# CROCODILES OF CONSERVATION IMPORTANCE IN THE RUZIZI PLAIN, SOUTH KIVU, DEMOCRATIC REPUBLIC OF CONGO: A POTENTIAL RAMSAR SITE

**BY**

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## LIST OF ACRONYMS

| | | |
|---|---|---|
| CBD | : | Convention on Biological Diversity |
| CITES | : | Convention on International Trade in Endangered Species of wild Fauna and Flora |
| CMS | : | Convention on the Conservation of Migratory Species of wild Animals |
| CSG | : | Crocodile Specialists Group |
| CSM | : | The Christian Science Monitor |
| CRH | : | Centre for Research in Hydrobiology (Uvira, DRC) |
| CRSN | : | Centre de Recherche en Sciences Naturelles (Lwiro, DRC) |
| DFID | : | Department for International Development (United Kingdom) |
| DRC | : | Democratic Republic of Congo |
| GPS | : | Global Positioning System |
| ICCN | : | Institut Congolais pour la Conservation de la Nature (DRC) |
| IUCN | : | International Union for Conservation of Nature- The World Conservation Union |
| MEA | : | Millennium Ecosystem Assessment |
| MENCT | : | Ministry of Environment, Nature Conservation and Tourism |
| MDG | : | Millennium Development Goal |
| RBP | : | Rusizi Burundian plain |
| RCP | : | Ruzizi Congolese plain |
| RRP | : | Rusizi Rwandian plain |
| NGO | : | Non-Governmental Organization |
| USAID | : | United States Agency for International Development |

| | | |
|---|---|---|
| UNDESA | : | United Nations Department of Economic and Social Affairs |
| UNDP | : | United Nations Development Program |
| UNEP | : | United Nations Environmental Program |
| UNESCO | : | United Nations Organization for Education, Science and Culture |
| WCMC | : | World Conservation Monitoring Centre |
| WCS | : | Wildlife Conservation Society |
| WEC | : | World Energy Council |
| WWC | : | World Water Council |
| WWF | : | World Wide Fund for Nature |

**ABSTRACT**

In the Democratic Republic of Congo (DRC), biodiversity components provide products and services that millions of people depend on. However, many of the wild animals legally protected in DRC are found in unprotected wetlands where they are also threatened and declining and this can have serious livelihood consequences for the communities who depend on them. Identifying which species are most at risk and which ones are to be conserved is therefore critical. In this study I undertook a survey in the Ruzizi Congolese plain, South Kivu Province, eastern end of DRC, to assess crocodiles which are protected animals by the Constitution o DRC, but here they are found in unprotected wetland, the Ruzizi Congolese plain.

Crocodiles were counted using visual encounter surveys in 17 sites of the Ruzizi Congolese, Burundian and Rwandian plains, in wetland as well as in lake shore and landscape areas. Fieldwork took place during November 2011.

Two species of crocodiles were recorded: Nile Crocodile (*Crocodylus niloticus*) and Sharp-nosed Crocodile (*Crocodylus cataphractus*). The densities and relative abundances in Burundi were significantly greater than the densities and relative abundance of crocodiles in DRC.

The study showed that many wild crocodiles even protected animal by international environmental law and by the constitution of DRC were facing diverse and high levels of defaunation, deforestation and habitat encroachment viewed largely as human function actions in the Ruzizi Congolese plain. Then, for them to persist in the future in the area, there is a need to work with farmers, cattle keepers and fishermen for a compliance with the environmental law of 20 to 50 m free from ponds, rivers and lake shore area as stated by the Forest code (Law No 11/02, dating 29th August 2002). Human factors that

influenced conservation of biodiversity in Rwanda should be applied by local DRC people for wise agriculture to mitigate hill soil erosion, wildlife respect, and wise cattle keeping and landscape reforestation.

Finally, NGOs and the DRC local, provincial and national governments should use this data to suggest the designation of the Ruzizi Congolese plain as a Ramsar site as the case is in Burundi for the Rusizi Burundian Ramsar site. The Ramsar designation will greatly improve the conservation status and the biodiversity of the Ruzizi Congolese plain.

# CHAPTER ONE:

# GENERAL INTRODUCTION

## 1.1 Background

Wetlands, freshwater habitats and the species they support are among the most threatened ecosystems worldwide (Dudgeon, 2000; Abell, 2001; Beeton, 2002; Jenkins, 2003; Barret *et al.*, 2003; Dudgeon e*t al.*, 2005; Revenga *et al*., 2005;Thieme *et al.*, 2005 and Abell *et al.*, 2007). This problem is particularly pressing in the African Rift Valley region, where the need for reliable freshwater resources is increasing due to rampant population growth while degradation of freshwater habitats continues unabated (Odada *et al.*, 2003, 2004; Darwall *et al.*, 2005; UNEP, 2005 and Olago & Odada, 2007).

The Albertine Rift is one of the most important regions for conservation in Africa. It contains more vertebrate species than any other region on the continent and contains more endemic species of vertebrate than any other region on mainland Africa (Plumptre *et al*., 2007). The Ruzizi flood plain comprises of the Ruzizi Congolese plain, the Rusizi Burundian plain and the Rusizi Rwandian plain. The Ruzizi flood plain, a wetland located in the southern part of the Albertine Rift, provides resources for the expanding human populations while simultaneously conserving biodiversity. The Ruzizi Congolese plain are located on western side of the Ruzizi River; the Rusizi Burundian plain is located on the eastern south of the Ruzizi River and the Rusizi Rwandian plain, is the north eastern part of the Ruzizi flood plain. The river is called Ruzizi in DRC, and Rusizi in Burundi and in Rwanda.

Biodiversity refers to the variety of life on Earth. As defined by the United Nations Convention on Biological Diversity, it includes diversity of ecosystems, species and genes, and the ecological processes that support them. Natural diversity in ecosystems provides essential economic benefits and

services to human society such as food, clothing, shelter, fuel and medicines, as well as ecological, recreational, cultural and aesthetic values, and thus plays an important role in sustainable development (CBD, 2007).

Conservation of biodiversity in the Ruzizi Congolese plain is important for several reasons. Wetlands are a globally significant hotspot of freshwater biodiversity and endemicity (Groombridge & Jenkins, 1998). Estimates suggest the Ruzizi Congolese plain supported 242 bird species (Pedersen, 2000), although species number might be updated; they could also vary according to the taxonomic authority. Invertebrates, amphibians, reptilians, birds and mammals have not yet been systematically studied in the Ruzizi plain.

Moreover, the Ruzizi Valley is listed as an important area for birds, both in Burundi (Gaugris & Vande Weghe 1993) and in DRC (Demey & Louette, 2001), but because of lack of local data on birds, the Ruzizi Congolese plain have not yet been listed accordingly, as an Important Bird Area (IBA) by Birdlife International. On the other hand, the Ruzizi Congolese plain provides an important source of drinking-and domestic water, means of transportation, and economic venues for an estimated total of 120,000 people, including 19,500 Burundians who sought refuge since 2004 (Mushombe, 2010;Vircoulon, 2011).

The Ruzizi Congolese people have been very unstable during the last ten years. According to Mangala (2011), 63, 898 people have been repatriated into and around the area as following: 6,744 people in December 2005; 16, 500 in 2006; 24, 750 in 2007; 14, 550 in 2008; 1, 299 in 2009, and finally 54 people repatriated in 2011. The instability of local people has a negative influence on biodiversity by decreasing local people's incomes and increasing their complete dependence on natural resources.

Local people are merely farmers, fishermen, cow keepers, and state workers with a mean salary of almost 50,000 Congolese francs per month, equivalent of $ 56 ($ 1.9 per day) for a state diploma teacher in primary and/ or secondary school, single or married, without or with children. Local people's incomes are very low so that their livelihoods pressure accelerates the decreasing of biodiversity and other natural resources of the area. There is no electricity, no regular road in the area, and only very few people have access to the only station of clear drinking water, located 1.5km from the nearest village. To meet the Millennium Development Goals, particularly the goal of halving extreme poverty, talking about environmental and biodiversity degradation is an integral part of effective and lasting poverty reduction (Wolfensohn *et al.*, 2002).

The area is intensively cultivated, and the wet areas are frequented by domestic cattle in the dry season when large areas of wetland are burned. Reeds are used for thatching and other domestic crafts. The Ruzizi Congolese plain is one of the most eroded and deforested area in all of tropical Africa and as the region becomes more densely populated, some species of wildlife are dwindling or disappearing. Much of the land has suffered a loss of fertility because of soil erosion from poor agricultural practices, irregularity of rainfall, lack of fertilizer, and shortened fallow periods (Mushombe, 2010; Vircoulon, 2011).

In general, the conservation of tropical freshwater biodiversity is hampered by a lack of essential ecological data (Dugeon, 2000, 2003; Abell, 2001). There is increasing concern that the emphasis of applied research on economically important taxa reduces the capacity to understand the functioning of wetland ecosystems as a whole (Denny, 2000, 2001; Moss, 2000; Meester & Declerck, 2005; Lévêque et al., 2005; Moustakas & Karakassis, 2005). To better understand patterns of freshwater biodiversity and the functioning of wetland ecosystems, data on key functional groups is critical.

In this study, faunal communities of the Ruzizi plain were used as a case study for examining ramifications of conservation decisions focusing on crocodiles which are known to be protected by the Constitution of the DRC, when they are found in protected area. But in the unprotected Ruzizi Congolese plain, they are facing high and diverse threats relating to defaunation, deforestation and human settlements in wetland areas.

This study has provided empirical and local data that can serve as a framework for initiatives aiming to preserve biodiversity in the Ruzizi Congolese plain by designating the area as a National Protected Reserve, to be ten designated as a Ramsar Site, for the sustainability of natural resources found in general in that large wetland area, like the neighbour Ramsar Site of Burundi.

