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ABAKIR

SUMMARY

Lake Kivu and Ruzizi/Rusizi River Basin

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Lake Kivu and Ruzizi/Rusizi River Basin: Summary

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List of abbreviations

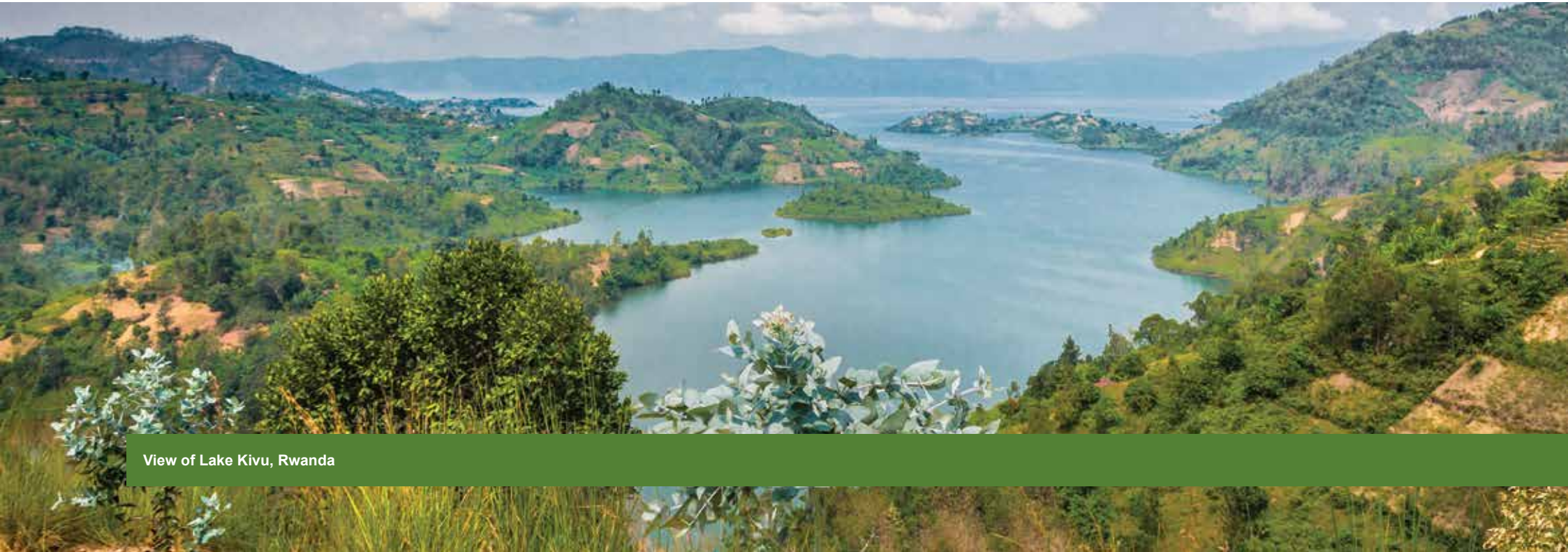
ABAKIR	Autorité du Bassin du lac Kivu et de la rivière Ruzizi/Rusizi
CICOS	International Commission of the Congo-Oubangui-Sangha Basin
DRC	Democratic Republic of the Congo
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
IPCC	Intergovernmental Panel on Climate Change
IWRM	Integrated Water Resources Management
MININFRA	Ministry of Infrastructure (Rwanda)
PES	Payments for Ecosystem Services
RUSLE	Revised Universal Soil Loss Equation
SWOT	Strengths, Weaknesses, Opportunities and Threats
WEF	Water-Energy-Food Security

CHAPTER 1

Context of the study

The three Member States of the Lake Kivu and Ruzizi/Rusizi River Basin, the Republic of Burundi, the Democratic Republic of the Congo (DRC) and the Republic of Rwanda, have established **the cross-border Lake Kivu and Ruzizi/Rusizi River Basin Authority, known by the French acronym 'ABAKIR'** (Autorité du Bassin du lac Kivu et de la rivière Ruzizi/Rusizi), as the authority responsible for the integrated management of water resources in the Lake Kivu and Ruzizi/Rusizi River Basin. In support of making this authority operational, the present study, financed by the European Union and the German Federal Ministry for Economic Cooperation and Development, follows a request from Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ) for an extended baseline study of the transboundary basin of Lake Kivu and the Ruzizi/Rusizi River.

The study focuses on **Integrated Water Resources Management (IWRM)**, which involves the coordination, development and management of water, land and related resources to produce economic and social well-being, while also considering sustainability and environmental and ecosystem aspects. By supporting ABAKIR, the study also provides an opportunity to foster regional cooperation.



View of Lake Kivu, Rwanda

CHAPTER 2

Integrated management of the water resources of the Lake Kivu and Ruzizi/ Rusizi River Basin

The **International Convention on Integrated Water Resources Management in the Lake Kivu and Ruzizi/Rusizi River Basin** was signed on 4 November 2014 by representatives of Burundi, DRC and Rwanda. However, the three countries have **not yet ratified the convention**.

ABAKIR was established as a transitory body after the convention was signed. **ABAKIR's mission** is to promote economic, industrial and social development in each of the Member States through optimising the benefits of water resources and increasing the use of water resources for energy production and other beneficial purposes while preserving the environment. ABAKIR's objective is to ensure the protection and conservation of water resources in the watershed of Lake Kivu and the Ruzizi/Rusizi River through integrated and sustainable management.

To achieve this objective, the parties to the convention must:

- cooperate in the development of a common strategic vision for the management of the basin and the implementation of the resulting action programmes;
- cooperate in the design and implementation of harmonised rules and standards for water resources management in the basin;
- pay particular attention to current and future riverside communities so that these benefit from the sustainable use of natural resources and basin management.

Currently, ABAKIR is working via a temporary governance structure with headquarters in Rubavu, Rwanda. This temporary structure comprises a Director Coordinator, a Co-Director in charge of Operations and a Co-Director in charge of Administration and Finance. Its mandate is to undertake preliminary actions to **support the ratification of the convention and the establishment of a permanent trilateral ABAKIR**. This is in line with the sectoral policies and strategies of Burundi, DRC and Rwanda, which aim to strengthen regional collaboration around the management of natural and energy resources, while protecting the environment.

At the political level, a permanent ABAKIR will **promote regional stability and good governance** by strengthening relations between the Member States. It will thus contribute to the maintenance of peace, as the management of shared resources is often a source of conflict when not structured and regulated.

CHAPTER 3

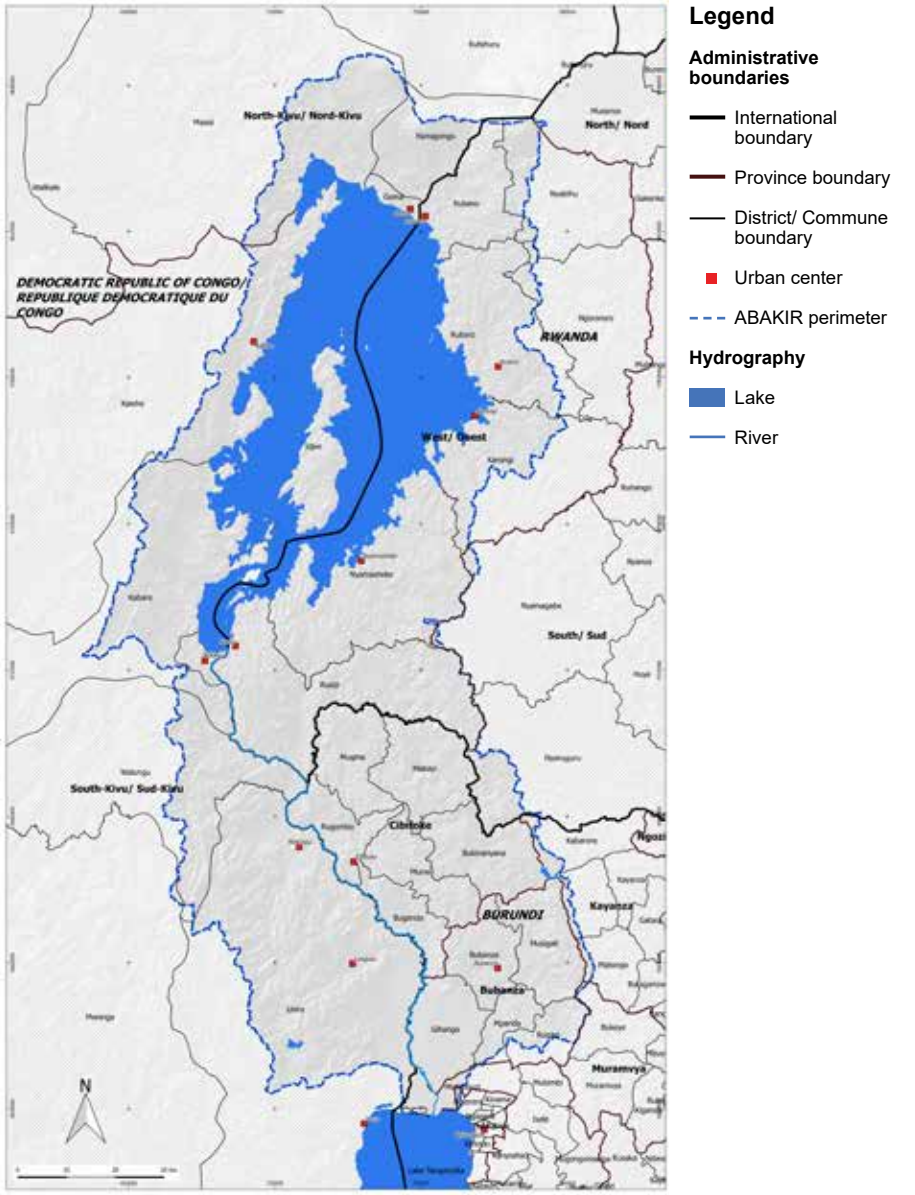
Definition of the study area

The study area encompasses the cross-border catchment area of Lake Kivu and the Ruzizi/Rusizi River up to its mouth at Lake Tanganyika. It lies in the zone of intervention of ABAKIR, and includes areas of Burundi, DRC and Rwanda. In these countries, the availability of certain data and the quality and precision of these data are not always equivalent. To achieve a harmonised level of data throughout the basin for the purposes of this study, a combination of available and accessible field data together with global data was used.

The total surface of the study area is 1**3 449 km²**, with 2 706 km² (20.2%) belonging to Burundi, 6 227 km² (46.5%) to DRC and 4 452 km² (33.3%) to Rwanda. Taking account of the surface area of Lake Kivu (2 412 km²), the land area of the study area is 10 973 km². The Lake Kivu basin is shared between DRC and Rwanda only.

From an administrative point of view, the three countries have a first-level administrative division corresponding to provinces. The study area encompasses **eight provinces:** Cibitoke, Bubanza, Kayanza and rural Bujumbura in Burundi; North Kivu and South Kivu in DRC; and West and South in Rwanda (see Figure 1).

