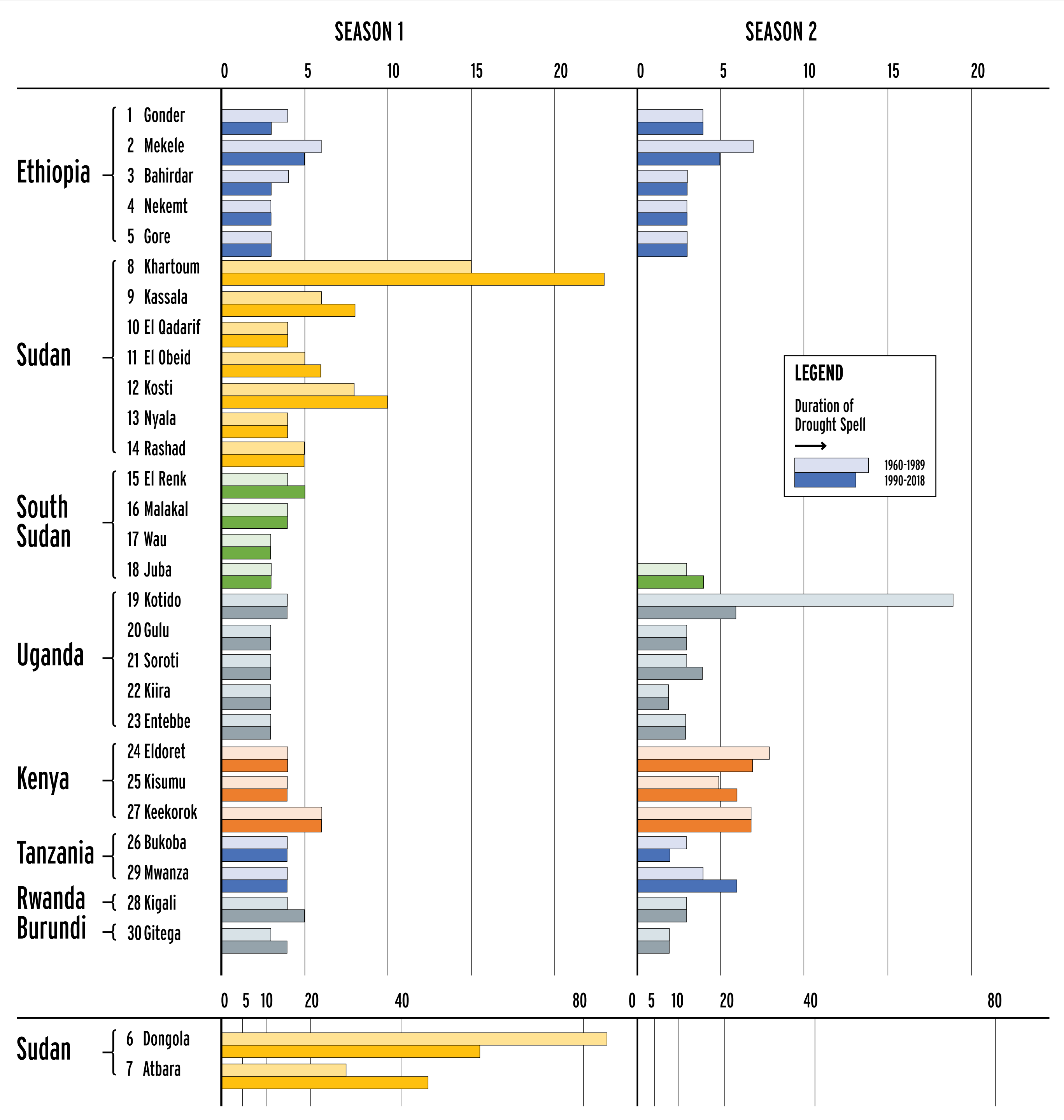
Note: the figure compares the timing of the first high rain event (> 50 mm) before and after 1990 in the respective wet seasons for 30 rainfall stations across the Nile basin. Daily rainfall data are obtained from the Princeton Daily Precipitation dataset. The stations are sorted on there geographical location from North to South, and grouped by colour according to the country. The light colour bars show the period prior to 1990 (1960-1989) and the dark colour bars show the time from 1990 (1990-2018). The average is shown by the vertical black stripe inside each bar.

DURATION OF RAINLESS PERIODS IN THE CROP SEASON

The output of crops and pastures is not only affected by the total amount of rainfall received in the crop season, but also by the duration of rainless periods. Prolonged dry spells within the rainy season can cause moisture deficits at critical stages during plant grow, which adversely affect yields and can ultimately lead to crop failure. This, despite otherwise abundant seasonal rainfall.

Figure 6.6 compares the duration of consecutive days without rainfall in the rainy season before and after 1990 for 30 rainfall stations in the Nile Basin. Daily rainfall data are obtained from the Princeton Daily Precipitation dataset.

FIGURE 6.6: COMPARISON OF THE DURATION OF CONSECUTIVE DAYS WITHOUT RAINFALL IN THE RAINY SEASON BEFORE AND AFTER 1990 FOR 30 RAINFALL STATIONS IN THE NILE BASIN



Note: the figure shows the length of dry spells for 30 station in the Nile basin. The stations are sorted on there geographical location from North to South, and grouped by colour according to the country. The light colour bars show the period prior to 1990 (1960-1989) and the dark colour bars show the time from 1990 (1990-2018).

Source: [Sheffield et al., 2006]

The following observations are made:

- In the Ethiopian part of the Nile Basin, the average duration of the rainless periods during the rainy season has slightly decreased since 1960–1989.
- In Sudan, the average length of the dry spells during the rainy season has increased, thereby increasing the unpredictability of rainfall; in the Nile Basin, Sudan is generally subject to the longest period without rainfall in the rainy season; it will reduce the productive use of rainfall.
- For Kenya, South Sudan, and Uganda no significant changes have been observed, with one exception.
- The average duration of dry spells has slightly increased in Rwanda and Burundi but remains short.

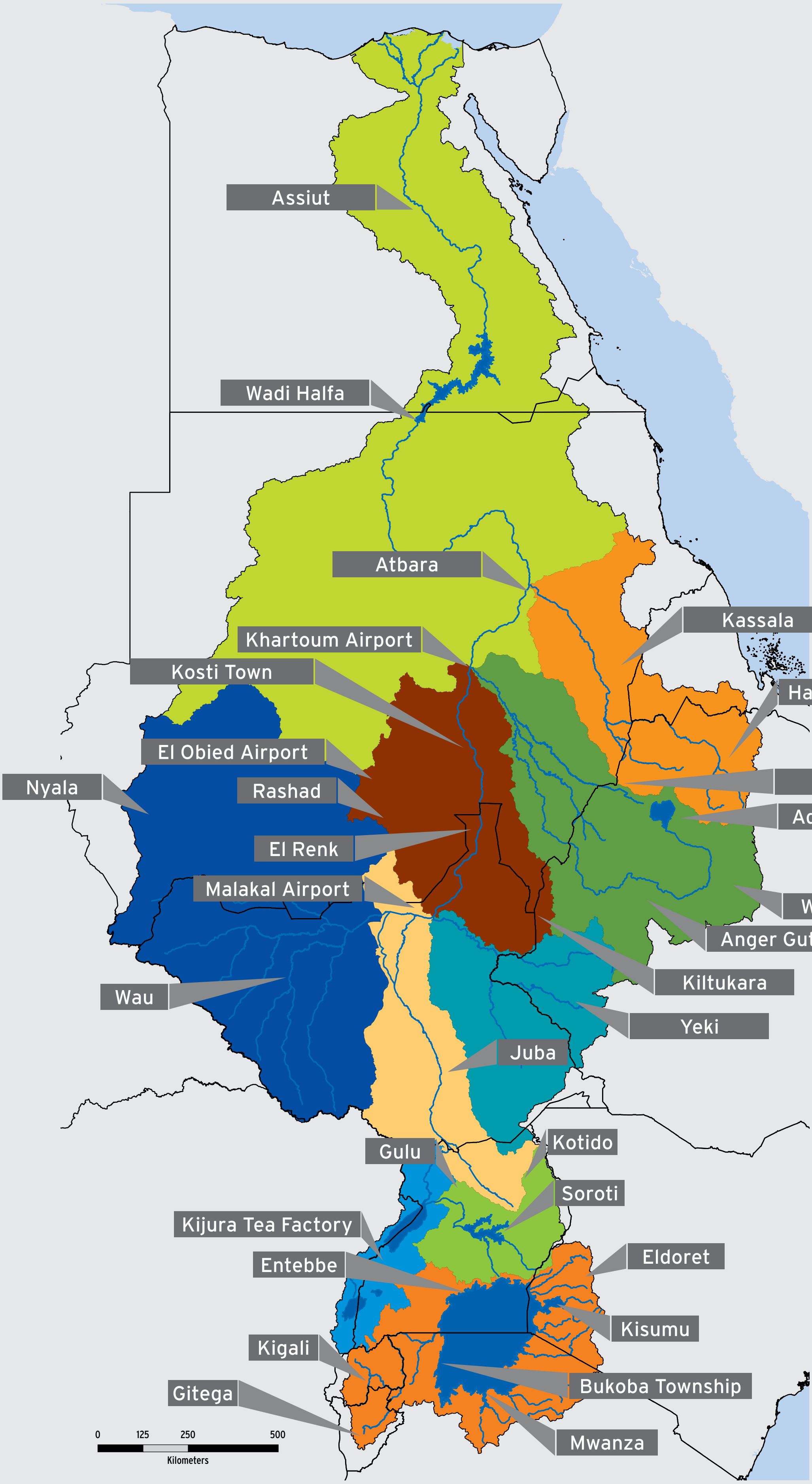
ANNUAL RAIN STATISTICS

The high temporal variability of rainfall over most of the Nile Basin is constraining its productive use. Box plots are used to illustrate the interannual variability of rainfall. Comparing plots for 1960–1989 and 1990–2018 provides a measure of the inter-annual variability of rainfall and the changes observed in the last 30 years. In all, 31 stations have been included in the analysis (Figure 6.7).

The following has been observed:

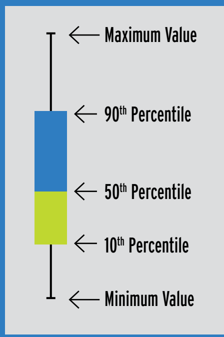
- There is no uniform signal that points towards a changing climate; interannual variability has been observed to increase for some stations while for others it has decreased; there is no uniform signal or direction of change for distinct regions; it is clear that different parts of the Nile Basin are affected in different ways by the changing climate.
- Changes in rainfall patterns because of climate change therefore remain uncertain.
- The spatial and temporal variability of rainfall over the Nile Basin is generally high.

FIGURE 6.7: RAINFALL STATIONS FOR WHICH BOX PLOTS ARE PRESENTED OVERLEAF

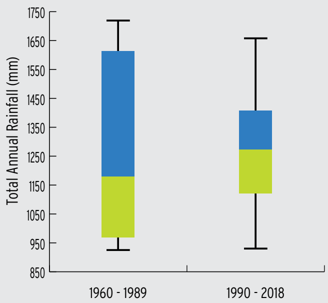


BOX 6.2: Box Plot

A box plot graphically shows groups of numerical data through their summaries. In this case, the smallest observation (sample minimum), 10th percentile, 50th percentile (median), 90th percentile and largest observation (sample maximum) are presented. The lines extending vertically from the boxes (whiskers) indicate variability outside the upper and lower percentiles, the band inside the box (boundary of the two colours) is the 50th percentile (the median), and the end of the whiskers represent the minimum and maximum of all the data as seen on right.

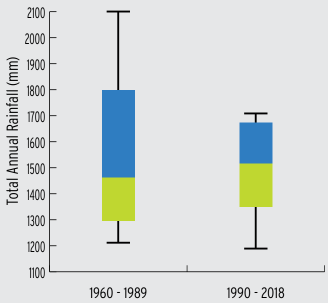


Addis Zemen



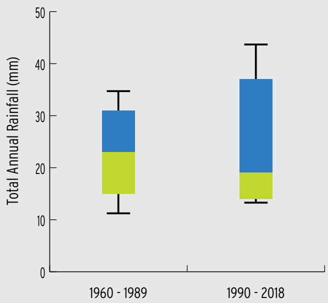
	1960 - 1989	1990 - 2018
Minimum	922	927
10th Percentile	968	1122
50th Percentile	1179	1273
90th Percentile	1613	1407
Maximum	1724	1661

Anger Gutin



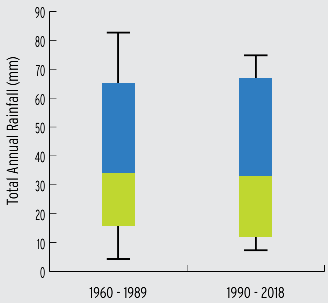
	1960 - 1989	1990 - 2018
Minimum	1209	1186
10th Percentile	87	163
50th Percentile	166	167
90th Percentile	337	157
Maximum	307	40

Assuit



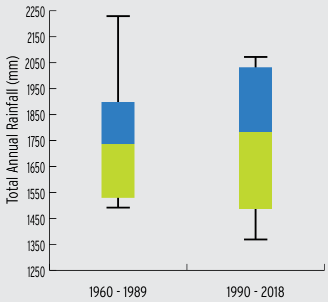
	1960 - 1989	1990 - 2018
Minimum	11	13
10th Percentile	4	1
50th Percentile	8	5
90th Percentile	8	18
Maximum	4	7

Atbara



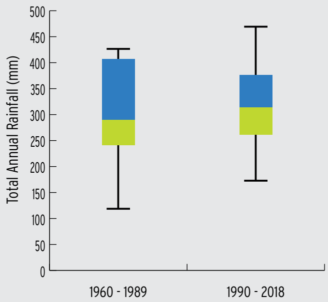
	1960 - 1989	1990 - 2018
Minimum	4	7
10th Percentile	12	5
50th Percentile	18	21
90th Percentile	31	34
Maximum	18	8

Bukoba



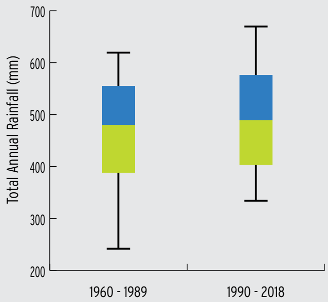
	1960 - 1989	1990 - 2018
Minimum	1486	1367
10th Percentile	44	119
50th Percentile	204	297
90th Percentile	164	249
Maximum	335	45

El Obeid Airport



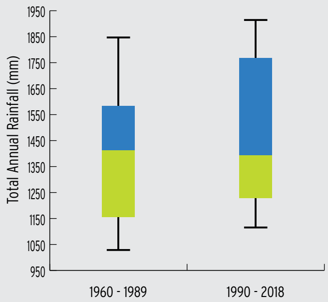
	1960 - 1989	1990 - 2018
Minimum	0	0
10th Percentile	0	0
50th Percentile	0	0
90th Percentile	0	0
Maximum	0	0

El Renk



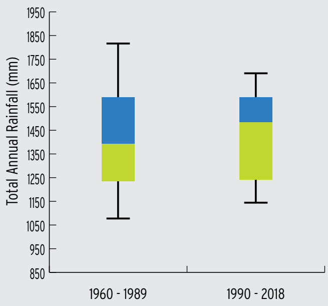
	1960 - 1989	1990 - 2018
Minimum	237	332
10th Percentile	151	72
50th Percentile	92	85
90th Percentile	75	87
Maximum	66	96

Eldoret



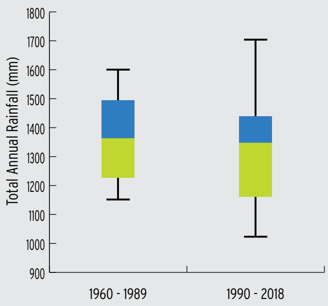
	1960 - 1989	1990 - 2018
Minimum	1025	1111
10th Percentile	130	117
50th Percentile	257	164
90th Percentile	171	376
Maximum	267	150

Entebbe



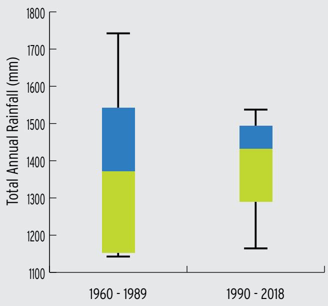
	1960 - 1989	1990 - 2018
Minimum	1073	1138
10th Percentile	1235	1241
50th Percentile	1393	1483
90th Percentile	1590	1589
Maximum	1819	1699

Gitega



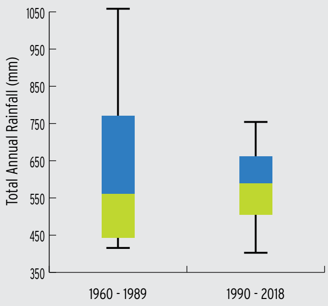
	1960 - 1989	1990 - 2018
Minimum	1149	1019
10th Percentile	1227	1162
50th Percentile	1362	1348
90th Percentile	1494	1439
Maximum	1603	1709

Gulu



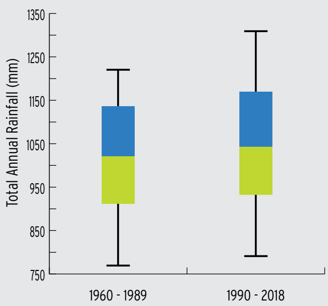
	1960 - 1989	1990 - 2018
Minimum	1140	1162
10th Percentile	1153	1290
50th Percentile	1371	1432
90th Percentile	1543	1493
Maximum	1745	1540

Hagere Selam



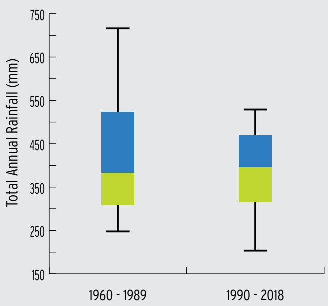
	1960 - 1989	1990 - 2018
Minimum	411	400
10th Percentile	443	505
50th Percentile	561	589
90th Percentile	770	662
Maximum	1061	758

Juba



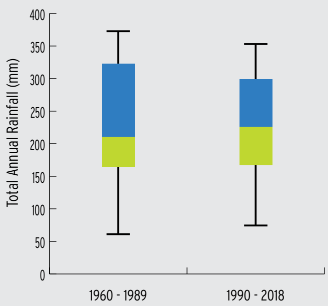
	1960 - 1989	1990 - 2018
Minimum	767	788
10th Percentile	912	933
50th Percentile	1021	1043
90th Percentile	1136	1169
Maximum	1224	1312

Kassala



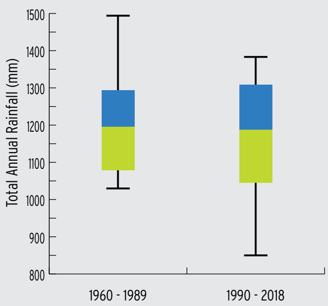
	1960 - 1989	1990 - 2018
Minimum	246	201
10th Percentile	308	315
50th Percentile	382	395
90th Percentile	523	469
Maximum	719	532

Khartoum



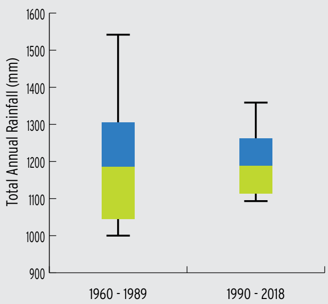
	1960 - 1989	1990 - 2018
Minimum	59	73
10th Percentile	165	167
50th Percentile	211	226
90th Percentile	323	299
Maximum	374	355

Kigali



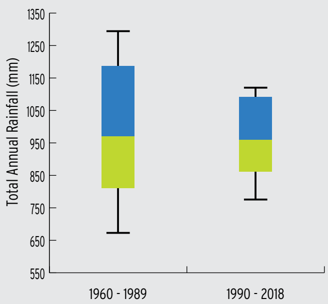
	1960 - 1989	1990 - 2018
Minimum	1025	846
10th Percentile	1078	1045
50th Percentile	1195	1187
90th Percentile	1294	1308
Maximum	1497	1386

Kijura



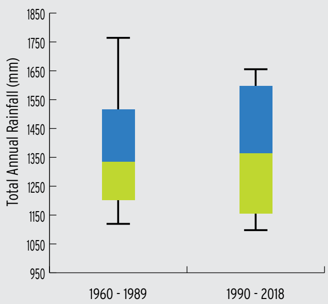
	1960 - 1989	1990 - 2018
Minimum	997	1091
10th Percentile	1045	1114
50th Percentile	1185	1189
90th Percentile	1305	1263
Maximum	1546	1361

Kitukara



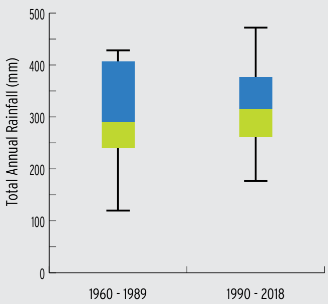
	1960 - 1989	1990 - 2018
Minimum	669	772
10th Percentile	811	861
50th Percentile	970	959
90th Percentile	1187	1092
Maximum	1298	1124

Kisumu



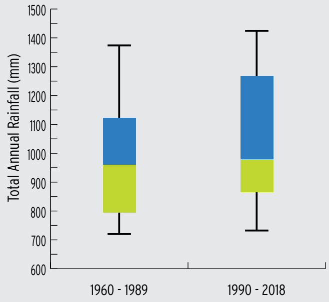
	1960 - 1989	1990 - 2018
Minimum	1114	1094
10th Percentile	1202	1156
50th Percentile	1334	1364
90th Percentile	1517	1597
Maximum	1769	1661

Kosti



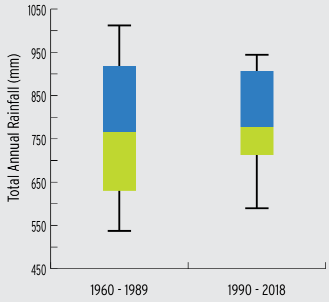
	1960 - 1989	1990 - 2018
Minimum	118	173
10th Percentile	240	262
50th Percentile	290	315
90th Percentile	407	377
Maximum	430	475