By investigating the movements of crocodiles, I wanted to indicate that riparian countries cannot distinguish their own animals and so that they have no right to agree with local people pressure of hunting them even when local people's demands are highly being done in the Ruzizi Congolese plain. The area might be managed by international environmental law as Ramsar site now implemented on the side of Burundi, but the Ruzizi plain of the DRC's side, still is an unprotected area.

### 1.2 Links of reptiles and ecosystems

Biodiversity is the resource upon which families, communities, nations and future generations depend. It is the link between all organisms on earth, binding each into an interdependent ecosystem, in which all species have their role. The Earth's natural assets are made up of plants, animals, land, water, the atmosphere and humans. Together we all form part of the planet's ecosystems, which means if there is a biodiversity crisis, our health and livelihoods are at risk too.

According to CBD (2005), humans are currently using 25% more natural resources than the planet can sustain. As a result species, habitats and local communities are under pressure or direct threats (for example from loss of access to fresh water). Biodiversity underpins the health of the planet and has a direct impact on all human lives. Human health is strongly linked to the health of ecosystems, which meet many of human's most critical needs.

I examined the biodiversity of conservation importance in the Ruzizi plain, focusing on reptiles, the case of crocodiles which have never been studied in the area.

The Ruzizi flood plain is a large permanent wetland in the southern part of the Albertine Rift, closely connected to the northern end of Lake Tanganyika, including the Ruzizi delta (Rusizi Burundian Ramsar site), which is worldwide known as hotspots for biological diversity and endemism. Biodiversity studies are very important to set global and national facilities including designation of Ramsar site on the Congolese side of the Ruzizi River.

The Ramsar criteria are measures for species of conservation importance of a given area (Fishpool & Evans, 2001; Demey & Louette, 2001; CBD, 2005; Ramsar convention, 2007).

Among the reptiles, crocodiles presented a particular ecological interest of lacking data on abundance and species richness, both in the Ruzizi Congolese and the Rusizi Burundian areas. Economical and cultural importance of crocodiles is increasing and their trade in Tanzania (Castro, 2012) has raised additional reason for them to be studied and suggested for effective conservation in the area.

Moreover, crocodiles are cornerstone species to design the area as a national reserve in DRC, because these are vulnerable animals found in unprotected wetlands.

In this dissertation, chapter one concerns the general introduction: background, problem statement and objectives of the study. Chapter two deals with the literature reviews on biodiversity, conservation and the millennium development goals of environmental and biodiversity sustainability. Chapter three reports the methods and materials used to crocodiles. Chapter four underlines the results, chapter five gives the discussion and finally, chapter six deals with the conclusion and recommendations.

## 1.3 Problem statement and rationale

The Democratic of Congo (DRC) is endowed with a wealth of natural resources which, if managed properly, can help the country recover from the devastation created by years of conflict and mismanagement that have made it the poorest country in Africa. According to Seyler *et al* (2010), the country has fertile soils, ample rainfall, immense water resources, enormous mineral wealth, immense wetlands and the second largest block of tropical forest in the world (145 millions hectares approximately 62 percent of national territory).

The forests and wetlands are critical to the livelihood of about 66 million Congolese (census 2009), providing food, medicine, domestic energy, building materials, and cash. Forests play a vital role in regulating the global environment. They harbour much unique biodiversity.

DRC's wetlands and forests could provide many national and global benefits in perpetuity. Yet DRC's wetlands, forests and biodiversity are under threats from a variety of fronts including clearing for agriculture, illegal logging, a high rate of bush meat consumption, population growth and migration, poverty, and conflict. Recognizing these and other threats, the Government of DRC

seeks to develop and institutionalize a vision of DRC's forests and wetlands as an enduring provider of multiple goods and services rather than an arena for the rapid extraction of timber and other resources. In 2002, the government of the DRC committed to increase protected areas coverage to 15% from just over 8%, to undertake a country wide biodiversity assessment, including a rapid inventory and prioritization of the biodiversity value of wetlands (ICCN, 2007).

Integration of biodiversity into local business decision- making and management through Operational Excellence Management system needs local data on biodiversity monitoring and conservation as well as Environmental; Social and Health Impact Assessment; and Risk Management system (Seyler *et al.*, 2010). Local data have been lacking, thus the study pointed first of all birds, crocodiles and hippopotami, for the Ruzizi Congolese plain to be listed as an Important Bird Area, and finally to be designated as Ramsar site like its neighbouring Rusizi Burundian Ramsar Site.

Understanding that humans and the natural environment are interdependent and interact with each other in various ways is the only way to save the remaining biological diversity of the Ruzizi Congolese plain. The Ruzizi Congolese plain can be integrated into the national and international networks of protected areas, by being designated as a Ramsar site which is only possible through local scientific findings. My study is going a long way in providing information required for the conservation of the Ruzizi Congolese plain.

## 1.4 Objectives

### 1.4.1 General objective

Investigate the status of crocodiles in the Ruzizi plain.

### 1.4.2 Specific objectives

- Compare abundance and density of crocodiles of the Ruzizi plain, between the Ruzizi Congolese plain and the Rusizi Ramsar site of Burundi ;
- Identify environmental and human factors that influence conservation of Crocodiles, in the Ruzizi Congolese plain, the Rusizi Burundian plain, and the Rusizi Rwandian plains;
- Suggest the plots of a potential Ramsar site in the Ruzizi Congolese plain.

### 1.4.3 Justification of the study

The study was highly significant for the followings:

- Updated data to launch the natural protected national reserve of the Ruzizi Congolese plain for biodiversity conservation;
- Sensitize local people, local and national governments of DRC to the necessity of environmental law implementation by applying the human factors that influence conservation of biodiversity in Burundi, and in Rwanda;
- Local, national and international NGOs will use local data for decision making to biodiversity conservation in the Ruzizi plain (DRC, Burundi and Rwanda), and in Lake Tanganyika by mitigating the sedimentation of the Ruzizi River;
- Pupils, students, and researchers of DRC will use local updated data to facilitate their education.

According to Buyinza (2009), ecosystem services are the multiple benefits provided by ecosystems (wetlands, ponds, lake, forests etc) to humans. Human use of ecosystem services of all ecosystems is increasing; while the use of resources such as food, water and timer has increased rapidly, and continues to grow, sometimes unsustainably. Today, rapidly growing demands for food, freshwater, timber, fibber, and fuel are increasing; the result has been a substantial and largely irreversible loss in the diversity of life on Earth.

Human interventions have led to changes in the regulation of climate, disease, and other ecosystem processes. The use of ecosystems for recreation, spiritual enrichment, and other cultural purposes is growing. However, the capacity of ecosystems to provide these services has declined significantly. The case of waterbirds, crocodiles and hippopotami in the Ruzizi Congolese plain is examined, discussed and suggested to a Ramsar site for biodiversity and ecosystem sustainability.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 Ecosystems and biodiversity services

Loss of biodiversity results in serious reductions in the goods (such as food, medicine and raw materials) and services (such as clean water and nutrient cycling) provided by the earth's ecosystems, which make human survival and economic prosperity (Anonymous 2002).

Through the provision of biological resources and ecosystem services, biodiversity is an essential component of human development and human security. Through agriculture, forestry and fishing, biodiversity provides crops, timber, fish and contributes significantly to national economies and employment. Ecosystem goods range from food and water to timber and fodder to genetic resources. In addition, ecosystem provide essential services including nutrient cycling, air and water purification, flood and drought mitigation and soil production, free of charge. These services can not be replaced at a reasonable price (Revenga *et al.*, 2000). The direct economic benefits of biodiversity run into trillions of dollars per year (Costanza *et.al*. 1997).

## 2.2 Economic values of wise use of biodiversity

Some of the significant benefits provided by ecosystems, biodiversity and their services include: an annual market value of crop production in the United States to tunes of about US$40 billion which is completely dependent on insect pollinators; biological pest control that saves an annual revenue of US$ 100-200 billion; and, biological nitrogen fixation has an estimated annual worth of US$50 billion (Leader-William & Albon, 1998). While recognition of the values of the goods

and services that biodiversity offers is increasing, the relationship between the role of biodiversity in environmental sustainability, poverty reduction and sustainable development needs further attention and understanding.

Wildlife is an important source of protein for the rural peoples in tropical forests and wetlands and its sale is an important source of cash (Redford & Robinson, 1987; Redford, 1993). However, harvesting of natural resources has become more widespread, especially under most depressed economic conditions (Arcese et al., 1995) and in areas where people have evicted from their land to make way for wetland or protected area (Hough, 1998; Leader- William & Albon, 1998; Van Schulenburg, 2009). One major management implication out coming of such settlements is how to best direct wildlife crime prevention and to mitigate natural resources destruction. Decisions support efforts should include identifying places where illegal activity is prevalent and determining where crime types occur with greatest frequency. If its biodiversity and natural resources are wise used, DRC's people livelihoods can significantly improve at least for clean drink water, food, medicines, spirituals and cultural divertissement. According to Seyler *et al.* (2010), in the DRC, people are very poor meanwhile because the benefits of biodiversity and other natural resources are not sustained and equitably shared.

**2.3 International and national environmental enforcement law**

Law enforcement has been identified as one of the most important factors in making parks work (Brockelman et al., 2002; Mubalama, 2010). Biodiversity conservation efforts are more and more severely compromised by poor enforcement. In the absence of enforcement, both traditional and innovative solutions for countering biodiversity loss may not be successful. Despite the efforts of

conservationists over time, the quality and effectiveness of enforcement still fall far short of wildlife managers' expectations. This however requires appropriate manpower and adequate funding (Bell & Clarke, 1984). Our glaring failure has been in treating the symptoms of wildlife conservation problems rather than their root causes (Pletscher & Schwartz, 2000). Studies show it is common for wildlife to provide 20- 30% of rural people's income in developing countries (Vedeld et al., 2004).

One aspect of human warfare that has not changed appreciably over the past few decades is the need for human populations and isolated military forces to 'live off the land' by foraging indiscriminately for food, shelter, and material good. Local people undergoing food and fuel shortages in lawless landscapes heavily toll on wildlife and habitats (Pech, 1995). The Ruzizi Congolese areas have been occupied by armed militia forces from 1996 to late 2006.

