

# Crocodile ecology, conservation and Management in the Ruzizi Delta, Northern End of Lake Tanganyika, in Burundi and the Democratic Republic of Congo

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## ABSTRACT

Crocodile's ecology, conservation and management in the Ruzizi Delta were investigated during the period from April 2019 to April 2021 by interviews using a survey questionnaire, and by direct observation using binoculars during the day, and at night on the secure coastline of Lake Tanganyika between the mouth of the Small Ruzizi River and the mouth of the Kalimabenge River. The investigations were part of a doctoral research aimed at the creation of a Community Reserve in the Ruzizi Congolese Delta and at the conditions improvement for birds, crocodiles and lasting biodiversity conservation in the Ruzizi Burundian Delta. The average density of the Nile crocodile, *Crocodylus niloticus* (Laurenti, 1768) was higher in the protected Ruzizi Burundian Delta (19 crocodiles/ km<sup>2</sup>) and lower in the unprotected Ruzizi Congolese Delta (6 crocodiles/ km<sup>2</sup>). Similarly, the density of the Slender-snouted Crocodile (*Mecistops leptorhynchus*) was higher in the protected Ruzizi Burundian Delta (40 crocodiles/ km<sup>2</sup>) and lower in the unprotected Ruzizi Congolese Delta (11 crocodiles/ km<sup>2</sup>). The Ruzizi Congolese wetland stakeholders accepted (90%) the protection of the Ruzizi Congolese wetlands as a Ruzizi Congolese Community Reserve to be submitted later to the Ramsar Secretariat for designation as a Ruzizi Congolese Ramsar Site. The sustainable management of crocodiles and biodiversity will require the formulation of joint conservation projects by the Authorities of the Ruzizi Congolese Delta and the Ruzizi Burundian Delta.

**Key words** - Crocodile's Ecology; Conservation and Management; Ruzizi Congolese Delta; Ruzizi Burundian Delta; Crocodile's density.

## INTRODUCTION

There are some 23 species (King & Burke, 1989) found throughout the world, belonging to Family Crocodylidae which is further divided into 3 subfamilies: a) Crocodylinae, b) the Alligatorinae and c) the Gavialinae. Crocodylians exist throughout the tropics and are considered "keystone" species (Thorbjarnarson, 1992) that maintain ecosystem structure and function. These include selective predation on fish species (Pooley, 1982) recycling nutrients and maintenance of wet refugia in droughts (Thorbjarnarson, 1992).

Throughout their range, crocodylian populations are threatened by overexploitation, hunting, habitat loss and pollution (Cornejo *et al.*, 2021). Many species worldwide are exploited for their skins and many populations are threatened due to hunting for trade. The

crocodile skin trade generates an international income of \$ 500 million annually (Ross, 1998). Crocodile ranching and farming has the potential to harm populations if it is not managed correctly, taking into account population status and demographic trends, and releasing a proportion of wild originated juveniles back into the systems from which they came.

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The loss of any species of crocodylian would represent a significant loss of biodiversity, economic potential and economic stability (Ross, 1998).

Ecologically, crocodylians are long-lived animals with very high mortality rates in their first year of life due to predation (Sven, 2007). They are without exception the largest predators in their aquatic environments and terrestrial mammals, including humans and livestock, fall victim to the larger individuals (Sven, 2007). Crocodylians exhibit indeterminate growth, and *adult male* Nile crocodiles can *attain* a length of 5 m, although adults average 2.8 - 3.5 m in length (Alexander & Marais, 2007). They can tolerate a broad range of habitat types including small brackish streams, fast flowing rivers, swamps, dams and tidal lakes and estuaries (Deon, 2018). Crocodiles are ectothermic animals, regulating their body temperature behaviourally by moving between sun-exposed sandbanks and the water (Deon, 2018). Along with several other reptile species, crocodylians exhibit temperature-dependent sex determination (TSD) (Sven, 2007). There are no sex chromosomes and the sex of the hatchlings is determined by the incubation temperature during the middle trimester of the incubation period (Sven, 2007).

Global warming could potentially also advance at a rate faster than these animals can adapt to rising temperatures, leading directly to male biased populations initially, followed by extinction in a worst-case scenario (Sven, 2007). The incubation temperature of the clutch does not only affect gender, but also the probability that embryos will survive to hatching, growth rates before and after hatching and the probability of hatchlings surviving to two years of age (Ziegler & Sven, 2021). The selective advantage of TSD is that it assigns maleness to embryos with high probabilities of surviving and good potential for post-hatching growth (Ziegler & Sven, 2021). Crocodylians have excellent eyesight and can see well during both the day and night (Deon, 2018). The eyes lie laterally on top of the head and protrude above the water when the animal surfaces (Deon, 2018).

They possess clear nictitating membranes or third eyelids that protect the eye when swimming or hunting and increases underwater vision (Ziegler & Sven, 2021). The pupils are vertically slit in daylight, very much like those of a cat and expand to become round at night when the animal is most active (Deon, 2018). The eyes possess lachrymal glands that cleanse the eyes with tears (Deon, 2018). The ears are relatively small and have protective flaps that close when the crocodile is submerged (Ziegler & Sven, 2021). Crocodiles also possess ossified scales on the back and tail called osteoderms that form protective armour (Deon, 2018). Crocodylians use their webbed hind feet and tail to swim at speeds reaching 30-35 km/hr (Deon, 2018). They can walk on land and gallop for short distances at speeds ranging up to 14 km/ hr (Deon, 2018).

The Nile crocodile is the largest of the four African crocodile species (Slender-snouted crocodile, *Mecistops Cataphractus*, *Mecistops leptorhynchus*, Dwarf Crocodile, *Osteolaemus tetraspis* and Nile crocodile, *Crocodylus niloticus*) and second to the Australian saltwater crocodile (Ziegler & Sven, 2021). Adult Nile crocodile males average a total body length of 5 m (maximum 6.1 m) and a mass of 400-500 kg (maximum 900 kg) (Deon, 2018). Females are 20-30% smaller with an average body length of 3.5 m (maximum 5 m) and a mass of 150-350 kg (maximum 600 kg) (Deon, 2018). Nile crocodiles are known to reach a greater size in the hot Afro-tropics and individuals of >5 m weighing >750 kg are sporadically reported from Lake Nasser in Egypt (Deon, 2018).

Crocodile ecology, conservation and management in the Ruzizi Delta were investigated during the month of April 2019 until April 2021. The fieldwork targeted in Burundi extended from Vugizo, along the Great Rusizi River banks to the Great Rusizi River Bridge (GRRB) «Pont de l'Unité», the banks of the Great Rusizi River downstream to its mouth, the coast of Lake Tanganyika between the Great Rusizi River Mouth (GRRM) and the Small Rusizi River Mouth (SRRM) and then, the Easter banks of the Small Ruzizi River upstream to Vugizo.

In the Democratic Republic of Congo (DRC), the research field targeted by the study was the coast of Lake Tanganyika between the mouth of the Small Ruzizi River Mouth (SRRM) and Kilomoni 2, the Kyamvubu marshes in connection with this coast, the eastern part of the pond of Nyangara encompassing the offices of the General Directorate of Customs and Assizes (DGDA) of Kavimvira, the marshy village of Kahorohoro, and the western banks of the Small Ruzizi River upstream to Vugizo (Vug) and then the Western banks of the Small Ruzizi River downward the Small Ruzizi River Mouth. Two crocodile species are found in the Ruzizi Delta: Nile Crocodile, *Crocodylus niloticus* (Laurenti, 1768) and Slender-snouted Crocodile, *Mecistops leptorhynchus* (Shirley et al. 2018).

Their ecology, conservation and management will strengthen the bird ecology, conservation and management in the claims of a protected area meeting the Ramsar criteria to be designated as a Congolese Ramsar site in the Ruzizi Delta in continuity of the Rusizi Burundian Ramsar Site for a sustainable conservation of crocodiles, birds and biodiversity of the Ruzizi Delta in the Republic of Burundi and in the DR of Congo.

## Literature Review

Living with crocodiles should no longer pose problems in the Ruzizi Delta. Indeed, Aboriginal people have coexisted with saltwater crocodiles (*Crocodylus porosus*) for around 65,000 years (Grahame, 2020). They hunted and ate crocodiles and their eggs, while at the same time being

hunted and preyed upon by crocodiles (Grahame, 2020). Aboriginal people attribute many different values to crocodiles, for intrinsic, cultural, spiritual and utility purposes (Grahame, 2020). Crocodiles and Aboriginal people have adapted to past climate change events, including sea level rises of 100-150 m (Grahame, 2020). We hypothesize that as soon as the wetlands of the Ruzizi Congolese Delta are protected, crocodiles will not be seen wandering, their number and average size will increase and they will no longer attack anyone as is the case currently in Uvira and in the surroundings of the Ruzizi Congolese Delta. Indeed, when saltwater crocodiles in the Australia Northern Territory were protected (1971), they were rarely sighted anywhere (Grahame, 2020).

A wild population of around 100,000 individuals had been reduced to 3000-5000 (Grahame, 2020). The challenge for the crocodiles of the Ruzizi Congolese Delta is the regular sensitization of the public on the ecological, economic, cultural and scientific benefits of crocodiles. Indeed, in addition to traditional knowledge and skills, engagement of Aboriginal Australian people in the crocodile industry has involved training with eggs, embryos and incubation technology (Grahame, 2020).

Raising public awareness on the industrialization of crocodile breeding productions and the financing of the Hydrobiology Research Centre (CRH) for the supply and breeding of crocodiles could contribute to the well-being, to the knowledge of crocodiles, and the development of the City and Territory of Uvira and its surroundings, especially on the Lake Tanganyika Congolese shore areas, over a distance of approximately 674 km (Fermon, 2007). A Ramsar Description Sheet (RIS) 2009-2014 version of the Ruzizi Ramsar Site provides information on the wetlands of the Ramsar Convention (MINATET & MINEEATU, 2013). It presents the characteristics of the environmental monitoring of a Ramsar site. It could serve as a benchmark for the management of the future Ruzizi Delta Congolese Ramsar site.

The Lake Tanganyika Biodiversity Project (LTBP) aimed, among other things, to set up a long-term regional management program for fitting pollution and for the conservation and maintenance of the biodiversity of Lake Tanganyika (MINATET & MINEEATU, 2013). It presents the results and observations drawn from the UNDP/ GEF conservation initiative (RAF / 92 / G32) which involved Burundi, the Democratic Republic of the Congo (DRC), Tanzania and Zambia between August 13, 98 and July 2000 (Kelly, 2001). The Ruzizi River which feeds the Ruzizi Delta starts from Lake Kivu, at 1460m altitude until its mouth on Lake Tanganyika at 775m altitude over a distance of 117 km, with an average flow of 100 m<sup>3</sup>s<sup>-1</sup> (GWP & UNECE, 2019). It crosses the DRC, Rwanda and Burundi.

All the tributaries Luvimvi, Luvungi (Luvubu), Luberizi, Sange, Runingu and Kiliba on the western bank, Ruhwa, Nyakagundu, Nyamagana, Muhira, Kaburantwa, Kagunuzi, Nyabundari, Kajange, and Mpanda on the eastern bank, take their source on the slope of the Congo from the ridges separating the Nile Basin from the Congo Basin (GWP & UNECE, 2019).