Figure 1: Administrative boundaries in the study area



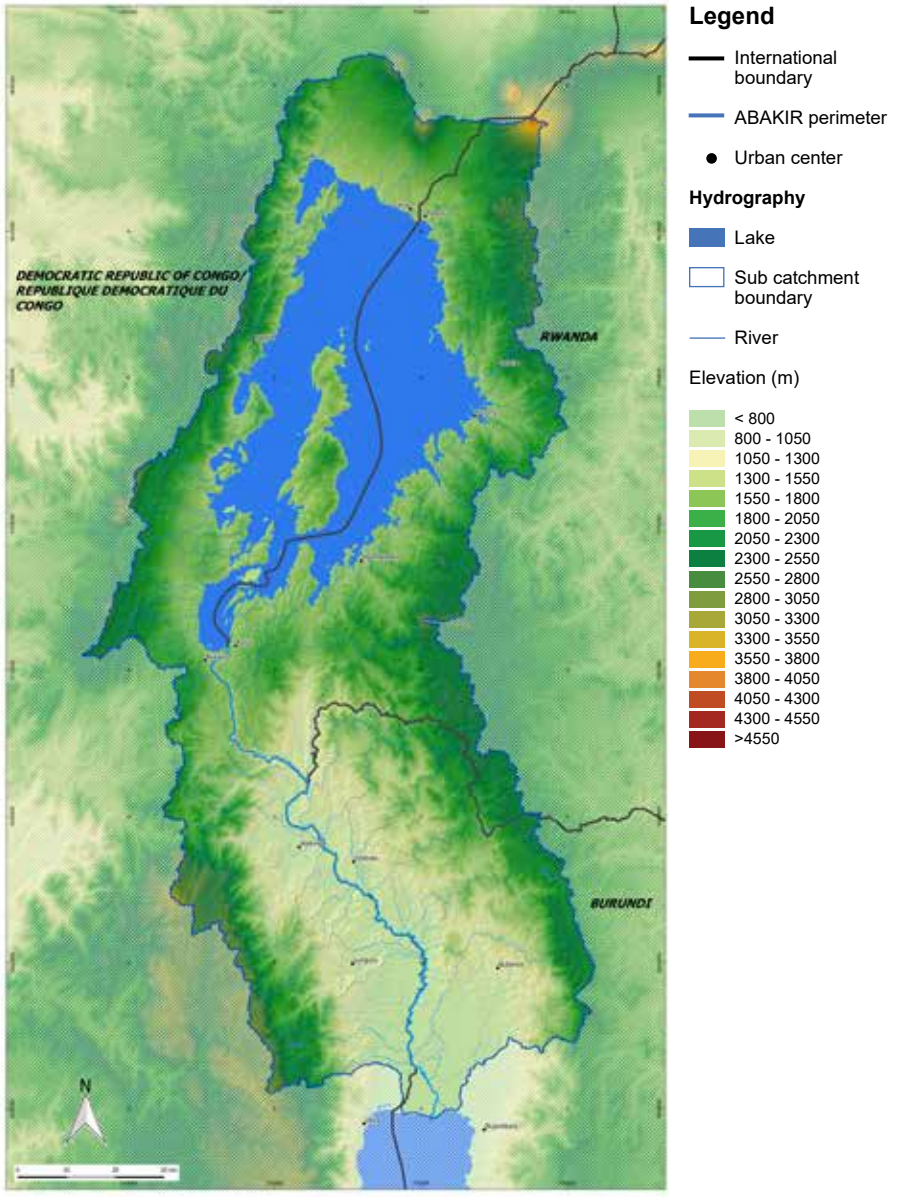
CHAPTER 4
Physical environment

4.1 Topography, geomorphology, soil types and geology

Burundi, DRC and Rwanda are part of Africa's Great Lakes region, with high mountains, volcanoes, eroded land and lakes, including Lake Kivu in the study area. The topography, altitude and relief offer varied landscapes, marked by the greenness of the abundant vegetation that thrives in the equatorial high-altitude climate (see Figure 2).

In the northern part of the basin, mountains exceed 3 000 m in altitude, reaching 3 058 m, 3 470 m and 4 507 m, respectively, at the summits of the Nyamulagira, Nyiragongo and Mount Karisimbi volcanoes. These constitute the northern limit of the basin within the Virunga Mountains range. The generally very rugged relief in the north of the basin is reflected in steep slopes, with **gradients frequently exceeding 60%**.

Figure 2: Topography of the study area



Lake Kivu, at an average altitude of 1 462 m, is a volcanic dam lake, the shores of which are divided into numerous bays, capes and islands. The outflow of Lake Kivu is the Ruzizi/Rusizi River, which flows southwards for **168 km**, carving gorges through basalt piles, to empty into Lake Tanganyika. The river drains the vast Ruzizi/Rusizi plain, which extends over approximately 1 345 km^2 at altitudes between 770 m and 950 m.

The geological configuration of the Lake Kivu and Ruzizi/Rusizi River Basin essentially comprises Precambrian-age lithostratigraphic units. The main metamorphic rocks are gneiss and gneissic and micaschist complexes, as well as quartzites, quartzite, granitoid and schist metasediments, and numerous granitic intrusions. The study area also includes Cenozoic-age fluviolacustrine sedimentary deposits (mainly in the plain of the Middle and Lower Ruzizi/Rusizi), as well as volcanic rocks (mainly basaltic) that have been formed from the Tertiary period to the present day through successive volcanic eruptions (see Figure 3).

The soils of the basin are grouped into six main groups – Umbrisols, Leptosols, Ferralsols, Gleysols, Acrisols and Andosols (see Figure 4).

4.2 Climate context

The study area is characterised by a **tropical climate**, marked by a seasonal regime with a long and a short dry season, as well as a long and a short rainy season.

Temperatures and evapotranspiration are closely linked to the topography (see Table 1 on the next page). The average annual temperatures in the nine main urban centres of the basin range from **14.7 °C (Bigogwe) to 23 °C (Bubanza and Bugurama)**, while the average annual rainfall ranges from **1 020 mm (Cibitoke and Rubavu) to 1 830 mm (Kalonge)**. Rainfall varies with altitude and season and follows a four-cycle pattern. Table 1 shows the average values of temperature, rainfall and evapotranspiration for nine centres in the catchment area.

Figure 3: Geology of the study area

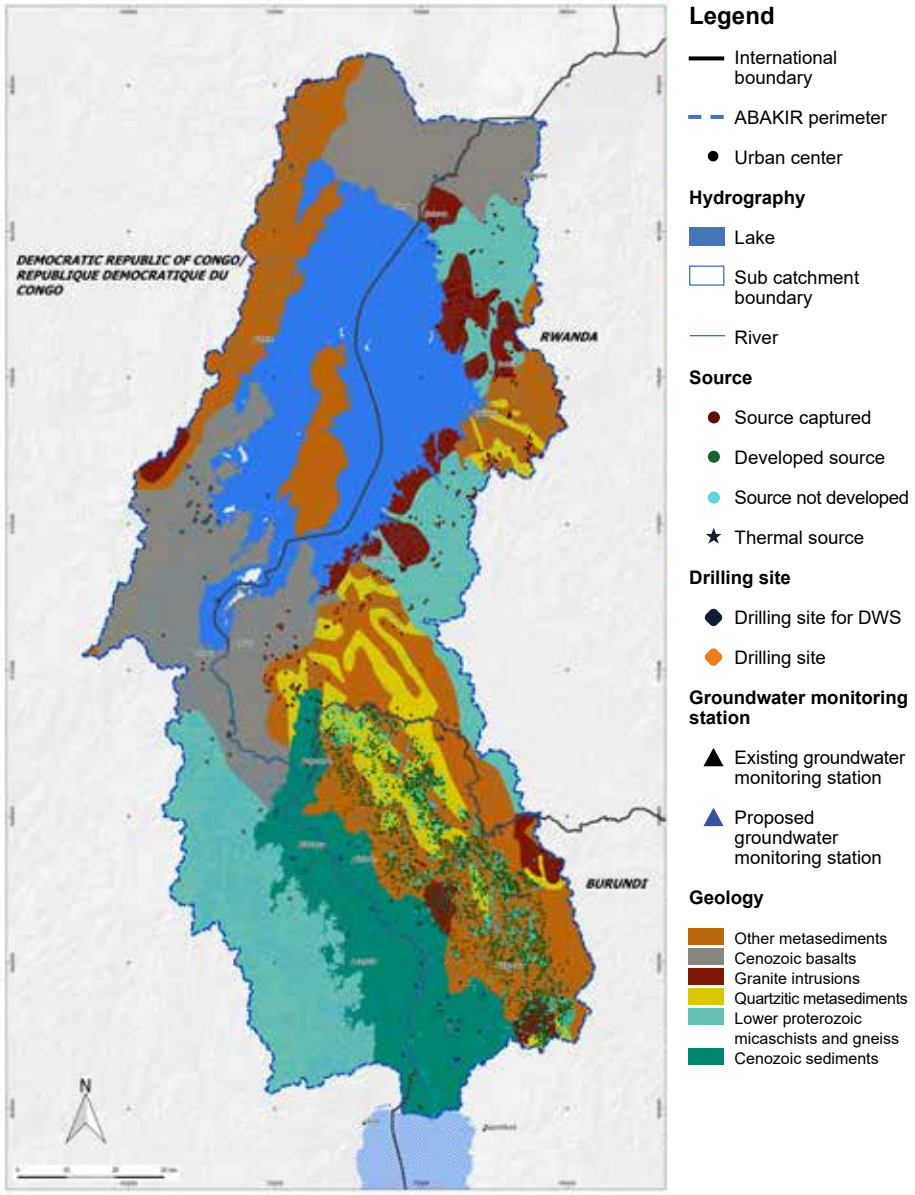


Figure 4: Soil classes in the study area

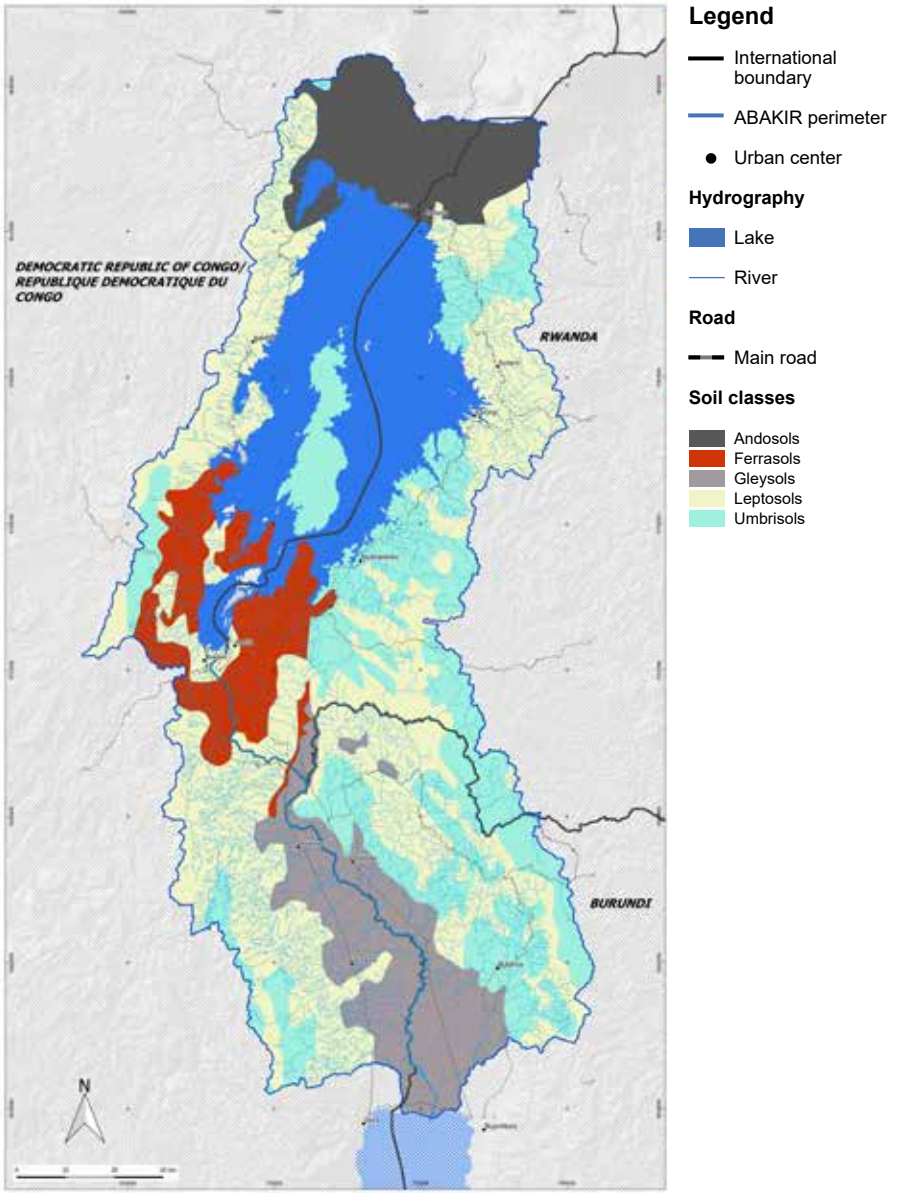


Table 1: Climate variables in locations within the Lake Kivu and Ruzizi/Rusizi River Basin

	ALTITUDE (m)	TEMPERATURE (°C)	PRECIPITATION (mm/year)	EVAPOTRANS-PIRATION (mm/year)
Bubanza (Burundi)	1 063	22.5	1 120	1 900
Cibitoke (Burundi)	930	23.0	1 020	1 970
Mount Lungera (Burundi)	2 470	15.4	1 650	1 200
Bigogwe (Rwanda)	2 350	14.7	1 250	1 190
Bugarama (Rwanda)	970	23.0	1 160	1 990
Rubavu (Rwanda)	1 510	19.2	1 020	1 200
Bukavu (DRC)	1 550	19.4	1 400	1 260
Kalehe (DRC)	1 850	16.8	1 530	1 170
Kalonge (DRC)	2 165	15.1	1 830	1 250

To predict how climate change might impact the study area, projections of monthly precipitation data were analysed for four scenarios of radiative forcing as proposed by the Intergovernmental Panel on Climate Change (IPCC).[1] Sixteen global circulation models developed by the IPCC were used as references for this study. In all scenarios, **annual rainfall tended to increase slightly due to the impact of climate change**.