Military and militia forces lacking established or secure lines or supply often subsist partly or entirely on wild animals and plants. Large mammals, crocodiles and even birds, when available are often an important source of food for isolated military groups operating within war zones and disputed territories (Plumptre e*t al.*, 1997). Therefore overexploitation of natural resources is primary concern for protected and unprotected area managers as many endangered species, more and more, find their last stronghold in natural reserves (Leader- Williams *et al*., 1990; Bruner *et al.*, 2001; Struhsaker *et al.*, 2005). The trade of Nile Crocodile in Tanzania and high demand of killing hippopotami by local people in the Ruzizi Congolese plain, even using guns, may lead to overexploitation and misuse of biodiversity and natural resources.

Following the overall neglect of wildlife Act during the spiralling wartime, the widespread poaching resulting from the free-for-all access to natural resources, each pursuing his own best interest in a society that believes in the freedom of the commons (Mubalama, 2010) and given the fact that guards' actions of local chefs were far less precise because the areas were not yet effectively protected. An understanding of the local needs, these human pressures and factors determining them was essential for successful and cost effective law enforcement activities.

Understanding the geographical distribution of wildlife, poaching risk and its causes are key challenges and central to determining spatial priorities for the focus of conservation responses. With accurate measures of illegal activities, managers would monitor success of conservation efforts allowing them to design more efficient intervention (Davies 1996; Hockings *et al.*, 2000). With appropriate methods, illegal resource use may be detected before it has biological impact and, thereby, provide early warning of threats to biodiversity (Pitcher et al., 2002). Nevertheless, the illegal nature of the activities poses unique methodological challenges. To inform local people about the kinds of birds, their ecological migration and the movements of crocodiles and hippopotami, may yield good results in changing the mentality on finite of natural resources and biodiversity though educative seminars and meetings.

## 2.4 Biodiversity levels in DRC

Given the enormous biodiversity of the DRC and the high level of endemism, there must be large numbers of species of animals and plants that depend upon as yet unidentified critical natural areas for their survival. Documenting the biodiversity of the DRC and its distribution and critical habitat areas needs to be an important priority for the universities and natural resources agencies of the DRC and their foreign partners. In 2007, ICCN in collaboration with partners undertook an important first

step in this direction by conducting a strategic evaluation of biodiversity in the DRC which identified a number of areas of high biodiversity importance outside of the protected area system. In addition to this evaluation, a few smaller sites for the protection lower-profile species have been identified, and the bird conservationists have taken the lead here, identifying critical bird conservation areas in the fragmented forests of the eastern highlands and elsewhere (Seyler *et al.*, 2010).

## 2.5 Crocodiles

The description of crocodiles, their habitats, continental distribution, mating behaviour, taxonomy, and the trade of Nile Crocodile from Tanzania, have been reported (Rafael, 1986; Wood, 1983; CSG, 1996; Nashotaky & Amira, 2000; IUCN, 2012 and UNEP WCMC, 2010).

To confirm the permanent and temporary presence of crocodiles is one key for the Ruzizi Congolese plain to be listed as a potential Ramsar site to be protected as natural reserve and the to be submitted by the Congolese Government using available data.

## 2.6 Why biodiversity and natural resources conservation?

According to Mubalam (2010), the conservation of natural resources is the fundamental problem in DRC; unless that problem is solved, it will avail little to solve all others. The provision of science-based information to enable protected and non protected area managers to better manage conservation sites within DRC has been proved to be a major shortfall in supporting management authorities to manage the sites through financial support for the basic operating costs, planning, training, monitoring and research programs. The process of decision- making needs reliable information as an important input for various managerial tasks (Harmon, 1994). Information is a

vital component of the organizational functioning; just as our body depends on air, water and food for survival, we also depend on information (Oka, 1996).

Optimal decision- making tools can be used to indicate the best allocation of limited resources and budgets to achieve conservation goals. The more the limited the resource, the greater the desire should be to use those resources as wisely as possible (Mackenzie, 2009). Thus getting the right kind of information available at the right time is very important for immediate management action to support biodiversity conservation.

To that end, continued importance of biodiversity conservation requires a system to monitor the kinds of wild mammals, reptiles and birds and law enforcement effort on a timely temporal and spatial basis for identifying spatial relationship and distributions of wildlife patterns. Large- bodied species are vulnerable to overexploitation. They are important "habitat landscapers" (Fa & Peres, 2001); and they play a key role in the structuring and functioning of ecosystems. Birds are used as indicators of ecosystem health and biodiversity indicators in environmental impact assessments.
I have limited this study to large mammals (hippopotamuses), crocodiles and birds for many reasons:

First, because of their ecological impact, hunting potential, and conservation attention;
Second, among all wildlife taxa, the large herbivore (hippopotami) is the most prone to hunting by humans especially in the Ruzizi Congolese plain. Also, justifiable or not, large mammals receive a disproportionate share of attention in conservation activity and research (Young, 1994). The death of larger species has a domino effect on other species, since they structure the whole ecosystem. Hippopotami for example, enrich ponds and the lake with their excrements for food of fish and

micro-organisms. They may also keep some dominant vegetation down, leaving room for other species; in such way they encourage diversity (Harrisson, 1992; Sheil, 2001 and Danielson et al, 2005);

Third, hippopotamuses, crocodiles and water birds are protected animals found in unprotected wetland areas, where they are running a danger to extinction. Thus, understanding the impact of human haunting on large mammals, crocodiles and birds is of critical importance in planning realistic strategies for biodiversity conservation (Madhusudan & Karanth, 2002) in the DRC as well as in the Ruzizi Congolese plain.

## 2.6 The Millennium Development Goals and biodiversity

Environmental Sustainability and Biodiversity conservation according to MDG Goal 7- target:

"Integrate the principles of sustainable development into country policies and programs and reserve the loss of environmental resources; Halve, by 2015, the proportion of people without sustainable access to safe drinking water and; Have achieved, by 2020, a significant improvement in the lives of at least 100 million slum dwellers" (Balakrishna & Warner, 2003).

Countries contracting the Convention on Biological Diversity (CBD, 2007) are obliged to monitor biodiversity (Article 7. c - *identify processes and categories of activities which have or are likely to have significant adverse impacts on the conservation and sustainable use of biological diversity and monitor their effects through sampling and other techniques* -). Protected area is the cornerstone of conservation efforts but the latter performance remains poorly documented.

To achieve the millennium goal 7 in the Ruzizi Congolese plain, the ponds of that large wetland connected by the Ruzizi River, should be protected as a Ramsar site. The connection of those ponds is very important for crocodiles and hippopotami to access to the lake when there is calamity, such drought or climate change.

## 2.7 Biodiversity conservation in DRC

According to Seyler *et al.*, 2010), aquatic resources in the DRC play an important role in many people's livelihoods and are often the only means of subsistence for local populations, particularly since the onset of the war in the 1990s, which increased the isolation of the majority of rural communities from economic alternatives outside the exploitation of local resources.

This dissertation aims to investigate the status of hippopotamuses, crocodiles and birds for their protection, and biodiversity conservation in the Ruzizi Congolese plain. It is thus written as a contribution towards fulfilling the above conservation and management needs. The need of both qualitative and quantitative measures of biodiversity outcomes in protected and unprotected areas is underscored by the Millennium Development Goals on environmental sustainability (MEA, 2005), and by the Convention on Biological Diversity (UNEP, 2002).

The effects of the recent war (1998-2003) upon conservation in the area are still fresh and a great loss too. Substantial efforts have been made by numerous conservation organizations to maintain a conservation presence in the DRC, even under the most difficult of conditions (Draulans & Van Krunkelsven, 2002). However, cost of recovery programs will be numerous yet not everything lost may be recovered. The nature resource-based capital lost in terms of individual wildlife species and

related revenue should be an eye-opener to the relevant authorities to protect the region more adequately than before for prosperity.

According to Mac Kinnon *et al.*, (1986), there is no foolproof management to protect natural resources under circumstances of warfare. However, given that the pie of funding for biodiversity protection is sadly small, there is a critical need of public support, more condensed international linkage and monitoring and adaptive management approach if this region is to be protected as a Ramsar Ste. "Wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters" (Ramsar, 2007). The Ruzizi Congolese plain composes the flood plain riparian with the Rusizi Burundian Ramsar site. Their designation as Ramsar site should enforce the stability of wildlife on both sides of the Ruzizi River and in the north-western end of Lake Tanganyika (Marijnissen, 2007).

The nature of modern natural resource management requires a wide range of skills. In the particular context of DRC, these skills include enforcement of local capacity, local findings, surveillance techniques including patrol-based law enforcement monitoring, bio-monitoring, and community or sub- community conservation. With the war coming to an end, it is crucial to evaluate through the conservation status of the unprotected wetlands, how far to turn for the worse, their integrity and the impact of the conflict on the values for a designation of a new protected areas especially a Ramsar Site in the Ruzizi Congolese plain.

# CHAPTER THREE

# METHODS AND MATERIALS

## 3.1 Study areas

The Ruzizi plain is a large wetland areas located between the eastern Democratic Republic of Congo (DRC), the Republic of Burundi and the Republic of Rwanda. The main river feeding the areas is called Ruzizi River in DRC, and Rusizi River in Rwanda and Burundi (see figure 2).The areas belong to the southern end of the Albertine Rift and comprise the Ruzizi Congolese plain (RCP), the Rusizi Burundian plain (RBP) and the Rusizi Rwandian plain (RRP).

The study was carried out in the eastern DRC, the second largest country in Africa. The DRC borders the Central Africa Republic and South Sudan on the North; Uganda, Rwanda and Burundi on the East, Zambia and Angola on the South, the Republic of the Congo (Brazzaville) on the West, and is separated from Tanzania by Lake Tanganyika on the South-East. The country has access to the ocean through a 40 km stretch wide mouth of Atlantic coastline, and the roughly nine kilometre wide mouth of the Congo River which opens into the Gulf of Guinea. The size of DRC is 2,345,408 $km^2$ with a total population of 70.9 million people (Petraeus, 2011).