Kotido



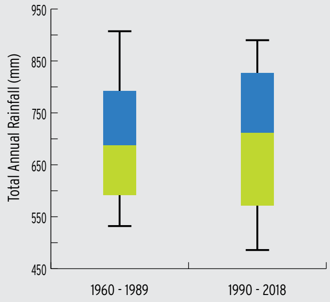
	1960 - 1989	1990 - 2018
Minimum	718	729
10th Percentile	795	866
50th Percentile	961	979
90th Percentile	1122	1268
Maximum	1378	1429

Malakal



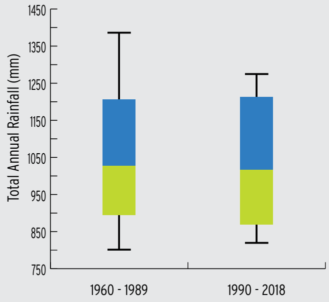
	1960 - 1989	1990 - 2018
Minimum	536	587
10th Percentile	631	714
50th Percentile	766	778
90th Percentile	918	907
Maximum	1015	947

Metema



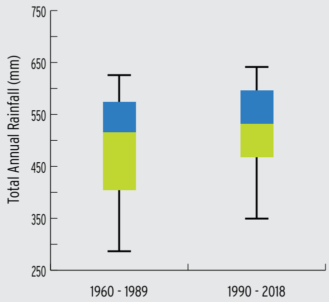
	1960 - 1989	1990 - 2018
Minimum	530	484
10th Percentile	592	572
50th Percentile	688	712
90th Percentile	792	827
Maximum	909	893

Mwanza



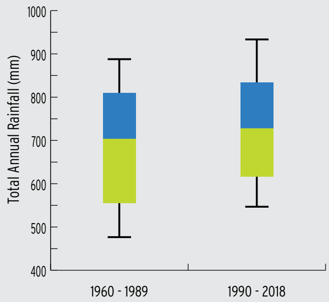
	1960 - 1989	1990 - 2018
Minimum	801	815
10th Percentile	895	869
50th Percentile	1028	1016
90th Percentile	1206	1213
Maximum	1389	1277

Nyala



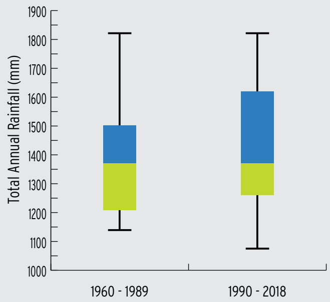
	1960 - 1989	1990 - 2018
Minimum	284	348
10th Percentile	404	468
50th Percentile	515	532
90th Percentile	574	596
Maximum	628	643

Rashad



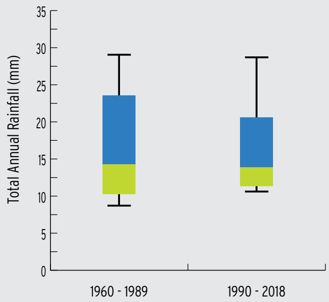
	1960 - 1989	1990 - 2018
Minimum	477	544
10th Percentile	556	617
50th Percentile	704	728
90th Percentile	809	834
Maximum	891	935

Soroti



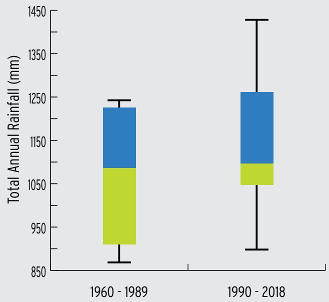
	1960 - 1989	1990 - 2018
Minimum	1136	1072
10th Percentile	1210	1261
50th Percentile	1371	1371
90th Percentile	1502	1620
Maximum	1825	1825

Wadi Halfa



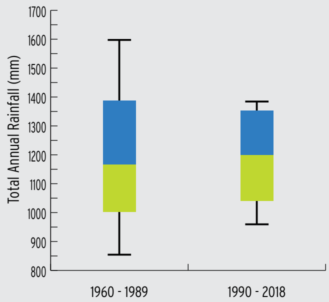
	1960 - 1989	1990 - 2018
Minimum	8.55	10.49
10th Percentile	10.31	11.32
50th Percentile	14.3	13.86
90th Percentile	23.55	20.6
Maximum	29.18	28.79

Wau



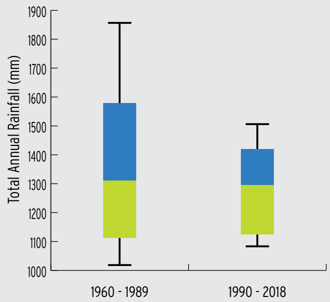
	1960 - 1989	1990 - 2018
Minimum	867	896
10th Percentile	910	1047
50th Percentile	1086	1096
90th Percentile	1226	1261
Maximum	1245	1431

Wonji



	1960 - 1989	1990 - 2018
Minimum	851	956
10th Percentile	1003	1040
50th Percentile	1166	1199
90th Percentile	1387	1352
Maximum	1602	1388

Yeki



	1960 - 1989	1990 - 2018
Minimum	1014	1080
10th Percentile	1113	1124
50th Percentile	1311	1295
90th Percentile	1579	1420
Maximum	1861	1508

VULNERABILITY TO CLIMATE IMPACTS

« The Nile Basin economies are highly vulnerable to climate shocks because they depend heavily on natural resources and lack economic diversification »

Various factors amplify the vulnerability of the Nile Basin to climate impacts, including high poverty levels, the expansive and fragile dryland zone, the high natural variability of rainfall over most of the Basin, low water-storage capacity, poor farming practices in the large rainfed area, lack of reliable early warning systems, and the large and growing rural population that is reliant on the natural resource base for its livelihood.

This section differentiates between economic systems, livelihood systems, and natural systems (World Bank, 2017), as presented in Figure 6.1. It will analyse the vulnerability to climate impacts of the most important elements of the above systems:

- energy;
- agricultural, which is sub-divided into irrigation, rainfed agriculture, and pastoralism;
- land catchment areas; and
- aquatic ecosystems.

Fisheries, navigation, industry, and municipal water supply are not included in the analysis. Although they are evidently affected by climate change, water demand for domestic purposes and industries are minute compared to those for agriculture, while these sectors are well positioned to benefit from advances in technology and improved management that will make them more robust. Navigation is not yet important in the Nile Basin, while the fisheries sector is discussed under aquatic ecosystems.

BOX 6.3: NILE DELTA

The low-lying Nile Delta is highly vulnerable to a rise in sea level. The rich arable lands make an important contribution to Egypt's agricultural production, while the area is densely populated and home to about one-third of the country's population.

Sea-level rise will seriously threaten the delta. This threat is compounded by the weakening of the protective offshore sand belt because of reduced silt supply from the Nile after the construction of the High Aswan Dam, and by land subsidence because of increased groundwater extraction.

Higher sea levels, reduced Nile flows, and possible over-pumping of groundwater combine to accelerate saltwater intrusion into the underlying aquifer. Projections show that 60% of the Nile Delta could be salt saturated and 20% submerged by late 21st century (Gebre and Ludwig, 2015).

ENERGY SECTOR

The principal vulnerability in the energy sector is caused by the preference for hydropower of several riparians, notably Ethiopia, Sudan, and Uganda. Table 6.1 lists the climate impacts on hydropower production.

TABLE 6.1: WATER-RELATED CLIMATE IMPACTS ON HYDROPOWER PRODUCTION
Increased aridity
• Land degradation due to drying out of the landscape and vegetation loss will increase sediment loads in rivers that will accelerate silt deposition and associated reduction of reservoir storage capacity, and cause possible damage to the electro-mechanical equipment • It will result in less water available for power production and higher maintenance costs
Higher temperatures
• Higher open-water evaporation; less water available for power production • Higher irrigation-water demand; less water available for power production
More frequent and more intense droughts
• More water needs to be reserved for irrigation; less water available for power production • It results in less firm-energy and decreased reliability of power production
More frequent and more prolonged floods
• Higher flood peaks, which implies that more storage capacity and coordination of dam operation is required for flood management of the downstream river reach; less water available for power production • Higher risk of dam failure
Increased seasonal and interannual variability of rainfall and associated river flow
• More water needs to be harvested and reserved for supplementary irrigation and drinking water; less water available for power production • Less reliable power production; less firm energy

Hydropower production on the White Nile is very sensitive to the impacts of climate change. Lake Victoria is the principal reservoir for the cascade of planned and existing hydro facilities on the Victoria and Kyoga Nile, as well as for planned facilities on the Bahr el Gebel. These facilities are operated on a run-of-river basis and only have small reservoirs that serve to regulate daily, or at most weekly power production. Thus, a change in outflow from Lake Victoria impacts power production at all facilities.

The water balance of Lake Victoria is dominated by two components: over-lake rainfall and lake evaporation. This makes Lake Victoria very sensitive to changes in precipitation and temperature. While the warming trend of the regional climate will lead to higher lake evaporation, the possible impact on the rain regime on the Equatorial Plateau is projected to increase . Other studies by NBI have shown that neither the magnitude nor direction of change of net-Basin supply of Lake Victoria – which determines outflow to the Nile – has been established. Although the medium value of 43 model outcomes suggests a reduction of Victoria Nile flows of about 30% (Section 6.7 of the Appendix), the model runs show a very diverging picture. Future power production on the White Nile, therefore, is subject to high uncertainty and can be either much higher or much lower.

Because of the multi-purpose nature of the existing and planned reservoirs on the Blue Nile, climate change affects hydropower production in the Eastern Nile region in four major ways: 1) change in river flow, 2) increase in flood-control reservation to accommodate higher flood peaks, 3) increase in irrigation water demand in the downstream region because of higher evapotranspiration, and 4) increase of reservoir storage reserved for drought management. Elements 2, 3, and 4 will reduce the volume of water available for power production. Thus, the impacts of climate change on hydropower production in the Eastern Nile are to a considerable extent determined by a trade-off analysis and negotiated process with affected stakeholders. While firm energy production will probably remain predictable, total yearly power production will become more variable.

RAINFED FARMING

The large rainfed farming sector is very vulnerable to the impacts of climate change, as listed in Table 6.2.

More variable and unpredictable rainfall will increase the risk of crop failure or crop losses due to moisture deficits at critical stages during plant growth. Storms can increase crop damage. Higher temperatures will lead to higher crop-water requirements and heat stress experienced by plants, and thus increase drought risks and susceptibility of plants to pests and diseases. The rising risk of crop failure will encourage farmers to adopt low-risk strategies that are associated with low yields and returns, and therefore impede agricultural modernisation and rural development.

The consequences of these development are potentially large. With some 87% of arable land in the Nile Basin under rainfed farming, the increased risk of crop failure because of climate-change impacts will have serious adverse impacts on food security, the economic viability of rainfed farming, rural development, rural livelihoods and poverty alleviation, and rural–urban migration.

TABLE 6.2: WATER-RELATED CLIMATE IMPACTS ON RAINFED AGRICULTURE
Increased aridity
• Higher crop water requirements; higher risk of moisture deficits during plant growth and associated crop failure • Land degradation due to drying out of the landscape and vegetation loss result in an increase in the risk of soil erosion through wind or water; loss of soil fertility and moisture-storage capacity
Higher temperatures
• Higher crop water requirements; higher risk of moisture deficits during plant growth and associated crop failure • Higher risks of pest infestation and crop diseases
More frequent and more intense droughts
• Higher risk of moisture deficits during plant growth and associated crop failure • Farmers will adopt low-risk strategies with low yields and returns
More frequent and more prolonged floods
• Increased crop damage • Increase in risk of destruction of infrastructure (electricity, roads, etc.) essential to storage of agricultural produce, agro-processing, and agricultural trade
Increased seasonal and interannual variability of rainfall and associated river flow
• Higher crop failure because of unpredictability of onset of rains • Higher risk of water stress during plant growth and associated crop failure • Farmers will adopt low-risk strategies with low yields

IRRIGATION SECTOR

The large rainfed farming sector is very vulnerable to the impacts of climate change

The main vulnerability of the large irrigation sector is related to uncertainties about future water availability because of increased competition over water resources and because of changes in the hydrologic regimes of the Nile and its tributaries. The availability of water resources is also impaired by increased water losses from reservoirs, lakes, and wetlands due to higher evaporation. Note that this section is only concerned with areas equipped for irrigation with full water control. Table 6.3 presents the water-related impacts of climate change on the irrigation sector.

TABLE 6.3: WATER-RELATED CLIMATE IMPACTS ON IRRIGATION
Increased aridity
• Higher evapotranspiration that increases crop water requirements • Higher evaporation could exacerbate salination and soil pollution/degradation • Higher sediment load resulting in higher maintenance costs of the water delivery system
Higher temperatures
• Higher irrigation water demand • Increase in risk of pests and crop diseases
More frequent and more intense droughts
• Higher risk of moisture deficits during plant growth; more water storage required
More frequent and more prolonged floods
• More harm to crops because of intensive rainfall • Increase in risk of destruction of infrastructure (electricity, roads, etc.) essential to storage of agricultural produce, agro-processing, and agricultural trade • Higher flood peaks, which implies that more storage capacity is required for flood management of the downstream river reach; less water available for irrigation
Increased seasonal and interannual variability of rainfall and associated river flow
• Higher risk of moisture deficits during plant growth; more water storage required

PASTORALISM

While pastoralism is well adapted to rainfall unpredictability and variability – and makes good use of land and rainfall that is otherwise less productive – it is nevertheless vulnerable to the impacts of climate change. Table 6.4 lists the water-related climate impacts on pastoralism.

Pastoralism is the dominant land-use system in the expansive drylands in the Nile Basin. It makes an important contribution to GDP, and a large segment of the population in the dryland zone depends at least partially on livestock for their livelihood and food security.

Intensified drying and associated land degradation will reduce the quantity and quality of forage and will impair the capacity of the land to sustain livestock. Since drylands are fragile, land degradation is not easily reversed, and it will be difficult to recover carrying capacity once it is lost.

While pastoralism is generally resilient, it will be very vulnerable to more frequent and intense droughts, which is associated with conflicts over pasture and water resources, loss of animals and income, possibly famine, poverty, and rural–urban migration.

While pastoralism is generally resilient, it is vulnerable to increasing droughts, which is associated with conflicts over pasture and water

TABLE 6.4: WATER-RELATED CLIMATE IMPACTS ON PASTORALISM
Increased aridity
• Land degradation; loss of forage; diminishing carrying capacity of the land • Increase in competition for land resources; associated conflicts and lack of peace
Higher temperatures
• Higher water demand for animals
More frequent and more intense droughts
• Higher risk of shortage of forage • Drying out of rivers and small reservoirs; constraining options for watering animals • Intensified land degradation near remaining watering points
More frequent and more prolonged floods
• Intensified land degradation
Increased seasonal and interannual variability of rainfall and associated river flow
• Higher risk of periodic water shortages for watering animals • Intensified land degradation (and competition) near remaining water points

TERRESTRIAL ECOSYSTEMS

The unique biodiversity and ecosystems of the Nile Basin are under increasing threat because of climate change

Forests, savannahs, and grasslands are vulnerable to the impacts of climate change, and their associated hydrological and ecological functions will be affected in a variety of ways. As for the rest of the report, the sections on the impacts of climate change on terrestrial ecosystems pay particular attention to mountain forests, given the fundamental role they play in providing hydrologic services. Terrestrial ecosystems could increasingly experience water stress and degradation if plant species are unable to cope with temperature changes and droughts. This could change the extent and distribution of habitats with, for example, forests turning into savannahs. In water towers like the Rwenzori Mountains or Ethiopian Highlands, temperature increases will force plant and animal species to move towards higher altitudes. At the same time, habitats in high elevations with a cool and moist climate will shrink or disappear entirely, most likely causing sharp declines in populations, and species extinctions. The higher incidence of drought has already resulted in more wild fires in forests and savannahs. Increasing temperatures in combination with prolonged droughts are likely to accelerate this trend (Birdlife International, 2012).

Differences in topography, climate and levels of biodiversity across the Nile Basin mean that climate-change impacts on terrestrial ecosystems will vary considerably. Mountain ecosystems are among the most vulnerable to climate change (EAC, UNEP, and GRID-Arendal, 2016). In many parts of the Nile Basin, they are suffering from multiple causes, including weak tenure, burning, firewood gathering, poor agricultural practices, and deforestation. Already-degraded ecosystems are particularly vulnerable to climate change. For example, large-scale clearance of forests has occurred in all the Basin's water towers, making them more prone to future wildfires driven by higher temperatures and droughts. A majority of the Eastern Afromontane Biodiversity Hotspot is located in East Africa, including the Albertine Rift, the Ethiopian Highlands, and Mount Elgon. More than one-third of its species is endemic (Birdlife International, 2012). Endemic species are particularly vulnerable to climate change because they have low tolerances for changes in temperature and humidity. Their restriction in habitat range therefore easily leads to extinctions. Moreover, many invasive species have a high adaptive capacity towards climate. Thus, they will become an even greater threat to native species than they already are (see Chapter 5).

Climate-change impacts will affect the provision of ecosystem services and goods provided by forests, savannahs, and grasslands. Degraded forests through slow drought-imposed degradation or disruptive forest fires are expected to change runoff dynamics and downstream flows, which could be particularly problematic for Basin higher altitudes. Damaged and thinned-out forests, no longer able to hold back runoff efficiently, increase the risk of flood events, of lower dry-season flows and reduced groundwater recharge. While predicting future consequences for biodiversity is challenging (Dawson et al., 2011), some studies have offered insights into possible scenarios. In the Albertine Rift, one of the most bio diverse regions on Earth, the global range of endemic species is expected to fall by as much as 75% by 2080, given that many will be forced to shift habitats to higher altitudes; many alpine ecosystems will disappear completely (Plumtree et al., 2017). Degraded mountainous forest ecosystems will affect local human communities through a reduction in goods and services due to diminishing biodiversity, more frequent floods and landslides, reduced and possibly more polluted dry season flows, loss of top-soil, and warmer local climates, with adverse implications for food security, rural development, and poverty alleviation.

TABLE 6.5: WATER-RELATED CLIMATE IMPACTS ON LAND CATCHMENT AREAS
Increased aridity
• Changes in the distribution and extent of forests, savannahs and grasslands • Expansion of dryland and desert areas that threaten local livelihoods (e.g. through reductions in the carrying capacity for livestock)
Higher temperatures
• Lower soil moisture and water availability, affecting plant growth and agricultural activities • Shifts, shrinkage, and disappearance of specific ecosystem habitats and species such as cloud forests • Increased frequency and intensity of fires in forests and in shrub and grass savannahs
More frequent and more intense droughts
• Changes in volumes and timing of runoffs, especially during dry periods, as well as lower groundwater recharge • Reduced plant productivity and biomass, with negative effects for energy security as fuelwood and charcoal become scarcer
More frequent and more prolonged floods
• Deforested mountain slopes, prone to more extreme flood and landslide events • Higher soil erosion and hence sediment influxes to water bodies and dam reservoirs
Increased seasonal and interannual variability of rainfall and associated river flow
-

FRESHWATER ECOSYSTEMS

Climate change will affect the Basin's aquatic ecosystems – lakes, rivers, and wetlands – through variable rainfall patterns, floods, and droughts, altering flow regimes or habitat structure. Not all impacts will be negative. Higher rainfall in the headwaters is expected to raise flows of the White Nile and the Blue Nile. This could partially alleviate increasing human pressures caused by rising water demands or impoundments, which will be especially crucial in places like the Nile Delta, where water stress is already generally high (Conway, 2017). At the same time, rainfall will become more variable. Flows in 20 out of 23 rivers in the Lake Victoria Basin, for example, will be less consistent than previously; they will consequently experience more frequent seasonal water shortages, among others (LVBC, 2018). The predicted increase in floods will increase sediment and nutrient influxes into freshwater ecosystems, spurring levels of eutrophication or turbidity, which is a particular problem for the Basin's lakes (see Chapter 5).

Making projections with high accuracy about the vulnerability of aquatic ecosystems in the Nile Basin towards ongoing hydro-climatic changes is difficult. Information is not only lacking about how climate change will affect the hydrology of major freshwater systems such as the Sudd wetlands. Comprehensive assessments of the status and distribution of freshwater species exist only for a few ecosystems, compounding attempts to evaluate their vulnerability. However, some observations can be made. Especially in the Basin's northern part, the number of wetlands and river systems is very limited because of the arid climate. Here, climate-driven loss of habitat can have strong impacts for range-restricted populations, especially as a third of the freshwater species in the region is already threatened (Garcia et al., 2010). In less water-stressed parts, freshwater ecosystems are also threatened through climate change, although in other ways. In Lake Victoria, for example, freshwater species, and particularly fishes, are deemed vulnerable due to changes in temperature and lake productivity. This applies especially to the high number of endemic species, of which 76% are already threatened (Sayer et al., 2018).

The climate impacts on ecosystem goods and services are manifold. One is an estimated further decline of fisheries in the Basin. Climate change essentially magnifies many of the threats – eutrophication, turbidity, or the spread of invasive species – that have contributed to the decline of fisheries in the Basin's lakes in the past. It is therefore expected that under a changing climate, already overfished stocks – for example in Lake Victoria – will further decline, affecting millions of people who depend on them (Sayer et al., 2018). The same applies to the Nile Delta, where sea-level rise threatens freshwater fisheries through habitat loss and seawater intrusion. Despite predictions that water availability in the headwaters is to increase, small wetlands and rivers could run dry under more variable rainfalls, and cease to function as water reserves for domestic and agricultural purposes during dry periods.