Concerning the near-surface atmospheric temperature, the 16 models indicated a significant temperature increase by 2050, regardless of the baseline scenario. According to the forecasts, **an increase in hot days and nights is to be expected** in the future.

Increased temperatures and a changed monthly rainfall distribution make the **occurrence of prolonged and more frequent droughts more likely.**

4.3 Demography

The population of the basin in 2020 was estimated at 11 million inhabitants, with 6.8 million inhabitants in DRC (62%), 2.5 million in Rwanda (23%) and 1.7 million in Burundi (15%). Given the current annual population growth rate in the three countries, the population of the basin is predicted to reach 27.5 million inhabitants in 2050, an increase of almost 150% over 30 years (see Figure 6).

Burundi is currently experiencing significant expansion of its population, which is growing at over 3% per year, linked to a high fertility rate (5.5 children/woman). This growth is occurring alongside a very high poverty rate, with 72.9% of the population living below the national poverty line in 2016. There are also large disparities between rural and urban areas. These disparities are reflected in, for example, access to drinking water, with 60% of the population in rural areas having access to drinking water in 2013, compared with 83% of the population in the city of Bujumbura. Only 39.6%

[1] The four scenarios are named according to the range of radiative forcing thus obtained for the year 2100: scenario RCP2.6 corresponds to a forcing of +2.6 W/m² and scenarios RCP4.5, RCP6 and RCP8.5 correspond respectively to a forcing of +4.5 W/m², +6 W/m² and +8.5 W/m².

Figure 5: Projected population density in the study area in 2020

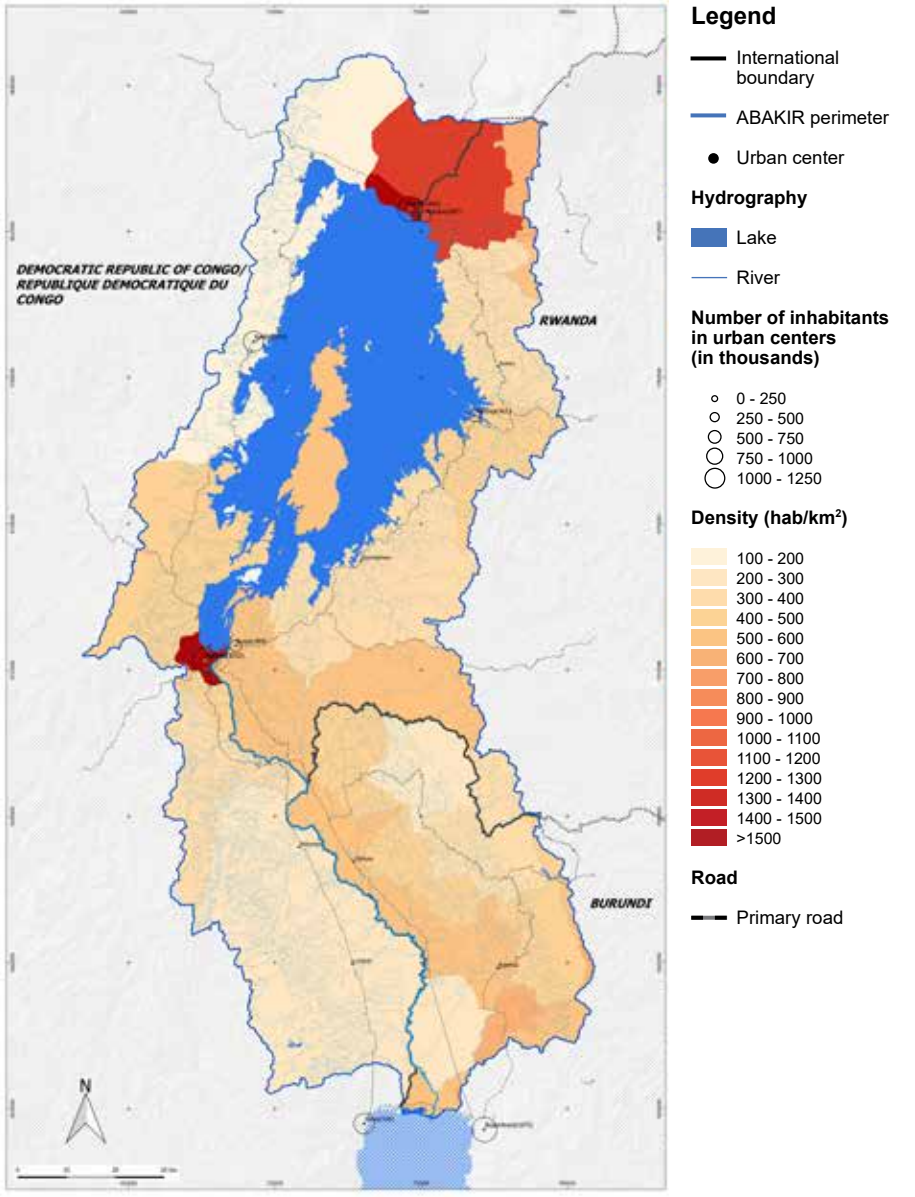
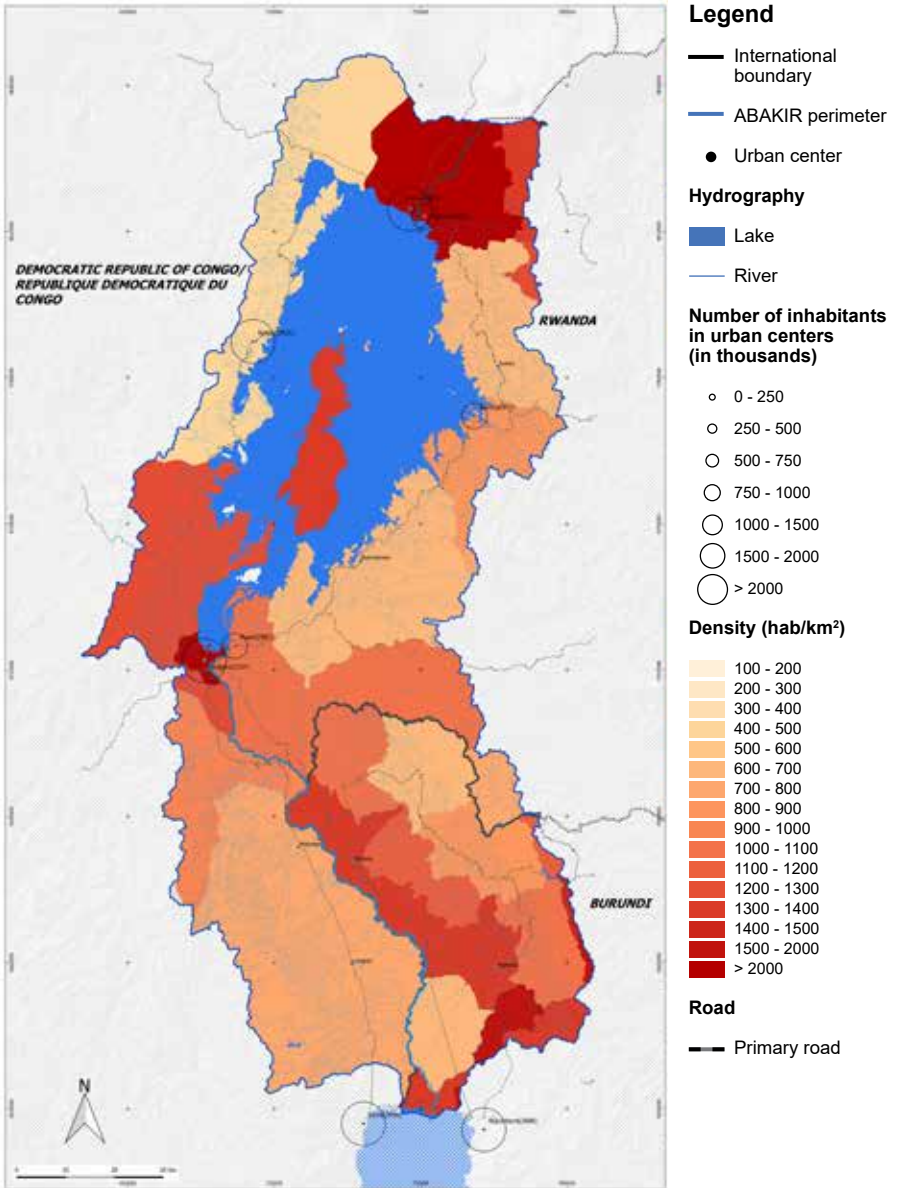


Figure 6: Projected population density in the study area in 2050



of the urban population has access to domestic electricity. More than 85% of working-aged men were recorded as working in agriculture in 2014 (see Figure 5 on previous page).

In the provinces of South Kivu and North Kivu in **DRC**, more than 40% of the population lives in urban areas. The poverty rates in South Kivu (84.7%) and North Kivu (72.9%) are above the national average (71.3%). This is related to the informal agricultural sector, which provides nearly 70% of jobs. Only 38% of the population has access to electricity (52% in urban areas, 23% in rural areas) while 82% of the population has access to an improved source of drinking water (94% in urban areas, 69% in rural areas).

Over the past two decades, the population growth rate in **Rwanda** has decreased to 2.2%, with a fertility rate of 4.6 children/woman. Between 2000 and 2017, Rwanda's economy grew by an average of 6% per year, placing it among the 10 fastest growing countries in the world. This has led to a rapid reduction in poverty, with 38% of the population living below the national poverty line in 2017. In Western province, 75% of the population works in the informal sector, with agriculture being the main occupation and source of income for most of the population, except for the richest 20% of households. By 2017, 34% of the population had access to electricity, and 87.1% had access to an improved water source.

The percentage of the population experiencing food insecurity in the provinces along the Ruzizi/Rusizi River and Lake Kivu ranges from an average of 30% in Rwanda and 40% in Burundi to 70% in DRC.