In eastern the DRC, the study was carried out in the Ruzizi Congolese plain, located from the locality of Kafunda (Kafunda site) in Kamanyola, (S 02° 42', E 028° 59'; altitude: 997 m) to the small Ruzizi River mouth (S 03° 21', E 029° 12'; altitude 782 m), almost 67.5 km on the western

side of the Ruzizi River (Figure 2). The area belongs to lower altitudes of the Afrotropical Highlands Biome, the Southern part of the Albertine Rift (Plumptre, 2006**)**. The Ruzizi flood plain has a surface area of 335 $km^2$ (33,500 ha), of which 16,750 ha currently free of human settlement and can therefore be put aside for biodiversity conservation.

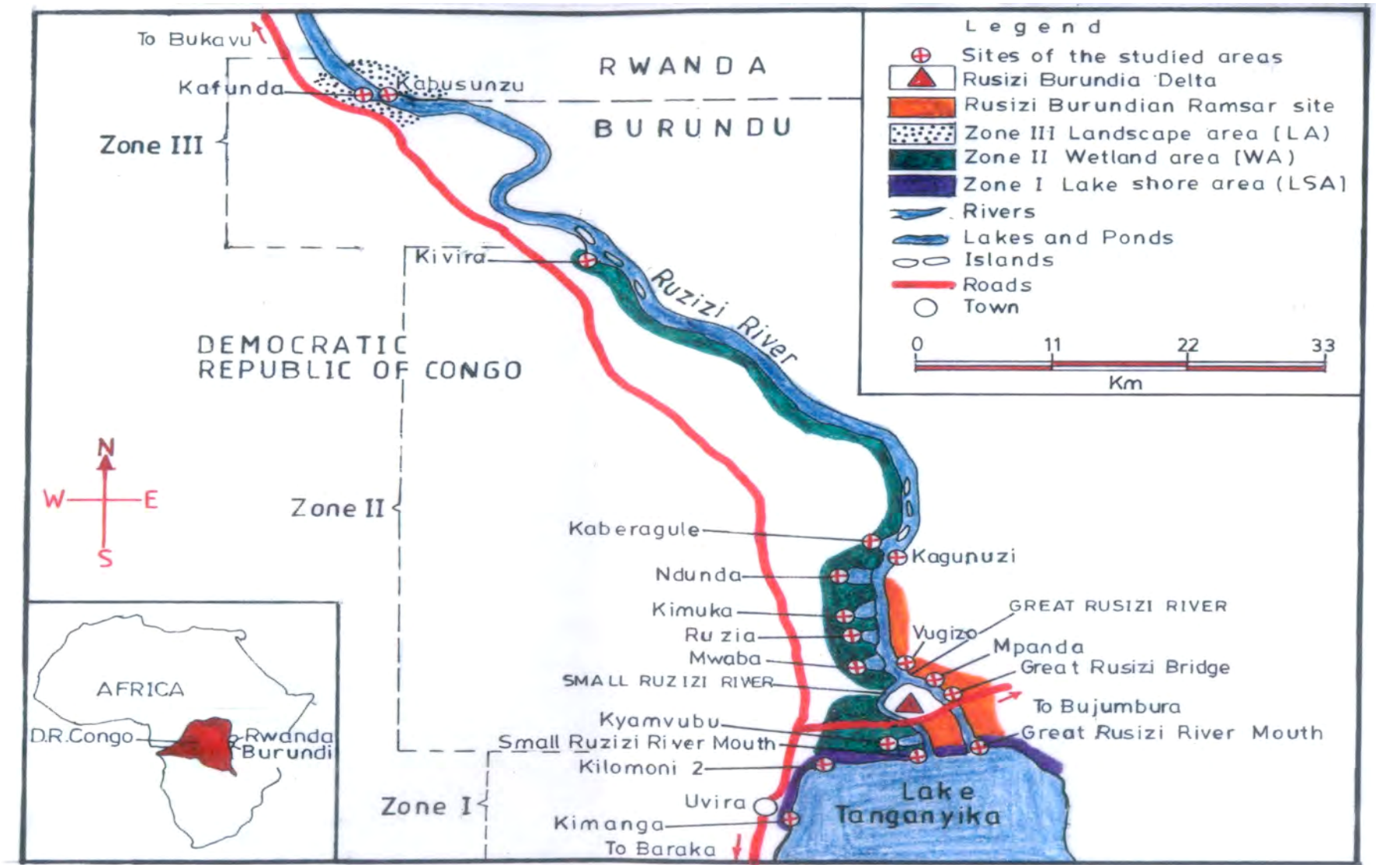



**Figure 1: Map showing the study areas and study sites in the Ruzizi Plain**

The area is essentially a wet tropical climate region with wet and dry seasons. There are 2 rain seasons, the long rains in February-June and the short rains in October- December. The long dry season occurs in July-October and the shortest occurs January-February. The mean annual temperature is 24º C and the mean precipitation is 800mm (Felton *et al.*, 2007.

### 3.2 Study sites

Crocodiles were investigated in

**Zone I,** the lake shore area (LSA), 27 km length, from Kimanga (S 03º 25'/ E 029 08'0 altitude 784m) to Great Rusizi River mouth (S 03º 21'/ E 029º 16', altitude 779 m) comprised of 4 sites: 3 of them in DRC; Kimanga, Kilomonin 2 and the site of Small Ruzizi River mouth, and one site in Burundian; at the Great Rusizi River mouth.

(i) Kimanga site near Uvira city;

(ii) Kilomoni 2, located 20 km eastern from Kimanga and 3 km western from the small Ruzizi River mouth in.

(iii) Small Ruzizi River Mouth (SRRM), located at the entry of the Small River into Lake Tanganyika.

(iv) Great Rusizi River mouth in Burundi eastern direction, 8 km from the small Ruzizi River mouth.

**Zone II,** the wetland area (WA); from the site of Kyamvubu (S 03º 20/ E 029º 12', altitude 784m) to Kivira site (S 02º 44'/ E 029º 02', Altitude 938m), almost 50 km length) included 11 study sites of which 7 in DRC, and 4 study sites in Burundi

(v) Kyamvubu site, in DRC, 3 km of wetland marshes, swamps and small ponds, from the lake shoreline at the small Ruzizi River mouth

(vi) Mwaba site, in DRC, 13 km from the small Ruzizi River mouth. The site included Mwaba pond, the largest pond, with 4 km length, 3 km wide and 1.5-2.5m mean depth. The pond is polluted by people living all around. According to the local chief, the village of Mwaba comprised of 25 families, most of them were fishermen, farmers and cattle keepers.

(vii) Ruzia site, in DRC, 2 km from Mwaba site, important for bird investigations, was the smallest pond with 1 km length, 0.75 km large and 1.70 m depth. According to the local chief, the village of Ruzia was made of 15 families of fishermen, farmers and cattle keepers. Figure 4 showed transect counts team from Ruzia pond.

(viii) Kimuka site, in DRC, 4 km from Ruzia comprised Kimuka pond, the second large pond with a mean of 3 km length, 2 km wide and 1.5-2 m depth. The pond and its adjacent swamps and marshes were located at 3-4 km away from human habitation. The Local chief reported that the Kimuka village comprised of 550 families. A family had a mean of 10 people. Many of them were farmers, fishermen, cattle keepers, shopkeepers and state workers.

(ix) Ndunda site, in DRC, 6 km from Kimuka. The Ndunda pond located at 3-4 km away from human habitation had an estimate of 2 km length, 0.75 km wide and 1-1.5 m depth. The area was the richest one in biodiversity; with waterbirds of which ducks were most conspicuous, crocodiles, hippopotamuses, fish, reptiles, amphibians and micro organisms. Threatened species move to Ndunda swamp area for life because the area is the most secured for wildlife in the whole Ruzizi Congolese plain. The local chief of Ndunda

village reported that the village comprised of 350 families of farmers, fishermen, cattle keepers, shopkeepers and state workers. Here a family had a mean of 10 people.

According to Blanchard *et al* (2007), lakes have at least an area of 5 acres ($500m^2$), and 15 feet (4.6m) to 20feet (6m) deep. For Ramsar convention (2007), a pond is a body of freshwater that is less than 8 hectares or below 20 acres ($2000m^2$). In this respect, most bodies of freshwater of the Ruzizi flood plain were ponds because they were shallow, less than 4m deep and less than 8 hectares each, except Mwaba, with 12 hectares and 2.5m deep. For Ramsar convention, Mwaba is a lake; with winds, no vegetation inside. Generally, a lake is an area of open, relatively deep water that is large enough to produce a wave-swept "washed" shoreline, which can prevent vegetation from growing along the shore (Blanchard et al., 2007).

(x) Kaberagule site, in DRC, 15 km from Ndunda, is just the Ruzizi River flowing slowly, with three small islands holding old hippopotamuses and their babies. The site was 3-4 km away from human habitation.

(xi) Kivira site was located 20 km north from Kaberagule.

(xii) Great Rusizi River Bridge (GRRB), in Burundi, 3 km upstream from the Great Rusizi River mouth on the main road towards Bujumbura town was important for investigations of crocodiles and hippopotami.

(xiii) Mpundu site, in Burundian, at the junction of Mpundu River and Great Rusizi River, almost 10 km upstream from the Great Rusizi River mouth.

(xiv) Vugizo site, in Burundi, at the Small Ruzizi River turn off from Great Ruzizi River, located at 15 km upstream from the Great Rusizi River mouth, was important for crocodiles.

(xv) Kagunuzi, in Burundi, 25km upstream from the Great Rusizi River mouth, was important for crocodiles and hippopotami investigations.