TABLE 6.6: WATER-RELATED CLIMATE IMPACTS ON FRESHWATER ECOSYSTEMS
Increased aridity
• Habitat loss and degradation through desertification • Chronic water scarcity (e.g. threatening permanent rivers and wetlands)
Higher temperatures
• Increased eutrophication and algae blooms • More stable thermal stratification in lakes, impairing oxygen and nutrient exchange • Spread of invasive species with high adaptive capacity
More frequent and more intense droughts
• More frequent and prolonged water stress (e.g. causing drought mortality) • Increase of periods with low water quality • Fragmentation and loss of habitats (e.g. interrupted connectivity in lake systems or absence of seasonal wetland flooding)
More frequent and more prolonged floods
• Turbidity and sedimentation causing destructing of habitat and spawning grounds • Physical habitat, vegetation damages, and species mortality
Increased seasonal and interannual variability of rainfall and associated river flow
-

BOX 6.4: FLOOD RISKS IN THE NILE BASIN

The populated regions around Lake Victoria, Lake Kyoga, Lake Albert, Lake Tana, and along the Main Nile valley and Blue Nile valley in Sudan is subject to flooding that causes property damage, disrupts productive activities, causes livestock and agricultural losses, and leads to water-related diseases and associated health risks. The floodplain is an attractive area for diverse economic activities, and flood damage risks are steadily increasing because of economic development and population growth.

Climate change is anticipated to lead to higher variability of rainfall and river flow, and more frequent and more intense flood events.

STATUS OF ACTION TO BUILD CLIMATE RESILIENCE

ENERGY SECTOR

The vulnerability of the energy sector to climate impacts is mainly related to the high dependency on hydropower of some riparians, notably Ethiopia,Uganda and Sudan. Table 6.7 lists and reviews possible measures to strengthen the climate resilience of the sector. The table is organised around the three I's: Information, Institutions, and Infrastructure, as discussed in Section 6.1.

TABLE 6.7: POTENTIAL ADAPTIVE RESPONSES IN THE ENERGY SECTOR

		Level	Status
Information	More accurate climate models at adequate scales for long-term water resources planning	Regional	Mostly absent
	Seasonal and multi-year climate forecasts	Regional	Mostly absent
	Short and medium-range weather forecasts	Regional	Some
	Real-time data on lake levels and river flow	Local	Some
	Models to optimise hydropower production, flood protection, and other beneficial water uses at (sub) basin level	National/regional	For some sub- basins
Institutions	Regional power pools	Regional	In progress
	Policies & mechanisms to feed small-scale solar into grid	National	Some countries
	Procedures for seasonal water allocation at (sub) basin level	Regional	Absent
Infrastructure	Power interconnectors	Regional	In progress
	Alternative power sources	National	In progress
	Off-grid and mini-grid systems	Local	Few
	More water storage	Local/national	Insufficient

While the short- and medium-term dependency on hydropower is increasing in Ethiopia and Uganda, the energy sector is steadily increasing its resilience to climate impacts. The imminent completion of various power interconnectors is integrating national power grids and operationalising the Eastern Africa Power Pool (EAPP). In addition, work is ongoing to link the EAPP to the Southern Africa Power Pool. It will further diversify power sources, reduce power-generation costs, reduce the reserve capacity required at national level, and increase the reliability of power supply.

Because of the steady reduction of the costs of renewable energy sources such as geothermal, wind, and solar – in combination with sizable natural gas reserves – the combined Nile countries have ample options to diversify power production and gradually reduce the dependency on hydropower in the longer term. It is noted that all the above power-production options are currently being implemented in the Nile Basin – at various scales and locations. Moreover, the anticipated rise in application of off-grid and mini-grid systems will gradually decentralise power production and increase redundancy and diversity, thereby further increasing climate resilience of the energy sector.

<< Climate resilience is improving in the energy sector >>

IRRIGATION SECTOR

The discussion in this paragraph is concerned with areas equipped for irrigation, which does not include rainfed areas with supplementary irrigation.

The main climate vulnerability of the irrigation sector is concerned with securing bulk volumes of water required to cultivate the full area equipped for irrigation, both existing and planned. This section, therefore, also discusses measures to reduce irrigation water requirements at scheme and plot level. It is, however, not concerned with measures to increase agricultural productivity or yields, which have been discussed in Chapter 4 FOOD SECURITY AND AGRICULTURAL DEVELOPMENT. Table 6.8 lists and reviews measures to strengthen climate resilience of the irrigation sector.

TABLE 6.8: POTENTIAL ADAPTIVE RESPONSES IN THE IRRIGATION SECTOR

		Level	Status
Information	More accurate climate models at adequate scales for long-term water resources planning	Regional	Mostly absent
	Seasonal climate and river flow forecasts;	Regional	Mostly absent
	Models to optimise bulk water allocation for productive purposes at (sub) basin scale	Regional	Some
	Short and medium-range weather forecasts	Local	Mostly absent
	Accurate and timely data on climate, soil moisture, crop conditions, and crop water requirements	Local	Mostly absent
	Accurate and timely data on water conveyance systems	Local	Mostly absent
	Models for irrigation scheduling at plot level (including deficit irrigation)	Local	Some
Institutions	Procedures for seasonal bulk water allocation at (sub) basin level	Regional	Absent
	Procedures for seasonal bulk water allocation at scheme level	Local	Some
	Procedures/compensation for fallow land in drought years	Local	Some
	Procedures/compensation for deficit irrigation in drought years	Local	Some
	Procedures to improve water productivity at scheme level through crop selection;	Local	Some
	Reduced water losses in existing reservoirs (such as Lake Nasser and Jebel Aulia)	Regional	Absent
Infrastructure	More water storage	Local/nat./reg.	Insufficient
	More effective water conveyance systems	Local	Insufficient
	More effective irrigation systems (drip, sub-surface]	Local	Some
	Effective drainage systems and reuse of drainage water	Local	Some
	Facilities that reduce post-harvest losses (roads, cold-storage, storage, electricity, etc.)	Local	Some

The irrigation sector is vulnerable because of uncertainties about future water availability. It is noted that the direction and magnitude of change in river flow in the Nile and its tributaries because of climate change has not yet been established. The sector is unprepared for a scenario with less river flow, and thus less water available for irrigation purposes. There are currently no data, information products, or institutions to forecast seasonal flows, nor institutions to manage water over the various water-use sectors and irrigation schemes in an equitable manner and through a negotiated process. The information, institutions, and infrastructure needed to increase water-use efficiencies are mostly absent, while procedures to cope with possible seasonal water shortages at scheme level – for instance by increasing fallow land or deficit irrigation – exist only incidentally.

Nevertheless, the area equipped for irrigation is robust to a more variable climate under the condition that water supply for the remaining cultivated area can be secured and crop failure is avoided. Thus, total agricultural production will decrease proportionally to the reduction of irrigated area. A total collapse of agricultural output from irrigated areas is unlikely.

RAINFED AGRICULTURE

The large rainfed sector is very vulnerable to a warmer and more variable climate, which will increase the risk of crop failure and thus discourage farmers to adopt modern high-yielding farming practices. Measures to prepare the sector for climate impacts are listed in Table 6.9.

Table 6.9 shows that the critical rainfed sector remains very fragile and almost completely unprepared for a more variable climate. Most rural people depend on agriculture for their livelihood and food security and have little savings or food reserves. Because of high poverty levels, few farmers have the capacity to prepare their farms for more variable weather. Hence, climate impacts resulting in increased risks of crop failure will have serious implications for rural development and food security.

TABLE 6.9: POTENTIAL ADAPTIVE RESPONSES IN THE RAINFED AGRICULTURAL SECTOR

		Level	Status
Information	Seasonal climate forecasts	Local	Mostly absent
Institutions	Drought early warning systems	Local/national	Not effective
	Insurance schemes against crop failure	National	Not effective
	Diversified income sources for farmers	Local	Some
	Farming practices that conserve moisture and soils, and capture and store rainfall	Local	Some
	Improved land husbandry	Local	In place
	Catchment management plans	Local	
	Conjunctive use of ground and surface water for supplementary irrigation	Local/national	Some
	Agro-forestry rather than broad-acre agriculture	Local	Some
	Increased agricultural trade at local and sub-regional level	Local/national	Some
Infrastructure	Micro, small, and medium size water reservoirs	Local/national	Insufficient
	Supplementary irrigation	Local	Insufficient
	Soil and water conservation structures and measures	Local	Insufficient
	Rainwater harvesting structures;	Local	Insufficient
	Cropping patterns adapted to more variable climate	Local	Some
	Food storage	Local/national	Insufficient

PASTORALISM

« Widespread methods of food production small-scale rainfed agriculture and pastoralism are most vulnerable to climate change »

Due to the advantage of mobility, pastoralism is less susceptible to a more variable climate than more sedentary land uses, such as crop agriculture and livestock ranching. Nevertheless, the sector is very vulnerable to climate shocks that manifest in more frequent, widespread, and intense droughts.

Droughts affect the pastoralist sector in three critical ways: 1) drying up of water sources for the animals, 2) declining forage resources, and 3) herders being forced to sell animals in order to raise cash to buy food for their families and animals. Because of declining livestock prices and rising grain prices during a major drought, the number of animals that must be sold is typically in excess of those required to bring animal numbers in balance with fodder availability. It compromises the ability to reconstitute a viable pastoral existence in the post-drought period (Sommer 1998). Table 6.10 lists the potential adaptive responses in the pastoralist sector.

An effective response to a drought is based on a controlled reduction of the herd size in order to balance the number of animals with the available forage while maintaining the capacity to quickly reconstitute the herd in the post-drought period. It requires timely intervention to detect drought-related stress to pastoralist livelihoods, to support pastoralists in herd management, and provide temporary support to maintain livelihood and/or food security. It is noted that once pastoralists become destitute, food insecurity becomes a chronic problem because economic opportunities outside the pastoralist sector are generally poor (Sommer 1998).

Table 6.10 indicates that the pastoralist sector is fragile and unprepared for the anticipated climate impacts. Neither the information, institutions, nor infrastructure are adequate to cope with the more frequent and more intense drought events that are anticipated.

TABLE 6.10: POTENTIAL ADAPTIVE RESPONSES IN THE PASTORALIST SECTOR

		Level	Status
Information	Seasonal climate forecasts	Local/national	Mostly absent
	Soil erosion mapping	Local/national	Existing
	Drought early warning systems focused on pastoralist sector	Local/national	Mostly not effective
Institutions	Herd management	Local/national	Not effective
	Support in movement of livestock during drought (e.g. subsidised transport)	Local/national	Mostly absent
	Support in marketing of livestock during drought (e.g. price controls]	Local/national	Mostly absent
	Forage supplementation during drought (e.g. subsidised transport of fodder]	Local/national	Absent
	Strategies to increase seasonal wetlands for fodder production during drought years	(Sub) basin	In place but often too late
	Alternative food security strategies during droughts; provision of food aid	Local/national	Insufficient
	Diversified income sources	Local	Some
Infrastructure	Valley tanks and small reservoirs	Local	Insufficient
	Deep boreholes and wells	Local	Insufficient
	Reserve land reserved for droughts	Local/national	Absent
	Reforestation and catchment protection	Local/national	Some
	Food stores for use during drought	Local/national	Some

TERRESTRIAL ECOSYSTEMS

Proactive adaptation is fundamental for safeguarding terrestrial ecosystems in a changing climate. The information provided in Section 6.3 shows that many terrestrial ecosystems are vulnerable to the impacts of climate change. In considering their state of resilience, it needs to be acknowledged that there is an array of adaptation interventions by single countries or through multilateral efforts underway, such as the Kenya Water Tower Climate Change Resilience Program. Starting in 2015, it seeks to protect and restore Kenya's five prime water towers, including Mount Elgon. The protected area coverage for some mountain ecosystems, such as the Albertine Rift, is extensive and considered appropriate, while conservation plans with adaptation elements exist (Plumetree et al., 2017). Another important work for informing and guiding adaptation efforts for mountain ecosystems is Sustainable mountain development in East Africa in a changing climate. Co-led, among others by UNEP, it has identified remaining gaps in research and adaptation efforts, and formulated 12 priority areas for future action (EAC, UNEP, and GRID-Arendal, 2016).

Despite significant progress made, adaptation efforts are fragmented and short-lived. Governance systems are generally weak, and specific provisions for mountain forest ecosystems in policies rarely exist. Enforcement is also often poor, being constrained by a general lack of human and financial resources, data, political instability, or corruption. There have been efforts to restore forest cover in some areas, but interventions need to be replicated at a much larger scale, given the small fraction of the catchment area they cover and the high degree of human-driven pressures through unsustainable land management. While some mountain ecosystems are well protected (as noted before), protection coverage in the Ethiopian Highlands is minor compared to its large geographical extent (see Chapter 5). And yet, even some well-protected ecosystems face enormous threats from surrounding human activities (Watson et al., 2014). At the same time, conservation

TABLE 6.11: POTENTIAL ADAPTIVE RESPONSES IN TERRESTRIAL ECOSYSTEMS

		Level	Status
Information	Comprehensive assessments of species distribution and status	Local/national/cross-national	Some
	Long-term biological monitoring	Local/national/cross-national	Mostly absent
	Climate vulnerability assessments for terrestrial ecosystems	Local/national/cross-national	Mostly absent
Institutions	Investments and financial resources for mountain ecosystem and biodiversity conservation	Local/national	Mostly absent
	Adaptation plan(s) for the basin's mountain forests	Local/national	Inadequate
	Policies and institutional frameworks specifically related to mountain ecosystems at all political-administrative levels	Local/national	Inadequate
	Sustainable land-use planning and land management practice policies	Local/national/cross-national	Mostly absent
	Effective conservation of key terrestrial ecosystems inside and outside of protected areas	Local/national/cross-national	Some
Infrastructure	Ecosystem restoration and afforestation projects	Local/regional	Some
	Establishment of wildlife corridors	Local	Some
	Re-establishment of sustainable land management systems	Local/regional	Inadequate
	Expansion of rural electrification	Local/regional	Inadequate

projects tend to focus on protected areas. Many terrestrial ecosystems accommodate high biodiversity and endemism or provide significant services and goods but remain unprotected (Birdlife International, 2012).

Several actions will be imperative to increase the resilience of terrestrial ecosystems. First, there is a need to strengthen subnational, national, and transboundary governance structures for sustainable development of mountain ecosystems (such as the Greater Virunga Transboundary Collaboration). Second, it is critical to expand restoration projects for mountainous ecosystems to increase their resilience against climate change. In the face of rapid population growth, these will fail unless they are able to improve the livelihoods of mountain communities. The re-introduction of traditional agroforestry systems, which have been abandoned to deploy modern agricultural techniques, has been proven to meet both ends. By blending crops and trees of different species, they are able to maintain soil fertility, provide food, and supply bark, fuel, timber, and wood products. Third, there is a need to increase the network of protected areas and the effectiveness of managing them. This is especially true for the Ethiopian Highlands. With its population set to double by 2050, already heavily degraded soils, very low forest cover, and weakly protected landscapes require much greater efforts. Common to all of these priority actions is that they will need to be informed by vulnerability assessments, which build the basis for adaptation actions by offering insights into priority areas and appropriate interventions.

FRESHWATER ECOSYSTEMS

Proactive climate-change adaptation is fundamental for safeguarding freshwater ecosystems. Significant hydrological changes can be expected to strongly affect aquatic ecosystems in a variety of ways. Globally, rivers, lakes and wetlands have been declining more rapidly than any other ecosystem. Many freshwater ecosystems are consequently in a poor state and vulnerable to further change, with the Nile River Basin being no exception. Determined action is needed to buffer ecosystems most vulnerable to severe climate-change impacts; the investments needed for early intervention will be lower than the eventual costs arising from delayed responses or inaction.

TABLE 6.12: POTENTIAL ADAPTIVE RESPONSES IN FRESHWATER ECOSYSTEMS

		Level	Status
Information	Biological and hydrological monitoring	All scales	Mostly absent
	Comprehensive assessments of species distribution and status	All scales	Mostly absent
	Vulnerability assessments of species and ecosystems	Local	Mostly absent
	Climate forecasting and scenario-based models	Local/regional	Some
	Mapping of key ecosystems and water-related ecosystem services	Local/regional	Some
	Environmental flow assessments	Local/regional	Some
Institutions	Climate modelling expertise and technical know-how	All scale	Some
	Basin-wide conservation plan; Regional and Basin-wide adaptation plan(s	All scale	Some
	Climate-resilient water resources planning and decision-making	Transboundary	No
	Protected areas for freshwater ecosystems	All scales	Mostly absent

Infrastructure	Removal and retrofits of impoundments and construction of fish passages	Local	Mostly absent
	Restoration of freshwater ecosystems	Local	Some
	Species translocations and population stock-ups	Local/Regional	Mostly absent
	Projects for tackling invasive species and replanting of native vegetation	Local/Regional	Some
	Implementation of e-flows in dam-projects and water allocation regimes	Local/Regional	Mostly absent

While progress on advancing climate adaptation is generally limited, interventions adapting freshwater ecosystems to future changes are even fewer. First, there is inadequate long-term hydrological and biological monitoring capability, and therefore limited information (including vulnerability assessments) with which to inform adaptation responses. Second, current conservation efforts for freshwater species (including the network of protected areas) are insufficient. Even within protected areas, freshwater ecosystems experience significant pressure, in part because the designation 'protected area' was designed for terrestrial ecosystems (Sayer et al., 2018; Allan et al., 2019). Very few adaptation plans exist, and the extent to which they address freshwater ecosystems is inadequate. The Climate Change Adaptation Strategy and Action Plan 2018–2023 for the Victoria sub-Basin (LVBC, 2018) or climate-sensitive Conservation Action Plan for the Albertine Rift (Plumtree et al., 2018) are the exceptions.

Several strategies will be central to increasing ecosystem resilience. Tackling non-climate stresses and strengthening ecosystem functions through conservation (e.g. expansion of protected areas, especially for freshwater ecosystems) and water-management activities (e.g. pollution control as part of watershed-management projects) is of vital importance. Given rapidly increasing water demands, establishing environmental flows be a high priority for many rivers. Implementing them would ensure that the water needs of freshwater ecosystems were not compromised during prolonged dry periods, among other benefits. In the face of limited resources, a risk-based approach drawing on scenario analysis can help identify aquatic ecosystems most vulnerable and at risk. Vulnerability assessments should hence inform planning activities and operations (e.g. National Adaptation Plans, water-sector policy and or infrastructure decision-making).

FLOODING IN THE NILE VALLEY

Flood risks in the Nile Basin are increasing because of more variable and extreme rainfall caused by climate change. Moreover, potential flood damage in many areas is rising because of steadily growing economic activities in the floodplain. Potential adaptive measures to cope with flooding in the Nile Valley are listed in Table 6.13.

The Nile Basin River Flow Forecasting System which has been developed by Nile Basin Initiative Secretariat will provide information about volume of stream flow that can be expected at particular points in the river network with lead times that could range from few days to a season. The forecast system will have a web-interface for dissemination through the NBI Integrated Knowledge Portal (IKP). In addition, the Nile Basin River Flow Forecasting System will also provide the following type of information:

- Flows at selected points in the river network.
- Water levels at selected reservoirs and Lakes.
- Catchments rainfall.

Furthermore, the Eastern Nile Technical Regional Office (ENTRO) has implemented the Flood Preparedness and Early Warning

« NBI is supporting short-term seasonal river-flow forecasts for critical rivers in the basin with the aim of mitigating flood damage »

(FPEW) project to increase the capacity to respond to flood events in the flood-prone areas, including along the Blue and Main Nile. ENTRO has also provided a flood-warning service through the Flood Seasonal Monitoring Program.

It is noted, however, that collaborative mechanisms among neighbouring countries to establish operation rules for the large reservoirs on the Blue Nile and Tekeze that prioritise effective flood management are not yet in place.

Nevertheless, important progress is being made in terms of infrastructure, however, progress is still low in data and information sharing and coordination to prepare for more frequent and intense flooding in the Main and Blue Nile valleys caused by climate change.

TABLE 6.13: POTENTIAL ADAPTIVE RESPONSES TO FLOODING IN THE NILE VALLEY

		Level	Status
Information	Floodplain delineated; flood risk mapping	(Sub) basin	Mostly available
	Seasonal climate and river flow forecasts	(Sub) basin	Inadequate
	Short and medium-range weather forecasts	(Sub) basin	Inadequate
	Accurate and real-time data on rainfall, river flow, and reservoir levels	Local	Some
	Flood forecasting and routing models	(Sub) basin	Some
	Models to optimise reservoir operation for diverse purposes, including flood control	(Sub) basin	Some
Institutions	Flood early warning systems (including communication]	(Sub) basin	On Blue Nile
	Land use policies that discourage settlement in flood prone areas	Local/national	Inadequate
	Emergency relief services & post-flood rehabilitation	Local/national	Inadequate
	Coordinated transboundary reservoir operation policies	(Sub) basin	Absent
	Transboundary data sharing	(Sub) basin	Absent
Infrastructure	Upstream storage capacity	(Sub) basin	adqt
	Dyke system in flood prone areas	Local	Some
	Critical infrastructure such as roads and telecommunication on elevated lands	Local	Some
	Cattle (and people) refuges on elevated lands	Local	Some
	Latrines and drinking water points on elevated lands	Local	Some
	Watershed management	Local	Some

A STATUS REPORT

Photo: Salahaldeen Nadir / World Bank

Scenes from Al Nnuhoud Livestock Market, North Kordofan where livestock is brought and traded from places nearby.

This chapter has reviewed the potential implications of climate change in the Nile Basin, and the resilience of the riparian's economies, societies, and ecosystems to cope with these impacts. The overall conclusion is that preparations for the impacts of a warmer and more variable climate are currently inadequate and that climate change poses a serious risk to the Nile Basin.

Specifically, the large rainfed agricultural sector is very vulnerable to climate impacts. Very limited progress has been made to improve land husbandry and increase the capacity to capture and store rainfall for use in agricultural production, or secure water supply by other means, such as small-scale supplementary irrigation. Hence, farmers are almost totally unprepared to cope with more unpredictable weather and more frequent dry spells. The implications manifest are at two levels. At a direct level, crop failure will threaten the livelihood and food security of the large rural population, with dire need. At a more indirect level, higher risk of crop failure will obstruct agricultural modernisation, with ensuing consequences for rural development, poverty alleviation, regional food security, land degradation and environmental sustainability, rural–urban migration and lack of peace and security. It is unlikely that food security in the Nile Basin can be achieved without reducing the substantial yield gap in rainfed farming, which is becoming more difficult because of climate impacts. For this reason, the absence of progress in climate proofing the rainfed sector is a cause of serious concern.