The project to create a Ruzizi Community Reserve (PRCR) in the Ruzizi Congolese Delta aims to contribute to the achievement of the following overall objective: "Contribute to the sustainable development and stabilization of the Ruzizi Delta Region in the DRC and in Burundi by stimulating economic development through the integrated management of natural resources, in all its dimensions (energy, commercial, education, training, ecological, biodiversity, tourism, etc.)" (GWP & UNECE, 2019). The convention of the Project Ruzizi Community Reserve in the Ruzizi Congolese Delta intends:

- Cooperate in the development of a common vision for the management of the Delta;
- Implement the rules and ecological standards for the exploitation of resources;
- Involve local communities directly in the management of these resources.

This holistic management of the Ruzizi Congolese Delta is only possible under the conventional support of a credible international organization such as the Ramsar Convention, capable of financing the regular monitoring of biodiversity and the wetlands that host it (GWP & UNECE, 2019). The project Ruzizi Community Reserve (PRCR) in the Ruzizi Congolese Delta will support the implementation of the strategies to sustainably manage the environment, mitigate climate change and improve land use planning contained in the National Development plans of the DRC, « *Plan National Stratégique de Développement 2018-2022* » as given by GEF<sup>1</sup> & UNEP (2020) in the following areas:

Sustainable Agriculture, Sustainable Fire Management, Sustainable Pasture Management, Sustainable Forest, Ecosystem Approach, Restoration and Rehabilitation of Degraded Lands, Community-Based Natural Resource Management, Improved Soil and Water Management Techniques, Influencing models, Convene multi-stakeholder alliances, Demonstrate innovative approaches, Strengthen institutional capacity and decision-making, Stakeholders, Beneficiaries, Indigenous Peoples, Private Sector, Large corporations, Individuals/ Entrepreneurs, SMEs (Small and Medium-sized Enterprises), Financial intermediaries and market facilitators, Local Communities, Civil Society, Community Based Organization, Academia, Non-Governmental Organization, Gender Equality, Gender Mainstreaming,

<sup>1</sup> *GEF, Global Environment Facility; UNEP, United Nations Environmental Programme*

Sex-disaggregated indicators, Women groups, Gender-sensitive indicators, Gender results areas, Capacity Development, Awareness Raising, Knowledge Generation and Exchange, Access and control over natural resources, Participation and leadership, Capacity, Knowledge and Research, Enabling Activities, Knowledge Exchange South-South, Peer-to-Peer, Field Visit, Conference, Knowledge Generation, Workshop, Training, Innovation, Learning, Indicators to measure change, Adaptive management, Targeted Research (GEF & UNEP, 2020).

The deltaic form of the outlet of the Rusizi River into Lake Tanganyika is a permanent tropical inland delta, renowned for its biodiversity, which includes impressive resident and migratory bird faunas (130 and 90 species respectively), a rich endemic fish fauna (90 species), a specialized plant flora (190 species) as well as hippopotamus, viverrids, antelopes, small mammals, African Crocodiles, varanids and smaller lizards, snakes and amphibia (IUCN & ISI, 2010). The Rusizi floodplain, upstream of the delta is also of great regional importance as it supports the livelihoods of tens of thousands of Burundian and Congolese people who cultivate, fish, graze cattle and harvest wetland products, as well as harbouring an important biodiversity of a Central African floodplain in the Albertine Rift Valley (IUCN & ISI, 2010). However, conflicts have erupted over natural resource use and current resource use patterns are proving to be unsustainable (IUCN & ISI, 2010). The main reason is thought to be lack of awareness of the globally important wetland resources of the Rusizi floodplain, delta and adjacent littoral zone (IUCN & ISI, 2010). These wetland resources are currently increasingly being exploited as a result of the ever-increasing human population and economic pressures (IUCN & ISI, 2010).

Our fieldwork 2019-2021 and our interview respondents have confirmed that loss and degradation of ecological habitats, sedimentation due to deforestation, eutrophication, excessive water withdrawal, overexploitation of riparian and woodland resources, and pollution are the leading causes of fresh water species decline. These threats stem from the ever increasing demand for goods and services by the human population. Furthermore, owing to civil insecurity in both Bujumbura and Uvira, refugees have put an enormous pressure on the fisheries, forest and wetland resources of the (former) Rusizi National Park thus its downgrading from a national park to a nature reserve (which allows for some human activities).

A coordinated management of the Rusizi floodplain, delta and adjacent littoral zone at the national level and transboundary level is very important for the Republic of Burundi and the DRC for sustainable resource-use practices (IUCN & ISI, 2010).

The governments of Burundi and the DRC, with funding from the European Commission and technical assistance from IUCN (World Conservation Union), began a project to sustain the important ecosystem functions of the Rusizi Delta and floodplain in January 2005 (IUCN & ISI, 2010). Several project objectives have been realized since then and these include biodiversity field studies to address management questions (1st and 2nd quarter, 2005), popularization of the status and distribution of biodiversity in Eastern Africa (3rd and 4th quarter, 2005) whereby the project went a step further and gathered species information, that were then subjected to the IUCN Red Listing process to determine their threatened status and the analysis of new freshwater biodiversity data both nationally and regionally (1st and 2nd quarter, 2007).

This study has assisted in priority setting exercises for species conservation, demonstrated the great importance of the Rusizi River, its floodplain and delta as valuable and vulnerable ecosystems important for biodiversity conservation and human welfare (IUCN & ISI, 2010). IUCN also assisted Burundi in developing a management plan for the Rusizi Delta Ramsar Site and a national capacity for wetland management planning in order to conserve and promote sustainable use of freshwater biodiversity (IUCN & ISI, 2010). The awareness campaign was launched to enlighten communities, resource managers and decision makers of the important biodiversity values in the Rusizi floodplain, delta and adjacent littoral zone in line with the purpose of this study which was to demonstrate the process of applying biodiversity information in development plans in order to sustain the important ecosystem functions of the Rusizi Delta and river system and the livelihoods that depend upon them (IUCN & ISI, 2010).

Legal Status of crocodiles in the DRC tells, crocodiles are protected by Ordinance 6G -074 of 8 March 1968, Chapter one, Section one (amending the decree of 21 April 1937)<sup>2</sup> (SSC & IUCN, 1972 ). Without the permission of the administration no person may hunt, capture, sell, offer for sale, buy, give, receive by any means, transport or hawk crocodiles or their skins or any part of these creatures (SSC & IUCN, 1972 ). The challenge is that crocodiles are animals protected by Congolese law which are found in large numbers and permanently in large and permanent unprotected wetlands of the Ruzizi Congolese Delta in continuity with the protected Burundian delta part.

Public awareness on the reduction of threats to crocodiles in the Ruzizi Plain and the Lake Tanganyika shore areas in Uvira DRC was conducted from 2016 to 2018 (Bashionga B. A., 2019). The following awareness message was given to the public. «Wetlands along the Ruzizi River, along ponds and Lake Tanganyika shoreline, which are ecological habitats for crocodiles, have been degraded.

<sup>2</sup> J. C. Heymans, Service de Zoologie, Université Officielle du Congo, Lubumbashi, p 15-16 in ISSC & IUCN, 1972.

Scavenging crocodiles are captured, injured and killed; they too mud and kill people (Bashionga A. B., 2019). The project aims to raise public awareness about the reduction of threats to crocodiles, birds and biodiversity in general, in application of the law n° 011/2002 of 29/8/2002, for the protection of the wetlands (Bashionga A. B., 2019). Sensitisation was done in 14 sites of DRC including Ruzizi 3, Kafunda, Kivira, Kindobwe (Luvungi), Kaberagule, Kindava (Ndunda), Kimuka, Ruzia, Mwaba, Small Ruzizi River Mouth (Fishermen), Kyamvubu, Kilomoni 2, Kimanga (Maendeleo) and Kalimabenge (river mouth); one site in Rwanda, Kabusunzu; and seven sites in Burundi including Kagunuzi, Mpanda, Vugizo, Great Rusizi River Bridge (GRRB), Great Rusizi River Mouth (GRRM), Mukartutsi Ponds (Gatumba), and Gatumba Burundian Migration Post Offices (MPO) (Bashionga A. B., 2019). The density of crocodiles in the Ruzizi plain was presented at the 3rd conference of the CSG (Crocodile Specialists Group) in Abidjan, Ivory Coast from 07 to 12/12 2015 thanks to the financial support of the CSG.

Then, public awareness on the reduction of threats on crocodiles and biodiversity in the Ruzizi plain was led by financial support from the IRSNB (Belgian Institute for Research in Natural Sciences) in 2016-2017. The restitution was made at the workshop hold from 28/09 to 04/10/2017 organized by IRSNB/ CEBioS-MRV with the CSB (Biodiversity Monitoring Centre) of the University of Kisangani in DR Congo (Bashionga A. B., 2019).

The monitoring of threatened animals, (including crocodiles first) by degrading acts in Uvira and in the Ruzizi plain was conducted from January to December 2020 jointly by the Centre for Research in Hydrobiology (CRH) with the NGO ASPADA (Social Actions for Agricultural Promotion and Defense of Animal Rights) through the financial support of IRSNB / CEBioS-MRV by means of the project 2019-2021.

With the financial support of the GSC, the current state of the crocodiles of the Ruzizi Delta which forms the body of this publication was investigated between March 2019 and February 2021 as part of our doctoral thesis. Our doctoral research is going along way to provide the information needed for the creation of a Community Reserve which could be designated as a Congolese Ramsar site in the Ruzizi Congolese Delta for a sustainable conservation of crocodiles and biodiversity both in DRC and in Burundi (CSG, 2018).

While crocodiles were strongly threatened by poaching and the degradation of their environment since 2018-2019, the General Directorate of the Burundian Office for the Protection of the Environment (OPE) released on May 05, 2021, three crocodiles in freedom in the Rusizi river upstream of the Delta (Nahimana, 2021). These crocodiles were donated voluntarily by an inhabitant of the Kabondo Quarter, tamer and breeder of crocodiles. The OBPE is concerned with the protection of nature and biodiversity

in Burundi (Nahimana, 2021). The author (Bobby, 2018) featured in Hampi, Valley of the Kings India, a wildlife documentary featuring informational videos on the ecosystems of crocodiles, hippos and birds of the Rusizi Delta, in 2014, 2016 and 2018.

During the years 2003 to 2013, a Nile Crocodile monster, known as Gustave, controlled the Ruzizi plain killing around 300 people caught by its gigantic jaws in 10 years (Corillon & Jeannita, 2004). To put an end to this carnage, the team led by the Belgian Patrice Faye living in Burundi for more than 20 years, the South African Drew Leslie (PhD) and the French Marc Gansuana (PhD), set up for 60 days a device to capture this invisible man-eating Gustave crocodile alive but they didn't get it (Corillon & Jeannita, 2004). The Ruzizi Delta occupies around 1000 hectares, to the south of the Ruzizi plain, which is 8000 hectares wide (Corillon & Jeannita, 2004). Some images allow us to estimate that Gustave was between 6 and 7 meters long and weighed more than a tonne, while Nile crocodiles (*Crocodylus niloticus*) rarely reach 5 meters and 500 kilos (Corillon & Jeannita, 2004). Since Dr Leslie and Marc Gansuana left Burundi, the crocodile monster Gustave has remained invisible in the Rusizi delta and no attack has been reported (Corillon & Jeannita, 2004). He is believed to have moved to the Nsumbu Park in Zambia but no scientific source reports it. The disappearance of the Gustave crocodile remains scientifically enigmatic (Corillon & Jeannita, 2004).