## 3.3 Methods and techniques

### 3.3.1 Visual encounter surveys of crocodiles o f the Ruzizi plain

Visual Encounter Surveys (VES) are a time- honoured technique similar to the Timed Constrained Count (TCC) method described by Heyer *et al*., (1994). Visual encounter surveys are used to document presence of herpetiles (amphibians and reptiles) and are effective in most habitats and for most species that tend to breed in lentic habitats. They generate encounter rates of species in their habitats in a unit hour. The method involved moving through a habitat, turning logs or stones, inspecting retreats and watching out for surface-active species.

Visual encounters of Crocodiles (45 days) were carried out by foot daily for 3 days per each of 15 sites of the Ruzizi Congolese and Burundian areas, using binoculars and a telescope where they were needed to distinguish individuals following their tail marks. Fieldworks were carried out between 25 August and 25 October 2011. Then, for a check out of collected data, I conducted nocturnal fieldwork using a zodiac, along the Lake Tanganyika shore line up to the small Ruzizi River mouth, and upstream from Mwaba pond to Kivira site (Figure 2), two times up and down stream during November 2011. Table 3 presented effort of visual encounter for sampling crocodiles in the Ruzizi Plain.

Distance encounter visual changed according to the location of crocodiles in the site. In lake shore area, we walked easily on sandy area, searching for crocodiles in sandy area, near the lagoons and through the vegetation around lagoons. In the wetland area, crocodiles were found at précised areas, so we had not to walk much for searching them. We watched them through binoculars on small islands of the Ruzizi River at Kivira, and of Ndunda. Table 3 presented effort of visual encounter for sampling crocodiles in the Ruzizi plain.

Crocodiles were also watched by binoculars in Mpanda site, and in the Great Rusizi River mouth of the Rusizi Burundian areas. The transformation of table 3 per country and per ecological zone gave for DRC: 90 kilometre-count-hours in Zone I (lake shore area) and 90 kilometre-count-hours in Zone II (wetland areas), for Burundi: 6 kilometre-count-hours in Zone I (lake shore area) and 30 kilometre-count-hours in Zone II (wetland area). There was no zone I or Zone II in Rwanda. Data from these surveys are given by appendix 1 as S1(sample 1) and S2(sample 2).

**Transect count from a zodiac day and boarding**

Crocodiles were finally counted from zodiac in DRC, lake side area and wetland area up to Kivira during November 2011.Data from these surveys are given by appendix 1 as S3 (sample 3)

**Table 1: Effort of visual encounter for sampling crocodiles of the Ruzizi plain**

| | Day 1 | | | Day 2 | | | Day 3 | | | Effort |
|---|---|---|---|---|---|---|---|---|---|---|
| DEV Sites | DEV km | hours | kmh | DEV km | hours | kmh | DEV km | hours | kmh | Tkmh |
| 1 | 4 | 4 | 16 | 4 | 4 | 16 | 4 | 4 | 16 | 48 |
| 2 | 2 | 4 | 8 | 2 | 4 | 8 | 2 | 4 | 8 | 24 |
| 3 | 1.5 | 4 | 6 | 1.5 | 4 | 6 | 1.5 | 4 | 6 | 18 |
| 4 | 1.5 | 4 | 6 | 1.5 | 4 | 6 | 1.5 | 4 | 6 | 18 |
| 5 | 1.5 | 4 | 6 | 1.5 | 4 | 6 | 1.5 | 4 | 6 | 18 |
| 6 | 1.5 | 4 | 6 | 1.5 | 4 | 6 | 1.5 | 4 | 6 | 18 |
| 7 | 1 | 4 | 4 | 1 | 4 | 4 | 1 | 4 | 4 | 12 |
| 8 | 0.5 | 4 | 2 | 0.5 | 4 | 2 | 0.5 | 4 | 2 | 6 |
| 9 | 1 | 4 | 4 | 1 | 4 | 4 | 1 | 4 | 4 | 12 |
| 10 | 0.5 | 4 | 2 | 0.5 | 4 | 2 | 0.5 | 4 | 2 | 6 |
| 11 | 1 | 4 | 4 | 1 | 4 | 4 | 1 | 4 | 4 | 12 |
| 12 | 0.5 | 4 | 2 | 0.5 | 4 | 2 | 0.5 | 4 | 2 | 6 |
| 13 | 0.5 | 4 | 2 | 0.5 | 4 | 2 | 0.5 | 4 | 2 | 6 |
| 14 | 0.5 | 4 | 2 | 0.5 | 4 | 2 | 0.5 | 4 | 2 | 6 |
| 15 | 0.5 | 4 | 2 | 0.5 | 4 | 2 | 0.5 | 4 | 2 | 6 |
| **Total** | **18** | **60** | **72** | **18** | **60** | **72** | **18** | **60** | **72** | **216** |

**DEV**: Distance visual encounter; **kmh**: kilometre- visual encounter- hour; **T**: Total;
**1**: Kimanga; **2**: Kilomoni 2; **3**: Small Ruzizi River mouth; **4**: Kyamvubu; **5**: Mwaba;
**6**: Ruzia; **7**: Kimuka; **8**: Ndunda; **9**: Kaberagule; **10**: Kivira; **11**: Kagunuzi; **12**: Vugizo;
**13**: Mpanda; **14**: Great Rusizi River Bridge; **15**: Great Rusizi River mouth; **hrs**: Hours.

### 3.3.2 Questionnaire for sampling the presence of crocodiles and human factors that influenced conservation of biodiversity

During 3 days in each of 15 sites of the Ruzizi Congolese, Burundian, and Rwandian Plain, 12 people were interviewed on the presence and the movements of crocodiles in the area. Among them, 2 members of the local administration, 2 members of the military security where possible, 2 members of environmental security, and 2 people among cattle keepers, 2 fishermen or 2 farmers active in the area. Questionnaire sampling fieldworks (45 days) were conducted between 05 January and 15 March 2012. The questionnaire used is shown in appendix 2.

### 3.4 Data analysis

Almost all census techniques sample animal populations imperfectly (Mackenzie et al., 2002). Thus references to abundance in this paper referred to the indices of abundance derived from our sample techniques (abundance/sample effort) rather than the ‘‘true’’ abundance, which is not known.

Chi square was used to compare abundance and density of crocodiles between the lake shore area (Zone I) and the wetland area (Zone II) It was also used to compare abundance and density of Nile Crocodile and Sharp-nosed Crocodile between DRC and Burundi.

Two-way ANOVA was used to compare abundance and density of crocodiles between DRC and Burundi.

# CHAPTER FOUR

# RESULTS

## 4.0 Introduction

Visual encounter method was used to sample crocodiles. Surveys aimed to compare the density and relative abundance of crocodiles of the Ruzizi Congolese unprotected areas with the Rusizi Burundian areas, which currently are protected as a Ramsar site.

## 4.1 Introduction

Two species of crocodiles were recorded in the Ruzizi Congolese plain: the Nile Crocodile (*Crocodylus niloticus*) and the Sharp-nosed Crocodile (*Crocodylus cataphractus*), also known as African Slender-snouted Crocodile (*Mecistops cataphractus*) (CSG, 1996; El-Nashotaky & Amira, 2000; Britton & Adam, 2004; Ross, 2004 and Seyler *et al.*, 2010).

Crocodiles were sampled in a fixed width of 1.5km, but the length of point surveys varied with sites. In The Ruzizi Congolese plain the total length sampled was 45km. The sampled area was 45km*1.5*100= 6750ha. In Burundi the sampled length area was 9km. The sampled area was 9km*1.5*100= 1350 ha (see table 3, point 3.2, and sampling techniques).

## 4.2 The density

### 4.2.1 The density of Nile Crocodile of the Ruzizi plain

Table 23 presented the density of Nile Crocodile in the Ruzizi Congolese plain (RCP) and the Rusizi Burundian plain (RBP). The densities of Nile crocodile were the same in DRC and in Burundi (chi square= 0.008, df= 2, p> 0.001).

**Table 2: The density of Nile Crocodile in the Ruzizi plain**

| Studied areas | RCP | RBP | Total |
|---|---|---|---|
| Nile Crocodile | 32 | 44 | **76** |
| **Sampling effort (kmh)** | **180** | **36** | **216** |
| **Abundance** | **0.18** | **1.22** | **0.35** |
| $X^2$ | **0.451** | | |
| **df** | **2** | | |
| **p>** | **0.001** | | |
| **Significance** | **No** | | |

**RCP**: Ruzizi Congolese plain; **RBP**: Rusizi Burundian plain; Density= Number of animals recorded/Total area sampled including at least one individual in a site (Brower *et al.*, 1997; Barlow et al., 2007).Table 3 gave Sampling effort of crocodiles per studied site, see point 3.2. Sampling techniques

### 4.2.2 The density of Sharp-nosed Crocodile of the Ruzizi plain

Table 24 presented the density of Sharp-nosed Crocodile in the Ruzizi Congolese plain (RCP) and in the Rusizi Burundian plain (RBP). The densities of Sharp-nosed Crocodile were the same in DRC and in Burundi (chi square= 0.0004, df= 2, p> 0.001).

**Table 3: The density of Sharp-nosed Crocodile in the Ruzizi plain**

| Studied areas | RCP | RBP | Total |
|---|---|---|---|
| Sharp-nosed Crocodile | 87 | 46 | **133** |
| **Sampling effort (kmh)** | **180** | **36** | **216** |
| **Abundance** | **0.48** | **1.28** | **0.62** |
| $X^2$ | **0.230** | | |
| **df** | **2** | | |
| **p>** | **0.001** | | |
| **Significance** | **No** | | |

**RCP**: Ruzizi Congolese plain; **RBP**: Rusizi Burundian plain; Density= Number of animals recorded/Total area sampled including at least one individual in a site (Brower *et al.*, 1997; Barlow et al., 2007).Table 3 gave Sampling effort of crocodiles per studied site, see point 3.3. Sampling techniques.