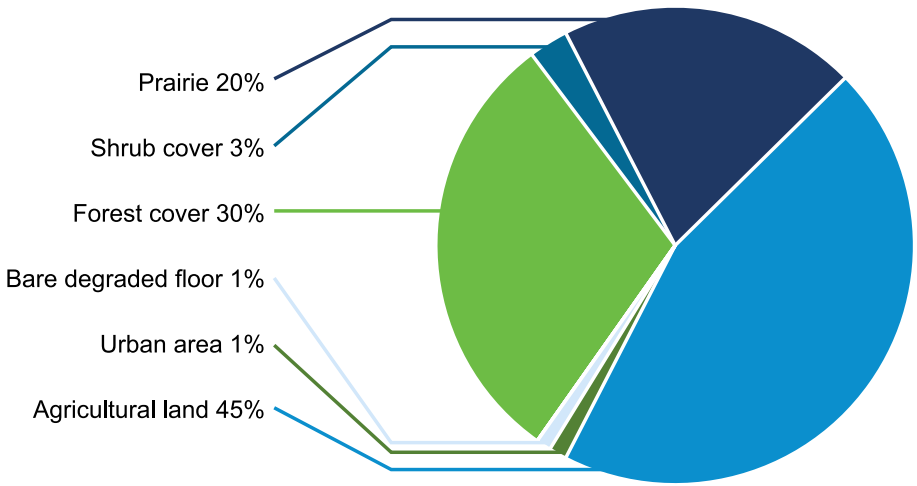
4.4 Land use

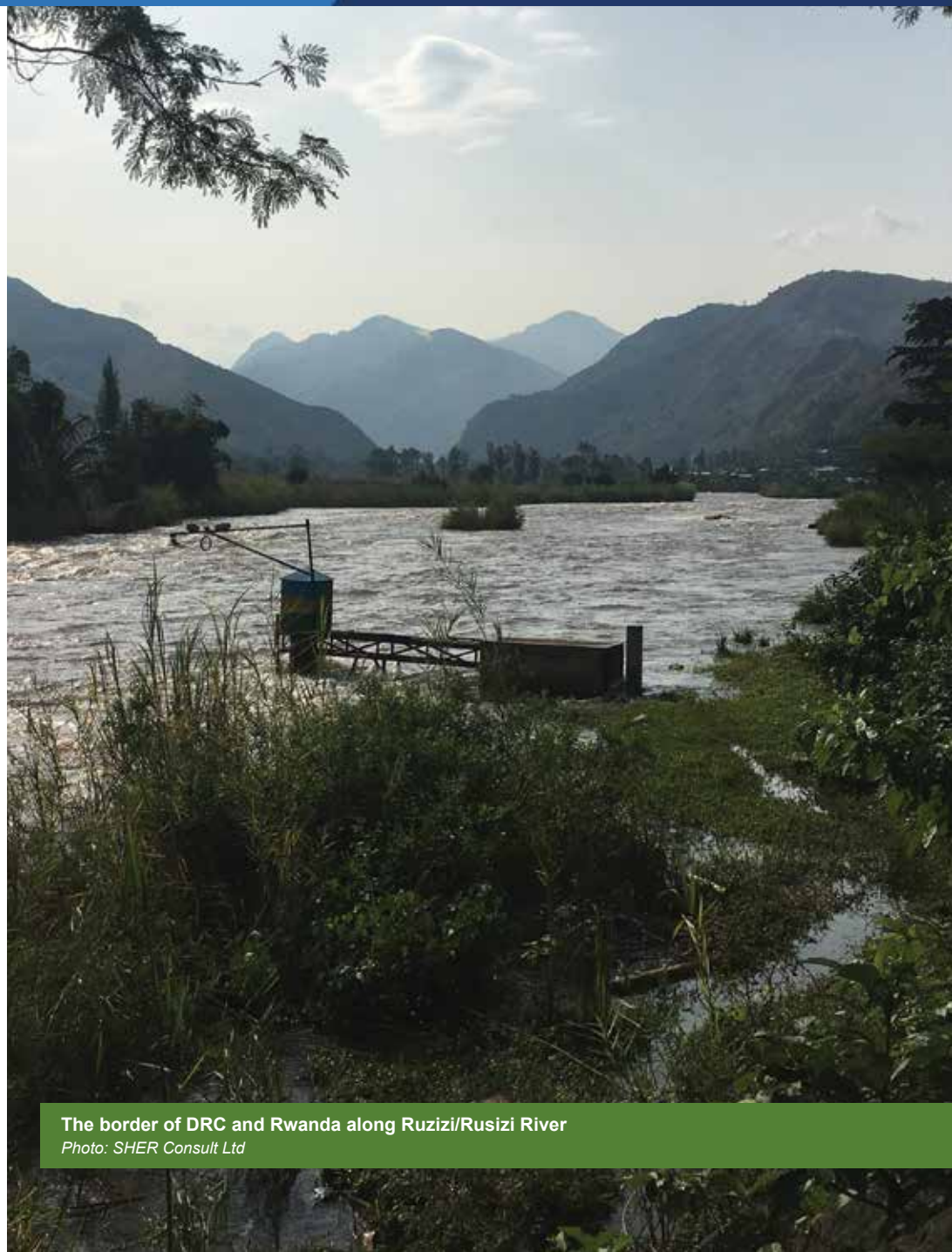
In 2016, the catchment area of the Lake Kivu and Ruzizi/Rusizi River Basin comprised 45% agricultural land (see Figure 6), 30% forest, 20% grassland, 3% shrubland and 1% urban area.

The agricultural areas around Lake Kivu and the Ruzizi/Rusizi River are mainly located on steep slopes, with smaller irrigated areas in the Ruzizi/Rusizi plain. Over the past 25 years, the land area dedicated to **agriculture has increased by 29%, with more than 3 200 km²** now used for agricultural purposes. Conversely, the area covered by forest has decreased to 530 km² and grassland areas have declined to 2 500 km².

Although urban land use represented only 1% of the study area in 2016, the size of the urban area increased by 43%, from 164 km² to 290 km², between 2011 and 2020, with an average annual growth rate of around 3%. This means that **cities are expanding rapidly**, with Goma and Rubavu (see Figure 8), for example, growing by 47%.

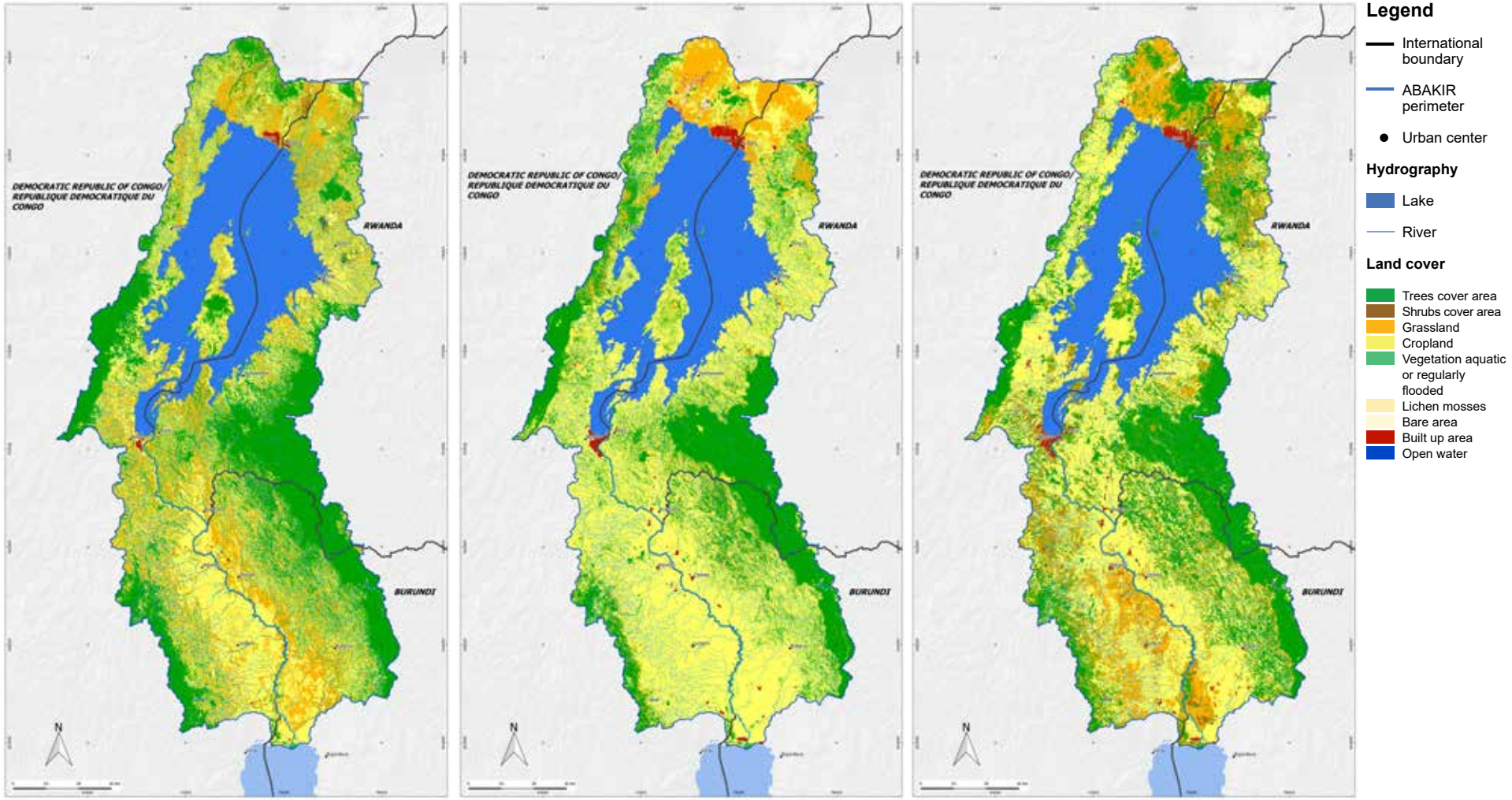
Figure 7: Ground cover in the pool slopes of Lake Kivu and the Ruzizi River in 2016





The border of DRC and Rwanda along Ruzizi/Rusizi River
Photo: SHER Consult Ltd

Figure 8: Changes in land cover and built-up areas between (from left to right) 1989, 2011 and 2016



Forest ecosystems

The Lake Kivu and Ruzizi/Rusizi River Basin is delimited over a large part by high mountains resulting from tectonic ridges covered with dense primary forests at high altitude. Within the National Parks, these forests are reinforced by afforestation mainly comprised of Eucalyptus and Pinus or even tea plantations in the buffer zone (Rwanda and Burundi).

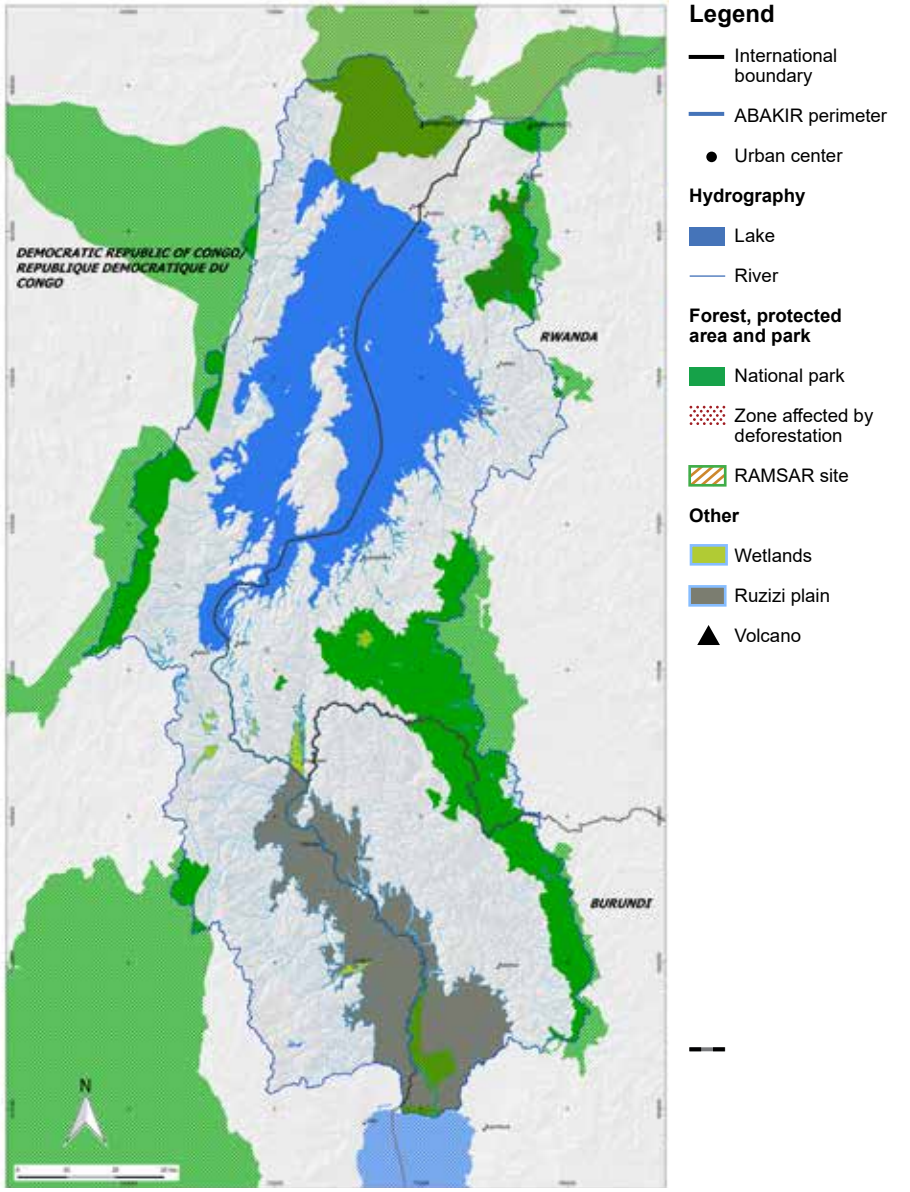
Forest areas with a particularly interesting biodiversity are also present in and near the study area (Table 2).

All these forests, parks and natural areas have a major **impact on soil conservation, water resources and biodiversity** and are part of a complex system of tropical forests in equatorial Africa (see Figure 9).

Table 2: Forested areas within National Parks in the Lake Kivu and Ruzizi/Rusizi River Basin

FOREST AREAS IN THE BASIN	INTERESTING BIODIVERSITY
Virunga National Park (DRC) and Volcanoes National Park (Rwanda), 7 769 km²	Home to several species, including primates such as mountain gorillas (Ramsar site since 2002)
Gishwati-Mukura National Park (Rwanda), 270 km² currently (although used to be 1 000 km²); a corridor is being replanted to connect it to Nyungwe Forest in the south	60 species of tree, chimpanzees and a huge variety of bird species
South Masisi Nature Reserve and Kahuzi Bieza National Park (DRC), 6 000+ km²	Habitat for lowland gorillas, among others
Nyungwe Forest Transboundary National Park between Rwanda and Burundi (since 2002), 980 km²	Home to primates such as chimpanzees, but also baboons and colobus, velvet and other monkeys (Ramsar site since 2002)
Ruzizi/Rusizi Natural Park, 85 km²	Home to hippopotamuses and crocodiles, among others (Ramsar site since 1996)

Figure 9: National Parks and protected areas surrounding the study area



CHAPTER 5
Water resources

The watersheds of Lake Kivu and the Ruzizi/Rusizi River have surface areas of 7 392 km² and 6 057 km², respectively, for a **total surface area of 13 449 km²**, representing the entire study area.