Almost equally vulnerable and unprepared is the pastoralist sector. Although it is more adapted to rainfall variability and unpredictability, no measures are in place for improved land management, herd management, or post-drought herd reconstitution. It could compromise the peace, economic viability of the pastoralist lifestyle and encourage rural–urban migration since economic opportunities outside the pastoralist sector are generally poor in the dryland zone.

« The Nile Basin region is grossly unprepared for the impacts of climate change »

The irrigated agricultural sector is unpre-

« Scaling-up measures proven to mitigate the impacts of climate change is the biggest challenge »

pared for a scenario in which Nile flows decrease. In instances of bulk water deficits, no mechanisms exist to manage the remaining water resources over the existing schemes in an equitable and reasonable manner and through a negotiated process. It is noted that the direction and magnitude of change of the Nile flows is yet uncertain. Nevertheless, some individual schemes for which water supply can be secured are mostly somehow resilient to climate impacts. Some progress is being made in improving agricultural water productivity in underperforming schemes.

The energy sector is gradually becoming more resilient to climate impacts. Several interconnectors are completed, or in an advanced state of completion, while regional power pools are being operationalised. It is expected that the dependency on Nile waters for energy supply will progressively decrease in the longer term with the expected diversification of the energy production mixes, in combination with the establishment of functional regional power markets.

While climate resilience is improving in some sectors – notably the energy sector and regarding flood protection in the Nile Valley – current measures to prepare the Nile region for a hotter and more variable climate are inadequate. This is particularly worrying since the Nile Basin is very vulnerable to climate impacts because of high poverty levels, the large and fragile dryland regions, and the large rural population that depends on the natural resource base for their livelihood and food security.

Measures to strengthen the climate resilience of the large pastoralist and rainfed agriculture sectors exist and are proven. The challenge is to scale up these measures quickly enough to make a significant impact. This is a daunting task in view of the scale of the action required. However, most climate-adaptation measures directly contribute to overall development objectives and can therefore be classified as 'no-regret' measures. Accelerated implementation of these 'no-regret' measures constitute a sensible course of action. Failure to adequately prepare for a changing climate in the Nile region will have severe societal, economic, and environmental consequences.

APPENDIX

NBI (2017) employed the 23 RCP 4.5 and 20 RCP 8.5 scenarios climate models to assess the implications of climate change on catchment yield. Table 6.14 presents the relative change in streamflow at selected locations for four dominant climate change model runs: 1) dry, with moderate GHG emissions, 2) dry, with high GHG emissions, 3) wet, with moderate GHG emissions, and 4) wet, with high GHG emissions. These four model outcomes capture the impacts for extreme temperature and precipitation changes and should thus represent a broad spectrum of possible outcomes.

Table 6.14 illustrates the diverging picture obtained from climate models regarding the future flow of the Nile River. At present, neither direction nor magnitude of change can be established with any degree of certainty.

TABLE 6.14: RELATIVE CHANGE IN STREAM FLOW RESULT FOR CLIMATE-CHANGE SCENARIOS AT SELECTED LOCATIONS IN THE NILE BASIN [SOURCE: NBI, 2017A TECHNICAL NOTE IV]

	1	2	3	4
	GISS-E2-H_run1_rcp85	_bcc-csm1-1_run1_rcp45	MIROC5_run1_rcp85	ACCESS1-3_run1_rcp45
Blue Nile at Diem	-46%	-28%	-7%	19%
Blue Nile at Khartoum	-58%	-40%	-15%	42%
Upper Atbara	-55%	-57%	-25%	72%
Tekeze downstream of Tekeze Dam	-40%	-37%	2%	306%
Atbara outflow into Nile	-53%	-53%	-14%	241%
Downstream of Merowie	-47%	-32%	-7%	76%
Dongolla	-47%	-32%	-7%	76%
Kagera outflow	-57%	12%	44%	11%
Lake Victoria outflow	-30%	10%	40%	20%
Sudd outflow	-8%	9%	18%	21%
White Nile at Malakal	-13%	-4%	2%	16%
Sobat at mouth	-18%	-18%	-16%	10%
Mongala	-30%	10%	40%	22%
Downstream of Aswan	-45%	-21%	-12%	84%
Cairo	-62%	-32%	-18%	126%

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CHAPTER 7

TRANSBOUNDARY WATER GOVERNANCE

Photo: Shutterstock

CONTENTS

KEY MESSAGES

There are several regional organisations that have mandates related to the management and development of the common Nile water resources.

There is overlap in the geographical area of jurisdiction of these authorities, and country membership also overlaps. Co-ordination between the different regional organizations is generally low, although a few Memoranda of Understanding have been signed between some of the regional organizations.

NBI has a strong and coherent policy framework to guide Nile riparian states towards attaining sustainable management and development of the Nile water resources.

The strength of the regional policy environment for transboundary water management is characterised by a suite of around 33 policies, strategies and guidelines adopted by the policy organs of the NBI and its subsidiary action programmes.

All riparian states have established institutional arrangements for dealing with transboundary water management issues. As a knock-on effect, capacity for transboundary water cooperation has been enhanced in all countries, and asymmetries between countries decreased.

Nile Basin Initiative has successfully coordinated technical cooperation between the Nile riparian states that has produced greater tangible results on the ground.

Within the Nile Basin Initiative, several mechanisms have been set up for deliberation by stakeholders on issues concerning the management and development of the common Nile water resources.

The measures established have allowed for discussion of NBI projects and programs, and participation by different stakeholders in decision making processes on programs and projects.

Many state-of-the-art tools and systems have been developed, and are being applied, under the NBI to support evidence-based decision making in the sustainable management and development of the Nile water resources.

The tools include the Nile Basin Regional HydroMet System; system for Monitoring of the Nile Basin Using Satellite Observations; Nile Decision Support System; Eastern Nile Planning Model, Nile State of Basin Report and periodic strategic water resources assessments.

The NBI investment projects are expected to benefit millions of people – both directly and indirectly – when fully implemented.

They will contribute to the NBI's impact objectives of ensuring water, food, energy and environmental security, and of enhancing resilience to climate change.

All the regional organizations in the Basin are supporting investment projects but there is no system in place to coordinate their planning.

There is need to speed up and strengthen processes to increase collaboration between NBI and the other regional organizations in the Basin in the areas of investment planning, and increase support for process. This will ensure that multi-sectoral projects being promoted by the different regional organizations are optimized from a basin-wide perspective and that there is efficiency in resource utilization.

Photo: NBI

Pressure on the finite and modest water resources of the Nile is rising to unprecedented levels due to population growth, rapid urbanisation and economic development. The resulting higher requirements for water for food and energy – which are in turn exacerbated by environmental degradation and the impacts of climate change – have the potential of not only adversely impacting on long-term water availability, but also of giving rise to water disputes.

Water governance is a prerequisite for improving water management but over the last two decades there has been much debate over what constitutes water governance. Different schools of thought have adopted and interpreted governance from different perspectives, and international forums and platforms have understood and used the term with different interests, and sometimes with conflicting objectives (Lautze et al., 2011[1]). For this discussion, we use the framework proposed by Jiménez et al., 2020[2] in which water governance is defined as "a combination of functions, performed with certain attributes, to achieve one or more desired outcomes (related to management and development of water resources), all shaped by the values and aspirations of individuals and organisations".

Water governance can be divided into eight key overlapping and closely interrelated functions, including

a) Policy and law – which comprises the set of norms, principles and priorities to achieve desired outcomes in water governance, as well as the set of rules, procedures, programs and/or mechanisms needed to achieve such ends
b) Regulation – which covers formal legal

[1]Lautze, J.; de Silva, S.; Giordano, M.; Sanford, L. 2011. Putting the cart before the horse: Water governance and IWRM. Nat. Resour. Forum. Vol. 35, 1–8 pp.
[2]Jiménez A., Saikia P., Giné R., Avello P., Leten J., Liss Lymer B., Schneider K., and Ward R. 2020. Unpacking Water Governance: A Framework for Practitioners. Water Vol. 12, 827; doi:10.3390/w12030827.

mechanisms, enforcement processes and other rules to ensure that stakeholders fulfill their mandates, and that standards, obligations and performance are maintained, as well as to ensure that the interests of each stakeholder are respected

c) Planning – the process of data collection and analysis, and formulation of actionable plans for integrated water resources management and development
d) Management arrangements – which refers to the combination of organisational, managerial and institutional arrangements at local, sub-national, national and regional levels, that support—or undermine—water resources management and development
e) Coordination – which comprises the processes, mechanisms, instruments and platforms that promote and ensure multilevel, multi-sectorial, and multi-stakeholder cooperation among all actors. The coordination function which also entails information sharing, dialogue and collaborative decision-making linked to policy making and planning
f) Financing – relates to the processes of raising funds from different funding sources to finance water resources management and development. At transboundary level, it includes developing instruments for joint financing of transboundary water infrastructure or management institutions; and distribution of financial risk
g) Monitoring, evaluation and learning – refers to on-going, systematic processes of collecting, analysing, evaluating, and using data to track performance and inform planning and decision-making. Learning includes formal and informal processes to identify and document good practices and use the newly acquired knowledge in managerial decisions to adapt and improve policies and programmes.
h) Capacity development – which refers to the processes by which organisations, society and individuals systematically stimulate, develop, strengthen and maintain their capabilities to set and work to deliver their goals and objectives.

Successful performance of the above water governance functions is dependent on the framework within which the process is carried out including (i) multilevel governance, (ii) stakeholder participation, (iii open communication and discussion, (iv) equity and inclusiveness, (v) transparency and accountability, (vi) Evidence-based decision-making, (vii) Efficiency, (viii) impartiality and rule of law. The success of any transboundary water governance endeavour will depend on the degree to which these attributes are achieved.

Transboundary Water Governance (TWG) in the Nile Basin is complicated by many factors including: (i) presence of multiple actors/ institutions, (ii) parallel cooperation processes, from bilateral to regional (involving multiple countries in a given part of the basin, e.g. East African Community, IGAD) to basin-wide, (iii) diversity of socioeconomic, cultural and environmental conditions across the basin; (iv) historical perspectives and agreements; (v) distinct development agendas and involvement/support of several development partners.

The overall objective of TWG in Nile Basin is to find best approaches to enhance governance (technical, legal and institutional) within and across institutions, in order to achieve the goals of regional economic development and, in parallel, to address the water security concerns of Nile riparian countries. The chapter presents the current state of transboundary water governance in the Nile Basin and the roles of different organisations that work to achieve this, with a particular emphasis on the Nile Basin Initiative (NBI) as the only basin-wide platform for countries to deliberate on how to cooperatively plan, manage and develop the Nile to benefit current and future generations.

THE MULTIPLE REGIONAL ACTORS IN THE NILE BASIN

There are a number of intergovernmental institutions and Regional Economic Communities (RECs) operating within the Nile region that have mandates related to the management and development of water resources. The main regional actors are the Nile Basin Initiative (NBI) with its two subsidiary arms ENTRO and NELSAP-CU; the East African Community (EAC) with two of its specialized institutions – the Lake Victoria Basin Commission (LVBC) and Lake Victoria Fisheries Organization (LVFO); Common Market for Eastern and Southern Africa (COMESA) with one of its specialized institutions – the Eastern Africa Power Pool (EAPP); Intergovernmental Authority on Development (IGAD) with two of its specialized institutions – ICPAC and ICPALD; the Ramsar Centre for Eastern Africa (RAMCEA); and the African Union Development Agency (AUDA-NEPAD). Table 7.1 shows a mapping of the membership of Nile Basin countries in the regional agencies.

Some of the main institutions are briefly described in the sections below.

TABLE 7.1: MAPPING OF MEMBERSHIP OF NBI RIPARIAN COUNTRIES IN SELECTED REGIONAL ORGANISATIONS

COUNTRY	NBI	EAC/ LVBC	IGAD	COMESA	EAPP
Burundi	●	●	○	●	●
DR Congo	●	○	○	●	●
Egypt	●	○	○	●	●
Eritrea	◐	○	●	●	○
Ethiopia	●	○	●	●	●
Kenya	●	●	●	●	●
Rwanda	●	●	○	●	●
South Sudan	●	●	●	○	○
Sudan	●	●	●	○	●
Tanzania	●	●	○	○	●
Uganda	●	●	●	●	●

*List includes navigation as the seventh pillar

○ Not a member ◐ Observer state ● Full member

NILE BASIN INITIATIVE (NBI)

ESTABLISHMENT OF NBI

The Nile Basin Initiative (NBI) is a ten-member intergovernmental partnership established by riparian countries of the Nile on February 22, 1999. The NBI was the outcome of a protracted process of dialogue and discussions facilitated by the international community, which followed the closure of a WMO-funded hydrological observation project known as HYDROMET (1967-1992). Under the auspices of the Technical Cooperation Committee for the Promotion of the Development and Environmental Protection of the Nile Basin (TECCONILE), the riparian countries adopted a Nile River Basin Action Plan (NRBAP) in Feb. 1995) that included a Shared Vision towards which the countries collectively committed to work. Under the same framework of TECCONILE, the Policy Guidelines for the Nile River Basin Strategic Action Program were adopted alongside a plan of action for establishing the NBI. In accordance with the plan, minutes of Nile-COM formally establishing the NBI were adopted on February 22, 1999 and in May of the same year; the NBI Secretariat was set up in Entebbe. Ten of the eleven Nile Riparian countries (i.e. Burundi, DR. Congo, Egypt, Kenya, Rwanda, South Sudan, Sudan, Tanzania and Uganda) are participating in the NBI, with Eritrea being the only country maintaining an observer status in the NBI.

CORE FUNCTIONS

Formally launched in February 1999, the initiative provides an institutional mechanism, a shared vision, and a set of agreed policy guidelines to provide a basin-wide framework for cooperative action. On establishment, NBI was designed to move the partner states towards attaining their Shared Vision Objective: "to achieve sustainable socio-economic development through equitable utilization of, and benefit from the common Nile Basin water resources".

In 2012, the riparian countries refined and summarised the 'core functions' of the NBI as the following:

- Facilitating cooperation: The NBI provides the only all-inclusive regional platform for multinational and multi-stakeholder dialogue on the cooperative management and development of the shared Nile water resources.
- Water resources management: The NBI strengthens member states' institutional and technical capacities and provides analytic tools and a shared information system that enables Member States to monitor and sustainably manage the Nile Basin's water resources.
- Water resources development: The NBI assists Member States to identify development opportunities; prepare projects that are economically viable, environmentally friendly and socially acceptable; mobilize financial and technical resources for their implementation; and provide technical assistance during their implementation.

BASIN-WIDE LEVEL INSTITUTIONAL FRAMEWORK

The main governance organs in the institutional structure of the NBI are three: the Nile Council of Water Ministers (Nile-COM), Nile Technical Advisory Committee (Nile-TAC) and, the Nile Secretariat (Nile-SEC). The three organs are briefly described below.

- The Nile Council of Water Ministers (Nile-COM) – is the highest policy and decision-making body of the Nile Basin Initiative. The Council is comprised of Ministers in charge of water affairs in the NBI member countries. The Council provides policy guidance to the NBI, approves its annual work plans, budgets and progress reports; ensures timely mobilisation of country contributions; appoints the Executive Director (who is nominated by countries on a rotational basis); and also appoints other senior officials of the Nile Secretariat on the

Photo: NBI

Heads of State of the Nile Basin countries or their representatives, during the first Nile Basin Heads of State Summit held in Entebbe, in 2017

recommendations of the Nile-TAC. The chairmanship of the COM rotates annually according to the alphabet order of country names.

- The Nile Technical Advisory Committee (Nile-TAC) – provides advisory support services to the Nile Council of Ministers, follows up on implementation of Council decisions; oversees the technical work of the Initiative, including the identification and preparation of programmes and projects; provides recommendations to Nile-COM on appointment of senior staff of the Nile Secretariat; supervises the activities of the Nile Secretariat and; head the National NBI Offices in the Member Counties. The Committee is made up of senior government officials from the NBI Member States.
- The Nile Basin Initiative Secretariat (Nile-SEC) – is the executive organ of the Nile Basin Initiative (NBI). It serves to execute the programs and activities of the NBI while supporting and facilitating the operations of the Nile Council of Ministers (Nile-COM) and the Nile Technical Advisory Committee (Nile-TAC) through the provision of general secretariat services. The Nile Basin Initiative Secretariat is located in Entebbe, Uganda. The Secretariat began operations in June 1999 and was officially launched in 03 September 1999.

SUB-BASIN LEVEL INSTITUTIONAL FRAMEWORK

As described above, the Nile riparian countries, under the subsidiary principle, established two Subsidiary Action Programs: one is the Eastern Nile Subsidiary Action Program, with its secretariat known as the Eastern Nile Technical Regional Office (ENTRO) based in Addis Ababa, Ethiopia; and the other in the Nile Equatorial Lakes region, with its secretariat known as the Nile Equatorial Lakes Subsidiary Action Program Coordination Unit (NELSAP-CU) based in Kigali, Rwanda.

Each of the Subsidiary Action Programs has its own governance system (i.e. a Council of Ministers supported by a Technical Advisory Committee and Secretariat), that operate alongside the basin-wide governance organs. The ENTRO and NELSAP-CU provide general secretariat services and execute the work under the Subsidiary Actions Programmes (SAPs) of the Eastern and Equatorial Lakes sub-basins.

CONFERENCE OF HEADS OF STATE AND GOVERNMENT

The first Nile Basin Heads of State Summit was held in June 2017 in Entebbe, Uganda, and focused on strategic regional development issues. The Heads of State agreed to meet in future and to continue engaging under the institutional framework of the Nile Basin Initiative. Therefore, The NBI developed the concept note for the second Heads of State Summit, which was approved by the Nile-COM in August 2018. Preparations are currently underway to implement the Nile-COM decision. When operationalised, the Conference of Heads of State and Government will constitute the highest decision-making body of the Nile Basin Initiative.

EAST AFRICAN COMMUNITY (EAC)

THE EAC – A REGIONAL ECONOMIC COMMUNITY IN EASTERN AFRICA

The East African Community (EAC) is a regional intergovernmental organization made up of six Eastern African states, namely Burundi, Kenya, Rwanda, South Sudan, Tanzania and Uganda. All six EAC Partner States are Nile riparian countries. The EAC was established through a treaty (Treaty for the Establishment of the East African Community) that was signed on 30th November 1999 by three founding members (Kenya, Tanzania and Uganda) and entered into force on 7th July 2000. The Republics of Burundi and Rwanda acceded to the EAC Treaty on 18th June 2007 and became full members of the Community from 1st July 2007 while South Sudan acceded to the treaty in April 2016 and become a full member from 5th September 2016.

The EAC's mission is to widen and deepen economic, political, social and cultural integration in order to improve the quality of life of the people of East Africa through increased competitiveness, value added production, trade and investments. The EAC has its headquarter in Arusha, Tanzania.
The Treaty establishing the EAC is a framework agreement for cooperation in a wide range of fields related to socio-economic development. The treaty gives the EAC a broad mandate for promoting cooperation, including in the areas of inland waterways transport, meteorological services, management of natural resources, protection of aquatic and natural resources, wetlands management, and irrigation, rainwater harvesting and water catchment management.

EAC has established two major institutions to spearhead the delivery of its mandate concerning sustainable management and development of Lake Victoria natural resources, namely Lake Victoria Basin Commission (LVBC) and Lake Victoria Fisheries Organization (LVFO). These are briefly described below

LAKE VICTORIA BASIN COMMISSION (LVBC)

The LVBC, which operates from a regional secretariat in Kisumu, Kenya, is a permanent apex institution of the East Africa Community and a fully-fledged Lake Basin Organisation. The protocol establishing the LVBC – the Protocol for the Sustainable Development of the Lake Victoria Basin (2003) – conferred to the regional body a very broad mandate related to the promotion, coordination and facilitation of initiatives aimed at the socio-economic development of the Lake Basin, and sustainable management of its rich diversity of environmental and natural resources.

LAKE VICTORIA FISHERIES ORGANIZATION

The Lake Victoria Fisheries Organization (LVFO) is a specialized institution of the East African Community (EAC) with a mandate to coordinate the management and development of fisheries and aquaculture resources in the East African Community region. The objectives of LVFO is to foster co-operation among the Partner States, harmonise national measures for the sustainable utilisation of the fisheries and aquaculture resources of the East African Community water bodies, and develop and adopt conservation and management measures.

COMMON MARKET FOR EASTERN AND SOUTHERN AFRICA (COMESA)

The Common Market for Eastern and Southern Africa (COMESA) is a Free Trade Area and Regional Economic Community (REC) with twenty-one members stretching from Tunisia in North Africa to Eswatini in Southern Africa. The Agreement establishing COMESA was signed by 23 countries in November 1993 and ratified in December 1994. COMESA, which has its headquarters in Lusaka, Zambia is recognised by the African Union as a Regional Economic Community and is one of the pillars of the African Economic Community. The COMESA partner states in 2020 are: Burundi, Comoros, Djibouti, DR Congo, Egypt, Eritrea, Eswatini, Ethiopia, Kenya, Libya, Madagascar, Malawi, Mauritius, Rwanda, Seychelles, Somalia, Sudan, Tunisia, Uganda, Zambia and Zimbabwe. Former members are Angola, Lesotho, Mozambique, Namibia and Tanzania.

The aims and objectives of the Common Market, as set out under Article 3 of the Treaty, are the following:

1. to attain sustainable growth and development of the Member States by promoting a more balanced and harmonious development of their production and marketing structures;
2. to promote joint development in all fields of economic activity and the joint adoption of macro-economic policies and programmes to raise the standard of living of its peoples and to foster closer relations among its Member States;
3. to co-operate in the creation of an enabling environment for foreign, cross-border and domestic investment including the joint promotion of research and adaptation of science and technology for development;
4. to co-operate in the promotion of peace, security and stability among the Member States in order to enhance economic development in the region;
5. to co-operate in strengthening the relations between the Common Market and the rest of the world and the adoption of common positions in international fora; and
6. to contribute towards the establishment, progress and the realisation of the objectives of the African Economic Community.

EASTERN AFRICA POWER POOL

The Eastern Africa Power Pool (EAPP) was established in February 2005 with the signing of an intergovernmental memorandum of understanding (IGMOU) by seven countries, namely Burundi, D.R. Congo, Egypt, Ethiopia, Kenya, Rwanda and Sudan. The signing of the IGMOU was followed by the signing of an Inter-Utility Memorandum of Understanding (IUMOU) by the Chief Executive Officers/Managing Directors of the power utilities in the Member States.