## 4.3. Abundance

### 4.4.1 Abundance of Nile Crocodiles of the Ruzizi plain

Sampling effort of crocodiles was 180 kilometer-hours in DRC and 36 in Burundi (see table 2 point 3.2 sampling techniques). Table 25 presented abundances of Nile Crocodile in the Ruzizi Congolese plain and in the Rusizi Burundian plain. Abundances of Nile Crocodile were the same in DRC and in Burundi (chi square= 0.451, df=2, p<0.001).

**Table 4: Abundance of Nile Crocodile of the Ruzizi plain**

| Studied areas | RCP | RBP | Total |
|---|---|---|---|
| Nile Crocodile | 32 | 44 | 76 |
| Sampling effort (kmh) | 180 | 36 | 216 |
| Abundance | 0.18 | 1.22 | 0.35 |
| $X^2$ | 0.451 | | |
| df | 2 | | |
| p> | 0.001 | | |
| Significance | No | | |

**RCP**: Ruzizi Congolese plain; **RBP**: Rusizi Burundian plain; Abundance= Recorded animals/sampling effort, see Table 3.point 3.3.Sampling techniques. Reference is Barlow *et al.*, 2007.

### 4.4.2 Abundance of Sharp-nosed Crocodile of the Ruzizi plain

Table 26 showed abundances of Sharp-nosed Crocodile were the same in DRC and in Burundi (chi square= 0.230, df= 2, p> 0.001).

**Table 5: Abundance of Sharp-nosed Crocodile of the Ruzizi plain**

| Studied areas | RCP | RBP | Total |
|---|---|---|---|
| Sharp-nosed Crocodile | 87 | 46 | 133 |
| Sampling effort (kmh) | 180 | 36 | 216 |
| Abundance | 0.48 | 1.28 | 0.62 |
| $X^2$ | 0.230 | | |
| df | 2 | | |
| p> | 0.001 | | |
| Significance | No | | |

**RCP**: Ruzizi Congolese plain; **RBP**: Rusizi Burundian plain; Abundance= Recorded animals/sampling effort, see Table 3.point 3.3.Sampling techniques. Reference is Barlow *et al.*, 2007.

### 4.5 The Ruzizi Congolese plain: a potential Ramsar site.

The designation of the Ruzizi Congolese wetlands as a national protected reserve is very important and urgent at the local, national and regional levels for biodiversity conservation and natural resources wise use. Data on birds should be taken into account to recognize the area as an important zone for bird conservation like the neighbour Rusizi Burundian Ramsar site. The government will then submit the request to the Ramsar secretariat Bureau using these data and the following data on crocodiles and hippopotami for the designation of a Ramsar site in the Ruzizi Congolese plain.

### 4.6 Human factors that influenced conservation of biodiversity in the Ruzizi plain

The results of question 12 of the questionnaire in annexe 2 showed that the human factors that influenced conservation of biodiversity were:

- The Ramsar site in Burundi, namely the Rusizi Burundian Ramsar site;
- Environmental law enforcement in Rwanda;
- Landscape conservation by reforestation in Rwanda;
- Land use planning and management in Rwanda;
- Fishing activities control, planning and management to apply in DRC;
- Cattle keeping area control, planning and management in DRC.

### 4.7 A potential Ramsar site in the Ruzizi Congolese plain

The results showed there were resident bird species, waterbirds, migrants, Biome restricted species, regionally vulnerable and near threatened as well as globally vulnerable and near threatened species, which make the Ruzizi Congolese plain to qualify as an important bird area (Demey & Louette, 2001)

The comparisons of densities and abundances of crocodiles and hippopotami indicated that the densities and abundances of the VULNERABLE Hippopotamus in the protected Burundi Ramsar site were significantly greater than densities of crocodiles in the unprotected Congolese wetlands. So, there is a need for DRC to submit the Ruzizi Congolese wetlands to a designation as Ramsar site as did the government of Burundi.

In addition, according to Plumptre et al. (2006), the Rusizi Ramsar site of Burundi has 182 bird species, of which 123 waterbirds and 90 migrants. The remaining total area reported by IUCN (2010), is 1000 hectares. The comparison for the Ruzizi DRC indicates 252 bird species of which 108 waterbirds and 126 migrants in a total sampled area of 600 hectares. The total estimate wetland area for the Ruzizi Congolese to suggest for important bird area ranges from the small Ruzizi River mouth to the site of Kivira(57.5km length), and a width of 2.5km (143.75km$^2$ ,14375ha ).

According to IUCN (2004), the Rusizi Burundian Ramsar site fulfilled six of eight Ramsar conditions to be designated as a Ramsar site. The results showed that the Ruzizi Congolese plain, also qualifies as a Ramsar site, but this will not happen unless the DRC's government submits that request properly using available local data of this dissertation.

This information should be useful because, in the case of further national and regional projects (UNDP/RAF/92/G32), the DRC's government had given priority to the creation of a protected area in the Ruzizi delta and two sites in lake Tanganyika, for biodiversity conservation (IUCN, 2004). The Ruzizi flood plain should be well managed first, for Lake Tanganyika biodiversity conservation management to mitigate the sedimentation of the Ruzizi River into the lake (Marijnissen, 2007).

# CHAPTER FIVE

# DISCUSSION

## 5.0 Introduction

This section discusses the results on crocodiles and human factors that influenced conservation of biodiversity in Burundi and in Rwanda that should be applied in DRC.

## 5.1 Crocodiles

High wildlife value is based mainly on the presence of permanent water, the vegetation and plants; the fruits, seeds and/or nectar used as food for wildlife, and the relative number of species using the plant for food. But animals use leaves, twigs, roots and shoots for food or nesting material, and every plant has value as cover and/or nesting sites. In that respect, crocodiles were found in the wetland area, especially in small islands of the Ruzizi Congolese plain. Those islands including swamps along the Ruzizi River and lagoons of the lake shore area should be protected in accordance with the Congolese forest code (Article 11/02, dating 29 August 2002).

According to Lewison & Olivier (2008), the largest declines of hippopotami have occurred in the Democratic Republic of Congo, a country once thought to have the largest populations. Crocodiles stayed in small islands of the Ruzizi Congolese plain, located from Ndunda to Kivira (see Figure 2, map of study areas and study sites).

## 5.2 Human factors that influenced conservation of biodiversity in the Ruzizi Congolese Burundian and Rwandian plains

The survey showed that:

- Environmental law was enforced in the Rusizi Rwandian side than in DRC.

- Wise agriculture mitigating soil erosion from hills was found in the Rusizi Rwandian plain, using terracing on hills. This technique should be applied in DRC instead of the traditional technique called ‘’luhongolo’’ leading to soil erosion of hills.
- The landscape reforestation of Rwanda should be applied in DRC, where local NGOs sensitize local people to reforestation but
- The wetland protection as Ramsar site of Burundi should be applied in DRC by the designation of a Ramsar site in the Ruzizi Congolese plain

### 5.3 The Plots of a potential Ramsar Site in the Ruzizi Congolese plain

Targeting a compliance of 25 m free of logging along the Ruzizi River instead of 5m legally stated by the forest cod, and 2.5 km of flood area free from ponds we have mapped the remaining area that can be managed for the creation of a protected natural reserve or potential Ramsar site (Figure 11). Meanwhile an environmental education targeting respect wildlife, vegetation and wise use of land is very urgent and important. For example, birds are not uselessly chassed or killed in the neighbouring Rusizi Burundian and Rwandian Plain as the case is in the Ruzizi Congolese plain. The traditional agricultural technique called "Luhongolo" which accelerate the erosion of hills should be replaced by an agricultural technique by terraces as it is automatically used by the neighbouring population of the Rusizi Rwandian hills. We also found that environmental law is implemented and applied in the Rusizi Rwandian area, while it is not even known by the local people of the Ruzizi Congolese plain.

Protecting surface water and wetlands is important to promoting mammal, reptile and bird diversity. Identifying, monitoring and restoring local wetlands are great ways to educate ourselves and our community about the important functions and values of wetlands (EPA, 2003).