5.1 Surface water

For the purposes of the study, the total area was divided into 128 sub-basins, of which 97 related to rivers flowing into Lake Kivu, and 31 related to tributaries of the Ruzizi/Rusizi River.

Lake Kivu

Lake Kivu is situated 1 462 m above sea level and has a maximum depth of 485 m and an average depth of 240 m. It is a meromictic lake, meaning that the surface and deep waters never mix, mainly because of the great depth of the lake and its low exposure to winds as a result of its location between two mountain ranges. The water of the lake is relatively alkaline, the pH varying between 9.47 at the surface and 6.02 at maximum depth, becoming progressively more acidic approaching the greater depths.

Lake Kivu contains about **560 billion m³ of water** and a volume of dissolved gas equivalent to 300 billion m³ of carbon dioxide and about 60 billion m³ of methane, as well as other gases, including hydrogen sulphide.

The volumes of these dissolved gases have been observed to increase over the years for various reasons, including underground or surface magmatic fluids related to volcanic activities.

The Ruzizi/Rusizi River and its tributaries

The source of the Ruzizi/Rusizi River is located in the bay of Bukavu, in the southern zone of Lake Kivu. The Ruzizi/Rusizi River drains water from Lake Kivu to Lake Tanganyika and forms a natural border between Burundi, DRC and Rwanda. The river crosses an escarpment and the altitude decreases from 1 450 m to 770 m with numerous waterfalls (gorges), giving it potential for hydroelectric power production estimated at around **500 MW**.

5.2 Groundwater

The most important aquifer potentialities are found in the alluvial aquifer of the Ruzizi/Rusizi plain. This aquifer extends over an area of approximately 1 700 km2 across the whole of the Ruzizi/Rusizi alluvial plain, at the level of the low valleys of its tributaries. It lies at a depth ranging from 50 m to more than 150 m in the Ruzizi/Rusizi plain, and from 10 m to 30 m in the alluvial deposits of the lower inland valleys. Groundwater can be mobilised from boreholes, with an expected productivity of more than 10 l/s. However, it contains high levels of iron and manganese, often exceeding drinking water standards. Groundwater in the basin is mainly exploited from 550 natural springs (Burundi and Rwanda), largely for drinking water supply in rural areas.

Groundwater monitoring

Regular groundwater monitoring is very limited in the basin. There are only four automatic groundwater level monitoring stations and three piezometers, all located in Rwanda. Thus a network to monitor the levels and the quality of the alluvial groundwater in the Ruzizi/Rusizi plain is recommended. This network would aim to better understand and monitor the spatio-temporal dynamics of the accumulation of agricultural inputs (nitrates and pesticides) in the water table.

5.3 Physico-chemical quality of water

The major problem encountered in relation to surface water quality is the massive erosion observed in the basin, with an average **soil loss of around 100 t/ha/year**. This erosion generates extremely high and widespread turbidity in most of the basin's watercourses. Additionally, water resources are threatened by various forms of pollution linked to urbanisation and industrialisation.

Regular monitoring of the water quality (physico-chemical, bacteriological, biological) of the lake and its tributaries is very limited to date, although there are data from Rwanda. Parameters that are measured include pH, total dissolved solids, total suspended solids, temperature, electrical conductivity, dissolved oxygen and turbidity.

Monitoring of surface water quality

In Rwanda, 15 quality monitoring stations are listed in the study area but they are not subject to periodic monitoring. Of these, nine are currently functional. Eight stations are recorded on the Burundian side but no limnometric station has been reported in the DRC part of the catchment area. Expansion and intensification of the network are highly recommended to ensure consistent measurement of water quality.

5.4 Water balance

A hydrological balance sheet was developed at the basin scale as part of the study (Table 3). Analysis of the water balance results shows that from a quantitative point of view, the basin's water resources are sufficient to satisfy all the identified uses in a reference situation (2020) and for the different scenarios defined for 2050. At the scale of the basin and the main sub-basins, it can therefore be concluded **that the availability of water resources is not a limiting factor in the socio-economic development of the study area**.

The lake itself receives 3 billion m^3 of direct rainfall, while direct evaporation from the lake's open surface is estimated at 3.45 billion m^3. On an annual basis, the water balance of the Lake Kivu and Ruzizi/Rusizi River Basin thus presents a net non-consumed volume of 6.4 billion m^3.

Table 3: Hydrological balance sheet for the Lake Kivu and Ruzizi/ Rusizi River Basin

COMPARTMENT	FLOW (M^3/S/AVERAGE YEAR)	RAIN (MILLION M^3/ YEAR)	RUNOFF (MILLION M^3/ YEAR)	IRRIGATION (MILLION M^3/ YEAR)
Lake Kivu basin	71 (lake outflow to Ruzizi/Rusizi)	7 217	3 200	NA
Ruzizi/Rusizi River Basin to Kamanyola	8	979	532	19
Kamanyola to Lake Tanganika	206	6 899	3 603	467

View of Lake Kivu, Rwanda

CHAPTER 6
Water use

Water-Energy-Food Security nexus approach

Integrated Water Resources Management (IWRM) involves the coordination, development and management of water, land and related resources to produce economic and social well-being while also considering sustainability and environmental and ecosystem aspects. This study integrates all these aspects, notably through characterisation of the different water uses encountered in the basin and the interactions that may occur between these uses, in terms of water quantity and quality.

This study is also intended to be cross-sectoral and, in this sense, it is in line with the approach of the **Water-Energy-Food Security (WEF) nexus**. This approach focuses on the interdependencies between these three sectors and the need to create synergies and regulate equitable trade-offs between competing uses of resources. It is particularly relevant in the Lake Kivu and Ruzizi/Rusizi River Basin, which is characterised by significant population growth and by economic development based on both agriculture and energy production (hydroelectricity and gas), which means that demand for water is increasing (Table 4).

Table 4: Current and predicted WEF nexus water uses and demands in the Lake Kivu and Ruzizi/Rusizi River Basin

	CURRENT AND PROJECTED WEF USE	NEED FOR WATER
Drinking water supply	Needs 2020 11 million inhabitants	111 million m^3/year
	Needs 2050 27.5 million inhabitants	277 million m^3/year
Irrigation	Operational perimeters 12 500 ha	102 million m^3/year
	Operational and planned perimeters 59 000 ha	486 million m^3/year
	Irrigation potential of the Ruzizi/Rusizi plain 125 000 ha	1 billion m^3/year
Hydroelectricity	Installed power 80 MW	n.a.
	Potential power 683 MW	

6.1 Drinking water

In the basin, drinking water is mainly supplied from spring catchments, with the exception of the large urban centres, which use water intake structures from rivers or Lake Kivu. In urban areas, drinking water is supplied by public or partly state-run companies. In rural areas, water supply networks are, depending on the country, managed by communal utilities supported by a ministerial agency (Burundi); operated by non-governmental organisations, farmers' organisations or churches (DRC); or are entrusted to private operators (Rwanda). Table 5 provides a summary of population and drinking water needs in the basin for 2020 and 2050 (see Table 5 below).

Table 5: Estimated drinking water needs for the urban and rural populations of the Lake Kivu and Ruzizi/Rusizi River Basin in 2020 and 2050

YEAR	TYPE	POPULATION (million inhabitants)	WATER NEEDS (million m^3/year)
2020	Urban	2.5	49
	Rural	8.5	62
	Total	**11.0**	**111**
2050	Urban	6.5	125
	Rural	21.0	152
	Total	**27.5**	**277**

6.2 Agriculture

Agriculture in the Lake Kivu and Ruzizi/Rusizi River Basin relies almost entirely on **rain-fed and subsistence farming**; it is practised on sometimes steep slopes, highly exposed to erosion, and is associated with animal husbandry in stalls, particularly in Burundi and Rwanda. The Western province of Rwanda, which benefits from very fertile volcanic land and abundant rainfall, produces 50% of the country's agricultural exports

Traditional wooden fishing boats, Rwanda

(tea, coffee, pyrethrum, horticulture), and plays a key role in Rwanda's food security, with more than 50% of agricultural products (potatoes, beans, maize, etc.) as well as livestock products coming from this region.

Irrigated agriculture is mainly found in the Ruzizi/Rusizi plain. There are many irrigated areas, mostly split between Burundi and DRC, although functional **agricultural areas cover only 12 500 ha of the plain. However, the agricultural potential of the entire Ruzizi/Rusizi plain is estimated at 125 713 ha** out of a total area of 177 905 ha. The estimated annual water needs for all the areas (functional, planned and projected areas for irrigation) amount to 486 million m^3, with the water needs of the functional areas accounting for 102 million m^3 of this total. The irrigated areas suffer from technical (erosion, deterioration of irrigation network, etc.) and social (demographic pressure, etc.) issues that hinder the development and exploitation of their potential.

Animal husbandry

Throughout the study area, livestock rearing is practised in the traditional way, with a herd of three to five animals (including up to three large ruminants) reared on tethers or in stalls. In recent years, population growth and pressure on pastures have led to increasing conflicts between herders and farmers. This situation forces herders to regularly move their herds, particularly to the Rukoko nature reserve, a protected area, or to other grazing areas located in DRC.

Fishing and aquaculture

Before the introduction of *Limnothrissa miodon* (isambaza) into Lake Kivu in the 1970s, fishing was a marginal activity for the riverside populations. Fish production gradually increased from 1 500 t/year in the 1970s to reach an average annual production estimated at **6 000 t/year** (1999). Currently, the number of people working in this sector is estimated at between 6 500 and 7 000 in Rwanda and a similar number in DRC. Fishermen are organised in cooperatives and fish on trimarans (assemblies of three large non-motorised pirogues) or motorised pirogues. Alongside isambaza, the main fish species in Lake Kivu are Nile tilapia (*Oreochromis niloticus*), inkube or African catfish (*Clarias gariepinus*) and *Haplochromis* species.

Pressure on fishery resources is growing. A major problem is the increasing number of non-regular and/or poorer fishermen using illegal fishing equipment, including nets with a mesh size that is too small. This is particularly noticeable in the bay of Bukavu where the number of fishing units has risen sharply in recent years.

Aquaculture is an alternative to overfishing in Lake Kivu. The 2017 Master Plan for Fishing in Rwanda proposes the development of 25 cage aquaculture parks on Lake Kivu, each containing about 5 000 cages for an annual production capacity of 5 000 tonnes (1 t/cage). In the Imbo plain, numerous fishponds have already been installed. The main factors limiting the development of aquaculture are the high cost, the scarcity of floating fish feed (pellets are required to avoid polluting the lake) and the almost non-existent capacity of refrigerated storage and transport equipment.

Photo: Kristine Herbomel, GIZ

6.3 Hydroelectricity

The three countries bordering the Ruzizi/Rusizi River have cooperated for decades on the construction of a series of dams along the river's steep zone (Table 6).

Table 6: Dams along the Ruzizi/Rusizi River

DAM	YEAR CONSTRUCTED	CAPACITY
Ruzizi I	1959	29.8 MW (only 21.2 MW available)
Ruzizi II	1989	43.8 MW (only 36 MW available)
Ruzizi III	Planned (signed 2019)	Up to 230 MW proposed
Ruzizi IV	Planned	Up to 287 MW proposed

Although the hydroelectric potential on the first 50 km of the Ruzizi/Rusizi River is considerable, there are other sites with potential in the basin. Thus, while the current installed capacity of the river basin is 82 MW, including small-scale power stations such as the Rwegura power station, the potential capacity is estimated at 681 MW.

In the Lake Kivu basin, the hydroelectric potential is much more limited. Despite the escarpment, the watersheds are not large enough to generate rivers with a large flow.

6.4 Methane gas and oil extraction

Rwanda has embarked on the exploitation of methane gas from Lake Kivu for power generation and distribution in the national grid. A committee of international experts mobilised by the governments of DRC and Rwanda has recognised that the extraction of methane gas for energy production could be a viable solution from a risk management, environmental and economic point of view, but only if it complies with mandatory guidelines validated by the two countries. Two investments have been operational since 2015, namely the KivuWatt project with a gross nominal capacity of **26 MW** and the Symbion Power Lake Kivu Ltd project with a net capacity of **50 MW**.

The geological structure in some parts of Lake Kivu indicates a potential presence of oil. In 2017, DRC and Rwanda signed an agreement for oil exploration in the lake. This exploration started in 2018 on the Rwandan side with a series of shallow drillings and geochemical tests.

6.5 Other commercial activities

Multiple micro-industries, such as rice mills, coffee washing stations, tea factories, sugar production plants, milk collection and processing centres, and slaughterhouses, operate within the basin (see Figure 10).