Between 2010 and 2012, three other countries – Tanzania, Libya and Uganda – joined the partnership, bringing the total number of members in the power pool to ten. Nine of the ten EAPP Member States are Nile riparian countries. Only two Nile countries – Eritrea and South Sudan - are not members of EAPP. In a further development, the EAPP was adopted by the 2006 COMESA Summit of Heads of States and Governments as a specialised institution of COMESA and mandated by member states to coordinate investment in power generation and transmission for integration of the region's power system.

The EAPP operates under the framework of the New Partnership for the Development of Africa (NEPAD) and complements the NBI in the development of power interconnections in the Nile region. The mission of the EAPP is "to make available for the Eastern Africa region, an affordable, sustainable and reliable electricity in order to increase the rate of access to electricity by the population of the region thereby promoting regional integration by the pooling of electricity energy resources in a coordinated and optimized manner."

INTERGOVERNMENTAL AUTHORITY ON DEVELOPMENT (IGAD)

INTEGRATED WATER RESOURCES MANAGEMENT IN IGAD

The Inter-Governmental Authority on Development (IGAD) is a sub-regional economic block established in 1996 to replace the Intergovernmental Authority on Drought and Development (IGADD). IGAD currently comprises of eight members (Djibouti, Eritrea, Ethiopia, Kenya, Somalia, South Sudan, Sudan and Uganda) only two of whom (Djibouti and Somalia) are non-Nile Basin riparians. The original organisation – IGADD – was created a decade earlier (1986) to coordinate the effort of member states in combating drought and desertification in the Greater Horn of Africa. In the restructuring and revitalization that accompanied the establishment of the new institution, the IGAD mandate was broadened to include peace, security and stability issues alongside economic cooperation and regional integration issues.

The mandate of IGAD with respect to Integrated Water Resources Management (IWRM) is not explicitly defined but is implicit in references to natural resources and environmental management in the 1996 IGAD Agreement. Two articles of the IGAD Agreement – Articles 7 and 13A – deal with issues of mandate and functions and can be used to infer the IGAD mandate in the area of water resources management and development.

- Article 7: Aims and objectives: Relevant aims and objectives include to (a) harmonise policies with regard to trade, customs, transport, communications, agriculture, and natural resources; (b) achieve regional food security and support efforts of Member States to collectively combat drought and other natural and man-made disasters and their consequences; (c) initiate and promote programmes and projects for sustainable development of natural resources and environment protection; (d) develop and improve coordinated and complementary infrastructure, particularly in the areas of transport and energy; and (e) mobilize resources for the implementation of programmes.

- Article 13A: Areas of cooperation: Relevant areas of cooperation include, to (a) improve the handling and analysis of data in agro-meteorology and climatology, nutrition, social and economic indicators and establish a strong food information system; (b) coordinate efforts to preserve, protect and improve the quality of the environment; ensure the prudent and rational utilization of natural resources; develop harmonious environmental management strategies and policies; strengthen national and sub-regional meteorological networks and services; strengthen hydrological networks and services; strengthen land resource monitoring systems; and promote environmental education and training; (c) coordinate efforts towards the sustainable management and utilization of shared natural resources and; (d) cooperate in sustainable utilization and development of energy resources in the sub-region, and in the gradual harmonization of national energy policies and energy development plans.

IGAD CLIMATE PREDICTION AND APPLICATIONS CENTRE (ICPAC)

The IGAD Climate Prediction and Applications Centre (ICPAC) is a climate centre accredited by the World Meteorological Organization (WMO) as a Regional Climate Centre (RCC) of excellence in the provision of climate services. The Center is located in Nairobi, Kenya, and serves eleven countries of the Greater Horn of Africa. The countries are Burundi, Rwanda and Tanzania in addition to the eight IGAD Member States. The Centre, was initially established as a drought monitoring center (DMC) by countries of Eastern and Southern Africa in response to devastating droughts that afflict the region from time to time. The 10th Summit of the IGAD Heads of State and Governments held in 2003 in Kampala, Uganda, adopted the Drought Monitoring Center (DMC) based in Nairobi as a specialized IGAD institution.

The Center assists the region cope with present day challenges of climate variability while assisting them adapt to future impacts of climate change. ICPAC's mission is the "provision of timely climate early warning information and support to specific sector applications to enable the (IGAD) region cope with various risks associated with extreme climate variability and climate change for poverty alleviation, environment management and sustainable development of the Member States".

The objectives of the Centre are:

a. To provide timely climate early warning information and support specific sector applications for the mitigation of the impacts of climate variability and change for poverty alleviation, management of environment and sustainable development;
b. To improve the technical capacity of producers and users of climatic information, in order to enhance the use of climate monitoring and forecasting products in climate risk management and environment management;
c. To develop an improved, proactive, timely, broad-based system of information/ product dissemination and feedback, at both sub-regional and national scales through national partners;
d. To expand climate knowledge base and applications within the sub-region in order to facilitate informed decision making on climate risk related issues; and
e. To maintain quality controlled databases and information systems required for risk/vulnerability assessment, mapping and general support to the national/ regional climate risk reduction strategies.

ICPAC produces several drought related products including short- to medium-term weather forecasts and climate outlooks, consensus regional climate outlooks issued before the start of rainfall seasons over the region, cumulative monthly rainfall anomalies, environment monitoring products, rainfall severity index maps, cumulative rainfall series, distribution of rainfall events over several locations, maximum and minimum temperature anomalies and normalised difference vegetation indices among others.

Photo: NBI

IGAD CENTRE FOR PASTORAL AREAS AND LIVESTOCK DEVELOPMENT (ICPALD)

The IGAD Centre for Pastoral Areas and Livestock Development (ICPALD), which is located in Nairobi, Kenya, is a specialised center established by the IGAD Council of Ministers in July 2012 to serve as a regional policy reference institution for livestock and drylands development. ICPALD's mandate is to "promote and facilitate sustainable and equitable drylands and livestock development in the IGAD region".

The overall objective of the Centre is to "promote conflict-, gender- and environment-sensitive and responsive sustainable development of drylands and livestock underpinned by the development of supportive policy and legal frameworks in the Region."
The specific objectives of the Centre are to:

a. Promote the formulation and harmonization of policies and development initiatives in dryland and livestock development in member states; develop and promote an IGAD regional policy framework on livestock and drylands with a focus on conflict resolution, gender and environment sensitive responses and advocacy for people-centred sustainable development;
b. Facilitate appropriate research and technology development, and the domestication, adoption and transfer of appropriate technology in drylands and livestock development;
c. Develop networks linking institutions in the IGAD Member States with regional and international institutions concerned with drylands and livestock development; serving as an interface between research, extension, policymaking and policy execution;
d. Establish linkages and synergies with other specialized institutions of IGAD like ICPAC, ISSP and CEWARN with the aim of promoting drylands and livestock development; and
e. Facilitate demand driven capacity building of drylands and livestock development institutions in the Member States.

ICPALD, like other specialized IGAD institutions is implementing a number of projects. The main projects currently running that are related to NBI mandate in water are: (a) Management of Flood Disaster and the Rational Joint Utilization of the Dauwa (Daua) River Waters – a transboundary water management project being implemented in Kenya, Ethiopia and Somalia; and (b) Regional Pastoral Livelihoods Resilience Project (RPLRP) being implemented in Ethiopia, Uganda and Kenya.

RAMSAR CENTRE FOR EASTERN AFRICA (RAMCEA)

The Ramsar Centre for Eastern Africa (RAMCEA) is a regional initiative developed with the support and guidance of the Ramsar Convention and being implemented under the authority of the Convention. RAMCEA was endorsed at the 10th Conference of the Contracting Parties held in Changwon, Republic of Korea, in 2008. The Centre started its operations in 2009 and is hosted by the Wetlands Management Department in the Ministry of Water and Environment of the Republic of Uganda.

RAMCEA was established by its regional partners (Burundi, Kenya, Rwanda, Tanzania and Uganda) to build capacity and excellence in wetland management in East Africa. The mission of RAMCEA is to "support the East African contracting parties, non-contracting parties and other stakeholders to improve their capacity to implement the Ramsar Convention in the respective countries and institutions". The Centre's activities are focused in the five East African countries named above, with plans to extend coverage in the future to Djibouti, Ethiopia and South Sudan.

The Centre works with NBI and LVBC in promoting sustainable management of transboundary wetlands of the Nile Basin. Other functions of the Centre include publishing and disseminating policies, legislation, procedures, systems, tools and techniques on wetland management; publishing and disseminating information products documenting lessons learnt from case studies demonstrating best practices in wetlands management; conducting wetland assessments to determine the status and trends of wetland resources in the region; conducting refresher courses and tailor made capacity development programmes on wetland management; facilitating preparation of policy briefs on sustainable wetland management; and building capacity of Ramsar focal points and Ramsar site managers.

TABLE 7.2: COMPARISON OF KEY ORGANS OF THE REGIONAL ORGANISATIONS

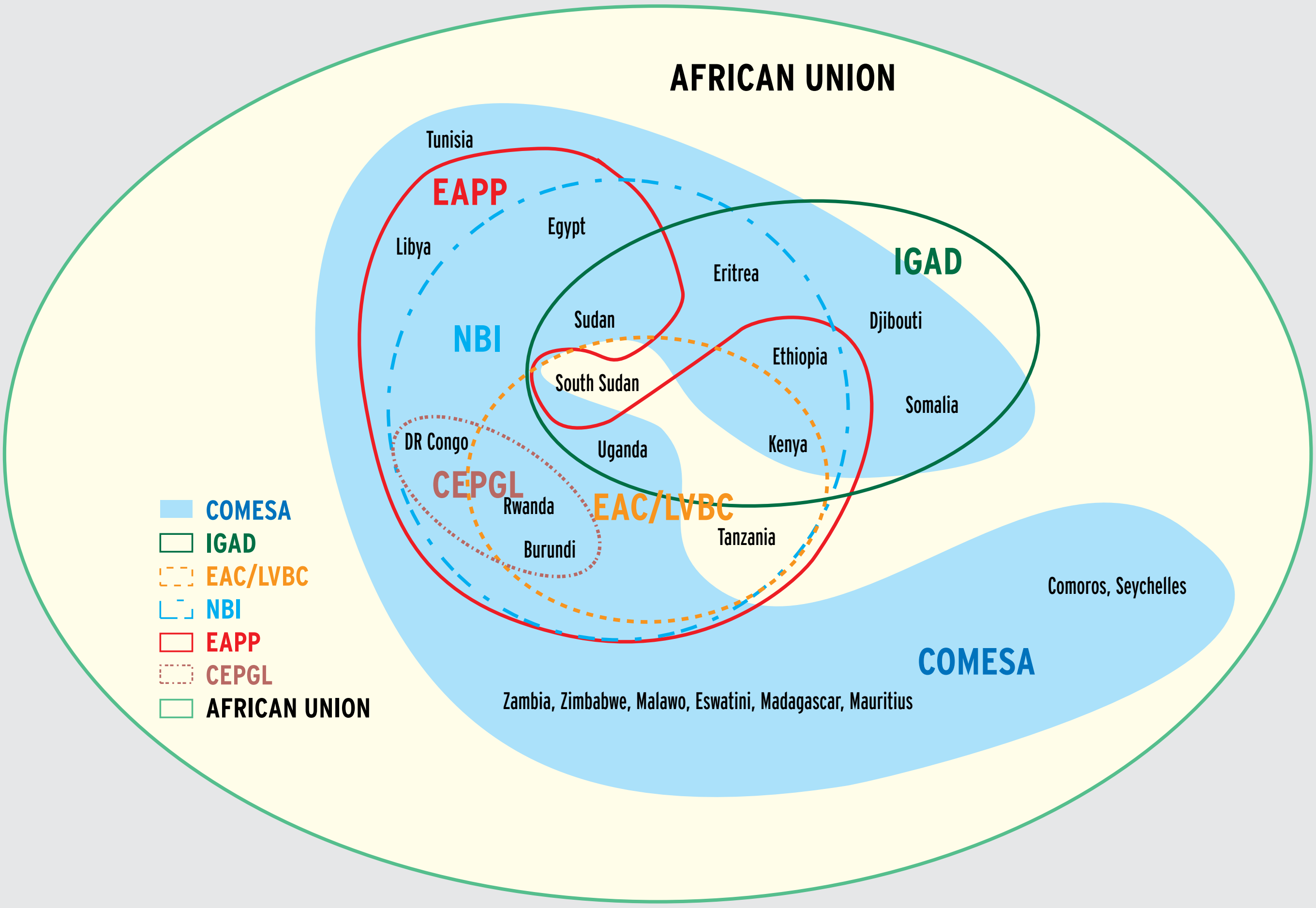
ORGAN	NBI	EAC/ LVBC/ LVFO	IGAD	COMESA	EAPP	RAMCEA
Summit of Heads of State and Government	✓	✓	✓	✓	X	X
Council of Ministers	✓	✓	✓	✓	✓	X
Committee of Ambassadors	X	X	✓	X	X	X
Court of Justice/ Independent Regulatory Board	X	✓	X	✓	✓	X
Legislative Assembly	X	✓	X	X	X	X
Committee of Permanent Secretaries/ Chief Executives	X	✓	X	✓	✓	X
Technical Advisory Committee/ Sectoral Committees of Experts	✓	✓	X	✓	✓	✓
Secretariat	✓	✓	✓	✓	✓	X
Committee of Stakeholder Groups	X	X	X	✓	X	X

✓ Present X absent

REVIEW OF THE INSTITUTIONAL FRAMEWORK OF THE REGIONAL ORGANIZATIONS

The different regional organisations in the Nile Basin differ with respect to their organizational structures. The Regional Economic Communities (EAC, IGAD and COMESA) have the most robust institutional setups that include among other things a Summit of Heads of States and Governments, sectoral councils of ministers, court of justice, legislative assembly (in the case of EAC), committee of Permanent Secretaries and varies committees of technical experts. The EAC has the most robust institutional framework closely followed by COMESA. The NBI has a less robust institution structure, which has implications for how it discharges governance functions. A summary of the key organs of the different regional organisations in the Nile Basin is shown below.

FIGURE 7.1: THE SPAGHETTI - BOWL DIAGRAM OF NBI RIPARIAN COUNTRY MEMBERSHIP IN REGIONAL ORGANISATIONS.



COORDINATION ARRANGEMENTS BETWEEN THE REGIONAL ORGANIZATIONS

MULTILATERAL GOVERNANCE IN THE NILE BASIN

The Nile Basin region has a polycentric system with respect to governance authorities. There are several regional institutions that have a mandate related to the integrated management and development of the common water resources of the Nile Basin. The regional organisations have organizational structures that differ in complexity and the extent to which national structures of the member states have been integrated into their governance structures. These institutions are independent of one another, and have power and financial autonomy. There is a large overlap in the geographical area of jurisdiction of these authorities, and large overlap in country membership in the organisations as shown by the spaghetti bowl (figure 7.1).

The above situation introduces redundancy and risk of duplication, and makes it imperative to establish coordination mechanisms between the organisations to avoid duplication, improve coherence in interventions, achieve greater efficiency in use of resources, leverage synergies and comparative advantage, and produce greater impact.

TOWARDS IMPROVED COORDINATION BETWEEN INSTITUTIONS

NBI recognizes the need to rationalize relationships and improve coordination, building on mandates and comparative advantages of each institution in order to enhance synergy, reduce duplication and effectively promote a joint development agenda in the Nile basin. NBI, with its basin wide mandate and convening power for all Basin states, will aim to establish and strengthen collaboration with the key regional players, lead constructive engagement with them in order to establish a coordination platform for dialogue, learning and joint planning for management and development of the Basin water and related resources and effective governance of the institutions.

NBI has made a strategic shift in its approach to:

1) Enhancing collaboration with the key regional players through jointly undertaking detailed reviews of their institutional mandates and programs, agree on collaboration plans and the most appropriate administrative tools (e.g. MoUs) to enable smooth implementation of the collaboration plans.
2) Promoting a joint agenda for water resources management and development with other actors in the region through establishing coordination platforms as a starting point to identify synergies, area of collaboration, agree to a coordination mechanism and tools for coordination. The platforms are also aimed at providing an opportunity to identify synergies and jointly agree on a multi-stakeholder approach to Basin planning and development.

As a result of the above strategic shift, NBI has signed memoranda of understanding with two regional actors as described below

- MoU between NBI and EAC/LVBC - In 2006, a memorandum of understanding was signed between East African Community and Nile Basin Initiative aimed at facilitating cooperation between the institutions through implementing activities for efficient management and sustainable development of the Lake Victoria basin and its natural resources and poverty reduction and environment protection with regard to the Lake Victoria Basin as part of the larger Nile Basin. As part of the MOU, the two institutions commit to cooperate in various areas including cooperation in joint implementation of projects (e.g. the NBI Hydromet Project and the Nile Basin Decision Support System) and holding of regular coordination meetings. Among the few achievements under this MoU was the support provided by NELSAP to Burundi and Rwanda to participate in LVBC's LVEMP II Program.

- MoU between NBI and IGAD/ICPAC - In 2018, a memorandum of cooperation was signed between IGAD and Nile Basin Initiative with aim to facilitate cooperation between the two parties in the efficient management and development of water and related natural resources within the IGAD region of the Nile Basin. In the implementation of the MOU, Nile Basin Initiative works closely with the IGAD Climate Prediction and Applications Centre (ICPAC).

NATIONAL INSTITUTIONAL FRAMEWORKS FOR TRANSBOUNDARY WATER MANAGEMENT

In eight Nile Riparian countries, the responsibility for transboundary water management is part of the purview of the Ministry of Water. In the remaining three countries (Burundi, D.R. Congo and Rwanda), this function falls under the ministry responsible for natural resources management or environment management. In six Nile riparian states (Egypt, Ethiopia, Kenya, Sudan, Tanzania and Uganda) there is a distinct unit within the Ministry of Water that is responsible for transboundary water management. The level of the transboundary water management unit within the ministry hierarchy differs from country to country, being at directorate, department, division or lower level in the different countries.

The political heads of the ministry responsible for water affairs in each country provide the representation of the country in the Councils of Ministers at basin-wide and subsidiary/sub-basin levels. The directors of the directorates or departments responsible for transboundary water management then make up the membership of the Technical Advisory Committees at basin-wide and subsidiary/sub-basin levels.

In many of the countries there are mechanisms for cross-sectoral collaboration with relevant sectors such as agriculture, energy, environment, forestry, natural resources, transport/navigation and foreign affairs, but these are often weak.

POLICIES AND LEGAL FRAMEWORK FOR BASIN COOPERATION

OVERALL FRAMEWORK

Since the establishment of the NBI in 1999, the Secretariat and the two Subsidiary Action Programs have been working together to put in place regional policy instruments for discussion and decision among the NBI member countries. Although the NBI is not a full-fledged River Basin Organization, but, similar to permanent RBOs, the institution was given powers to develop policy frameworks, guidelines in different NBI cooperation processes, and finally Strategies that guide NBI and the countries towards implementing a cooperative approach to the management and development of the common water resources.

NILE BASIN SUSTAINABILITY FRAMEWORK

Approved by Nile Council of Ministers (Nile-COM) in 2011, the Nile Basin Sustainability Framework (NBSF) lays down NBI's approach to developing guiding principles for water resource management and development across the Nile Basin countries. The NBSF is a suite of policies, strategies, and guidance documents which functions as a guide to national policy and planning process development and seeks to build consensus among riparian countries. It is intended that it will contribute to the gradual alignment of the Basin's body of (national) water policies to meet international good practice, and help to demonstrate to national governments and international financiers of water infrastructure that the NBI has a systematic approach for dealing with issues of sustainable development within the Basin.

The NBSF is therefore supporting the enabling environment for trans-boundary water management and planning of investment projects, and promote integration of shared benefits, participation, and environmental concerns that ensure investment projects have long-term benefits. Without the NBSF, there would be no consistent guidance for the sustainable development of new investments and no coherent guidance for the achievement of cooperation in sustainable water management and development at this stage.

With the NBSF, the Nile Basin riparian countries agreed on a conceptual structure for organising the policies, strategies and guidelines needed to attain sustainable management and development of the Nile River Basin in a coherent way. The NBSF is an important strategic planning tool that provides an overall direction for the cooperative management and development of the river Basin.

Despite the significant setbacks on the legal and political track, cooperation amongst riparian states continued on the technical track and led to the initiation of many investment projects and water resources management programs that were in support of the regional agenda of realizing the Shared Vision Objective. This technical cooperation needed to be grounded in a framework of polices, strategies, guidelines and procedures that streamline the NBI's work, ensures that it is based on international best practices, and supports the attainment of sustainable management and development of the Nile water Resources. This became the new role of the NBSF, which now comprises of 6 policies, 17 strategies and action plans, and 17 guidelines.