## MATERIAL AND METHODS

### Study Areas

#### *Ruzizi Congolese Delta*

In the Ruzizi Congolese Delta (RCD), the study areas include the coastline of Lake Tanganyika between the Small Ruzizi River Mouth (SRRM) and Kilomoni 2 about 3km length; Kyamvubu Pond (1.5km long by 1km wide and 0.8m average depth) and adjacent marshes; the Nyangara pond (3km long by 1.5km wide and 1.5m average depth) and the adjacent Kahorohoro marshes; the banks of the Small Ruzizi River from Nyangara via Kahorohoro to Vugizo, about 17km from the Small Ruzizi River Mouth (Figure 1).

#### *Rusizi Burundian Delta*

In the Rusizi Burundian Delta (RBD), the study environments include the banks of the Great Rusizi River from Vugizo areas downward to the Great Rusizi River Mouth (GRRM) about 17km away; then the shore of Lake Tanganyika between the mouth of the Great Rusizi River and the mouth of the Small Rusizi River about three kilometres apart; the two Mukartutsi 1 and 2 ponds and the surrounding marshes; and finally the Gatumba marshes between the city of Gatumba and the Burundian Migration Post Offices, about 3 km wide by 7 km long,



**Figure 1** Crocodile study area and sampled sites in the Ruzizi Delta

**Legend:** Sites in DRC: **Vug**, Vugizo Site; **Kah**, Kahorohoro flood village site; **NyP**, Nyangara pond site; **KMPO**, Kavimvira Migration Post Office; **Kilo 2**, Kilomoni 2 fishing beach site; **KyP**, Kyamvubu Pond site; **SRRM**, Small Ruzizi River Mouth site. Sites in Burundi: **Vug**, Vugizo site; **SSA**, Steppe and Shrub Area; **GRRB**, Great Rusizi River Bridge; **GMPO**, Gatumba Migration Post Office; **Mup1**, Mukartutsi Pond 1; **Mup 2**, Mukartsi Pond 2; **GRRM**, Great Rusizi River Mouth site.

*Source: Our fieldwork of 2019-2021*

between Mukartsi 2 Pond and the marshy village of Kahorohoro.

**Targeted studied sites**

In the Ruzizi Congolese Delta, the following sites were targeted by the study: the Vugizo site, 17km from the Small Ruzizi River Mouth (SRRM), the site of Small Ruzizi River Mouth (SRRM), the site of Kyamvubu Pond, 0,5km away from the SRRM, the site of Kilomoni 2, 3km away from the SRRM on the Lake Tanganyika shore areas, the

site of Nyangara Pond, 5km away from the SRRM, the site of Kahorohoro flood village, almost 7km away from the SRRM, and finally the site of Kavimvira Migration Post Offices, almost 3km away from the SRRM.

In the Rusizi Burundian Delta (RBD) the following sites were targeted: the Vugizo site, at the outlet of the Small Ruzizi River from the Great Rusizi River, almost 17km away upstream from the Great Rusizi River Mouth (GRRM); The Great Rusizi River Bridge (GRRB) downstream the Great Rusizi River from Vugizo, about

14km; The Great Rusizi River Mouth; The Mukartsi Ponds 1 and 2 site, almost 5km from the GRRM; and finally the Gatumba site, almost 7km from the GRRM (Figure 1).

### Research materials and crocodile surveys in the Ruzizi Delta

Crocodiles were counted by direct observation using binoculars. Then interviews were conducted with target populations: farmers, fishermen, breeders, law enforcement and public administration officials. The procedure for spotlight counts followed that of Yusuke *et al.* (2013), in which crocodiles were counted in a given area dimensions (Yusuke *et al.*, 2013). The surface area was calculated and the density of crocodiles was given by dividing the number of crocodiles by the surface area in km<sup>2</sup> (Mike & Greg, 2013). Spotlight counts were conducted only along the lakeshore areas, due to insecurity along the Small Ruzizi River and the Great Rusizi River upstream. The characteristics of the environments (lake, pond, temporary lagoon, river or marsh) were noted and their dimensions measured using a surveyor's chain, a one meter plastic slat graduated, a tape decametre, and a camera was used to photograph crocodiles in their study environment or in captivity. Finally, a 30cm graduated plastic slat was used to measure the length and parts of young crocodiles in distress or in captivity.

## RESULTS

Results relate to crocodiles ecology, conservation strategic actions, and crocodiles management planning actions including the Ruzizi Congolese Community Reserve (RCCR) creation procedures in the Ruzizi Congolese Delta, and the planning management for designation of the Ruzizi Congolese Community Reserve as a Ramsar Site.

### Crocodiles ecology

#### *Ecological habitats of crocodiles in the Ruzizi Delta*

In the Ruzizi Congolese Delta (RCD), crocodiles are found in Vugizo, the outlet of the Small Ruzizi River out of the Rusizi River, which becomes the Great Rusizi River (GRR), entirely in the Republic of Burundi. The Kiliba sugar factory was established in 1956 by a Belgian national, Baron Kronacker, under the name "Sucrierie de Kiliba" (Kiliba Sugar Factory).

The factory averaged between 15,000 tons and 19,000 tons of sugar, in annual output, with maximum production of 21,000 tons, achieved once in its history<sup>3</sup>. The Small Ruzizi River is a canal dug by the Kiliba Sugar Refectory Authority to irrigate the sugar cane cultivations in the

Democratic Republic of Congo (DRC) around 1956. From its outlet at Vugizo, the Small Ruzizi River goes into the Nyangara Pond, completely in the DRC. Then from the Nyangara Pond, it deflects to the Gatumba Burundian Migration Post Offices (MPO). Finally downward stream, the Small Ruzizi River goes into the Lake Tanganyika, at the Small Ruzizi River Mouth (SRRM). This course of the Small Ruzizi River, influenced by the ponds of Nyangara and Kyamvubu, and by an altitudinal rise of the littoral shoreline of Lake Tanganyika in relation to the Ruzizi plain, forms a permanently flooded environment ideal for the life of crocodiles and all kinds of biological diversity. This environment is characterized by permanent humidity, particularly during the rainy periods from October to January and from March to June of every year.

In addition to Vugizo site, other sites were Kahorohoro swamp village, Nyangara pond and adjacent marshes, Kavimvira Migration Post Offices (MPO), Kyamvubu pond and adjacent marsh, and finally the site of the Small Ruzizi River Mouth (SRRM) and Kilomoni 2 site 3km away from the SRM on the Lake Tanganyika Shoreline (Kilo 2). In those areas we surveyed three times (April, July and October 2019) a mean of 25,38km<sup>2</sup> surface area (SA). The Kiliba Sugar Refinery, which operated during the period 1956-2000, has launched its activities since March 2021 under the name of «Sucrierie du Kivu» (BAD & DPRC, 1995 ). It meets the needs of the local population in terms of food, economic, social, educational, cultural and spiritual (BAD & DPRC, 1995 ). The Kiliba Sugar Refinery was created in 1956 by Baron Kronacker of the Belgian nationality and occupies an area of 7,618 hectares, most of which is marshy (BAD & DPRC, 1995 ). The sampled mean surface area (SA) in the Ruzizi Congolese Delta was 25,38km<sup>2</sup> (Table 1).

In the Rusizi Burundian Delta (RBD), we sampled the following sites: Vugizo-Mpanda site, Great Rusizi River Bridge (GRRB) site, Great Rusizi River Mouth (GRRM) site, the site of Mukartutsi 1 & 2 Ponds, and finally the Gatumba Migration Post Offices (MPO) site. The sampled mean surface area (SA) in the Rusizi Burundian Delta was 13,75km<sup>2</sup> (Table 1)

### Crocodiles relative abundance in the Ruzizi Delta

Crocodile's relative abundance in the Ruzizi Delta is given by figure 1. In the Ruzizi Congolese Delta (RCD), the most abundant site in crocodiles is Vugizo (29%), then the site of Kyamvubu Pond (18%), the site of the Small Ruzizi River Mouth (17%), the site of the Nyangara Pond (14%), the site of Kilomoni 2 (10%), the site of Kahorohoro village (8%), and finally the site of Kavimvira Migration Post Offices (KMPO) (4%). The difference of crocodile

<sup>3</sup>Wikipedia,

<https://www.google.com/search?q=history+of+the+kiliba+sugar+factory> 07/12/2021

**Table 1 Study Areas, Studied Sites Dimensions and Surface Areas (SA)**

<b>Sudy Areas</b>	<b>Studied Sites</b>	<b>Length (Km)</b>	<b>Width (Km)</b>	<b>SA ( Km<sup>2</sup>)</b>
Ruzizi	Vugizo	1,5	0,5	<b>0,75</b>
Congolese	Kahorohoro	1,5	0,5	<b>0,75</b>
Delta	Nyangara	1	0,5	<b>0,5</b>
	Kavimvira MPO	1	0,5	<b>0,5</b>
	Kyamvubu	0,75	0,5	<b>0,38</b>
	Kilomoni 2	1	0,5	<b>0,5</b>
	SRRM	0,5	0,5	<b>0,25</b>
	<b>Mean SA</b>	<b>7,25</b>	<b>3,5</b>	<b>25,38</b>
	Rusizi	Vugizo	1,5	0,5
Burundian	GRRB	1	0,5	<b>0,5</b>
Delta	GRRM	1	0,5	<b>0,5</b>
	Muka Ponds 1 & 2	1	0,5	<b>0,5</b>
	Gatumba MPO	1	0,5	<b>0,5</b>
	<b>Mean SA</b>	<b>5,5</b>	<b>2,5</b>	<b>13,75</b>

**Legend:** SA, Surface Area; MPO, Migration Offices; Muka, Mukartutsi

**Source:** Our fieldwork of 2029-2021

abundance was significant between the sampled sites in the Ruzizi Congolese Delta ( $\chi= 27,71$ ;  $df= 6$ ;  $p< 0,05$ ).

In the Rusizi Burundian Delta (RBD) the most abundant site in crocodiles is as well Vugizo (37%), then the site of the Great Rusizi River Mouth (24%), the site of Great Rusizi River Bridge (21%), the site of Mukartutsi Ponds 1 and 2 (15%), and finally the site of Gatumba Migration Post Offices (GMPO) (3%). The difference of crocodile abundance is significant between the sampled sites in the Rusizi Burundian Delta ( $\chi= 30,37$ ;  $df= 5$ ;  $p< 0,05$ ).

The sites of Kavimvira MPO and Gatumba MPO are similar and have the same percentages (3%) of crocodiles abundance even if they were not sampled the same times (Figure 1). The challenge is that the Lake Tanganyika has the most abundant and permanent waters but crocodiles are most abundant in the outlet of Small Ruzizi River from the Rusizi River, 17km upstream away from Lake Tanganyika due to environment degradation in Lake Tanganyika littoral areas.

#### **The density of crocodiles of the Ruzizi Delta**

Figure 2 shows the density of crocodiles of the Ruzizi Delta in the Ruzizi Congolese Delta (RCD) and in the Rusizi Burundian Delta (RBD).

#### **Ruzizi Congolese Delta**

In the Ruzizi Congolese Delta (RCD), the most crocodile-dense sampling site is the Small Ruzizi River Mouth (SRRM), 47 crocodiles/ km<sup>2</sup>. It is followed by the sites of Kyamvubu pond (KyP), 24 crocodiles/ km<sup>2</sup>, Vugizo site (Vug), 20 crocodiles/ km<sup>2</sup>, Nyangara pond site (NyP), 14 crocodiles/ km<sup>2</sup>, Kilomoni 2 site (Kilo 2), 10 crocodiles/ km<sup>2</sup>, Kahorohoro Village Site (Kah), 5 crocodiles/ km<sup>2</sup>, and finally the Kavimvira Migration Post Office (KMPO) site, 4 crocodiles/ km<sup>2</sup>. The difference is highly significant between the densities of crocodiles sampled from different sites of the Ruzizi Congolese Delta ( $\chi= 411,23$ ;  $df= 6$ ;  $p< 0,05$ ). The mean density of crocodiles in the Ruzizi Congolese Delta was 26 crocodiles/ km<sup>2</sup> (Figure 2).