Food processing industry

Coffee washing stations are present in large numbers on the slopes of the Congo-Nile ridge in Burundi and Rwanda, taking advantage of the presence of numerous rivers for their water requirements. Additionally, a few **tea** factories operate in the basin, and are high energy consumers.

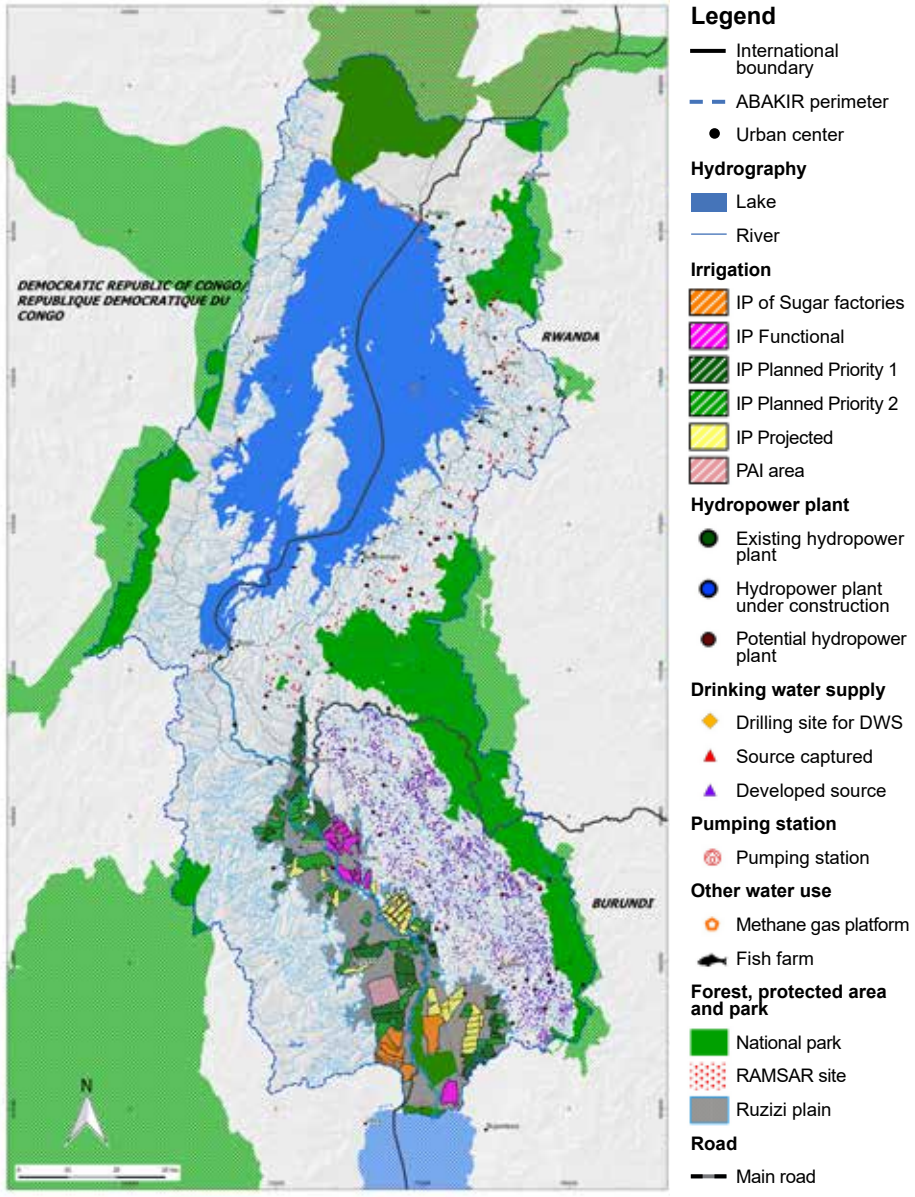
Building

Limestone rock is present in the south of the Kivu basin and in the Ruzizi/Rusizi River basin. Three energy- and water-intensive cement factories have been developed there. New **cement plants** are being developed in the northern part of the basin, at the foot of the volcanoes, to exploit the volcanic rocks present in profusion. All these plants face the challenge of accessing sufficient energy.

Mines

In Burundi, the exploitation of minerals takes place mainly in the riverbeds of the Ruzizi/Rusizi tributaries. This activity, mostly developed in an artisanal way (but on a large scale in places, particularly in the Muhira River), causes severe **degradation of the riverbeds** and conflict over the use of water.

Figure 10: Uses of water throughout the study area



resources, with river intakes and canals developed for irrigation being diverted for gold panning activities. The main minerals exploited in North Kivu and South Kivu are gold, colombite tantalite (coltan), diamonds and wolfram. Tin, monazite, limestone, cassiterite, methane gas and thermal waters are also extracted.

Navigation

Transport on Lake Kivu is essential for the local population. In DRC, a lake transport system exists for passengers and freight, linking the ports of Bukavu and Goma. On the Rwandan side of the lake, a project supported by TRADEMARK East Africa is underway, with the construction of four ports and shuttle facilities expected to increase passenger traffic volume in Ruzizi/Rusizi from 1.4 million passengers in 2017 to 2.7 million in 2036 and from 1.1 million to 2.1 million passengers in Rubavu.

Tourism

The Lake Kivu and Ruzizi/Rusizi River Basin has a large and diverse tourist potential. The recreational banks of Lake Kivu, the cultural and ecotourism sites, the Ruzizi/Rusizi Natural Park and the proximity of the Nyungwe and Volcanoes National Parks are all valuable assets for tourist activities. Tourist infrastructure is mainly concentrated in the northern part of the basin, in the cities of Goma and Rubavu.

CHAPTER 7
Environmental threats

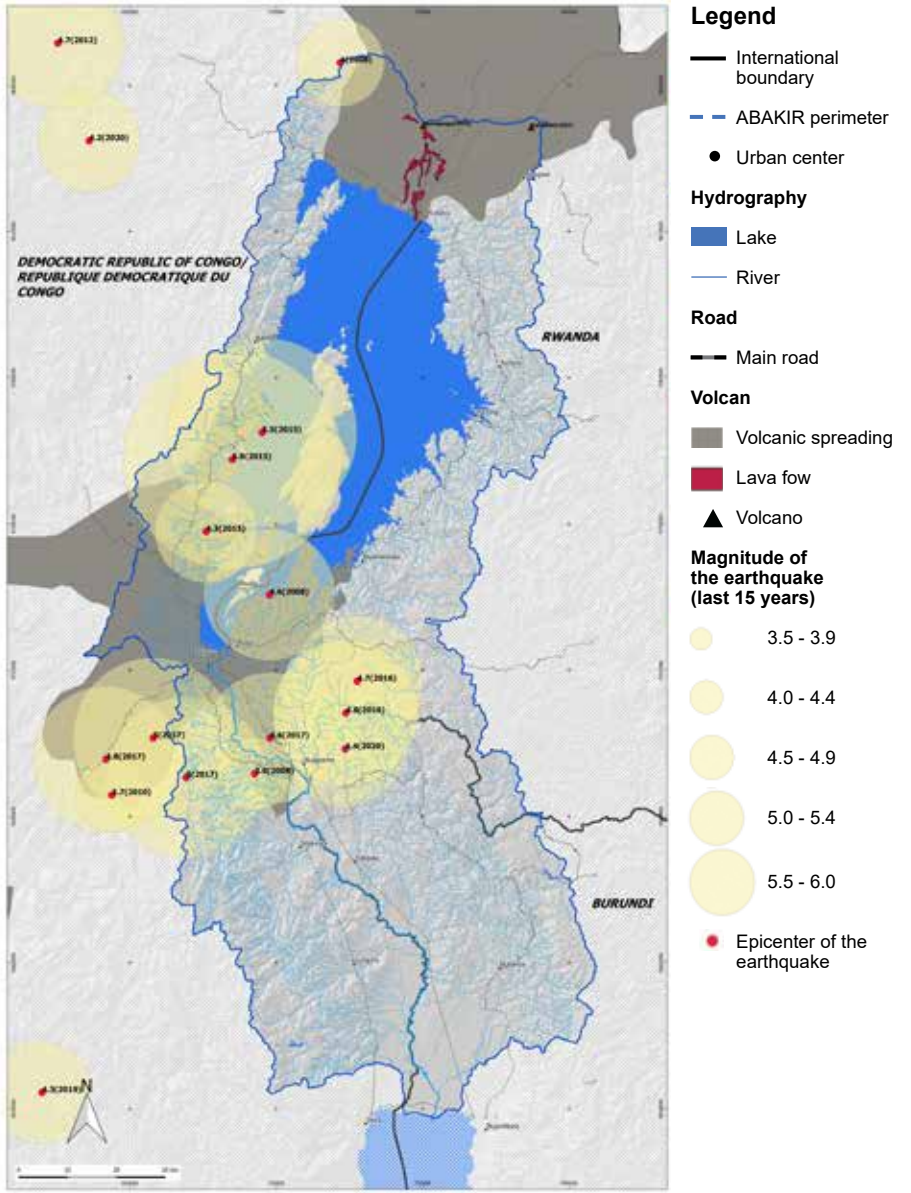
7.1 Natural hazards

The main natural risks identified in the study area are **volcanic eruptions, earthquakes, gas explosions, floods and landslides**.

In the north of the study area, there are several **volcanoes**, including Nyamulagira and Nyiragongo. The latter is an active volcano that rises to an altitude of 3 470 m, north of the city of Goma. It is well known for containing the largest lava lake in the world and poses a real danger to the cities of Goma and Rubavu. During eruptions in 1976 and 2002, tens of people died and thousands of others were displaced. A major disturbance from the volcanic activity of Nyiragongo, or from underwater volcanic cones, could cause the deep waters of Lake Kivu, which are loaded with dissolved gases, to explode. These waters would then **release a quantity of asphyxiating gas**, either in the form of limited and localised emanations, or in the form of a cataclysmic explosion affecting a large part of the lake, threatening the safety of millions of people in the basin (see Figure 11).

Floods are directly linked to a rainy event but also depend on the size and shape of the catchment area, its land use and topography. Floods will potentially be more numerous in the future due to climate change, increasing urbanisation and greater soil degradation linked in particular to land pressure. In April 2020, flooding of the Ruzizi/Rusizi River caused by run-off water affected around 6 000 households west of Bujumbura in Burundi. In DRC, nearly 20 000 farming households and 10 000 ha of food and market gardening crops were devastated.

Figure 11: Areas prone to natural hazards such as earthquakes and volcanic eruptions



The study area is located in the Albertine Rift, the western branch of the East African Rift, which is composed of divergent tectonic plates moving apart at a rate of 6 to 7 mm per year. Numerous **earthquakes** occur every year and in the past 15 years more than 28 earthquakes of a magnitude greater than 4 on the Richter scale have occurred in the study area, posing a threat to the safety of inhabitants.

Additionally, the slopes of the Albertine Rift on the shores of Lake Kivu are particularly prone to **landslides**. The number of landslide events has been increasing since the 2000s and 40% of the Rwandan population is vulnerable to landslides, with a higher risk in the districts of Ngororero, Nyabihu and Rutsiro.

7.2 Soil degradation

As a consequence of rapid population growth, small-scale agriculture is increasingly characterised by overexploitation of the natural resources on which it is based. In the short and medium term, this overexploitation leads to soil degradation phenomena that in turn lead to declining soil productivity, mud- or landslides and decreased quality and production of drinking water. In addition, canopy reduction, removal or alteration of understorey vegetation, mining, forest destruction, human-induced fires and soil compaction through grazing by domestic animals greatly increase the risk of soil erosion.

As Table 7 shows, calculations using the Revised Universal Soil Loss Equation (RUSLE) estimate that **annual soil losses in different parts of the basin range from 91 to 290 t/ha/year**. The highest erosion rate per hectare is found in the Chabiringa sub-catchment and is due to its young, poorly structured and friable volcanic soil type and limited vegetation cover. Conversely, the rate of erosion on undisturbed forest land is generally very low.

The sediments carried by the Ruzizi/Rusizi are mainly brought in by direct tributaries between the lake outflow and the last power plant. The absence of a natural sand trap between the tributaries of the lake and the Ruzizi/Rusizi has a direct impact on the filling of reservoirs and on the production level of power plants when run-off river intakes are involved. Power plants installed on the Sebeya River, for instance, frequently experience production drops or shutdowns due to the high turbidities observed during heavy rains.

Table 7: Average soil losses across the Lake Kivu and Ruzizi/Rusizi River Basin, estimated by the RUSLE erosion model

LOCATION	AVERAGE SOIL LOSS
Entire catchment area	102 t/ha/year
Ruzizi/Rusizi River Basin	91 t/ha/year
Lake Kivu basin	116 t/ha/year
Chabiringa sub-catchment	290 t/ha/year

The sustainability of irrigation schemes in the Ruzizi/Rusizi plain depends on both the maintenance of the irrigation infrastructure and on the management and conservation of soil in the catchment areas supplying the irrigation intakes. Degradation of the catchment areas leads to silting of the irrigation canals. Maintenance of infrastructure is partly effective in Burundi and Rwanda, but much less so in DRC, while the management of erosion in the catchment basins remains a common issue in all three countries.