The NBSF polices, strategies and guidelines are developed by NBI and validated and endorsed by the riparian country members but are only applicable to projects and programs being implemented by Nile riparian countries, individually or in collaboration with one or more other Nile countries, under the NBI framework. They do not apply to projects and programmes of the Nile riparian countries that are developed outside the NBI framework. However, NBI mem-

TABLE 7.3: RESPONSES TO IMPROVE WATER GOVERNANCE AT ALL LEVELS		
Document focus	Document name	Year
Legal Status	NBI Headquarter agreement	2002
	ENTRO Legal status	2000
	ENTRO Headquarter agreement	2000
	NELSAP Legal status	2004
	NELSAP Headquarter agreement	2004
	NBI Act	2002
Institutional Policy and Strategy	NBI 10 Year Strategy 2017–2027	2017
	NBI Basin Wide Programme (2017-2022)	2017
	NBI Result Based Strategy	2012
	NBI Anti-Corruption policy	2014
	NBI Long Term Capacity Development Strategy	2009
NBI Financing	NBI Financing Strategy 2017–2022	2017
	NBI Resource Mobilization Action Plan (2018/19-2022/23)	2010
Basin-wide and sub-basin planning	NBI - The Technical Annexes for the Nile Basin Sustainability Framework	2011
	NBI - Monitoring Strategy for the Nile River Basin	2010
	NBI–WRPMP Water Policy Guidelines and Compendium of Good Practice	2006
	Benefit sharing framework	2008
	Guidelines for Preparation of State of Basin Reports	2020
General transboundary information exchange	Nile Basin Interim Procedures for Data and Information Sharing and Exchange	2006
	NBI - Operational Guidelines for Implementation of the Nile Basin Interim Procedures for Data and Information Sharing and Exchange	2011
Project specific	NBI Information Disclosure Policy	2013
Stakeholder engagement and social management	NBI Communication and Stakeholders Engagement Strategy (2018-2023)	2018
	NBI Public Consultation framework	2008
	NBI Gender Mainstreaming Policy	2020
	NELSAP public / stakeholder participation guidelines	2014
	ENSAP Social Management Guidelines	2010
	NBI Gender Mainstreaming Strategy	2020
	NELSAP Gender mainstreaming guidelines and checklists	2014
Water resources development, especially infrastructure	EIA Framework in power projects	2007
	ENSAP Reference Dam Safety Guidelines	2014
	NELSAP Project Finance Manual	2014
Environmental management	NBI Environmental and Social Policy	2013
	NBI Wetlands Management Strategy	2013
	Wetlands Management Framework Plan (due before end of year)	due 2021
	ENSAP Environmental Management Guidelines	2011
	NELSAP Environmental and Social Management Guidelines	2012
	NBI Environmental Flow Management Strategy	2016
	Transboundary Water Quality Monitoring Strategy	2009
Climate change	NBI Climate Change Strategy	2013
	ENSAP Climate Change Strategy	2010
	ENSAP Climate-proofing Consolidation Action Plan	2010
	NELSAP Climate Proofing Guidelines and Tools	2012

ber states are free to voluntarily adopt and mainstream the NBI guidelines and tools in their national policy and regulatory frameworks, as they are recognized as best practice guides for the different themes of transboundary water cooperation.

Despite their limitation, the NBSF policies, strategies and guidelines have proved of critical importance in supporting the functionality of the NBI and ensuring good governance at the basin-wide and sub-basin levels by:

- Creating an environment supportive of trust and confidence building through encouraging: (a) accountability and transparency, fighting corruption, and orienting the work of the NBI towards a results-based approach; (b) data and information sharing and exchange, as well as disclosure of information on planned measures among riparian States and; (c) collaboration on resources mobilisation to finance investment in projects that confer transboundary benefits;
- Ensuring broad, inclusive and active stakeholder engagement and participation, include private sector participation;
- Emphasizing gender mainstream and social equity in all NBI activities;
- Mobilizing political commitment for, and promoting public awareness on the benefits of, transboundary water cooperation;
- Facilitating knowledge-based decision making on the sustainable management and development of the Nile water resources;
- Supporting the standardisation of processes related to the data collection and water resources monitoring;
- Providing detailed guidance in investment planning to ensure sustainable and efficient resource use; environmental and social protection while developing and utilising water and related resources; biodiversity conservation and ecosystem management and mainstreaming of disaster risk reduction and climate change adaptation and mitigation measures.

The documents that comprise the NBSF are listed in Table 7.2 and can be accessed on the NBI website (https://nilebasin.org/).

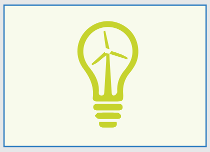
NBI TEN-YEAR STRATEGY (2017-2027)

The NBI Ten-Year (2017-2027) Strategy provides overall strategic directions for the NBI over the 10-yer period from 2017 to 2027. Six strategic priorities, corresponding to six key challenges in the Nile Basin, were identified under the strategy around which the NBI's interventions will be focused over the ten years as the Initiative works to achieve the Shared Vision Objective. The six key challenges were identified as the following:

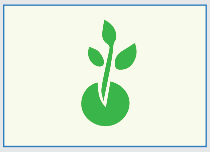
a) Inadequate availability, unsustainable use and poor management of transboundary water resources to support basic needs of the riparian communities;
b) Low rate of access to electricity due to low development of the considerable hydropower potential of the basin, and low connectivity of national electricity grids and low regional power trade;
c) Food insecurity, and inefficient use of water in agricultural production;
d) Environmental degradation, habitat destruction and unsustainable use of water-related ecosystems of the Nile Basin;
e) Increasing impacts of climate on all aspects of life and socio-economic development in the Nile Basin and;
f) Weak governance of the common Nile water resources.

For each strategic priority, a goal has been defined that articulates the desired result that the NBI will work to achieve with respect to the key challenge. Furthermore, a number of strategic actions have been identified to be implemented by the NBI in collaboration with the Member States and Development Partners to reach the goals of the Strategy. Table 7.3 summaries the goals and strategic actions of the NBI 10-year Strategy. The preparation of the Strategy involved extensive consultations covering a wide range of stakeholders including NBI staff, NBI governance organs, Nile riparian states, development partners, regional actors in the Basin and associations of water practitioners in the basin. The 10-year Strategy is implemented through 5-year medium term plans of the three NBI Centres (Nile-SEC, ENTRO and NELSAP-CU).

Water security



Energy security



Food security

Environmental sustainability

Climate-change adaptation

Transboundary water governance

TABLE 7.4: THE GOALS AND STRATEGIC ACTIONS OF THE NBI TEN-YEAR (2017-2027) STRATEGY

Goal	Strategic Actions
GOAL 1- Water Security: Enhance availability and sustainable utilization and management of transboundary water resources of the Nile Basin	▪ Enhancing water storage capacity for improved water supply reliability for multipurpose use. ▪ Improving productivity and efficient water use across water-using sectors. ▪ Enhancing coordinated management of water storage dams. ▪ Enhancing conjunctive use of groundwater and surface water. ▪ Strengthening joint monitoring of Nile Basin for sustainable water resources development and management. ▪ Strengthening joint basin and sub-basin water resources management planning. ▪ Strengthening basin investment programs preparation and management. ▪ Maintaining and improving water quality. ▪ Enhancing policy frameworks at regional and national levels for cooperative management and development of shared Nile Basin water resources. ▪ Strengthening shared knowledgebase and analytic tools.
GOAL 2 – Energy Security: Enhance hydropower development in the basin and increase interconnectivity of electric grids and power trade.	▪ Facilitating identification, preparation and implementation of requisite investment projects in power generation infrastructure. ▪ Facilitating identification, preparation and implementation of power interconnection projects to enable regional power transmission and trade. ▪ Enhancing capacity for systems management including operation guidelines in the region.
GOAL 3 – Food Security: Enhance efficient agricultural water use and promote a basin approach to address the linkages between water and food security	▪ Supporting the development and modernization of irrigated agriculture. ▪ Rehabilitating watersheds and improving of rain-fed agriculture. ▪ Promoting a basin approach to address the linkages between water and food security. ▪ Improving fisheries and aquaculture production. ▪ Enhancing navigability to boost regional agricultural trade and transport corridors.
GOAL 4 – Environmental Sustainability: Protect, restore and promote sustainable use of water related ecosystems across the basin	▪ Promoting sustainable management of wetlands of transboundary significance. ▪ Maintaining lake and riverine ecosystems. ▪ Promoting protection and sustainable management of critical water source catchments.
GOAL 5 – Climate Change: Improve basin resilience to climate change impacts	▪ Establishing and maintaining an NBI climate information service that will share data and information for climate resilient water resources planning and management. ▪ Supporting joint analysis, planning and implementation of climate resilient interventions to address climate risks and uncertainty in the basin. ▪ Improving and promoting regional policy and planning frameworks for effective climate change adaptation at regional and national levels. ▪ Improving preparedness of basin countries to flood and drought risk. ▪ Strengthen capacity to prepare bankable projects in the Nile Basin in order to tap into available climate finance opportunities.
GOAL 6 – Transboundary Water Governance: Strengthen transboundary water governance in the Nile Basin	▪ Facilitating establishment of effective governance arrangements for coordination of transboundary water resources at sub-basin and basin-wide level. ▪ Enhancing capacities of national and regional institutions and actors for effective transboundary cooperation. ▪ Improving coordination with other regional inter-governmental mechanisms with a mandate in transboundary water resources management. ▪ Building consensus among the countries public and stakeholders for cooperative basin development and management.

JOINT PLANNING AND MANAGEMENT INSTRUMENTS

OVERVIEW

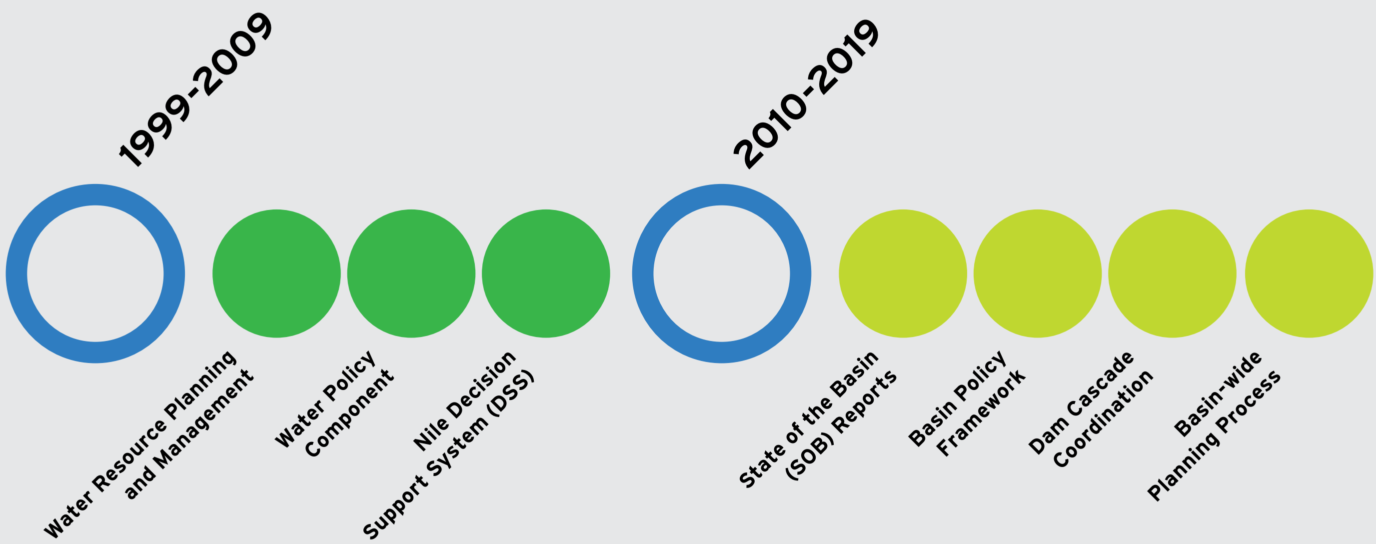
There are several initiatives under the NBI for supporting planning and evidence-based decision-making on the management and development of the Basin water resources. These include, but are not limited to, the Nile Basin Regional Hydromet System; the Monitoring the Nile Basin Using Satellite Observations bulletin; the Nile Decision Support System (Nile DSS); water resources assessment and preparation of the State of Basin Report. The timeline of the development of the various planning and management instruments is shown in Figure 7.5. Some of the main instruments developed by NBI are briefly described in the sections below.

NILE BASIN REGIONAL HYDROMET SYSTEM

The Nile Basin Initiative is in the process of establishing a basin-wide hydrometeorological system. The first phase of the project, which covers the rehabilitation of existing stations and installation of new stations, will run for three years from 2018 to 2021, and is funded through a USD 5.5 million grant from the European Union and German government. The Regional HydroMet System addresses the challenge of inadequate data and information to support cooperative development and management of the shared Nile Basin water resources. The Regional HydroMet project represents the second effort at multi-government cooperation in the Nile region on hydrometeorological observations following the HYDROMET project of 1967-1992 that operated a hydro-meteorological monitoring system in the catchments of Lakes Victoria, Kyoga and Albert.

When completed, the Nile Basin Regional HydroMet System, which will be based, and improve upon, existing systems, will comprise of approximately 80 hydrological and 323 meteorological monitoring stations equipped with state-of-the-art data collection and transmission instruments.

FIGURE 7.2: EVOLUTION OF THE BUILDING BLOCKS OF THE NBI PLANNING AND MANAGEMENT INSTRUMENTS (FROM 1999 UP TO NOW)



The system will further include a limited number of groundwater monitoring stations, upgraded water quality laboratories in the Nile countries and infrastructure for receipt and processing of data collected by Earth Observation Systems. Data collected under the Regional HydroMet System will be shared and exchanged with the NBI and between countries in accordance with NBI's data sharing policy and guidelines.

BULLETIN ON MONITORING OF THE NILE BASIN USING SATELLITE OBSERVATIONS

This quarterly bulletin that is published by the NBI provides information on hydrological and hydro-meteorological conditions in the Nile sub-basins based on satellite observations. The satellite observations are intended to supplement information collected through the Regional HydroMet System. Parameters reported upon in the bulleting include monthly and quarterly rainfall; actual monthly and quarterly evapotranspiration; monthly and quarterly runoff; and mean water levels in large lakes and reservoirs. Estimates of the above parameters, and comparison with long-term means for the sub-basins, provides insight into available opportunities for water management, and development, thereby supporting evidence-based management of the water resources.

THE NILE DECISION SUPPORT SYSTEM (NILE DSS)

The Nile Basin Decision Support System (NB DSS) is an analytical tool jointly developed by NBI and Member States from 2008 to 2012 to provide a framework for knowledge sharing, understanding river system behaviour, evaluating alternative development and management strategies, and supporting informed decision making.

The Nile DSS is a generic software system that can be applied at different scales – at watershed, national and transboundary levels, and is designed to support the process of complex water resources planning. It is made up of a collection of toolsets for diverse purposes as data processing, modelling, scenario development, optimization and multi-criteria decision making. It also offers tools for integrating environmental, social and economic objectives in investment project preparation.

Key focus areas where the tool is applies are the following (a) water resources development; (b) optimizing water resources use; (c) coping with floods; (d) improving rainfed and irrigated agriculture; (e) hydropower development; (f) navigation development; (g) watershed and sediment management; (h) climate change assessments and; (i) water quality management.

EASTERN NILE PLANNING MODEL

In 2012, the Eastern Nile Technical Regional Office (ENTRO) engaged two experts to build a RiverWare model of the Eastern Nile Region that could allow for assessment of future management options for the sub-region from a basin-wide perspective. The purpose of the initiative was to enhance the analytical capacity of ENTRO and other stakeholders in the Basin and allow the simulation and evaluation of alternative multi-objective management and development strategies for the principal Eastern Nile sub-basins, namely the Blue Nile, Baro-Akobo-Sobat, Tekeze-Setit-Atbara, and portions of the White Nile and the Main Nile.

After setup and calibration of the model, a baseline model was developed that accurately reflects current conditions and potential future conditions using existing reservoirs and established infrastructure.

Activities under the planning model project included the training of ENTRO staff in the operation, modification and enhancement of the model.

STATE OF BASIN REPORTING

Every five years, the Nile Basin Initiative prepares a State of Basin (SOB) report. The report seeks to provide accurate, reliable and up-to-date information on the Nile River and its tributaries, along with technical analyses and insights into the biophysical and ecological settings, as well as the social, political, cultural and economic drivers of change within the Nile River Basin. The report, which is targeted at policy makers, parliamentarians, senior government officials; scholars; the international development community; and the general public in the Nile Basin is also used to evaluate the performance of past NBI interventions. The report forms an integral part of the Nile Basin reporting system and a critical tool supporting transparency, accountability and evidence-based decision making.

WATER RESOURCES ASSESSMENTS UNDER THE NBI

The Strategic Water Resources Assessment was initiated following a directive of the Nile Council of Ministers in June 2015, to assess the current and projected future water demand in the Nile Basin and hence support the dialogue among the riparian states on how to address growing water demands in a sustainable manner. The Nile Basin countries have been involved in an in-depth collaborative assessment of water supply and demand (irrigation, municipal and industrial use, hydropower, wetlands, etc.) which will inform the process of exploring strategic options for future developments. The motivations for this process are drawn from the fact that, unless water resources development planning is coordinated, the Basin is very likely to face severe water shortages. In addition there are technical solutions through which greater water use efficiency can be achieved and water shortages substantially alleviated. Therefore, the strategic assessments serve two purposes, namely

a) to establish a mechanism for regular update of the baseline and future water resources development that can be used to inform basin planning; and
b) to provide strategic recommendations for improved water resources management and development, including of large-scale dimensions.

The first phase has been completed and established the status of water demand and water use in 2015. Further, preliminary projections of water demand over the 2050 time horizon were made based on water resources plans of the riparian states (focusing on irrigation, hydropower and dam development). Likely water shortages were quantified under a range of climate change and natural climate scenarios. The second phase focuses on refining the water demand projections and generating strategic options for addressing likely future challenges.

The work on dam cascade coordinated operation, one of the building blocks currently undertaken together with ENTRO, has also been reviewed under the Strategic Water Resources Assessment. The Experts agreed to extend the analytic work on dam cascade operation to the Nile Equatorial Lakes sub-basin (Lake Victoria to White Nile).

Overall, the main components of the Strategic Water Resources Assessment are: collaborative water demand and water supply assessment; hydro-economic analysis of trade-offs between water uses, management and optimization of water efficiency; as well as generation of strategic options for reducing any projected water shortfall. These options cover infrastructure and water resources management measures that can be implemented individually by NBI Member States or through regional investment and basin management plans.

MONITORING, EVALUATION AND LEARNING

The Nile Basin Initiative operates a Results Based Monitoring and Evaluation system that among other things requires the annual, mid-term and end of project/program evaluations of all NBI projects and programmes. M&E at NBI involves carrying out continuous, systematic processes of collecting, analysing, evaluating, and using data to track performance and inform planning and decision-making. The lessons learnt from these evaluations are documented, and used to inform the design of future programs and projects, and improve on-going programs and projects.

COMMUNICATION AND STAKEHOLDER ENGAGEMENT

Decision-making processes on how to develop, manage and use water in an efficient, sustainable and equitable manner are complex, requiring the interaction of governments, agencies, organisations, the private sector, and citizens at international, national and local levels. Under these conditions, it follows that expectations regarding future relations and cooperation are also a function of public awareness and appreciation of the benefits of water cooperation.

At its inception, active stakeholder involvement in NBI activities was constrained by three challenges: 1) attitudes deriving from inadequate capacity; 2) insufficient technical/transboundary knowledge; and, 3) scepticism in transboundary water cooperation. Therefore, stakeholder engagement is a key pillar in NBI's approach to transboundary water resources management to ensure that stakeholders are actively participating in all processes, feel ownership of all programmes through broadened awareness and, generally, gain more appreciation and trust in regional cooperation.

The sections below describe some of the main activities aimed at strengthening stakeholder cooperation.

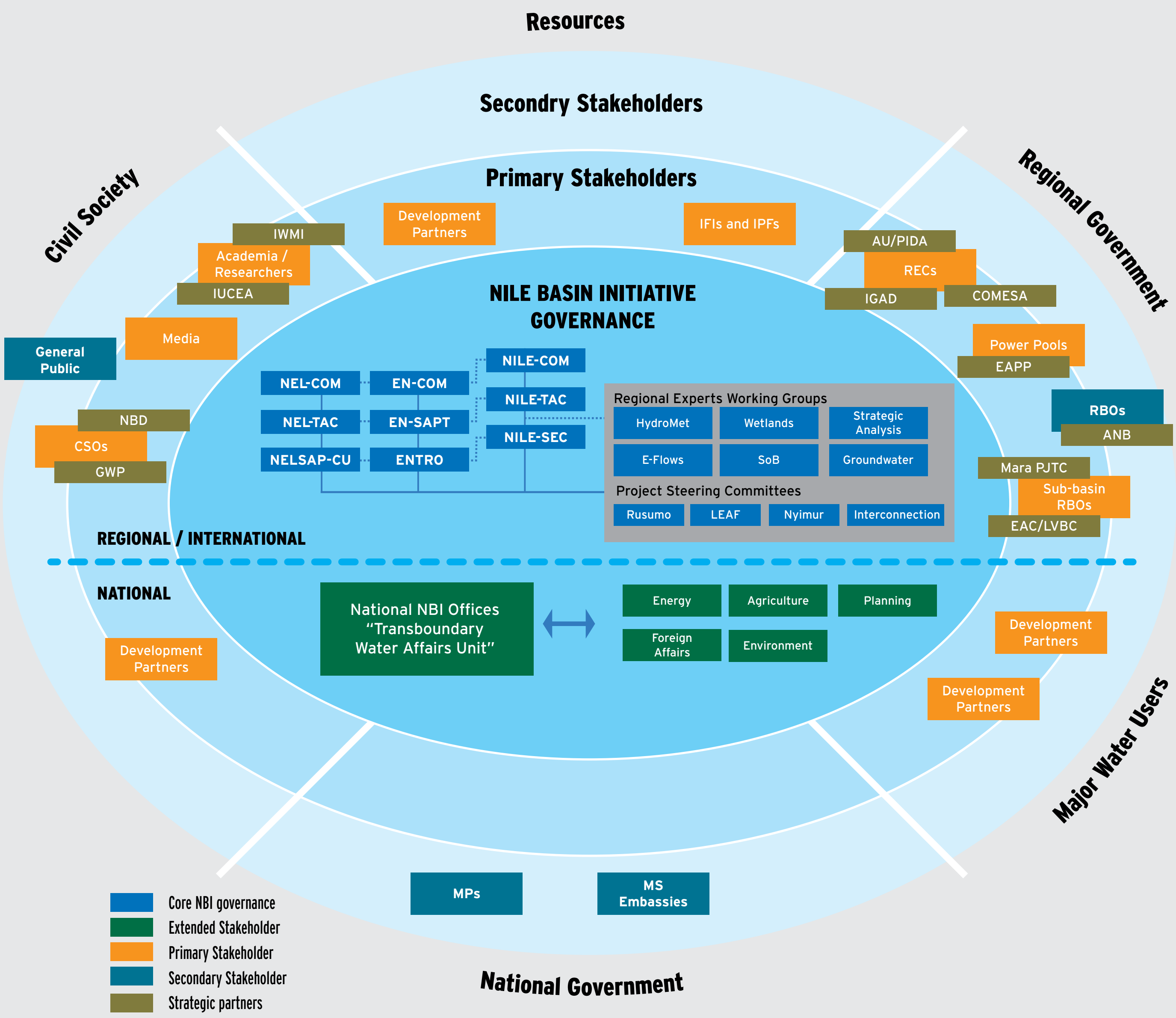
NBI STAKEHOLDERS

NBI stakeholders include all persons or institutions directly affected by or benefitting from NBI's projects, and their specific buy-in and support (for example, within Project Affected Communities) is essential to attaining more broader societal and political support or buy-in for NBI and its work.