#### **Rusizi Burundian Delta**

In the Rusizi Burundian Delta (RBD), the most crocodile-dense site is Vugizo (Vug), 87 crocodiles/ km<sup>2</sup>. It is followed by the sites of the Great Rusizi River Mouth (GRRM), 83 crocodiles/ km<sup>2</sup>, the Great Rusizi River Bridge (GRRB), 73 crocodiles/ km<sup>2</sup>, the Mukartutsi ponds 1 & 2 ponds (Muk), 54 crocodiles/ km<sup>2</sup>, and finally by the site of Gatumba Migration Post Office (GMPO), 10 crocodiles/ km<sup>2</sup>. There is no significant difference between the densities of crocodiles sampled from different sites of the Rusizi Burundian Delta ( $\chi= 0,368$ ;  $df=4$ ;  $p> 0,05$ ). The mean density of crocodiles in the Rusizi Burundian Delta is 64 crocodiles/ km<sup>2</sup> (Figure 2).



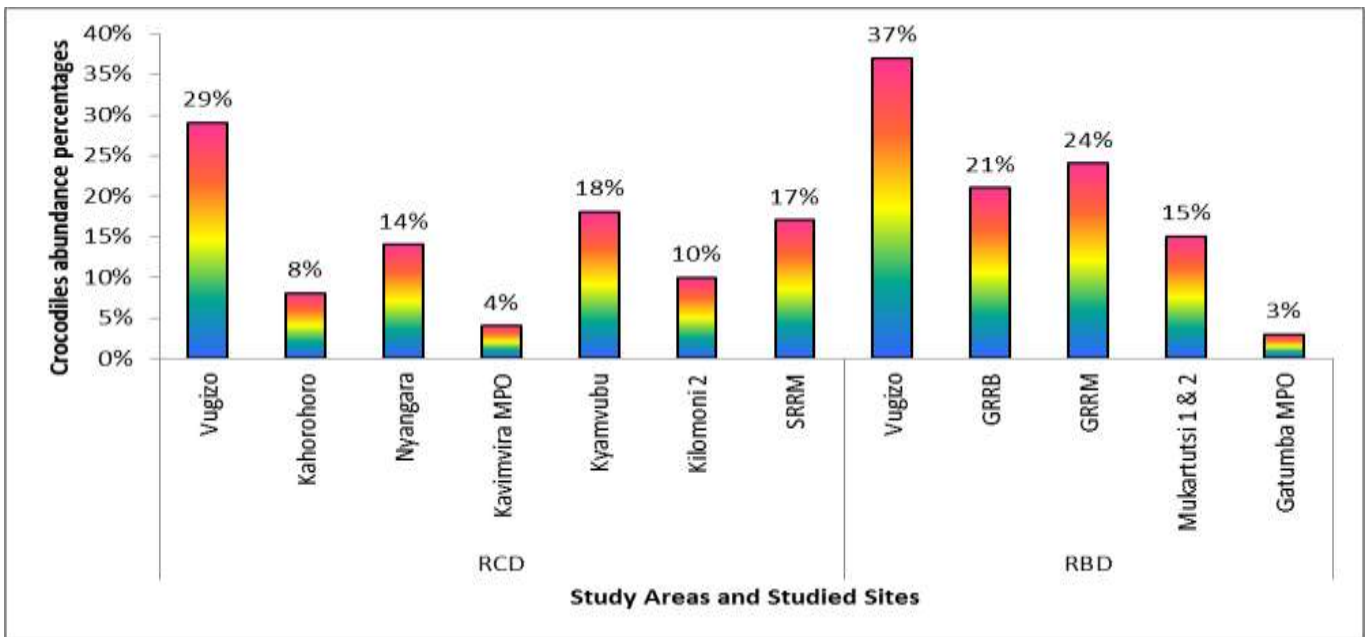


Figure 2 Distribution of crocodiles in the Ruzizi Delta

Legend: RCD, Ruzizi Congolese Delta; RBD, Rusizi Burundian Delta; SRRM, Small Ruzizi River Mouth; GRRM, Great Rusizi River Mouth; GRRB, Great Rusizi River Bridge; MPO, Migration Post Offices.

Source: Our fieldwork of 2019-2021

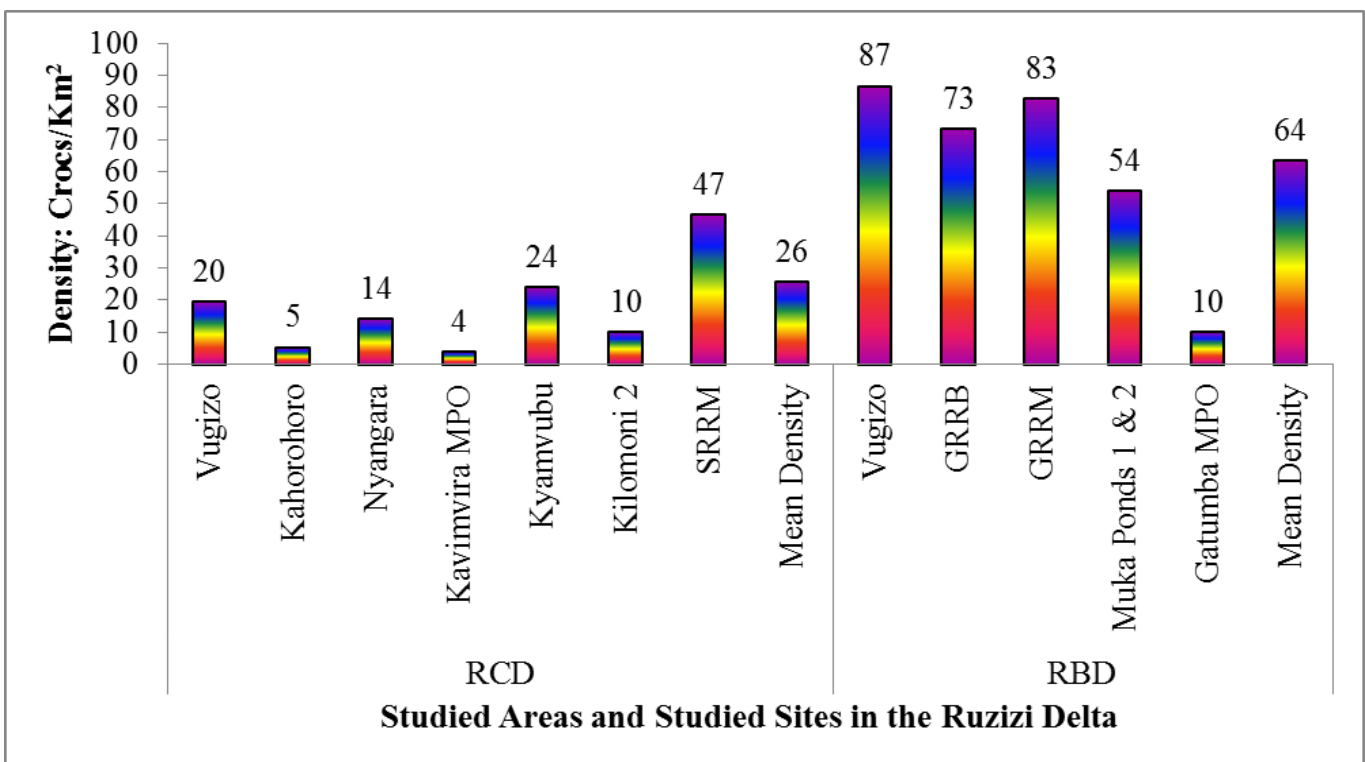


Figure 3. The density of crocodiles of the Ruzizi Delta

Legend: RCD, Ruzizi Congolese Delta; RBD, Rusizi Burundian Delta; MPO, Migration Post Office; SRRM, Small Ruzizi River Mouth; GRRM, Great Rusizi River Mouth; GRRB, Great Rusizi River Bridge; Muka, Mukartutsi.

Source: Our fieldwork 2019-2021

The Nile crocodile is found in rivers, freshwater marshes or lakes in most of Africa south of the Sahara, in an area corresponding roughly to the Afro-tropical eco-zone. It occurs as far south as the Eastern Cape and the island of Madagascar. In some cases they thrive in the brackish water of estuaries such as the St Lucia estuary and the Nile River delta (Deon, 2018).

The eyes lie laterally on top of the head and protrude above the water when the animal surfaces (Deon, 2018). Crocodiles possess ossified scales on the back and tail called osteoderms that form protective armour (Deon, 2018), so we could distinguish Nile Crocodiles while walking in sandy areas of the littoral zones.

The Nile crocodile is largest of the three African crocodile species and second to the Australian saltwater crocodile (Deon, 2018). Adult Nile crocodile males average a total body length of 5 m (maximum 6.1 m) and a mass of 400-500 kg (maximum 900 kg). Females are 20-30% smaller with an average body length of 3.5 m (maximum 5 m) and a mass of 150-350 kg (maximum 600 kg) (Deon, 2018). Nile Crocodiles have a wide habitat preference which reflects their success and distribution. They live in lakes, rivers, freshwater swamps and brackish water, in deep pools and on sand banks with suitable nesting spots and a sufficient food supply (Peter & Myrna, 2011). Surface water is essential. If it evaporates a crocodile will either migrate in search of another source or will aestivate. Fast flowing water and streams are generally avoided as they force the crocodile to lift its head above water more frequently for breathing.

During flooding crocodiles tend to leave the water entirely (Peter & Myrna, 2011). Slightly murky water is preferred over clear water as it improves the strike success when preying on fish as well as the stalking of antelope on the water's edge (Deon, 2018). Crocodiles are gregarious animals. Group sizes depends on food abundance and may range from two to >100 individuals (Deon, 2018). When food resources are depleted or when the surface water dries up, groups tend to break up and individuals may become temporarily solitary (Deon, 2018). Individuals in groups continuously communicate with a variety of pitched vocals. Body contact is tolerated and they often lie against or over each other (Deon, 2018). The mating season varies between May and August depending on the environment (Deon, 2018).

#### **Taxonomy of the African-snouted Crocodile (*Mecistops leptorhynchus*)**

Traditionally placed in *Crocodylus*, recent studies in DNA and morphology have shown that African-snouted Crocodile is in fact basal to *Mecistops*, thus was moved its own genus (Shirley, Vliet, Carr, & Austin, 2014). This genus itself was long considered to contain only one species, *Mecistops cataphractus*, but recent genetic analysis has revealed the existence of two species: the West African

Slender-snouted Crocodile (*Mecistops cataphractus*) and the Central African Slender-snouted Crocodile, *Mecistops leptorhynchus*, (Faux gavial d'Afrique Centrale ou Faux gavial centrafricain) (Shirley *et al.*, 2018). Both species diverged during the Miocene (about 6.5–7.5 million years ago) and are separated by the Cameroon Volcanic Line Shirley *et al.*, 2014) & (Shirley *et al.*, 2018).

The African Slender-snouted crocodile, *Mecistops leptorhynchus* (Bennett, 1835) belongs to the Kingdom of Animalia, Phylum of Chordata, Class of Reptilia, Order of Crocodylia, Family of Crocodylidae, Genus *Mecistops* (Gray, 1844), Species *leptorhynchus* (Shirley *et al.*, 2018), African Slender-snouted Crocodile, African Sharp-nosed Crocodile or African Gavial (Shirley, 2010); (Peter & Myrna, 2011).