Soil restoration measures can be implemented, including the establishment of progressive or radical terraces, crop strips, intercrop strips, agro-forestry and mulching. All these measures aim to protect soil cover during the months when erosion is most likely, by decreasing the speed of water run-off and thus increasing its infiltration.

7.3 Potential sources of pollution

Diverse potential sources of pollution present a real danger for Lake Kivu and the Ruzizi/Rusizi River. Throughout the study area, there is no collective **sanitation infrastructure**, nor solid waste collection. **Bacteriological and chemical contamination** due to inadequately treated, poorly treated or untreated domestic and industrial wastewater from rapidly growing urban agglomerations on the lake's shores adds chemicals, biochemical oxygen demand and effluent to the lake and river, constituting a significant risk of degradation of the quality of the lake water near these areas. The **intensification of agriculture** leads to contamination of surface and groundwater. The Imbo plain, for example, is an area of intensive agriculture, and both surface water and groundwater are likely to receive large quantities of pesticides and fertilisers, leading to eutrophication.

There is also pollution from industrial and mining sources as well as from the small-scale **agro-food industries** in the basin, which can be a source of pollution when wastewater is discharged directly into watercourses.

Mining activities in the region are dominated by artisanal mining, with very little investment in improving working conditions or environmental protection. Existing legislation is not really binding on these small-scale mines, which are a potential source of contamination of surface water through, for example, the release of mercury into water bodies. Artisanal gold mining has developed significantly in the region, particularly in South Kivu province and in the rivers of Burundi.

7.4 Other human impacts

There are a number of human impacts that affect the environment in the basin. A selection of these are explained below.

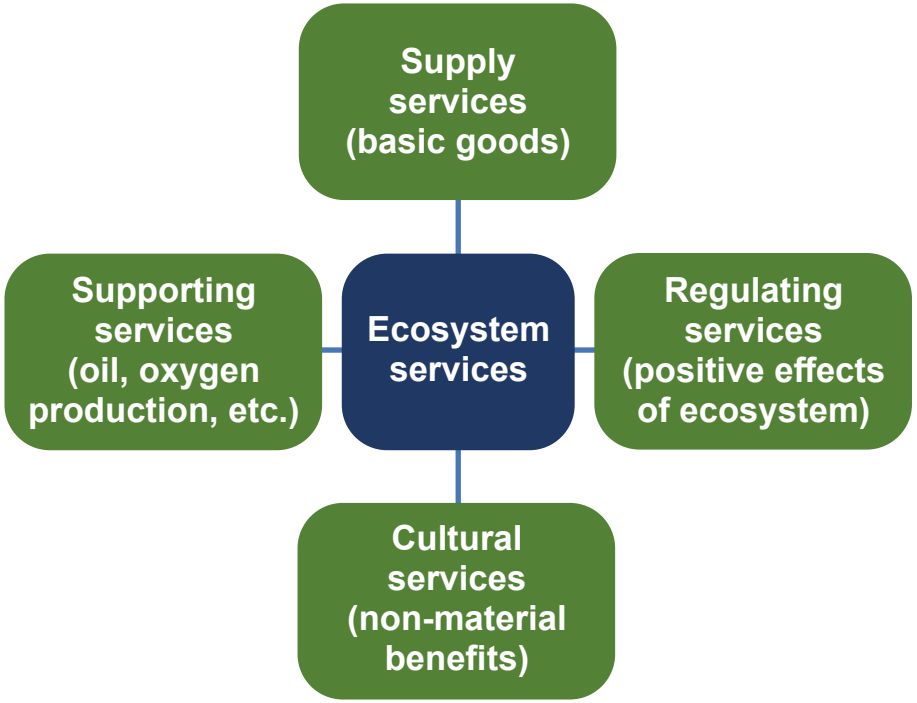
The conservation of buffer zones around Lake Kivu or the banks of the main rivers is not always respected, especially in city development zones, which leads to high risks of water pollution and destruction of the banks, which are also fish breeding areas.

Hydro-ecological discontinuity arises through the constructions required for the generation of hydroelectricity. Dams (mainly on the Ruzizi/Rusizi River) constitute a barrier for fish migration, in particular for Barbus altianalis, the only fish currently known to migrate from Lake Tanganyika to Lake Kivu, with possible breeding grounds in some tributaries of the Ruzizi/Rusizi River. Fish ladders have been built on the first two power stations installed, but require renovation, and similar structures should also be built on the power stations that are planned for construction.

While the surface area occupied by urban spaces in the basin currently represents just 1% of the total area, **certain challenges are particularly acute in urban areas**. The development of sanitation systems is urgent in all cities in the basin, particularly those with large populations. The majority of the cities in the basin are located in the foothills of mountains, **areas that are vulnerable to erosion and landslides**. Cities will have to adapt to extreme weather conditions by integrating resilience measures into their infrastructure design standards for roads, drainage networks, etc.

CHAPTER 8
Ecosystem services

Ecosystem services can be defined as the benefits that an ecosystem provides to society, either directly or indirectly. They occur at several scales, from climate regulation and carbon sequestration on a global scale, to flood protection, soil formation and nutrient cycling on local and regional scales.



The Millennium Ecosystem Assessment identifies four types of ecosystem services.

1. **Supply services** include the production of basic goods such as crops and livestock, fresh water, fodder, timber and biofuels, genetic resources and chemicals.
2. **Regulating services** are the benefits obtained when ecosystem processes affect the biological world around them. These services include flood and coastal protection, pollination, regulation of water and air quality, modulation of disease vectors, waste absorption and climate regulation.
3. **Cultural services** are the non-material benefits that people derive from ecosystems through enrichment, cognitive development, reflection, recreation and aesthetic and cultural experiences.
4. **Supporting services** are those necessary for the production of all other ecosystem services. Their impacts are indirect or extend over long timescales. They include the production of biomass through photosynthesis, soil formation, atmospheric oxygen production and nutrient cycling. Supporting services are basic ecological processes that maintain ecosystems without necessarily directly benefiting people. The value of these services is reflected in the other three types of services described above.

8.1 Aquatic ecosystem

Aquatic ecosystem services are characterised by the basin's potential to supply food, through fishing activities and aquaculture, to produce energy, through the exploitation of methane gas in Lake Kivu and the production of hydroelectric power on the Ruzizi/Rusizi River, and to supply drinking water for the basin's populations.

Drinking water supply

The aquatic ecosystem naturally ensures the supply of drinking water to the population living in the basin. The water consumed comes from rivers, lakes, springs or boreholes. The protection of watersheds to guarantee the quality

of the water consumed is a major public health and economic issue. **Quality aspects are crucial** and, for example, the degradation of catchment areas needs to be decreased to inhibit turbidity.

Food supply

Although poor in nutrients, the lake contains a sufficient planktonic population to allow fish production currently equivalent to about 3 000 t/year in Rwanda and about 4 700 t/year in DRC for an annual income varying between USD 770 000 and USD 1 000 000 to the benefit of the riparian populations. The sustainable management of fish stocks and an intact ecosystem are thus critical for maintaining these fishing populations.

Methane gas exploitation

It is estimated that there are about 60 km^3 of dissolved methane (at 0 °C and 1 °C) in the deep waters of the lake, which can be exploited for energy production. The exploitation of the lake's methane gas is a rare ecosystem service specific to Lake Kivu and must be carried out with the utmost care, bearing in mind the risks posed by disturbing the different water layers by pumping and especially by the discharge of wastewater. A natural disaster linked to poor handling is possible.

Hydropower

Hydropower is the main ecosystem service of the Ruzizi/Rusizi River, since the concentration of dissolved salts in the water does not allow for other uses (agricultural use, livestock farming or drinking water supply) without prior treatment.

8.2 Forest ecosystem

Supply services

Almost all the forests in the basin are water towers for the existing hydrographic networks. Most of the forests (Nyungwe-Kibira forests, Kahuzi-Biega forests and the forests of the Virunga Volcanoes) are Afro-mountain rainforests that capture rainfall from mist or clouds in the form of drops or run-off along the trunks and positively affect the water balance of the catchment area. The volume of water captured by these forests varies significantly according to rainfall regime, topographic location, cloud frequency or persistence, and the amount of wind-driven clouds. It can be in the order of 15 to 20% in areas receiving 2 000 to 3 000 mm of rainfall per year, and up to 50 to 60% in exposed ridges and areas of low rainfall.

Many of these forests are the main source of wood supply for domestic energy (biomass). Additionally, due to their deep and vigorous root bases, as well as the different levels of plant cover and their covering canopy, forests provide the best cover to reduce all kinds of surface erosion, especially sheet erosion. **Forest cover also constitutes the most suitable land cover to resist landslides**.

Climate regulation services

Because of their altitude and extent, the forests in the basin constitute a barrier to strong winds and are one of the reasons why Lake Kivu experiences very little mixing of its water layers. The presence of these high-altitude forests also explains the temperate climate in the northern part of the basin. Each hectare of old-growth tropical rainforest generally contains 120 to 400 tonnes of carbon equivalent in the above-ground vegetation and even more if underground biomass is considered. If the value is set today at USD 20 per ha, **the value in tonnes of carbon equivalent of nearly 1 545 100 ha of primary forests would be estimated at USD 31 million**.

Cultural and tourist services

All of the natural parks in the region have a unique, endemic wealth of biodiversity that makes them sites of global importance. As such, three forest massifs in Rwanda – Virunga National Park, Kahuzi-Biega National Park and Gishwati-Mukura National Park – have UNESCO World Natural Heritage Site status. The Virunga-Volcanoes-Mgahinga National Park complex is known to generate annual revenues estimated at nearly USD 9 million, mainly because of the biodiversity within the complex (the emblematic animal remains the mountain gorilla).

8.3 Potential solution: integrating Payments for Ecosystem Services (PES) into basin management

There is a critical lack of incentives and funding for ecosystem conservation in river basins, which ultimately leads to the degradation of natural ecosystems and/or their conversion into pasture, agricultural or other areas and the loss of ecosystem services.

Payment for Ecosystem Services (PES) is a mechanism to reverse this dynamic so that those who guarantee the functioning of ecosystem services are rewarded by the users of the services (e.g. water consumers in urban centres, or hydropower projects). For a PES scheme to be effective, at least six key elements must be satisfied, as follows.

1. The PES scheme must involve at least one user of an ecosystem service and at least one provider.
2. The process must be transparent and accepted by all parties.
3. The provision of services and payment for them, as well as the conditions under which such payments are negotiated and made, must be agreed between the two parties.
4. The PES scheme should involve a clearly defined ecosystem service and specify a land use that is known to provide that service.
5. The activities that are carried out on the area that produces the service must be able to be monitored and quantified.
6. The PES scheme must involve payment in cash or in kind by the beneficiary of a service.

Within the framework of the Lake Kivu and Ruzizi/Rusizi River Basin, ABAKIR could initiate and set up a PES mechanism by relying on existing national institutions in the three countries to ensure ecosystem services are valued and protected.

CHAPTER 9

Legal, institutional and cross-border frameworks for managing water resources and the environment in the basin

9.1 Legal frameworks

Burundi, DRC and Rwanda all have legislative frameworks for water and environmental management as outlined in Table 8.

A legal and regulatory framework is in place in the three countries for environmental management and the prevention of natural resource degradation, especially since all three countries have ratified numerous international conventions, including the Convention on Biological Diversity, the United Nations Framework Convention on Climate Change and the Convention to Combat Desertification. However, the regulations are currently not fully implemented in many areas and commitments at the international level do not always result in the establishment of the required national policies and regulations, nor in the mobilisation of sufficient funding for the implementation of such plans and strategies.

In the Lake Kivu and Ruzizi/Rusizi River Basin, the following issues exist.

- The prevention of water pollution by organic and chemical substances and the monitoring of water quality are unsatisfactory.
- There is no collaboration between countries to prevent banned fishing practices or the use of restricted pesticides or to protect river and lake banks from degradation.