Figure 7.3 shows the multitude of stakeholder groups involved in transboundary governance in Nile Basin. This includes NBI Governance Structures, as well as external Primary and Secondary stakeholders, as defined below. Outside the NBI Governance structures, Strategic Partners have been identified as the main implementing partners of NBI and, as such, the key target of NBI's external engagement efforts. Categorizing the stakeholders enables NBI to develop tailor-made communication and engagement products as well as targeted messages. The aim is to gain political and public support for NBI's work specifically and Nile cooperation more broadly, and achieves the set strategic objectives.

NBI works closely with Nile Basin Discourse (NBD) whose focus is strengthen the voice of civil society in transboundary development projects and programmes and ensure that NBI responds to the development needs of local communities. NBD carries out its mandate through advocacy for cooperation and coordinated development; communication, knowledge and information management; providing platforms for dialogue between stakeholders; and building partnership between the public, private and civil society sectors.

FIGURE 7.3: MAPPING OUT NBI STAKEHOLDERS



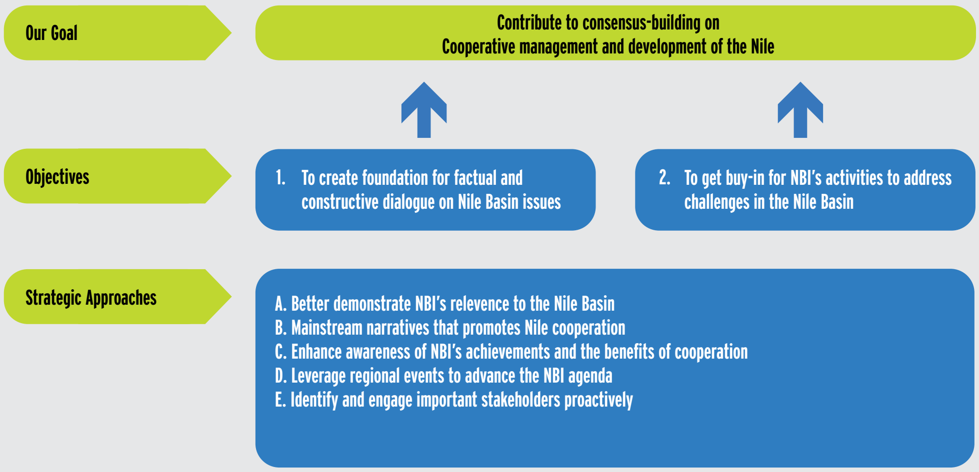
NBI COMMUNICATION AND STAKEHOLDER ENGAGEMENT STRATEGY (2018-2023)

The overarching NBI Communication and Stakeholder Engagement Strategy (2018-2023) is aimed at building consensus among the countries' public and stakeholders for co-operative Basin development and management. Well-structured stakeholder engagement will enable NBI to get the maximum buy-in and ownership from its stakeholders, as well as create a common understanding of the benefits and challenges of Nile cooperation and the risks of non-cooperation.

Communication serves to support and enable this process – and is therefore understood as a means towards successful stakeholder engagement. The overarching objectives for Communication and Stakeholder Engagement at NBI are;

1) To create foundation for factual and constructive dialogue on Nile Basin issues; and
2) To get buy-in for NBI's activities in order to address challenges in the Nile Basin.

FIGURE 7.4: FRAMEWORK OF NBI COMMUNICATION AND ENGAGEMENT



COMMUNICATION

COMMUNICATION CHANNELS

Communication at NBI is aimed at increasing the visibility of the NBI, its programmes and projects, so that updated information is provided to media outlets and the public(s) in general. NBI has been pioneering media trainings and forums that benefit several journalists from the Nile Basin, from all 10 member riparian states. And the outcomes reach many stakeholders, including the NBI Governance and other riparian's officials, including the media or journalists. Ultimately, these communication mechanisms (print, radio, video, publications, digital and social media engagement) are directly or indirectly contributing to more informed and balanced reports on Nile Basin issues (Figure 7.5).

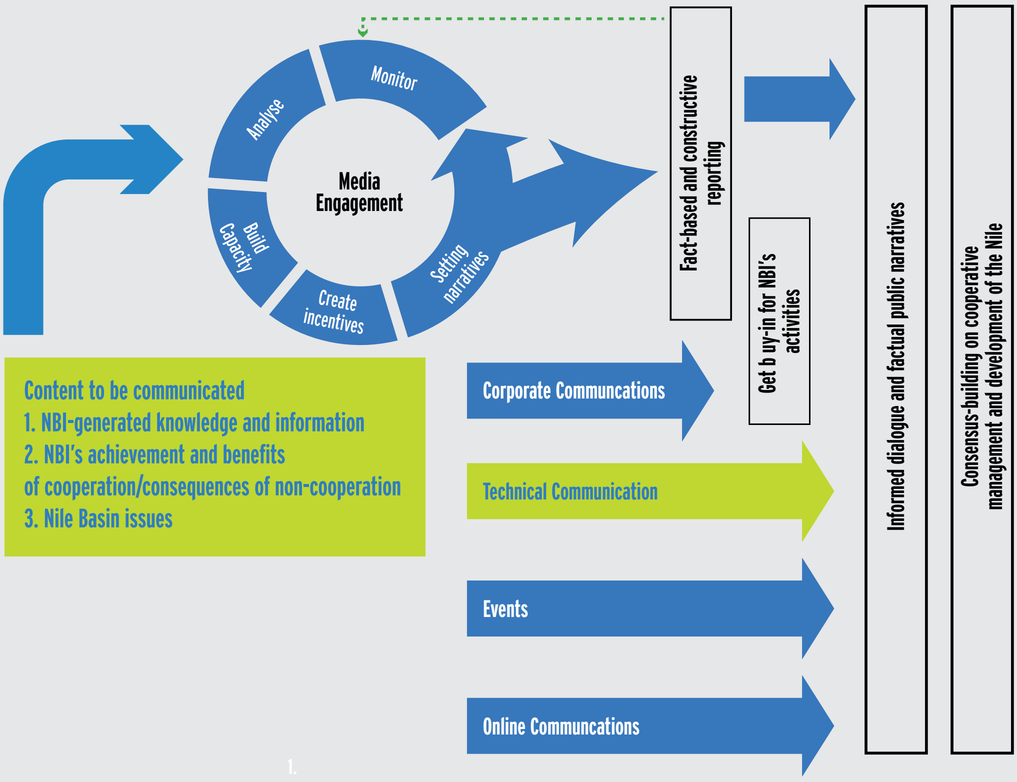
NBI utilises five key channels to disseminate and engage stakeholders. These are:

a) Online communications - A strong online presence (social media, websites, knowledge portals and e-learning platforms) makes NBI's information accessible to everyone.
b) Events - NBI organises consultations, forums and trainings to foster an informed basin-wide dialogue, most notably through Nile Day and the Nile Basin Development Forum.
c) Technical Communications - The direct provision of NBI-generated information and knowledge, targets largely (but not limited to) experts familiar with the respective topic.
d) Corporate Communications - Corporate publications strengthen the NBI brand and generate buy-in and ownership by Member States by communicating NBI's achievements.
e) Media engagement - The media has been singled out as a channel to amplify factual and constructive narratives on Nile cooperation. NBI therefore seeks to better respond to trends in the media landscape and enable factual and constructive reporting.

COMMUNICATION TOOLS

Several communication tools and products have been developed for each communication channel and implemented by NBI targeting specific stakeholders. In order to make sense of the parallel, but complementary ongoing activities, and their different stages of implementation, Table 7.4 below provides an overview on how NBI's communication tools contribute actively and systematically to the three core functions of the NBI of Water Resources Management (WRM) and Water Resources Development (WRD) and Fostering Basin Cooperation (FBC), as well as the Target Group of each of the channels.

FIGURE 7.5: NBI'S COMMUNICATION CHANNELS



STAKEHOLDER ENGAGEMENT

A well-structured stakeholder engagement is key to enabling NBI get maximum buy-in and ownership from its different and diverse stakeholders, as well as to create a common understanding of the benefits (current and potential) and challenges of Nile cooperation, and the risks associated with non-cooperation. Public information and communication in general, serves to support and enable this complex process. Below is a brief description of the key stakeholder engagements undertaken by NBI.

NILE DAY EVENT

On February 22 every year, Nile Basin countries and friends of the Nile come together to commemorate the establishment of the Nile Basin Initiative (NBI) in 1999. This day marked a major milestone in the history of Nile Cooperation, as prior efforts such as the Hydromet of the (1967-1992) and TECCO-NILE of the (1993-1998), were beset with lack of inclusivity and an institutional framework.

Nile Day provides an opportunity for Basin citizens to come together to celebrate the benefits of Nile cooperation and exchange experiences, views and ideas on topical issues related to the cooperative management and development of the common Nile Basin water and related resources. The occasion is also used by Member States to re-affirm their commitment to Nile Cooperation. This is in addition to enhancing stakeholders' appreciation of the importance of and commitment to Nile Cooperation while at the same time enhancing awareness of the results and visibility of NBI. The Nile Day also provides an opportunity to celebrate the rich and varied cultures which exist within the Nile Basin, with respect to cultural entertainment and traditional cuisine.

In addition, NBI convenes the Strategic Dialogue that brings together representatives of NBI Partner States and of Development Partners to discuss the Nile cooperation. The dialogue seeks to strengthen the Nile cooperation through exploring options of institutional sustainability. The discussions reflect on the evolving context of

TABLE 7.5: COMMUNICATION CHANNELS/TOOLS AND THEIR CONTRIBUTION TO THE NBI'S OVERALL STRATEGY AND CORE FUNCTIONS

Channel / Tools	WRM	WRD	FBC	Target Group	Reference Document
Channel 1: Online Communications					
Social Media	●	●	●	General public, media	Social media guidelines
Website	●	●	●	General public, media, NBI Governance	CMS Handbook
Knowledge Portals	●	●	●	Academia/Research, NBI Governance	
E-Learning Platform	●	●	●	NBI Governance, Academia/ Research, Partners	
Channel 2: Events					
Nile Day	●	●	●	NBI Governance, Media, Strategic Partners	Events checklist
Nile Basin Development Forum	●	●	●	NBI Governance, Media, Partners, Academia	NBDF Handbook
Thematic forums/ workshops	●	●	●	Various	Events checklist
Capacity-developments/ training/ study tours	●	●	●	Various	Events checklist
Community consultations		●		Project affected areas	
Channel 3: Technical Communication					
Technical Publications (incl. Atlas/ SoB / Reports)	●	●		NBI Governance, Media, Partners, Research	CD manual, Templates
Policy Handbook	●	●	●	TAC	CD manual
Policy Briefs	●	●	●	NBI Governance, MPs	Policy Brief Templates
Technical Bulletins	●			NBI Governance, Media, Partners, Research	CD manual
Channel 4: Corporate Communication					
Corporate Report	●	●	●	NBI Governance, DPs, Strategic Partners	CD manual
Newsletter	●	●	●	NBI Governance, DPs, Strategic Partners	CD manual
Factsheets/ Flyers/ Brochures	●	●	●	Various	CD manual
Success stories	●	●	●	NBI Governance, DPs, Partners, Media, PACs	CD manual
Channel 5: Media engagement					
Press briefing	●	●	●	Media	Media engagement, concept
Editors' breakfast	●	●	●	Media (editors)	Media engagement, concept
Media Radar			●	TAC, NBI staff, Strategic Partners	Media engagement, Guidelines
Media content analysis			●	TAC and NBI staff	Media engagement, concept
Media workshops/ field trips	●	●	●	Media	Media engagement, concept
Media Awards			●	Media, General Public, NBI governance, Partners	Media engagement, concept
Infographics	●	●	●	Media, General Public, NBI governance, Partners	Media engagement, concept
Press releases	●	●	●	Media	Media engagement, concept

TABLE 7.6: HOST COUNTRIES AND CITIES FOR NILE DAY		
Year	Host country	Theme
2007	Rwanda - Kigali	Enhanced Cooperation on the Nile for Peace and Prosperity
2008	Ethiopia – Addis Ababa	Land Degradation and Climate Change: Address Shared Threats, Sustain Nile Basin Cooperation
2009	Burundi - Bujumbura	United in Diversity by the River Nile – Our Heritage, Source for Regional Cooperation
2010	Uganda - Kabale	Nurturing 10 Years of Cooperation and Progress
2011	DR Congo - Goma	All Together for Better Cooperation
2012	Uganda - Jinja	Water, Energy, Food – Importance of Nile Cooperation
2013	Ethiopia – Bahir Dar	Land Degradation and Climate Change: Address Shared Threats, Sustain Nile Cooperation
2014	Uganda - Kampala	Water and Energy: National Challenges, Transboundary Solutions
2015	Sudan - Khartoum	Water and Improved Livelihoods – Opportunities in Nile Cooperation
2016	Kenya - Vihiga	Nile Cooperation: Gateway to Regional Integration
2017	Tanzania - Dar es Salaam	Our Shared Nile - Source of Energy, Food and Water for All
2018	Ethiopia – Addis Ababa	The Nile: Shared River Collective Action
2019	Rwanda - Kigali	NBI@20: Stronger Together
2020	Sudan - Khartoum	Joint Investments on the Nile for Regional Transformation
2021	Kampala Uganda – as a virtual event due to Covid-19 travel restrictions	Rethinking Regional Investments in the Nile Basin

emerging issues, challenges, opportunities to map prospects for institutional growth and sustainability. The Strategic dialogue has been established as an instrumental forum in generating ideas on institutional, technical as well as financial sustainability for the Nile cooperation. The forum is not a decision making body but a platform for analyzing issues and informing decisions of NBI governance as well as the development partners of NBI. The first Strategic Dialogue was held in 2006 and has been held annually. Beginning 2019, the event has been fixed on the NBI calendar to always take place on 23rd February of every year, just a day after the Nile Day celebrations.

Since 2007, Nile Day is celebrated at the regional level and national level with a selected rallying theme. The Regional event is spearheaded by the NBI Secretariat based in Entebbe, Uganda in coordination with the host country, the Subsidiary Action Programmes (ENTRO and NELSAP CU) and the Nile Basin Discourse, a civil society organisation. National celebrations on the other hand are coordinated by the NBI National Office in the various Member States.

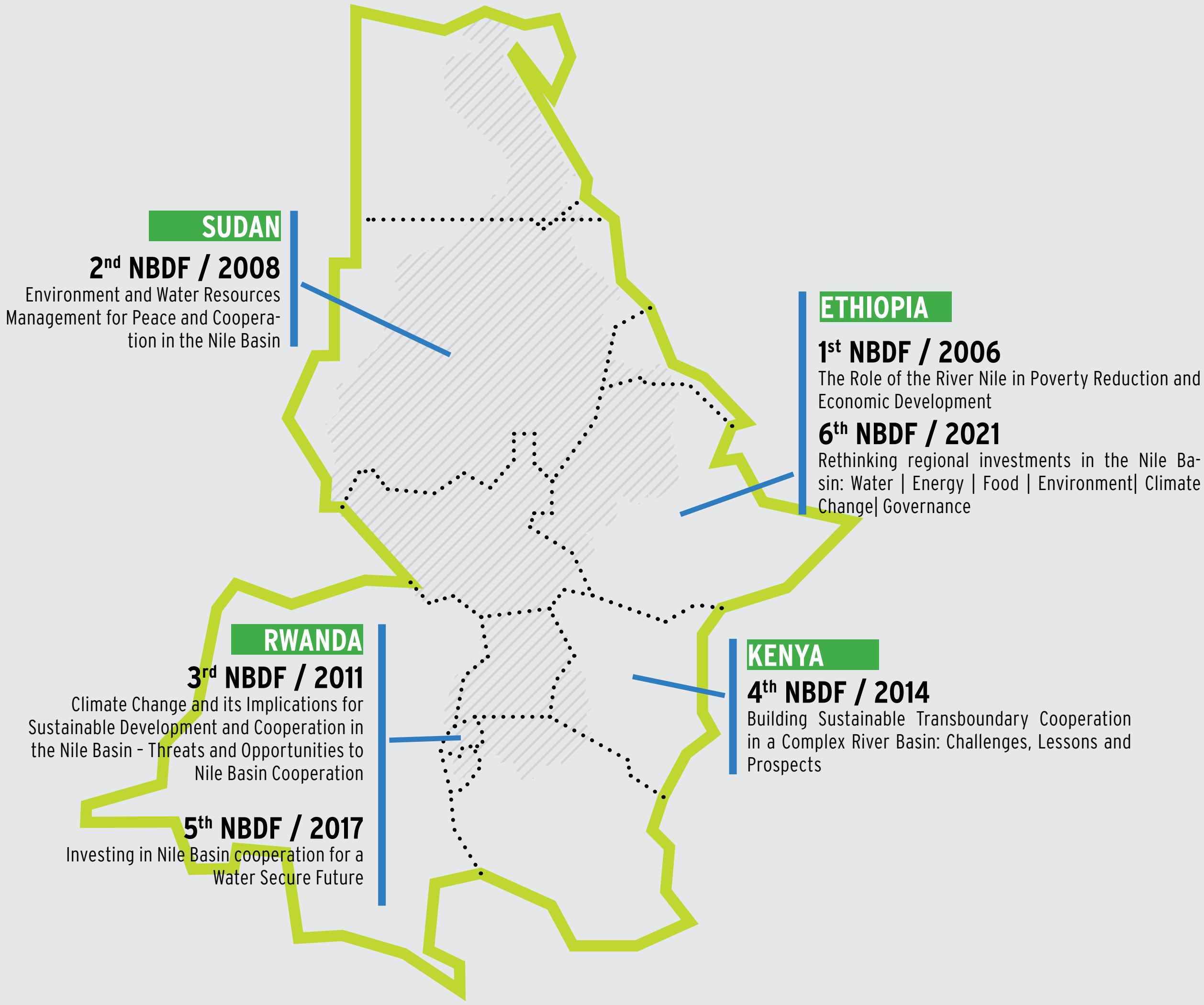
So far 14 such events have taken place under different themes as detailed in Table 7.6.

THE NILE BASIN DEVELOPMENT FORUM (NBDF)

The Nile Basin Development Forum (NBDF) is a high-level regional event convened every three years by the NBI in collaboration with its Member States and development partners. The event is a science-policy dialogue that provides opportunity for sharing latest information, knowledge and best practices as well as building partnerships and networks among professionals, in transboundary water resources management and development. The NBDF succeeded the Nile 2002 conferences that were focused on facilitating dialogue amongst stakeholders on their needs, challenges and opportunities in relation to development of the Nile region.

NBDF forum events attract a broad range of stakeholders who include ministers in charge of water and foreign affairs in Nile riparian countries, other senior government

FIGURE 7.6: HOST COUNTRIES AND THEMES OF NBDF



officials, parliamentarians, water resource managers, river basins organizations, economists, environmentalists, development planners, academics, researchers, media practitioners, civil society, local and international NGOs, UN agencies, and private individuals and corporations.

Each NBDF event looks at topical issues related to the protection of the ecosystem of the Nile and the sustainable management, development and governance of water and related natural resources of the Basin to address development challenges in the region. The NBDF normally takes the form of a three-day conference, with the first two days dedicated to parallel sessions on the themes of the conference and side events, and the final day to plenary sessions culminating in the High-Level Ministerial Panel discussion and conference declaration. The 6th edition of the NBDF was supposed to take place in October 2020, but was postponed to 2021 due to the COVID-19 pandemic. It was organised as a hybrid virtual/ physical event with a virtual launch ceremony during Nile Day celebrations on 22nd February 2021 followed by a series of webinars culminating in a physical closing ceremony from 6th to 7th May 2021 held in Addis Ababa, Ethiopia. Table 7.6 shows the 6 hosts of previous NBDF events and the themes of the events.

THE NILE BASIN DISCOURSE (NBD)

One of the unique mechanisms for deliberation and participation of ordinary citizens in the Nile Basin is the Nile Basin Discourse (NBD). The NBD is a civil society regional umbrella organization created to strength-

Photo: NBI

en civil society participation in NBI developmental processes and programmes and make the NBI accountable to the people of the Nile Basin.

The NBD vision is "a Nile Basin, which is secure, where resources are equitably and sustainably developed and managed, benefiting all its inhabitants" and its mission is "to ensure that a fully-informed and basin-wide civil society develops and plays a key role in achieving the NBD vision through proactive and critical influencing of projects, programs and policies of the Nile Basin Initiative and other development processes."

The NBD has a presence in all 11 of the riparian countries of the Nile Basin through national level Nile Discourse Forums. The members of the NBD – themselves civil society organisations – are 639 in number. The governance structure of the NDF consists of a General Assembly, which is the key governing body of the NDF, a Steering Committee that provides coordination and oversight to basin-wide programmatic issues, and a Discourse Desk located in Entebbe, Uganda, which serves as the Secretariat of the NDF.

The main achievement of the NBD and its member CSOs has been in raising awareness amongst grassroots communities on the development programmes and processes of the NBI; on the importance of cooperation on the Nile and potential socio-economic benefits to be derived from cooperation. Through their awareness raising activities, the CSOs have acted as a bridge between the NBI and riparian communities of the Nile Basin. The improved level of awareness has led to increased interest and participation from the communities in NBI programmes, and greatly facilitated the implementation of NBI projects.

Besides increased grassroots participation, the CSOs have helped to improve the planning of NBI projects and programmes through holding of multi-stakeholder dialogues on NBI programs and projects, increasing emphasis on the need to consider socio development issues in project planning – e.g. issues of gender, HIV/AIDS, poverty reduction, good governance, etc.; and bringing on board sector-specific knowledge, or expert knowledge of local conditions, local cultures or local opportunities and challenges with a bearing on program and project planning. The NBD and its member CSOs, especially the Nile Media Networks, have also been at the forefront of trust and confidence building for cooperation on the Nile.