For the above reasons, we adopted for this doctoral thesis, the species name *Mecistops leptorhynchus* (Shirley *et al.*, 2018) for the African Slender-snouted Crocodiles sampled in the Ruzizi Delta, northern end of Lake Tanganyika, in the Republic of Burundi and in the Democratic Republic of Congo (DRC). Slender-snouted crocodiles are native to freshwater habitats in central and western Africa (Shirley, 2010). They prefer highly vegetated bodies of water to hide from prey and potential predators (Peter & Myrna, 2011). They are medium-sized crocodiles, typically slightly smaller than the Nile Crocodiles, but are larger than several other species of crocodylians (Shirley, 2010).

Adults are typically about 2.5 m (8.2 ft) long, but have been known to reach 4.2 m (14 ft). They weigh between 125 and 325 kg (Peter & Myrna, 2011). Males are significantly larger than females (Shirley M. H., 2010). They have a slender snout used for catching prey, hence their name. They are incredibly shy and adversely impacted by human disturbance (Wilson & Primack, 2019). The diet of the Slender-snouted crocodile consists mainly of fish, amphibia, and crustaceans (Wilson & Primack, 2019).

Typically, we found them basking on land. Adults occasionally take smaller mammals, aquatic snakes, turtles, and birds (Wilson & Primack, 2019).

The female constructs a mound nest consisting mainly of plant matter (Shirley M. H., 2010). The nests are usually 50 to 60 cm high and 1 to 2 m in diameter (Peter & Myrna, 2011). Nests are placed on the banks of rivers, and construction generally begins at the onset of the wet season, although breeding is asynchronous even within members of one population (Peter & Myrna, 2011). It has a similar, but generally shorter nesting season than that of the sympatric dwarf crocodile, which may nest further from the riverine habitat frequented by *Mecistops* (Peter & Myrna, 2011). The breeding season begins in January or February and lasts until July (Peter & Myrna, 2011). In the Ruzizi Delta, we counted individuals of the Nile Crocodile (*Crocodylus niloticus*) and the Slender-snouted Crocodile (*Mecistops leptorhynchus*), we calculated their density by

**Table-2. The densities of Nile Crocodile (*Crocodylus niloticus*) and Slender-snouted Crocodile (*Mecistops leptorhynchus*) of the Ruzizi Delta**

St A	Studied Sites	Ap 19-21		Jul 19-21		Oct 19-21		MTNb		SA (km <sup>2</sup> )	Density	
		N Croc	SS Croc	N Croc	SS Croc	N Croc	SS Croc	N Croc	SS Croc		NC/km <sup>2</sup>	SSC/km <sup>2</sup>
RCD	Vugizo	3	11	2	13	3	12	3	12	0,8	4	16
	Kahorohoro	0	4	0	3	0	5	0	4	0,8	0	5
	Nyangara	0	5	0	7	0	9	0	7	0,5	0	14
	Kavimvira MPO	0	3	0	2	0	1	0	2	0,5	0	4
	Kyamvubu	4	5	3	5	3	7	3	6	0,4	9	15
	Kilomoni 2	2	5	1	2	2	3	2	3	0,5	3	7
	SRRM	5	3	6	3	4	4	5	3	0,3	20	13
	<b>Mean density</b>										<b>9</b>	<b>11</b>
RBD	Vugizo	15	40	17	48	21	54	18	47	0,8	24	63
	GRRB	11	19	13	22	14	31	13	24	0,5	25	48
	GRRM	17	20	17	23	19	28	18	24	0,5	35	47
	Mukartutsi 1 & 2	4	17	7	18	9	26	7	20	0,5	13	41
	Gatumba MPO	1	3	1	3	3	4	2	3	0,5	3	7
	<b>Mean density</b>										<b>20</b>	<b>41</b>

**Legend:** St A, Study Area; SA, Surface Area; N Croc/(N C), Nile Crocodile (*Crocodylus niloticus*, Laurenti, 1768); SS Croc/ (SSC), Slender-snouted Crocodile, (*Mecistops leptorhynchus*, Shirley et al., 2018); RCD, Ruzizi Congolese Delta; RBD, Rusizi Burundian Delta; MPO, Migration Post Office; SRRM, Small Ruzizi River Mouth; GRRB, Great Rusizi River Bridge (Pont de l'Unité; GRRM, Great Rusizi River Mouth; Mukartutsi 1 & 2 Ponds; Nyangara Pond; Kyamvubu Pond. **Source:** Our fieldwork of 2019-2021.

dividing the mean individual number by the sampled surface area in every site we found at least one crocodile, adult or young. Babies crocodiles were not counted for this survey.

### The density of crocodiles from the Ruzizi Delta

Table 2 presents the study areas, Ruzizi Congolese Delta (RCD) and Rusizi Burundian Delta (RBD), the studied sites, the survey periods from April to October 2019, the sampled surface areas (SA) in km<sup>2</sup>, and finally the densities in crocodiles/km<sup>2</sup> for the Nile Crocodile, *Crocodylus niloticus* (Nile Croc) and the Slender-snouted Crocodile, *Mecistops leptorhynchus* (SS Croc).

### The density of crocodiles from the Ruzizi Congolese Delta (RCD)

#### The density of the Nile Crocodile (*Crocodylus niloticus*)

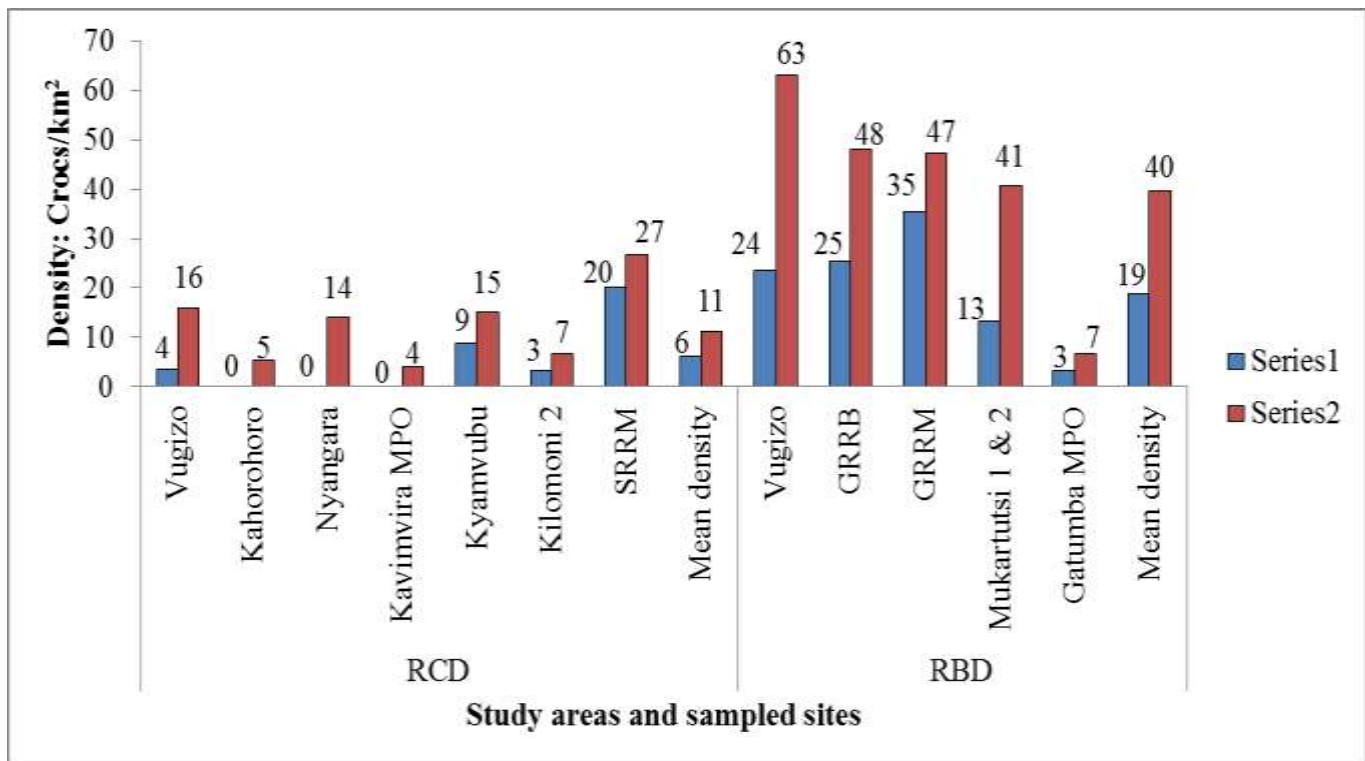
The site of the Small Ruzizi River Mouth (SRRM) is the denser in the Nile Crocodile, 20 crocodiles/ km<sup>2</sup>. It is followed by the Kyamvubu Pond (kyP) Site, 9 crocodiles/ km<sup>2</sup>, the Vugizo (Vug) Site, 4 crocodiles/ km<sup>2</sup>, and the Kilomoni 2 (Kilo 2) Site, 3 crocodiles/ km<sup>2</sup>. No Nile

Crocodile was found in the sites of Nyangara Pond (NyP), Kahorohoro (Kah) Village or in the Kavimvira Migration Post Office (KMPO) Site. The difference between the site densities of Nile Crocodile in the Ruzizi Congolese Delta (RCD) was highly significant ( $\chi= 174,79$ ;  $df=6$ ;  $p<0,05$ ). The mean density of Nile Crocodile for the Ruzizi Congolese Delta (RCD) is 6 crocodiles/ km<sup>2</sup> (Table 2).

#### The density of the Slender-snouted Crocodile (*Mecistops leptorhynchus*)

The site of Vugizo (Vug) was the denser in the Slender-snouted Crocodile (*Mecistops leptorhynchus*) in the Ruzizi Congolese Delta, 16 crocodiles/ km<sup>2</sup>. It is followed by the Kyamvubu Pond (KyP) site, 15 crocodiles/ km<sup>2</sup>, then the site of the Nyangara Pond (NyP), 14 crocodiles/ km<sup>2</sup>, the Small Ruzizi River Mouth (SRRM) site, 13 crocodiles/ km<sup>2</sup>, the site of Kilomoni 2 (Kilo 2), 7 crocodiles/ km<sup>2</sup>, the site of Kahorohoro (Kah), 5 crocodiles/ km<sup>2</sup>, and finally by the site of Kavimvira Migration Post Offices (KMPO), 4 crocodiles/ km<sup>2</sup>. The difference between the densities of the Slender-snouted Crocodile from the sampled sites was highly significant ( $\chi= 222,22$ ;  $df=6$ ;  $p<0,05$ ). The mean Slender-snouted Crocodile density in the Ruzizi Congolese Delta (RCD) is 10 crocodiles/ km<sup>2</sup> (Table 2).

**Figure 4** The density of Nile Crocodile (*Crocodylus niloticus*, Laurenti, 1768), Series 1 blue color and Slender-snouted Crocodile (*Mecistops leptorhynchus*, Shirley et al., 2018), Series 2 red color.



**Legend:** MPO, Migrant Post Office; **SRRM**, Small Ruzizi River Mouth; **GRRB**, Great Rusizi River Bridge (Pont de l’Unité); **GRRM**, Great Rusizi River Mouth; **Mukartutsi 1 & 2 Ponds**. **Source:** Our fieldwork 2019-2021.