Table 8: Legislation governing water and environmental management in the countries of the Lake Kivu and Ruzizi/Rusizi River Basin

	LAWS AND DECREES ON THE MANAGEMENT OF WATER AND THE ENVIRONMENT
Burundi	• Law 1/01 of 30 June 2000 on the environment code in Burundi • Law 1/02 of 26 March 2012 on the water code: fundamental rules and the institutional framework intended to ensure the rational and sustainable management of water resources • Convention on the Sustainable Management of Lake Tanganyika (2003)
DRC	• Law 11/009 of 09 July 2011 on fundamental principles relating to environmental protection: aims to promote the sustainable management of natural resources, prevent risks and combat all forms of pollution and nuisance • Law 15/026 of 31 December 2015 relating to water: establishes rules and instruments necessary for the rational and balanced management of water resources including their protection and uses
Rwanda	• Law 49/2018 of 21 September 2018 on the use and management of water resources in Rwanda: governs the use, management and protection of water resources • Law 48/2018 of 13 August 2018 on the modalities of protection, conservation and promotion of the environment: defines the fundamental principles of conservation

“Laws and decrees are still needed to harmonise legislation relating to land, water and environmental protection.”

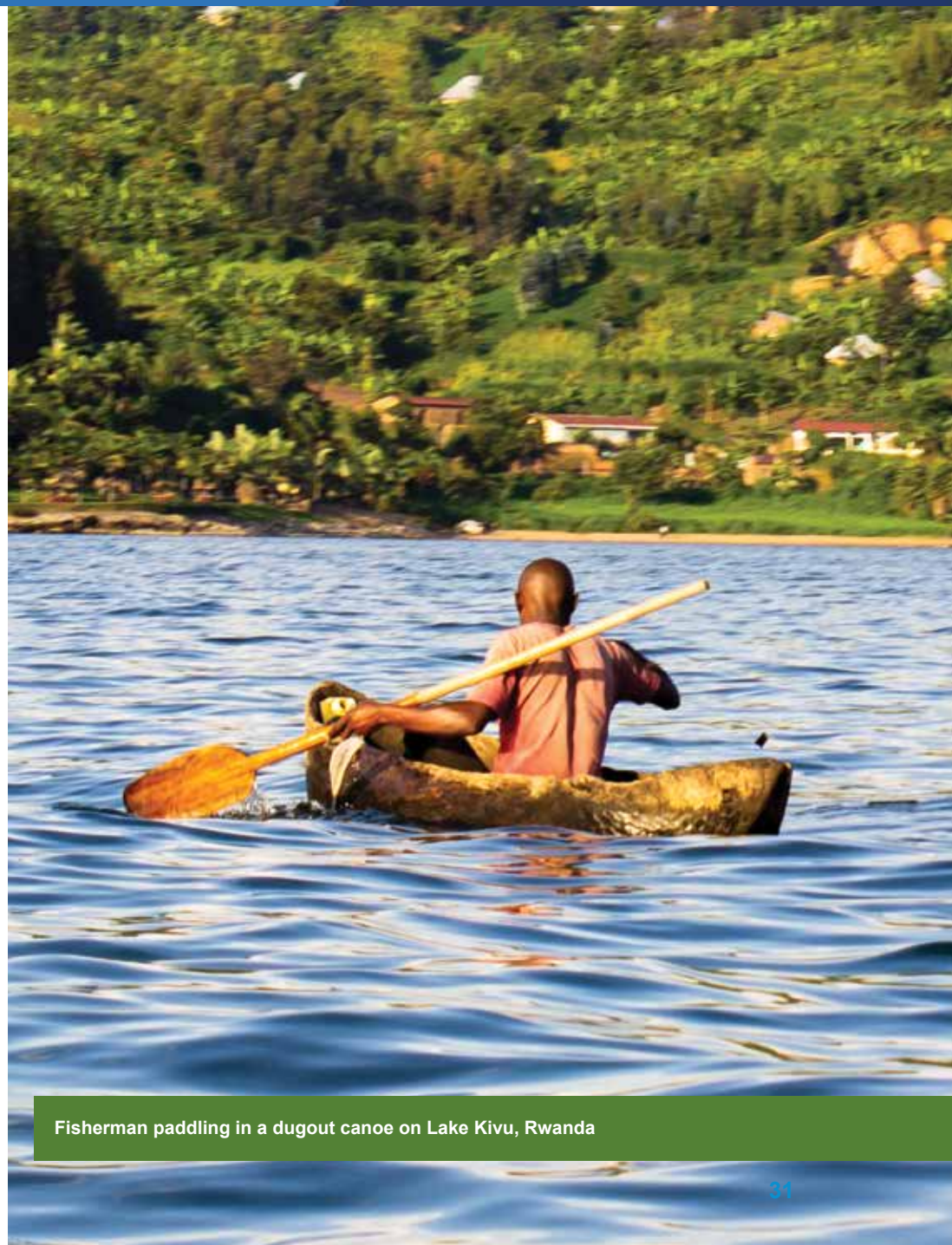
- There is no agreement for the conservation of transboundary primary forests (Nyungwe National Park and Kibira National Park) or transboundary wetlands.
- Laws and decrees are still needed to harmonise legislation relating to land, water and environmental protection.
- So far, land reform has only been carried out in Rwanda, which has set up a centralised digital land service that has made it possible to secure land titles and improve women's access to land; this has not yet occurred in DRC or Burundi. This presents several challenges, including unclear and insecure land tenure, which can prohibit or complicate the creation of PES schemes as the landowner is unclear.

9.2 Institutional frameworks

In **Burundi**, the management of natural resources has been the responsibility of the Ministry of the Environment, Agriculture and Livestock since 2018. For the water sector, the Ministry of Hydraulics, Energy and Mines is in charge of the planning, construction and management of hydraulic, energy and basic sanitation infrastructures.

In **DRC**, the Ministry of Environment and Sustainable Development is responsible for managing natural resources. The Ministry of Energy and Water Resources is responsible for the policy, management and distribution of drinking water and electricity/energy resources. The Ministry of Planning, through its National Water, Hygiene and Sanitation Action Committee, is responsible for coordinating the reform of the drinking water, hygiene and sanitation sector.

In **Rwanda**, the protection of the environment, the sustainable management of natural resources and the fight against climate change is entrusted to the Ministry of the Environment. Other ministries and authorities are also involved in the management of natural resources; more specifically in the field of water these are the Rwandan Water Resources Board, the Ministry of Infrastructure (MININFRA) for Water and Sanitation, the Ministry of Agriculture (through the Rwanda Agriculture and Animal Resources Development Board) and the General Directorate of Energy of MININFRA.



Fisherman paddling in a dugout canoe on Lake Kivu, Rwanda

9.3 Cross-border and international management frameworks

Table 9 lists the organisations operating in the basin and their respective objectives.

Table 9: Objectives of cross-border and international organisations working within the Lake Kivu and Ruzizi/Rusizi River Basin

ORGANISATION	FOUNDING COUNTRIES	OBJECTIVE
Regional organisations		
The Economic Community of the Great Lakes Countries (CEPGL)	Burundi, DRC, Rwanda	Revitalise political dialogue and economic integration in the great lakes
The Economic Community of Central African States (ECCAS)	Burundi, DRC, Rwanda, Chad, Central African Republic, Cameroon, Equatorial Guinea, Sao Tome and Principe, Gabon, Republic of Congo, Angola	Promote and strengthen harmonious cooperation and dynamic, balanced and self-sustained development
International Conference on the Great Lakes Region (ICGLR)	Angola, Burundi, Central African Republic, Republic of Congo, DRC, Kenya, Rwanda, Sudan, South Sudan, Tanzania, Uganda, Zambia	The Pact on Peace, Security, Stability and Development in the Great Lakes Region
Relevant basin management organisations		
Lake Tanganyika Authority (LTA)	Burundi, DRC, Tanzania, Zambia	Protection and conservation of biodiversity and the sustainable use of the natural resources of Lake Tanganyika and its basin
International Commission of the Congo-Oubangui-Sangha Basin (CICOS)	Cameroon, Republic of Congo, Central African Republic, DRC, Gabon, Angola	Promoting inland navigation; in 2007, the mission of CICOS was extended to include IWRM functions
Nile Basin Initiative (NBI)	Burundi, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, Uganda, DRC	Provide a platform for basin cooperation and for information systems-based water resources planning and management services, and facilitate transboundary projects
Lake Kivu and Ruzizi/Rusizi Authority (ABAKIR)	Burundi, DRC, Rwanda	Protection and conservation of the basin's water resources based on integrated and sustainable management

CHAPTER 10

Proposals to improve and harmonise the legal frameworks and action programme in the basin

Measures aimed at the sustainable management, preservation and restoration of water resources and associated environments of the basin are necessary, requiring enhanced cooperation between the Member States. An action programme comprising the following types of measures is proposed.

1. **Harmonisation of policies and regulations.**
   This can be achieved by strengthening the capacities and responsibilities of decentralised entities and organisations in charge of watershed management or protected areas. Similarly, the harmonisation of policies and regulations related to environmental assessment would prevent environmentally damaging investments and the use of hazardous chemicals. The establishment of common sanitation rules would prevent uncontrolled development of urban centres and hotel infrastructure and facilitate the provision of appropriate sanitation infrastructure.

2. **Implementation of PES mechanisms.**
   This requires good knowledge of the ecosystem services provided at the sub-basin level, the identification of beneficiaries of payments based on land tenure data and the establishment of a mechanism for collecting fees from service beneficiaries. This should be harmonised in the three countries.

3. **Strengthening and optimising existing hydrometeorological monitoring networks and knowledge enhancement measures.**
   Mechanisms to achieve this include maintenance of existing monitoring stations and establishment of new stations for surface and groundwater monitoring (hydrometric and piezometric monitoring). Additionally, further information should be gathered on:

   - hydrogeology
   - water abstraction and water discharge
   - sources of pollution
   - water quality
   - land degradation.

4. **Reinforcement of the structure of ABAKIR.**
   This will involve setting up operational technical structures and institutional support measures, for instance, an internal Planning and Studies Unit and an 'Observatory of water resources and associated environments of the basin'. Financial and technical support should help ABAKIR and the Member States prepare the proposed activities.

5. **Development of basin management tools.**
   These might include observation and warning systems, hydrological and water resources planning models, IWRM toolbox, etc.

6. **Reduction of pressure on the environment.**
   For example, through the selection of infrastructure projects with a lower impact on the environment and water resources. Most of the measures required are the domain of national governments, but ABAKIR should play a catalytic role. Additionally, the following measures have already been identified to reduce pressure on the environment, but others will be necessary in the future.

6. ***Continued...***

Water resources and biodiversity
- Improve access to water and sanitation
- Fight degradation of water resources
- Safeguard biodiversity

Access to energy
- Improve access to electricity
- Reduce use of firewood

Food security and biodiversity
- Protect fishing and fish farming
- Fight soil degradation
- Treat excrement from intensive livestock farming

Pollution control
- Improve solid waste management
- Improve industrial and mining processes
- Reduce pollution from tourism, health infrastructure and schools

7. **Introduction of natural risk management measures.**
   Human settlements in areas at high risk of natural disasters must be avoided at all costs. Natural risk management measures are also needed.

CHAPTER 11
General Conclusions

The current situation of management of water resources and associated environments in the Lake Kivu and Ruzizi/Rusizi River Basin can be summarised in the form of a **Strengths, Weaknesses, Opportunities and Threats (SWOT)** analysis, as shown below.

STRENGTHS
- A basin well supplied with generous water inflow with a large and beautiful lake that has remarkable potential for tourism, fisheries and aquaculture, and electricity production
- Protected forests and remarkable biodiversity that enhance the tourist potential, protect the basin and provide firewood
- A dynamic socio-economic area with a fast-growing population and gradual infrastructure development

WEAKNESSES
- Different governance models from three countries complicates management
- Population growth is difficult to control
- The surface area of the basin represents only a small part of the total surface area of each of the three countries, which does not encourage national involvement in management
- Alkalinity of Lake Kivu water and salinity of the Ruzizi/Rusizi River water and some tributaries
- Low river flow during dry months (June, July and August)
- Tributaries have low/limited flow rates
- Lack of hydrometeorological monitoring in the basin
- Rugged terrain of the basin, fragile land used for cultivation along the slopes, subject to erosion and landslides

OPPORTUNITIES
- Political stability and political will for environmental protection
- Donors ready to support the development of the basin and ABAKIR
- Cross-border projects strengthen regional cohesion and experienced researchers strengthen the knowledge base
- Countries updating their legal

THREATS
- Extreme poverty of the populations living in the basin, putting strong pressure on natural resources
- Uncontrolled explosive urbanisation combined with a lack of sanitation and collection/treatment of solid and liquid waste
- Uncontrolled and unsustainable use of wood, forest clearing and bush fires leading to loss of biodiversity and erosion
- Agriculture and livestock farming on steep slopes causing soil erosion and landslides
- Several industries (mines, quarries, cement, etc.) with little respect for the environment, and with little official oversight
- Overfishing in Lake Kivu and the Ruzizi/Rusizi River, and poaching in protected areas
- High natural risks: volcanic eruptions, limnic eruptions, strong seismicity, floods, landslides, etc.

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