PARTICIPATION IN NBI PROGRAMME WORK

The Nile Basin Initiative has a number of arrangements to allow for participation of different stakeholder groups in implementation of all programmes and projects. The NBI governance structure spans multiple sectors and extends to national levels thereby incorporating representation from the riparian states drawn from different sectors like agriculture and irrigation, environment and natural resources, fisheries, navigation, etc. The structures that serve this purpose include Coordinating Committees, Technical Committees, and Regional Expert Working Groups

Regional Expert Working Groups (REWG) are constituted for each major activity/ project with the goal ensuring full participation of riparian countries in all aspects of project implementation and guaranteeing basin-wide ownership of outputs and outcomes. The membership of the REWGs for each country is drawn from NBI governance and subject matter experts from government, academia, private sectors, etc. The REWG serves 3 important considerations in overall implementation of NBI programmes:

- Ensures full participation of the NBI Member States during the implementation of a given project or program i.e. in the scoping, system needs/ requirements, process design, system building, data collection and analysis and validation of results.
- Ensures responsiveness and alignment to the national (and related regional) needs and expectations.
- Is an opportunity to carry out capacity development for the engaged users from NBI Countries which knowledge can be shared by the experts when they return to their countries.

CAPACITY BUILDING

Photo: NBI

THE CHALLENGE

Capacity building is a key pillar for ensuring effective stakeholder participation and sustainable management of the basin water resources. Effective participation requires that adequate forums are provided and stakeholders have the capacity and access to information to engage with their co-riparian states on equal footing. However, the decision making processes in transboundary organisations are sometimes not underlain by sufficient capacity and result in sub-optimal outcomes as far as sustainable water resources development and management are concerned. This is evidenced in the regional challenges of low level of harmonization of regional and national policies; low uptake of regional policy frameworks; reduced mutual benefits for water users; uncoordinated water resources development; and loss of opportunities for optimal investments in water. There may also exist disparities in capacities among the riparian countries and associated regional institutions based on their unique backgrounds and practices. While capacity development within a transboundary context is broad and entails also other aspects like institutional capacity, these are covered elsewhere in this chapter. The description below relates mainly to human capacity building.

THE NBI APPROACH TO CAPACITY DEVELOPMENT

When the NBI was launched, there were substantive capacity differences between the Basin States. Many countries lacked trans-boundary water resources management and development capacities including in the academic and professional realms. Addressing this challenge, including capacity to cooperate and sustain gains over time became a prerequisite and therefore a priority. As part of the Shared Vision Program (SVP, 2002-2009), capacity needs assessment was conducted and critical short- and long-term gaps identified. A multi-pronged approach was taken that embedded capacity development in each of the projects of the SVP program. The latter was conceived as a special program aimed at capacity development not only of professional competencies and capabilities, but also of capacity to cooperate, building trust and confidence among Basin States as a means by which to provide a wider enabling environment for investments facilitated by the two SAPs. NBI has carried out capacity building using a two pronged approach as summarised below.

TRAINING NEW CADRES OF NILE EXPERTS

Extensive range of technical training intended to leverage the capacity of countries to manage water resources in a more sustainable manner and with a trans-boundary orientation continues to be offered in particular to government officials of Member States. This is through specific training programs, such as the Shared Vision Program's Applied Training Project which trained citizens at Doctorate, Masters and postgraduate diploma level, the Institutional Strengthening Project, as well as through other sub-programs and project preparation processes. Training has covered technical issues (e.g. hydrology, Integrated Water Resource Management, modelling tools, dam safety assessment and environmental and social issues) that address sectoral capacity constraints, of particular importance to upstream countries. Capacity to cooperate has been leveraged through training in various fields including communications, advocacy, media management, stakeholder dialogues, hydro-diplomacy and benefits of transboundary perspectives. Different modes, tools and approaches have been employed including various training modules and sessions, coaching and mentoring, technical support and assistance, e-learning (with modules on the Nile Basin Decision Support System and on-boarding, among others), hands-on demonstration and exercises, professional experience sharing programs, study tours, as well as internships and intensive engagement in all NBI activities and tasks. Capacity development has subsequently been approached from two main fronts: the long-term capacity development in which students from Basin States have pursued postgraduate training in masters, doctoral and postdoctoral courses, and short-term capacity development including training workshops, exchange visits and study tours. Many Basin citizens have benefited from this dual approach to capacity development.

CAPACITY DEVELOPMENT ACROSS SECTORS AND ON REGIONAL APPROACHES TO DEVELOPMENT

The NBI approach has also focused on specific challenges including fragmentation between sectors, limited integration among various sectors of water use, and between water quantity and quality, and surface and groundwater. Programs targeting both the short-and long-term capacity needs and specific areas were designed. The NBI also provided in-country and high priority training sessions related to water policy formulation and implementation, as well as trans-boundary and technical dimensions of Integrated Water Resources Management (IWRM). In order to address long term capacity needs, NBI provided fellowships that prioritized Training of Trainers targeting groups of postgraduate trainees. This is in addition to establishing the Nile Basin University Forum (NBUF) as a basin wide network of lead training institutions in IWRM. The benefits of cooperation are most keenly felt where regional processes are effectively integrated into national development. The NBI has implemented projects and activities aimed at strengthening the capacity of national institutions in order to improve inter-sector coordination and planning at a national level and to support cooperative management of Nile resources. This is in addition to improving the integration of NBI programs and projects into national development contexts including areas of finance, water, environment, energy, agriculture, and foreign affairs.

KEY RESULTS TO DATE

Considering that capacity development is a continuous process, the NBI continues to identify and seize capacity development opportunities so as to sustain gains made in the last 20 years and to keep up to date with evolving best practice in basin management and development. While it may be difficult to monitor and measure the impact and level of attribution to NBI's capacity development efforts it is known that much of the knowledge gained has been applied across sectors in the Member States. The following are some of the remarkable achievements from capacity development undertaken:

- A strong cadre of trained water professionals hitherto lacking in most Nile countries. Overall, more than 30,000 people have benefited from capacity development in key technical areas.
- The qualitative and quantitative disparities in capacities among the Member States and of the institutions and the professionals involved have been fairly even.
- There is increased recognition and relative uniformity in consideration of trans-boundary water resources management and development in the Member States.
- Trans-boundary dimensions have been strengthened in the national water policies of Member States, with technical assistance extended to Kenya and Rwanda, specifically, in the revision of their Water Policies.
- Transboundary considerations within institutional formations have been gaining prominence with an increasing number of countries establishing a dedicated department or unit within established structures.
- Six universities and tertiary training institutions have been strengthened by hardware, software, curriculum, and teaching materials with training modules subsequently adopted by universities
- Improved policy and decision makers' awareness on water resources planning and management enhanced through targeted appreciation workshops, exchange visits, and advocacy.
- Countries have developed capacity to identify and prepare bankable joint investment projects, with an impressive ratio of USD 1 spent on project preparation leveraging investment worth USD10.
- NBI countries are now capable of applying state-of-the-art analytical systems, using the most sophisticated technologies to derive multi-criteria and identify key trade-offs.
- The participation of NBI institutions and experts in the international arena within both high-level technical meetings and dialogues has greatly expanded during the past 20 years, especially in water resources development and related fields.
- Enhanced common understanding of the river system, including potential for development and the risks of non-cooperation.
- The presence of sophisticated monitoring and evaluation systems indicates significant human and institutional capacity in place.

FINANCING OF TRANSBOUNDARY COOPERATION

Effective transboundary governance depends on mechanisms to implement projects identified for their shared benefits, notably the ability to attract investment. Such investment can be a proxy for the level of confidence in political and technical pronouncements of cooperation arrangements.

Support for the NBI has been characterised by partnership since its inception. In the formative period of the NBI, a broad partnership encompassing the riparian countries of the Nile, the international donor community, financial institutions, investors and all other stakeholders in the riparians' Shared Vision was established. It was charged with the responsibility of raising and coordinating funding in support of cooperative water resources management activities, development projects, and other related projects in the Nile Basin.

FINANCING OF NBI ACTIVITIES

NBI has largely been funded from two major sources; country contributions from member states and external support from NBI Development Partners. Initially, the bulk of the financing was from Development Partners but the countries have gradually taken over the support of institutional core costs while the external funding was dedicated to program funding. Over USD 200 million grant funding has been mobilized by Development Partners and supported NBI in institutional as well as program activities.

In 2012, Nile-COM agreed to gradually increase member country annual cash contributions and fully finance the core operations of the NBI by 2017. The agreed annual contributions of member states duly grew from US$15,000 (agreed in Dar es Salaam in 1999) to over US$300,000 by 2017. Those countries that contributed to all three NBI centres would now contribute over US$400,000 per annum. This was a significant step forward to ensuring the financial sustainability of the NBI's core operations in its three centres. Table 7.7 shows the member states cash contribution to NBI activities for the period 200-2020. In addition, in-kind (non cash) contributions have accumulated to over 120 million US Dollars.

FIGURE 7.7: MEMBER STATES CASH AMOUNT (USD) CONTRIBUTIONS 2000-2020

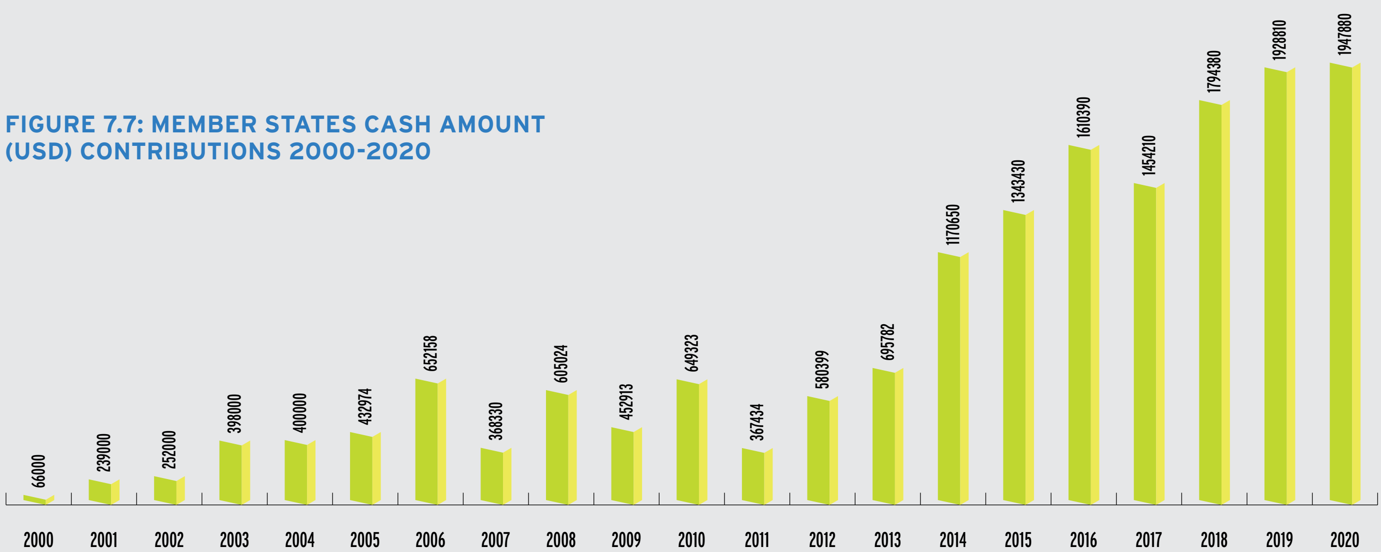


TABLE 7.7: INVESTMENT PROJECTS FACILITATED NBI			
PROJECT CATEGORY	Number of Projects		
	ENTRO	NELSAP-CU	TOTAL
Multipurpose Water Resources Management & Development	6	59	65
Power Transmission & Interconnection	2	22	24
Power Generation	2	12	14
Watershed Management	8		8
Irrigation and Drainage	4	6	10
Water Supply and Sanitation		2	2
Water Resources Monitoring and Assessment	3		3
Ecosystem Protection & Conservation	3	1	4
Transport and Navigation	2	1	3
Fisheries & Aquaculture Development		1	1
TOTAL	30	104	134

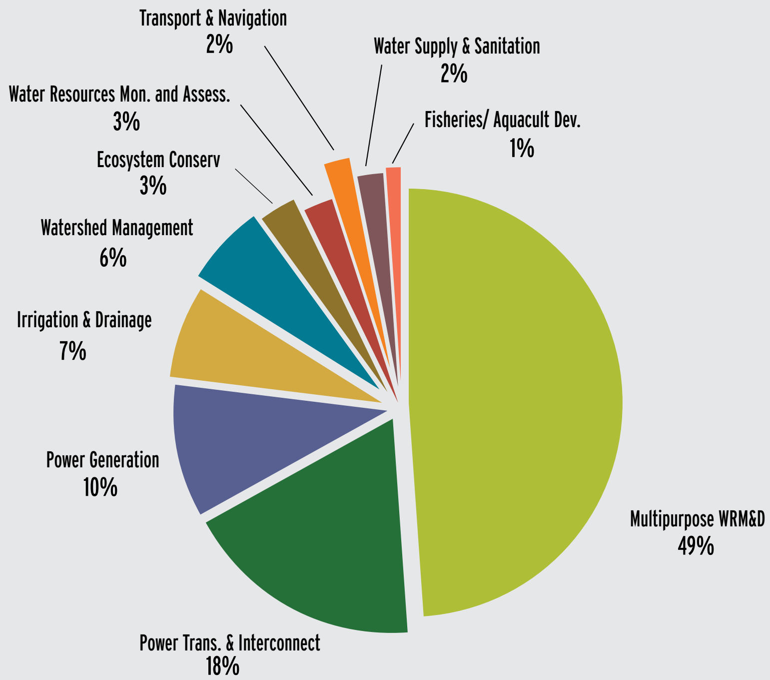
TRANSBOUNDARY WATER INVESTMENTS

Among the core functions of NBI is assisting Member States to identify and prepare investment projects, which are economically viable, environmentally friendly and socially acceptable as well as mobilize financial and technical resources for their implementation. Therefore NBI has been active in preparing and implementing investment projects across multiple sectors including power interconnection and generation projects, and multipurpose water resources management and development projects that covering agricultural irrigation, water supply, fisheries resources development and watershed management projects, in major sub-basins of the Nile.

Transboundary investment at NBI two subsidiary arms of ENTRO and NELSAP o have served to promote regional transboundary investments and deliver tangible actions on the ground to build early confidence for cooperation while responding to the development needs and aspirations of the Basin communities. Under the two SAPs, the NBI has coordinated processes by which riparian countries have identified and cooperatively implemented investment projects that confer mutual benefits to member states. The two SAPs play a facilitative role in the investments agenda that includes support in identification of potential investment areas; carrying out prefeasibility, feasibility and design studies; preparing projects to a bankable stage; mobilising finances for their implementation; and passing them on to the countries for implementation. All of these functions are carried out in close collaboration with the Nile riparian countries.

The NBI's two SAPs have identified a total of 134 investment projects that are at different stages of the project cycle. The number of investment projects per SAP, grouped by categories, is shown in the Figure 7.8 and Table 7.7. A detailed listing of the portfolio of in-

FIGURE 7.8: THE TYPES OF INVESTMENT PROJECTS SUPPORTED BY NBI



vestment projects is included in Appendix 1.

In the period 2000 to 2013, the NELSAP-CU applied a total of US$ 86.72 million in investment project preparation activities. The combined value of investment-ready projects prepared over this period amounted to US$ 1,059.33 million. This translates to a leverage factor of US$ 12.22 in investments for every dollar used in pre-investment activities. ENTRO applied a total of US$ 38.85 million in pre-investment activities over the same period with similar leverage factor. The low figure of investment compared to NELSAP-CU is attributed to the freezing of Egypt activities in NBI since 2010.

COORDINATION OF INVESTMENT PROGRAMS IN THE NILE REGION

A key weakness with present arrangements for investment programing in the Nile region is the lack of a framework for coordination of investment project identification and preparation among the various regional organisations, and lack of a mechanism for basin-wide project Prioritisation, or means to ensure that the multi-sectoral projects being promoted by the different regional organisations are optimized from a basin-wide perspective and designed to deliver equitable benefits to all Nile riparian states. Furthermore, there is lack of a common integrated multi-sectoral and multi-agency investment plan for the Nile River Basin. Such an investment plan would be a key tool for mobilization of resources towards the sustainable development and management of the common Nile Water Resources for the benefit of all Nile riparians.

Through its Ten-Year Strategy (2017-2027), the NBI has introduced a strategic shift in the approach to investment project development and promotion, as a way of addressing the aforementioned problem. Under the new approach, the NBI plans to work with Nile riparian states, Regional Economic Communities (RECs) and other relevant regional and continental organisations, to develop a multisectoral and multi-country portfolio of basin-wide and regionally significant investments. Furthermore, the NBI intends to establish an investment support function through which it will coordinate, promote and follow up the preparation and implementation of the basin-wide investment program, in collaboration with the Regional Economic Communities in the Nile region.

The NBI will follow two mutually reinforcing approaches in establishing the basin-wide, multisectoral investment program termed the Nile Basin Investment Programme (NBIP). In the first approach, the NBI plans to set up an alliance of regional actors that have investment programs that can contribute to the emerging Nile Agenda as described by the six pillars of NBI's Ten-Year Strategy (2017-2027) and directives of the Summit of Heads of State of the NBI riparian countries. The key pillars of the emerging Nile agenda are: (1) water security; (2) energy security; (3) food security; (4) environmental sustainability; (5) climate change; and (6) transboundary water governance. Regional and continental actors expected to be brought into the alliance include the East African Community (EAC)/ Lake Victoria Basin Commission (LVBC), Intergovernmental Authority on Development (IGAD), Common Market for Eastern and Southern Africa (COMESA), Eastern Africa Power Pool (EAPP) and African Union Development Agency (AUDA-NEPAD). Concurrent with the formation of the alliance of regional actors for Nile investment, the NBI will be working to increase awareness and visibility for its own investment programme through the preparation, and regular update, of an "Annual Status Report on the NBI Investment Pipeline." In the second approach, the NBI will work to develop a Nile River Basin Plan comprised of regionally optimized multisectoral priority investments that will generate a basket of benefits for all Nile riparian countries.

The first and second approaches will come together in the development of a multi-actor and multisectoral Nile Basin Investment Program (NBIP), which will be accomplished with the participation of the other regional actors making a contribution to the Nile development agenda The NBIP is envisaged to serve as a framework within which Nile riparian countries will prioritize and endorse packages of optimized investment projects. The Program will be designed to be a high-level coordination, resource mobilization and monitoring mechanism for the multiple regional agencies that contribute to the Nile development agenda. As the ultimate owners and beneficiaries of the process, the Nile riparian countries will be in charge of steering all processes including the development of the NBIP.

SUMMARY

This Chapter has discussed status of transboundary water governance in Nile Basin and the role that Nile Basin Initiative is playing to strengthen it. The NBI's salient contributions, from the foregoing review, are the following:

- Policy, law and regulations: The NBI has developed a large number of policies to promote the sustainable and cooperative management and development of the Nile Basin water resources. These policies are being applied by the NBI in the delivery of their mandate, day-to-day work. Due to its legal status, the NBI polices are not enforceable, but are available to countries to adopt as best practices. The NBI has also offered support to the countries to improve national policies and laws related to transboundary water management and development.
- Planning: The NBI has supported many Basin-wide and sub-Basin assessments to support planning, and has supported investment planning at the subsidiary level. The NBI is working to establish coordination arrangements for preparing a multi-actor, multi-sector Nile Basin development agenda and investment plan.
- Management arrangements: The NBI has established institutional arrangements through which various stakeholders within the riparian member states participate in the governance of the Basin. There are proposals to improve the robustness of these arrangements by including a Summit of Heads of States and Government as the highest NBI policy organ. The First HoS Summit was convened in Uganda - June 2017. NBI is now preparing for the Second HoS Summit.
- Monitoring: The NBI has designed, and is in the process of establishing, a Basin-wide hydrometric monitoring network. The NBI also collects information on the water resources of the Basin through remote sensing applications. Through numerous reporting mechanisms, the NBI documents and provides to the member countries and other stakeholders, progress being made under its various projects and programmes.
- Capacity development: NBI has played an important role in building capacity within the Basin in a broad range of areas, including appreciating transboundary water cooperation, identification and preparation of investment projects, and use of numerous analytical tools to support planning and evidence-based decision making.
- Stakeholder participation: The NBI has made many arrangements to enable various stakeholders and interest groups to participate in NBI processes, and thus contribute to governance of the Nile Basin.
- Communication: The NBI has developed and is applying a wide range of channels and tools include online tools, technical and corporate publications and media engagement, to keep stakeholders fully informed about the NBI's activities.
- Evidence based decision making: The NBI has developed and is applying a number of tools to support evidence-based decision making. These include decision-support tools, technical analyses, forecasting and early warning systems, and state of basin reports.
- Financing: The NBI has mobilized considerable financial and in-kind contribution from the riparian member states and development partners to support the NBI and transboundary water cooperation. Renewed efforts are required to attain financial sustainability of the institution, and enhance member countries ownership of the NBI through increased country contributions.

In addition, NBI is spearheading ongoing initiatives to further strengthen coordination between the different entities operating in Nile Basin and reduce duplication of effort, competition for resources and inefficiencies in delivery of development benefits to the region. The NBI is working on establishing an investment support function through which it will coordinate, promote and follow up the preparation and implementation of a basin-wide investment program, in collaboration with the Regional Economic Communities in the Nile region. The NBI plans to achieve this by establishing an alliance of regional actors that have investment programs that can contribute to the emerging Nile Agenda, and working with the regional actors to develop a Nile River Basin Plan comprised of regionally optimized multi-sectoral priority investments that will generate a basket of benefits for all Nile riparian countries. NBI has signed Memoranda of Understanding (MoUs) with EAC/LVBC and IGAD that but also provide vertical linkages to broader political fora at which to highlight water governance as an essential ingredient of sustainable development.

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ONE RIVER ONE PEOPLE ONE VISION

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