**The density of crocodiles in the Rusizi Burundian Delta (RBD)**

*The density of the Nile Crocodile (Crocodylus niloticus)*

The denser site in Nile Crocodile, *Crocodylus niloticus* is the site of Great Rusizi River Mouth (GRRM), 35 crocodiles/km². It is followed by the site of the Great Rusizi River Bridge (GRRB), 25 crocodiles/ km², then the site of Vugizo (Vug), 24 crocodiles/ km², the site of Mukartutsi 1 & 2 (Muk) Ponds, 13 crocodiles/ km², and finally the site of Gatumba Migration Offices (GMPO), 3 crocodiles/ km². There is a highly significant difference between the densities of Nile Crocodile sampled from different sites of the Rusizi Burundian Delta ( $\chi= 119,64$ ;  $df=4$ ;  $p<0,05$ ). The mean Nile Crocodile density calculated for the Rusizi Burundian delta (RBD) is 19 crocodiles/ km² (Table 2).

*The density of the Slender-snouted Crocodile (Mecistops leptorhynchus)*

The denser site in Slender-snouted Crocodile (*Mecistops leptorhynchus*), is the site of Vugizo (Vug), 63 crocodiles/ km². It is followed by the site of the Great Rusizi River Bridge (GRRB), 48 crocodiles/ km², the site of the Great Rusizi River Mouth (GRRM), 47 crocodiles/ km², the site

of Mukartutsi 1 & 2 (Muk) Ponds, 41 crocodiles/ km², and finally the site of Gatumba Burundian Migration Post Offices (GMPO), 7 crocodiles/ km². There is a highly significant difference between the densities of the Slender-snouted Crocodile (*Mecistops leptorhynchus*) sampled from different sites of the Rusizi Burundian Delta ( $\chi= 283,78$ ;  $df=4$ ;  $p<0,05$ ).

The mean Slender-snouted Crocodile density in the Rusizi Burundian Delta (RBD) is 40 crocodiles/ km² (Table 2).

*The densities of Nile Crocodile and Slender-snouted Crocodile in the Ruzizi Delta*

The Ruzizi Delta includes the Ruzizi Congolese Delta (RCD) in the Democratic Republic of Congo (DRC) and the Rusizi Burundian (RBD) in the Republic of Burundi.

Figure 3 presents the comparison densities of Nile Crocodile and Slender-snouted Crocodile in the Ruzizi Congolese Delta (RCD) and the Rusizi Burundian Delta. The denser site in the Nile Crocodile in Rusizi Burundian Delta is the Great Rusizi River Mouth (GRRM), 35 crocodiles/ km², as well the denser site in the Ruzizi Congolese Delta (RCD) in Nile Crocodile is the site of the Small Ruzizi River Mouth (SRRM), 20 crocodiles/ km².

**Table 3. Crocodiles conservation strategic actions to undertake for the Ruzizi Congolese Delta**

Ecosystems	Site	Coordinates	Distance	Conservation Strategic Actions
LSA	SRRM	S 03° 21' 15.8'' / E 029° 12' 45.2'' 773m	3km	Protect lake shore areas
	Kilomoni 2	S 03° 20' 48.0'' / E 029° 11' 30.8'' 779m		Protect lagoons wetland areas
KCPO	KMPO	S 03° 20' 24.3'' / E 029° 12' 45.1'' 781m	1.5km	Protect wetland areas
	KCO	S 03° 20' 22.4'' / E 029° 12' 08.6'' 783m		Protect wetland areas
KyWA	KyPA	S 03° 20' 49.2'' / E 029° 11' 30.7'' 775m	3km	Protect pond and wetland areas
	KyWA	S 03° 21' 15.5'' / E 029° 12' 44.5'' 775m		Protect pond and wetland areas
KaWA	KaQO	S 03° 19' 50.8'' / E 029° 12' 11.2'' 774m	1.5km	Protect wetland areas
	NPEA	S 03° 20' 04.7'' / E 029° 12' 36.4'' 775m	3km	Protect pond and wetland areas
VCA	VCPO	S 03° 16' 08.5'' / E 029° 14' 27.1'' 781m	7km	Protect watercourse
	KiRSA	S 03° 15' 41.6'' / E 029° 13' 34.8'' 785m		Protect watercourse

**Legend:** LSA, Lake Tanganyika Shore Areas; SRM, Small Ruzizi River Mouth; KCPO, Kavimvira Congolese Post Office; KMPO, Kavimvira Migration Post Offices; KCPO, Kavimvira Customs Post Offices; KWA, Kavimvira Wetland Areas; KyWA, Kyamvubu Wetland Areas; KyPA, Kyamvubu Pond Areas; KyWA, Kyamvubu Western Areas; KaWA, Kahorohoro Wetland Areas; KaQO, Kahorohoro Quarter Office; NPEA, Nyangara Pond Eastern Area; VCA, Vugizo Congolese Area; VCPO, Vugizo Congolese Post Office; KiRSA, Kiliba Refectory Sugar Areas. **Source:** Our fieldwork 2019-2021. **Source:** *Our fieldwork of 2019-3021.*

**Table 4 Crocodiles conservation strategic actions to undertake for the Ruzizi Burundian Delta**

Ecosystems	Sites	Coordinates	Distance	Conservation Strategic Actions
LSA	GRRM	S 03° 21' 47.7'' / E 029° 16' 01.6'' 777 m	7km	Respect the PA's regulations
	SRRM	S 03° 21' 15.8'' / E 029° 12' 45.2'' 773 m		Respect the PA's regulations
GRRDS	GRRB	S 03° 20' 27.8'' / E 029° 16' 23.5'' 779 m	3km	Respect the PA's regulations
	GRRM	S 03° 21' 47.7'' / E 029° 16' 01.6'' 777 m		Respect the PA's regulations
GRRUS	GRRB	S 03° 20' 27.8'' / E 029° 16' 23.5'' 779 m	7km	Reforest a protective buffer zone
	VBS/Mpanda	S 03° 19' 00.3'' / E 029° 16' 49.3'' 775 m		Reforest a protective buffer zone
SLA	NPA	S 03° 21' 11.1'' / E 029° 16' 16.3'' 779 m	5km	Respect the PA's regulations
Pond Area	MP 1	S 03° 21' 13'' / E 029° 14' 50'' 772 m	1.5km	Reforest a protective buffer zone
Pond Area	MP 2	S 03° 21' 14' 36'' / 029° 36'' 773 m	1.5km	Reforest a protective buffer zone

**Legend:** LSA, Lake Shore Areas; GRRM, Great Rusizi River Mouth; SRRM, Small Ruzizi River Mouth; GRRDS, Great Rusizi River Downward Stream; GRRB, Great Rusizi River Bridge; GRRUS, Great Rusizi River Upward stream; VBS, Vugizo Burundian Site; SLA, Shrub Landscape Areas; NPA, Numerator Point Areas; MP1, Mukartutsi Pond 1; MP2, Mukartutsi Pond 2. **Source:** *Our fieldwork 2019-2021*

As well the denser site in the Slender-Snouted Crocodile in the Rusizi Burundian Delta is Vugizo (Vug), 63 crocodiles/ km<sup>2</sup> and the denser site in the Slender-snouted Crocodile in the Ruzizi Congolese Delta is the Small Ruzizi River Mouth (SRRM) site, 27 crocodiles/ km<sup>2</sup>. The

Nile Crocodile is denser in the lake shore area between the Great Rusizi River Mouth and the Small Rusizi River Mouth, yet the Slender-snouted Crocodile even if it is found in all the sampled sites, is denser in the Vugizo

**Table 5 Strategic Action Plan for the Ruzizi Delta Authorities in DRC and in Burundi**

	<b>Management Planning Strategic Targets</b>
<b>Environmental Quality Objective</b>	- Enhanced resilience of ponds and river banks;
Ponds, river banks and wetlands, as well as human societies are sufficiently resilient to adapt to impacts of climate change and variability by the Ruzizi Delta protected Areas Authorities;	- Increased preparedness and capacity to adapt to impacts of climate change;
	- Improved knowledge-base, monitoring and information-management mechanisms;
Erosion and sedimentation rates are reduced through sustainable land management practises around ponds, and river banks;	-Sustainable agriculture activities increased;
	- Deforestation rates decreased;
	- Sustainable land management strategies in place;
Critical habitats are protected, restored and managed for conservation of crocodiles and biodiversity;	-Protected area resource management improved;
	-Critical aquatic and terrestrial habitats protected, restored and managed;
Biological invasions are controlled and future invasions are prevented by the Authorities of Ruzizi Delta Protected Areas;	-Existing biological invasions controlled and prevented from further spreading;
	- Future invasions prevented;
Pollution is reduced and water quality is improved to meet regionally agreed standards by the LATAWAMA Project, good governance of the Ruzizi Delta protected Authorities in Burundi and in the DRC.	-Urban and industrial pollution reduced;
	- Agricultural pollution reduced;
	- Harbour and lacustrine traffic pollution reduced;
	- Pollution from mining activities reduced;
	-Risks related to petroleum exploration and production reduced.

**Source:** Adaptation of the Lake Tanganyika Authority Report (LTA, 2012)

(Vug) Site, almost 17 km upstream from the Lake Tanganyika Shoreline.

The means densities of crocodiles are greater in the protected Rusizi Burundian Delta for the Nile Crocodile (19/km<sup>2</sup>) and Slender-snouted Crocodile (40/km<sup>2</sup>) than in the unprotected Ruzizi Congolese Delta, Nile Crocodile (6/km<sup>2</sup>) and Slender-snouted Crocodile (11/km<sup>2</sup>). The difference was significant between the densities of Nile Crocodile and Slender-snouted Crocodile sampled from the unprotected Ruzizi Congolese Delta (T cal= 3,623; df= 12; p< 0,05). As well the difference was significant between the densities of Nile Crocodile and the Slender-snouted Crocodile sampled from the protected Rusizi Burundian Delta ((T cal= 8,008; df=8; p< 0,05). The difference between the densities of the Slender-snouted Crocodile sampled from the unprotected Ruzizi Congolese Delta (RCD) and the protected Rusizi Burundian Delta (RBD) was highly significant (T cal<sup>4</sup>= 14,017; df=10; p< 0,05). Finally the difference was highly significant between the density of two crocodile species of the unprotected Ruzizi Congolese

Delta and the protected Rusizi Burundian Delta (T cal= 14,957; df=22; p< 0,05).

### **Crocodiles conservation strategic actions in the Ruzizi Delta**

#### *The Ruzizi Congolese Delta*

Crocodile's conservation strategic actions for the Ruzizi Congolese Delta are presented by Table 3. The Ruzizi Congolese Delta (RCD) is a marshy area of approximately 51 km<sup>2</sup> (5,100 ha) including two natural ponds, still open to fishermen, farmers, herders, hunters and collectors of all kinds of tree, plant or vegetation. This management method leads to the waste of natural resources and damages the trees, plants and vegetation that protect crocodiles and biodiversity. The results of our research recommend the protection of these wetlands for the sustainable conservation of the crocodiles that have made their home there, and of its rich biodiversity.

<sup>4</sup> Student T test calculated 3 pages (Antoine, 2019)

For the Provincial Forum on Nature Conservation in the Province of South Kivu held in Bukavu from 06 to 08 November 2019 (FOPROCONA, 2019), this protection must go through the creation of a Community Reserve, which will then be submitted by the ICCN (Congolese Institute for the Conservation of Nature) to the Ramsar Secretariat for designation as a Congolese Ramsar site in the Ruzizi Congolese Delta. The procedure for this approach required that the Community Reserve Authority submit the request simultaneously to ICCN and to the Ramsar Secretariat to request the designation of the Ruzizi Congolese Community Delta Reserve (RCCDR) as a Congolese Ramsar Site in the Ruzizi Delta.