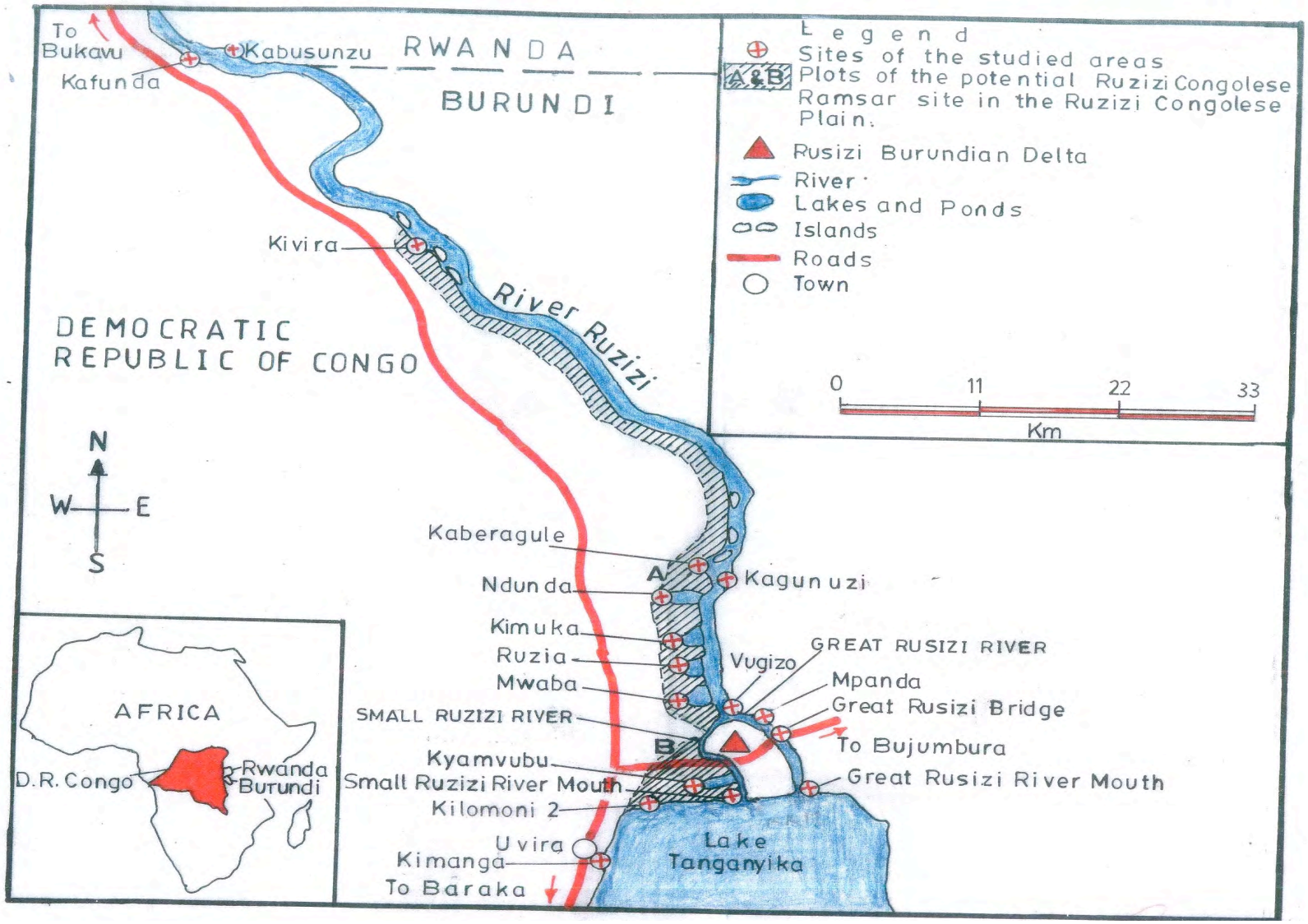



**Figure 2: Map showing the suggested plots of a potential Ramsar site in the Ruzizi Congolese plain**

# CHAPTER SIX

# CONCLUSION AND RECOMMENDATIONS

## 6.1 Conclusion

The study has shown that crocodiles were concentrated in the wetland area, due to logging and settlement in the lake shore area. In the Ruzizi Congolese plain, Logging the Lake Tanganyika shore area is an offence to the forest Congolese code (law no 11/02 dating 29$^{th}$ August 2002), that provides 50 m free of logging along the lake shore and along rivers, and even 100m all around sources of rivers. Congolese forest code should be implemented for biodiversity conservation (Mubalama, 2010).

### 6.1.1 Biodiversity of the Ruzizi plain

Biodiversity is an essential component of human development and human security through the provision of biological resources and ecosystem services. Biodiversity provides crops, timber, fishing, and contributes significantly to national economies and employment through agriculture, forestry, and biotechnology- industry. Ecosystem goods range from food and water to timber and fodder to genetic resources. In addition, ecosystems provide essential services including nutrient cycling, air and water purification, flood and drought mitigation and soil production, free of charge. These services cannot be replaced at a reasonable price (Revenga *et al.*, 2000). The direct economic benefits of biodiversity run into trillions of dollars per year (Costanza *et.al*. 1997).

While recognition of the values of the goods and services that biodiversity offers, the relationship is increasing between the role of biodiversity in environmental sustainability, poverty reduction and sustainable development. This relationship needs further attention and understanding. Overall,

defaunation, deforestation and habitat encroachment viewed largely as a function of human action are the three major factors that caused contraction of birds, crocodiles and hippopotamuses in the Ruzizi Congolese plain.

In short, the striking finding to emerge from the study indicated a clear tendency towards threats and wildlife clumping into both hot and cold spots areas. The wetland area supported hot spots, while the lake shore area and the landscape cultivated area supported the cold spots in the Ruzizi flood plain. The effective conservation and management of world biodiversity often involves a range of management interventions (for example, strict protection to harvesting), depending on the status of the species, their habitats and the national context within which biodiversity and people interact. The ability to quantify abundance of a population, and habitat richness is fundamental to management (Sven and Alison, 2012).

### 6.1.2 Crocodiles of the Ruzizi plain

#### 6.1.2.1 Introduction

Crocodiles were cornerstone species in the former designation of the area as national protected natural reserve. With the war disturbances, the environmental law was not yet implemented and the area got gradually logged and sold by plots up to now, people did not know what still reaming there was.

As stated by the IUCN (2010) report, we found during our fieldwork, only Kyamvubu area at the small Ruzizi River mouth (former Ruzizi National Reserve), was being sold by plots, but yet there were no people settled in the flood area.

### 6.1.2.2 The Nile Crocodile (Crocodylus niloticus Laurenti 1768)

**Description**

According to Rafael (1986), Nile crocodiles have a dark bronze colouration, with black spots on the back and a dirty yellow on the belly. The flanks, which are yellowish green in colour, have dark patches arranged in oblique stripes. There is some variation relative to environment; specimens from swift flowing waters tend to be lighter in colour than those dwelling in lakes. Nile Crocodiles were found mostly in rivers, marshes and in the lake.

They are supremely adapted aquatic predator, with a streamlined body. Their eyes are green. They have four short, splayed legs; a long, powerful tails; a scaly hide with rows of ossified scuttles running down their back and tail; and powerful jaws ideally suited for grabbing and holding onto prey. Nostrils, eyes, and ears are situated on the top of their head allowing them to lie low in the water, almost totally submerged and hidden from prey. A special valve at the back of the throat allows the mouth to be opened to catch and hold prey underwater without water entering the throat. In addition to a good sense of smell and excellent night vision, the Nile crocodile also possess sensory pits in the scales along the side of the jaw, used to detect movement and vibrations in the water (Rafael, 1986).

Like all true crocodiles, the enlarged fourth tooth on the lower jaw is clearly visible when the mouth is closed, a feature which distinguishes this group from other crocodilians, such as alligators (Rafael, 1986).

Juveniles are grey, dark olive, or brown; with darker cross- bands on their tail and body. As they mature they become darker and the cross- bands fade, especially those on the body. The underbelly

is yellowish. The Nile crocodile is the largest African crocodilian, usually measuring between 3.3 m (10.8 feet) and 5 m (16.4 feet), exceptionally to 6 m (19.7 feet). Good sized males weigh 500 kg, but can also reach up to 909 kg (CSG, 1996). The largest accurately measured male was shot near Mwanza, Tanzania and measured 6.45 m (21.2 feet) and weighed approximately 1,090 kg. The males are up to 30% larger than the females. The snout of Nile crocodile is significantly narrower and smaller than the snout of Sharp-nosed Crocodile (CSG 1996).

**The trade of Nile crocodile**

According to Castro (2012), the trade of the Nile crocodile has become an environmental concern especially in the Republic of Tanzania opposite to DRC by Lake Tanganyika. Crocodile skins are being exported from Tanzania in large quantities due to the high demand for leather goods. The Nile crocodile skins are being exported for the luxury leather goods market including shoes, handbags and belts, especially to Japan, Italy and France. This trade has caused the Nile crocodile to be classified as an endangered species because, in particular, the species has been a source of highly durable leather for a variety of products which can be crafted and manufactured (Rafael, 1986). At the same time, Tanzanian natives use crocodile parts as a part of their culture for decorations on ceremonial accessories and in sacrificial rites (Britton & Adam, 2004).

According to CSG (1996), crocodile meat is eaten by tribal people in Tanzania and especially in Western Africa. Recently, crocodiles have been used for meat and meat products for human consumption outside of tribal regions. Skeletal bones and osteoderms of the crocodile are being used for nutritional supplements in agriculture and animal feeds, and teeth and claws are being sold primarily to tourists as curios. Crocodiles have been used for medicinal purposes. The body fat and oil of crocodiles is believed to cure skin ulcers, burns and respiratory ailments.

The news of the healing powers of crocodile fat has spread to other countries and the demand for these medicines is increasing (Britton & Adam, 2004). For instance, it has already been reported that the recent outbreak of crocodile poaching in the Dominican Republic and Haiti is related to the use of crocodile fat as a folk remedy for asthma. In the Ruzizi Congolese plain, the trade of crocodiles has not been reported, but it might be possible because some private people are keeping crocodiles in captivity, and young crocodiles have been brought to the local research centre for sale, especially during the civilian war, 1998- 2003 .

**Habitat, mating and breeding**

Nile crocodiles may be found in a wide variety of habitat types including large lakes, rivers, and freshwater swamps. In some areas they extend down into brackish water environments.

According to El-Nashotaky & Amira (2000), for males, the onset of sexual maturity occurs when they are about 3 m (10 ft) long while for females, it occurs when they reach 2 to 2.5 m (6.5 to 8 ft) in length. This takes about 10 years for either sex, under normal conditions. During the mating season, males attract females by bellowing, slapping their snouts in the water, blowing water out of their noses, and making a variety of other noises. The larger males of a population tend to be more successful. Once a female has been attracted, the pair warbles and rubs the underside of their jaws together. Females lay their eggs about two months after mating.

Nesting is in November or December, which is the dry season in the north of Africa, and the rainy season in the central and the south. Preferred nesting locations are sandy shores, dry stream beds, or riverbanks. The female then digs a hole a couple of metres from the bank and up to 500 mm

(20 inch) deep, and lays between 25 and 80 eggs. The number of eggs varies between different populations, but averages around 50. Multiple females may nest close together (Ross, 2004).

Britton & Adam, 2004 and Ross, 2004 reported that eggs resemble hen eggs, but have a much thinner shell. Unlike most other crocodilians, female Nile crocodiles will bury their eggs in sand rather than incubate them in rotting vegetation. After burying the eggs, the female then guards them for the 3 month incubation period. The father-to- be will often stay nearby, and both parents will fiercely attack anything that approaches their eggs. The impending mother will only leave the nest if she needs to cool off (thermoregulation), by taking a quick dip or seeking out a patch of shade.