### *The Rusizi Burundian Delta*

Crocodile's conservation strategic actions for the Rusizi Burundian Delta (RBD) are presented by Table 4. The areas are legally protected. Crocodile conservation strategic actions that remain are to ensure respect the protected areas regulations along the Great Rusizi River banks and on the Lake Tanganyika shore areas and then, reforest buffer zones for demarcation of protected areas and urbanizing areas around Gatumba city and in Rusizi River Banks from Vugizo to the GRRM, including the Lake Tanganyika Shoreline between the Great Rusizi River Mouth and the Small Rusizi River Mouth.

### **Crocodiles management planning strategic targets**

Priority trans boundary concerns and national institutional mechanisms need to resolve the trans boundary threats to the biodiversity and natural resources have to be identified by creating the Ruzizi Delta Protected Areas Authorities in DRC and in Burundi (LTA, 2012). These two Authorities will deal with the Strategic Action Plan (SAP) summarised by Table 5.

## **Discussion**

### **Crocodiles Ecology**

#### *Ecological habitats of crocodiles in the Ruzizi Delta*

The Ruzizi Delta, northern end of Lake Tanganyika is situated in the Albertine Rift Valley between Burundi and the Democratic Republic of Congo (DRC). With an estimated age of 9-12 million years and a maximum depth of 1,470 meters, Lake Tanganyika is the oldest and deepest lake in Africa. It has a length of 673 km, total shoreline of 1,828 km, average width of 50 km, surface area of 32,600 km<sup>2</sup>, and an estimated volume of 18,900 km<sup>3</sup> (Cohen *et al.*, 1993); (Tiercelin & Mondeguer, 1991).

A wide diversity of aquatic habitats are found in the lake, including dense macrophytes, shallow nutrient and sediment rich plateaus near river deltas, extensive beds of

empty *Neothauma tanganyicenses* shells, cobble stones, rocky habitats, stromatolite congregations and large muddy areas that extend to the deepest depths of the lake. These habitats support a remarkable diversity of species, which have formed complex interrelationships and depend on the integrity of the lake ecosystem for their productivity (LTA, 2012).

In the Ruzizi Congolese Delta (RCD), crocodiles are found in Vugizo, the outlet of the Small Ruzizi River out of the Ruzizi River, which becomes the Great Rusizi River (GRR), entirely in the Republic of Burundi. In the Rusizi Burundian Delta (RBD), crocodiles are found in the Great Rusizi River, in the Great Rusizi River Mouth, along the Lake Tanganyika littoral zone, including the Mukartutsi 1 & 2 Ponds, and a few in the Gatumba marshes. These findings corroborate the book (Ross, 1998) stating that Crocodylians (crocodiles, alligators, caimans, and gharials), are prominent and widespread occupants of tropical and subtropical aquatic habitats.

### **Crocodile's abundance in the Ruzizi Delta**

In the Ruzizi Congolese Delta (RCD), crocodiles are more abundant in the site of Vugizo due to crocodiles of DRC from the entrance of Runingu River into the Ruzizi River and the out let of the Small Ruzizi River from the Great Rusizi River. These places of entry of the Runingu River into the Rusizi River and exit of the Small Ruzizi River from the Great Rusizi River, is the stronghold of the crocodiles of the Ruzizi Delta. We met the two species of crocodiles there: Nile crocodile, *Crocodylus niloticus* (Laurenti, 1768) the less abundant, and the Slender-snouted, *Mechistops leptorhynchus* (Shirley *et al.*, 2018), the most abundant crocodile, living in full harmony because these environments are rich in fish, thanks to abundant vegetation and hippos which as well have made their home there (Cyrille *et al.*, 2017). The interrelationships of this cohabitation of crocodiles and hippos are still to be elucidated (CSG & IUCN, 1989) by further investigations. At first, we argue that the excrement of herbivorous hippos are the main food of fish in that area, and that piscivorous crocodiles, feeding on sick and very old fish clean up the environment and these interactions, promote the life of each other, fish, hippos and crocodiles. The Slender-snouted Crocodile is one crocodylian that people acknowledge as harmless to humans compared to the Nile Crocodile, but being a fish eater it is treated as a competitor (Cyrille *et al.*, 2017). This triangular junction of the Runingu River, the Great Rusizi River and the Small Ruzizi River is as far from homes on the Burundian side at about seven kilometres from homes as on the Congolese side at about four kilometres from homes.

The first challenge is the free access to natural resources on the Congolese side. The second challenge is that the Lake Tanganyika has the most abundant and permanent waters but crocodiles are most found in the entrance of Runingu River into Rusizi River, not so far downstream to

the Vugizo areas, 17 km upstream from Lake Tanganyika due to environment degradation in the Lake Tanganyika littoral areas (Mike & Greg, 2013).

### **The densities of Nile Crocodile and Slender-snouted in the Rusizi Delta**

The Ruzizi Delta, northern end of Lake Tanganyika, in the Republic of Burundi and in the Democratic Republic of Congo, is a unique ecosystem and this is reflected in its extraordinary biodiversity, flora, fish, birds, crocodiles and hippopotami. The Nile crocodile (*Crocodylus niloticus* Laurenti, 1768) and the Slender-snouted Crocodile (*Mecistops leptorhynchus*, Shirley *et al*, 2018) are the apex predators, and perform a number of vital functions in this system, making it a keystone species (Sven, 2007). The Ruzizi Delta crocodile population has declined significantly over the last 25 years and is now threatened as a result of past over-exploitation and present human disturbance. In order to effectively conserve these species and in turn the health of this important region it is imperative to gain an understanding of their ecology and population dynamics (Sven, 2007).

The mean densities of crocodiles are greater in the protected Rusizi Burundian Delta for the Nile Crocodile (19/ km<sup>2</sup>) and the Slender-snouted Crocodile (40/ km<sup>2</sup>) than in the unprotected Ruzizi Congolese Delta, Nile Crocodile (6/ km<sup>2</sup>) and Slender-snouted Crocodile (11/ km<sup>2</sup>). The difference is significant between the densities of Nile Crocodile and Slender-snouted Crocodile sampled from the unprotected Ruzizi Congolese Delta (T cal= 3,623; df= 12; p< 0,05). As well the difference is significant between the densities of Nile Crocodile and the Slender-snouted Crocodile sampled from the protected Rusizi Burundian Delta ((T cal= 8,008; df=8; p< 0, 05).

The difference between the densities of the Nile Crocodile and the Slender-snouted Crocodile in the Burundian Delta (RBD) is highly significant (T cal<sup>5</sup>= 14,017; df=10; p< 0,05). Finally the difference is highly significant between the density of two crocodile species of the unprotected Ruzizi Congolese Delta and the protected Rusizi Burundian Delta (T cal= 14,957; df=22; p< 0,05). These results corroborate the findings of Sven Leon Bourquin, 2007 for Nile crocodile (*Crocodylus niloticus*) in the Panhandle Region of the Okavango Delta, Botswana (Sven, 2007).

### **Crocodiles conservation strategic actions in the Ruzizi Delta**

#### *The Ruzizi Congolese Delta*

The procedure for lasting crocodiles conservation in the Ruzizi Delta requires creating a protected area in the Ruzizi Congolese Delta (RCD), which will be led by a Community Reserve Authority, who will submit the request for a Ramsar Site designation in the Ruzizi

Congolese Delta simultaneously to ICCN(the Congolese Institute for Nature Conservation) and to the Ramsar Secretariat. The Ruzizi Congolese Delta Authority will connect with the Rusizi Burundian National Park Authority for financial projects to support conservation strategic actions for both, the Rusizi Burundian Delta and the Ruzizi Congolese Delta with transboundary conservation arguments (LTA, 2012).

For the Ruzizi Congolese Delta (RCD), almost 51 km<sup>2</sup> of wetland areas, including the western Small Ruzizi River bank, two natural ponds and the Lake Tanganyika shore areas between the Small Ruzizi River Mouth and the Kilomoni 2 beach, are still available for crocodiles and biodiversity conservation. According to the FAO (World Food and Agriculture Organisation) and UKAID (United Kingdom managing Aid for the poor Developing countries), the loss of primary forests contributing to climate change continues at an alarming rate (FAO & UKAID, 2015).

Once systematically protected, the wetlands of the Ruzizi Congolese Delta will become a permanent forest with regular circulation of water from rivers, streams, lagoons and the lake subject to the Congolese forest code (Kabila, 2003). According to article 45 paragraph 2 page 9 of the forest code in the DRC, are particularly prohibited, all acts of deforestation of areas exposed to the risk of erosion and flooding as is the case for the west bank of the Small Ruzizi River, on the shore of Lake Tanganyika at Kilomoni 2 and on the shores of the Kyamvubu and Nyangara ponds, targeted by this study (Kabila, 2003). Also, according to article 48, page 9 of the DRC forest code, all deforestation over a distance of 50 meters on either side of the rivers and within a radius of 100 meters around their sources is prohibited (Kabila, 2003).

Then, according to article 51, page 9 of the DRC forest code, in order to protect the biological diversity of the forest, the administration in charge of forests, even in the designated forest areas, can set aside certain species or enact any restrictions it may require find it useful (Kabila, 2003). Finally according to article 77, page 13 of the DRC forest code, the administration in charge of forests ensures the reconstitution of forests through the development and application of natural regeneration and reforestation programs that it updates regularly (Kabila, 2003). Within the meaning of Law No. 11/2002 of August 29, 2002 on the commented and annotated forest code, supplemented version, conservation means management measures allowing a sustainable use of forest resources and ecosystems, including their protection, maintenance, restoration and improvement (VUNDU & KALAMBAY, 2013). My doctoral research is going a long way to provide the needed information for the Ruzizi Congolese Delta wetlands protection for crocodiles and biodiversity

<sup>5</sup> Student T test calculated 3 pages (Antoine, 2019)



conservation. The Provincial Forum on Nature Conservation (FOPROCONA) in the Province of South Kivu had decided to set up a National Advisory Council (CCNF) and Provincial Forestry Advisory Councils (CCPF) for such decision makings.

The first, the National Advisory Council will mainly deal with planning and coordination of the forest sector at the national level, while the second, the Provincial Forest Advisory Council will oversee the forest management of the provinces and other decentralized entities, on the one hand, and of on the other hand, they will be responsible for giving advice on forest classification or declassification projects (CFAC & FOPROCONA, 2019). The results of our doctoral thesis will first be submitted to the Provincial Consultative Council of the Forests of South Kivu which will be able to give its opinion on the classification of the wetlands of the Ruzizi Congolese Delta with a view to their protection as a Congolese Community Reserve in the Ruzizi Delta (CFAC & FOPROCONA, 2019).

The notice of the creation of a Community Reserve of the Ruzizi Congolese Wetlands came out of this Provincial Forum on the Conservation of Nature of Bukavu from September 6 to 8, 2020 (CFAC & FOPROCONA, 2019). We thus started by targeting the Ruzizi Congolese Delta to then extend our investigations to the entire Ruzizi Congolese Plain when the time and financial supports will be available.

The scope of international and especially regional dialogue on the conservation of biological diversity is often limited to the national level, indigenous and local communities are not at all affected by these international and sub-regional dialogues, whereas they are at the centre of the issue of the sustainable use of forest resources in general and wildlife in particular (CFAC & FOPROCONA, 2019).

### **The Rusizi Burundian Delta**

The Rusizi Burundian Delta areas are legally protected. Crocodile conservation strategic actions that remain are to ensure respect the protected area regulations along the Great Rusizi River banks and on the Lake Tanganyika shore areas and then, reforest buffer zones for demarcation of protected areas and urbanizing areas around Gatumba city (IUCN, 2010).

The deltaic form of the outlet Small Ruzizi River out of the Great Rusizi and their mouths into Lake Tanganyika is a permanent tropical inland delta, renowned for its biodiversity, which includes impressive resident and migratory bird fauna, a rich endemic fish fauna, a specialized plant flora as well as hippopotami, viverrids, antelopes, small mammals, African Crocodiles, and smaller lizards, snakes and amphibia (IUCN, 2010).

The Rusizi floodplain, upstream of the delta is also of great regional importance as it supports the livelihoods of tens of thousands of Burundian and Congolese people who cultivate, fish, graze cattle and harvest wetland products, as well as harbouring an important biodiversity of a Central African floodplain in the Albertine Rift Valley (IUCN, 2010).

However, conflicts have erupted over natural resource use and current resource use patterns are proving to be unsustainable. The main reason is thought to be lack of awareness of the globally important wetland resources of the Rusizi floodplain, delta and adjacent littoral zone (IUCN, 2010). These wetland resources are currently increasingly being exploited as a result of the ever-increasing human population and economic pressures. Reviews have shown that loss and degradation of habitat, sedimentation due to deforestation, eutrophication, inappropriate introduction of alien species that have become invasive, excessive water withdrawal, overexploitation of riparian and woodland resources, and pollution are the leading causes of fresh water species decline (IUCN, 2010).

These threats stem from the ever increasing demand for goods and services by the human population. Furthermore, owing to civil insecurity in both Bujumbura and Uvira, refugees have put an enormous pressure on the fisheries, forest and wetland resources of the (former) Rusizi National Park thus its downgrading from a national park to a nature reserve, which allows for some human activities (IUCN, 2010). There is little or no coordinated management of the Rusizi floodplain, delta and adjacent littoral zone at the national level and transboundary level (it is shared by Burundi and DR Congo) and as a result, current resource-use practices are not sustainable. It has been acknowledged that this is a problem and help is being sought (IUCN, 2010).

The coordination of an Authority for the Ruzizi Congolese Delta Community Reserve and the Authority for the Rusizi Burundian Delta National Park is an innovation suggested by this doctoral thesis for wise biodiversity conservation of the Ruzizi Delta in the Republic of Burundi and in the Democratic Republic of Congo, the northern end of Lake Tanganyika, in east Africa.

### **Crocodile's management planning strategic targets**

Priority trans boundary concerns and national institutional mechanisms needed to resolve the trans boundary threats to the biodiversity and natural resources have to be identified by creating the Ruzizi Delta Protected Areas Authorities in DRC and in Burundi (LTA, 2012). These two Authorities will deal with the Strategic Action Plan needed for the wise biodiversity conservation in the area, including the creation of a protected wetland community reserve in the Ruzizi Congolese Delta, whose Authority will join the Rusizi Burundian National Park

Authority for transboundary strategic action plan to submit together to partners (LTA, 2012). The Ruzizi Delta Strategic Action Management programme will address problems in a systemic manner both in Burundi and in the DRC and identify six main priorities. These priorities are: (a) adaption and resilience to climate change impacts, (b) sustainable fisheries, (c) sustainable land management, (d) protection, restoration and management of critical habitats, (e) control and prevention of biological invasions, and (f) reduced pollution and improved water quality (Bank, 2018).

The Ruzizi Delta Management Programme may at first focus on two top priorities from the list: (i) adaption and resilience to climate change impacts by protecting wetlands and reforesting a buffer zone for demarcation of the protected areas; (ii) protection, restoration and management of critical habitats (Bank, 2018). In addition, The Ruzizi Delta Strategic Action Plan Programme will contribute to enhancing resilience of communities and ecosystems to climate change impacts (Bank, 2018). Funders are the DRC, the Republic of Burundi, LTA (Lake Tanganyika Authority), local, national and international Non-Government Organisations (NGOs).

Funders may increase according to the strategic management plan adopted by the authorities both in the Ruzizi Congolese Delta and in the Rusizi Burundian Delta to enhance among the following areas (GEF & UNEP, 2020): Sustainable Agriculture, Sustainable Fire Management, Sustainable Pasture Management, Sustainable Forest, Ecosystem Approach, Restoration and Rehabilitation of Degraded Lands, Community-Based Natural Resource Management, Improved Soil and Water Management Techniques, Influencing models, Convene multi-stakeholder alliances, Demonstrate innovative approaches, Strengthen institutional capacity and decision-making, Stakeholders, Beneficiaries, Indigenous Peoples, Private Sector, Large corporations,

Individuals/ Entrepreneurs, SMEs (Small and Medium-sized Enterprises), Financial intermediaries and market facilitators, Local Communities, Civil Society, Community Based Organization, Academia, Non-Governmental Organization, Gender Equality, Gender Mainstreaming, Sex-disaggregated indicators, Women groups, Gender-sensitive indicators, Gender results areas, Capacity Development, Awareness Raising, Knowledge Generation and Exchange, Access and control over natural resources, Participation and leadership, Capacity, Knowledge and Research, Enabling Activities, Knowledge Exchange South-South, Peer-to-Peer, Field Visit, Conference, Knowledge Generation, Workshop, Training, Innovation, Learning, Indicators to measure change, Adaptive management, Targeted Research (GEF & UNEP, 2020). It might be decided to encourage the establishment of a commercial Nile Crocodile (*Crocodylus niloticus*) and Slender-snouted Crocodile (*Mecistops leptorhynchus*) skin

industry based upon the wild population or upon captive-bred crocodiles (CSG & IUCN, 1989).

## Conclusion

We investigated the ecology, conservation and management of crocodiles in the Ruzizi Delta, in the Republic of Burundi and in the Democratic Republic of Congo, the northern end of Lake Tanganyika. On the ecology side, we focused on the distribution, abundance and density of the two species of crocodiles found in their respective habitats. Regarding conservation, we referred to previous surveys among users of wetlands, to propose the creation of a community reserve in the Ruzizi Congolese Delta, as it had been suggested during the Provincial Forum on the Conservation of Nature from 06 to 08 September 2020 in Bukavu, capital of the Province of South Kivu. As for the management of crocodiles and the biodiversity of the Ruzizi Delta, we have proposed a strategic action plan to be jointly addressed by the two authorities of the Ruzizi delta in the DRC and the Rusizi delta in Burundi.

We have shown that both abundance and density of crocodiles are statistically higher in the protected areas of the Rusizi Burundian Delta, compared to those of the Ruzizi Congolese unprotected delta.

We suggested the protection of the wetlands of the Ruzizi Congolese Delta in order to perpetuate the conservation of crocodiles of the Rusizi Burundian Delta, to mitigate the impacts of climate change, and contribute to the sustainability of the conservation of crocodiles and the biodiversity of Lake Tanganyika, already inscribed on the list of world heritage protected by UNESCO. We are convinced that the development of joint projects at regional and international levels will ensure the conservation of crocodiles in the Ruzizi Delta, to the point of considering industrial commercial transactions of crocodile skins on the wild population and even on the breeding of crocodiles in captivity as is done in Côte d'Ivoire with the financial support of the Crocodile Specialists Group.

## Recommendations

At the end of this chapter on the ecology, conservation and management of crocodiles in the Ruzizi Delta, the northern end of Lake Tanganyika, our recommendations are addressed in turn to the local population using wetlands, to the local administration, to the provincial government of South Kivu, to the national government of the Democratic Republic of Congo, to the Congolese Institute for the Conservation of Nature (ICCN), and finally to the government of the Republic of Burundi.

To the local population, we recommend: (i) to respect the 50 meters of shoreline on the banks of rivers, on the shores

of natural ponds, the coast of Lake Tanganyika because they are reserved for wild animals and biodiversity, article 48 forest code, page 9 (Kabila, 2003) ; (ii) to subscribe to the protection of the Ruzizi Congolese Delta wetlands as a Community Reserve in the Ruzizi Congolese Delta for the conservation of biodiversity, for their socio-cultural and economic promotion; (iii) to respect the breeding areas of crocodiles and hippos so as not to get caught by crocodiles or be killed by hippos; (iv) denounce poachers of aquatic animals such as crocodiles, hippos and birds; (v) to practice citizen actions to protect their environment such as the cultivation of fruit tree reforestation, erosion control, trees for shelter, for firewood, and for crop protection and erosion protection hedges; (vi) to practice responsible fishing by avoiding the use of mosquito nets and very small mesh nets which catch very young fish (IRSNB & UE, 2009);

To the local administration at the levels of the Town Hall, groups and districts up to the heads of avenues: (i) to properly supervise the population by enforcing the laws and regulations on the protection of the environment; (ii) not sell by lots wetlands, breeding areas for crocodiles and hippos; (iii) to discourage the recovery of areas flooded by the rising water levels of May 16- 17, 2020, which until now remain occupied by crocodiles, hippos and particularly aquatic birds protected by law; (iv) not to practice agriculture within 50 meters of shore to avoid getting caught by crocodiles or being killed by hippos; (v) to allocate to the households of the disaster victims of May 16- 17, 2020, who still remain in disaster camps or in host families, non-marshy plots so that they do not return to the coastal areas, or on the banks of rivers or the shores of natural ponds, Lake Tanganyika or permanent lagoons;

7.3 To the provincial government of South Kivu, to decide on the classification of the wetlands of the Ruzizi Congolese Delta for the creation of a community reserve for the conservation of crocodiles and biodiversity and the economic promotion of stakeholders;

To the national government of the Democratic Republic of Congo to support the classification of the Ruzizi Congolese Delta wetlands by a ministerial decree for their protection as the Ruzizi Community Reserve (RCR) in the Ruzizi Congolese Delta (RCD);

To the Congolese Institute for the Conservation of Nature (ICCN), to receive the Ruzizi Community Reserve of the Ruzizi Congolese Delta among its protected areas under its jurisdiction, and to submit it to the Ramsar Secretariat for its designation as a Ruzizi Congolese Ramsar Site in the Ruzizi Congolese Delta;

To the government of the Republic of Burundi, to enforce the laws and regulations on environmental protection and to reforest a buffer zone demarcating the urban spaces of Gatumba City from the protected areas of the Ruzizi National Park (PNR).

## Conflicts of Interest

Authors declare that there is no conflict of interests regarding the publication of this paper.

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**Appendix 1.** Slender-Snouted Crocodile Faux gavia d’Afrique Centrale *Mecistops leptorhynchus* (Shirley et al, 2018) of CRH-Uvira  
 Source: Our fieldwork 2019-2021



**Appendix 4.** Crocodiles Sampling in Kyamvubu Pond Ruzizi Congolese Delta, DRC  
 Source: Our fieldwork 2019-2021



**Appendix 2.** Public awareness on wetlands protection for crocodile’s conservation in the Ruzizi Congolese Delta and along the Lake Tanganyika Shoreline at Uvira (Kilomoni 2)  
 Source: Our fieldwork 2019-2021



**Appendix 5.** Crocodiles sampling in the Rusizi National Park, Burundi  
 Source: Our fieldwork 2019-2021, photography of Kisaro Mahangaiko



**Appendix-3.** Nile Crocodile Crocodile du Nile (*Crocodylus niloticus* Laurenti 1768) of CRH-Uvira  
 Source: Our fieldwork 2019-2021