Despite the attentive care of both parents, the nests are often raided by humans, monitor lizards, and other animals while the mother is temporarily absent. The hatchlings start to make a high-pitched chirping noise before hatching, which is the signal for the mother to rip open the nest. Both the mother and father may pick up the eggs in their mouths, and roll them between their tongue and the upper palate of their mouth to help crack the shell, and release their offspring. Once they are hatched, the female may lead the hatchlings to water, or even carry them there, in her mouth (El-Nashotaky & Amira, 2000; UNEP WCMC, 2012).

**Temperature-Dependent Sex Determination (TSD)**

According to CSG (1996), Nile crocodiles have Temperature-dependent sex determination, which means the sex of their hatchlings is determined not by genetics, but by the average temperature during the middle third of their incubation period. If the temperature inside the nest is below 31.7

°C (89.1 °F), or above 34.5 °C (94.1 °F), the offspring will be female. Males can only be born if the temperature is within that narrow 5-degree range.

Hatchlings are about 300 mm (12 inch) long at birth, and grow that much each year. The new mother will protect her offspring for up to two years, and if there are multiple nests in the same area, the mothers may form a crèche. During this time, the mothers may pick up their offspring to protect them, either in their mouth or in her gular or throat pouch, to keep the babies safe. The mother will sometimes carry her young on her back to avoid them getting eaten by turtles or water snakes. At the end of the two years, the hatchlings will be about 1.2 m (4 feet) long, and will naturally depart the nest area, avoiding the territories of older and larger crocodiles (El-Nashotaky & Amira, 2000). Crocodile longevity is not well established, but larger species like the Nile crocodile live longer, and may have an average life span of 70-100 years (CSG, 1996; Guggisberg, 1972; El-Nashotaky & Amira, 2000; Britton & Adam, 2004; and Ross, 2004).

**Scientific classification**

The Nile Crocodile belongs to the Kingdom of Animalia, Phylum: Chordata, Class: Reptilia, Super order: Crocodylomorpha, Order: Crocodylia, Family: Crocodylidae, Subfamily: Crocodylinae, Genus: Crocodylus, Species: *Crocodylus niloticus* Laurenti, 1768 (Wood, 1983; Nashotaky & Amira, 2000; UNEP WCMC, 2012).

### 6.1.2.3 Sharp-nosed Crocodile (Mecistops cataphractus)

**Description**

According to UNEP WCMC (2012), the Sharp- nosed Crocodiles (*Crocodylus cataphractus*) are native to freshwater habitats in Central and Western Africa. Their common name comes from their

extremely long, slender mouth. They have many common names including the African Slender-snouted Crocodiles, Long-snouted West-African crocodile, African gharial, Panzer crocodile, Long-nosed crocodile, African sharp-nosed crocodile, Loricate crocodile, Sub water crocodile..

The Sharp-nosed Crocodile is a small to medium sized crocodilian that stays around 2.5 m (8 feet) in length. The maximum size is reported to be 4.2 m (13.8 feet). It has a very slender snout and differs from all others members of the genus Crocodylus by having three or four rows of protective scales over the back of the neck where the other crocodilians have only two. It also is decorated with blotches that make it look like the Galivialidae and some members of the Alligatoridae. The diet of Sharp-nosed Crocodile is believed to consist chiefly of fish, amphibians and small aquatic invertebrates such as crustaceans. It is most likely an opportunistic predator like the other crocodilians that feed on wide range of prey if given the opportunity. It can live for at least 50 years. Its live life, average and maximum lifespan have not yet been reported. Their defining feature is the extremely slender snout, devoid of any bony ridges. The leathery skin of the adult is brownish-yellow with large black spots, and the olive coloured head is spotted with brown (Nashotaky & Amira, 2000; IUCN, 2012).

Young crocodiles are greenish- grey to greenish- yellow in colour with black blotches and markings. Six or so rows of tough scales run down the crocodile's back, leading to the species name *cataphractus*, meaning 'clad in armour' in Greek (CSG, 1996; UNEP WCMC, 2012).

**The breeding of Sharp-nosed Crocodile**

According to Crocodile Specialists Group (1996), and UNEP WCMC (2012), Sharp-nosed Crocodiles are generally a solitary species of crocodile and only come together during the rainy season for breeding purposes. After mating the female will build a nest of plant material on the banks of rivers. About one week after constructing the nest mound, the female will lie between 13 and 27 (average is 16) very large eggs within the nest. In approximately 3 1/2 months (110 days) the young begin to hatch. This is a much longer incubation period than most crocodilians. The young will chirp from within the nest inside the eggs, this is referred to as pipping.

The female will stay to her nest during the incubation time and when the young starts emitting their characteristic chirping she will assist them by opening the nest. The hatchlings then disperse across the vegetation which has become flooded by the rain. Predation by other animals is probably not an issue with this species because of their long incubation process and the fact that they have very sharp teeth and will defend themselves. It has been reported that soft shell turtles eat the young crocodiles. The litter sizes are usually small and very little is known about their range, even in areas where they are considered common not much is known about them. They are however believed to be in decline, primarily due to over hunting, and habitat loss is exacerbating the problem. Very little enforcement is used in protecting this species and many areas till allow the harvest of this species, despite its dwindling numbers (Wood, 1983; CSG, 1996).

In the Ruzizi Congolese plain, crocodiles breed in small islands inside the Ruzizi River between Ndunda and Kivira sites (see figure 22), because the lake shore area has been settled by a sandy belt area of 100-200 m which is regularly occupied by fishermen teams.

**Distribution in African continent**

The Sharp-nosed Crocodile lives in freshwater habitats in central and western Africa. It is known from following countries: Angola, Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Côte d'Ivoire, Congo-Brazzaville, Democratic Republic of Congo, Equatorial Guinea, Gabon, Gambia, Ghana, Guinea, Guinea- Bissau, Liberia, Mali, Mauritania, Nigeria, Senegal, Sierra Leone, Tanzania, Togo, and Zambia. It prefers freshwater environments with dense vegetation cover. It is primarily found in revering habitats but also known from lakes. It seems to be far less widespread than the Nile Crocodile (IUCN, 2012). In the Ruzizi Congolese flooding plain, the Sharp-nosed Crocodile was found more abundant than the Nile Crocodile in all the studied areas, probably due to the focus of study to wetland area.

**Scientific classification**

The Sharp-nosed Crocodile belongs to the Kingdom: Animalia, Phylum: Chordata, Class: Sauropsida, Order: Crocodilia, Family: Crocodylidae, Subfamily: Crocodylinae, Genus: Crocodylus, Species: *Crocodylus cataphractus*. Recent mitochondrial DNA analysis has indicated that placing the species in the genus Mecistops might be more accurate. If so; its name would remain *Mecistops cataphractus* (Wood, 1983; CSG, 1996; Nashotaky & Amira, 2000; IUCN, 2012).

### 6.1.3 The Millennium Development Goals

The Millennium Development Goals (MDGs) were formally established when the United Nations General Assembly adopted the Millennium Declaration in 2002. They address issues of poverty eradication and sustainable development through a set of targets and dates (Sarukhan *et al.*, 2005).

Achieving these targets is the responsibility of national governments. One of the significant features of the MDGs is that they seem to focus on developmental issues, leaving options of how to implement actions to achieve the goals open for interpretation. Goal 7 of the MDGs focuses on ensuring environmental sustainability without any explicit mention of the role of biodiversity and natural resources. However, the role of biodiversity in ensuring that the targets of the MDGs are successfully achieved is well recognized. Attempts are being made to mainstream biodiversity into, not only MDG 7, but also across other MDGs, as achieving the targets of the MDGs will directly or indirectly impinge on the status and use of biodiversity. These issues might be achieved in the Ruzizi Congolese plain, only by biological habitats recovering through a potential protected network under the Ramsar convention on wetland conservation.

### 6.1.4 MDG 7 ensure environmental sustainability

According to Annonymous (2002); Welfensohn *et al* (2002); Scherr (2003); Balakrishna & Warner (2003 and Buyinza (2009), MDG Goal 7 Targets integrate the principles of sustainable development into country policies and programs and reverse the loss of environmental resources; Halve, by 2015, the proportion of people without sustainable access to safe drinking water; have achieved, by 2020, a significant improvement in the lives of at least 100 million slum dwellers (Balakrishna & Warner, 2003). Since biodiversity impacts issues of poverty, a focus on using

biodiversity equitably and sustainably is fundamental to strategies and actions to eradicate/reduce poverty and to achieve sustainable development.

In the Ruzizi Congolese plain, only an international organization management like a Ramsar site can intend lasting and sustain the use of benefits of biodiversity: plants, fish, birds, crocodiles and hippopotamuses; by means of implemented Congolese environmental law and local people environmental education.

### 6.1.5 Links between biodiversity and poverty

The poverty goal of the MDGs addresses issues of extreme poverty, hunger and malnutrition.
These are closely related to the livelihoods and vulnerability of households. Rural households derive a significant proportion of their food and income from biological resources and, therefore, the availability and sustainability of biological resources is of direct relevance to poverty reduction for these people. In the Ruzizi Congolese plain, a large proportion of poor people live in marginal environments and in areas with low agricultural productivity or in fragile lands (Wolfensohn, 2002; Buyinza, 2009).

In these environments, there is a high dependency on genetic, species and ecosystem diversity to support local people's livelihoods. That is, aspects of biodiversity are of direct and indirect importance to food availability, health, nutrition, household development, income generation and vulnerability. Furthermore, improvements to core productive assets (including biodiversity-related factors of soils, water, trees and natural vegetation) is identified by the MDGs as the first step of the principle strategy for reducing under nutrition in households in such high-risk environments (Scherr

2003). The only way we found for conservation of biodiversity of the Ruzizi Congolese plain was to suggest that large wetland as integrated protected areas under the Ramsar convention which was ratified by the DRC since 1994.

Indeed, shortage of wood fuel imposes time and financial costs on poor households, putting a particular burden on those that are short of labour and making it harder for children to attend school. Poor people are affected by natural resource degradation and biodiversity loss much more than the better off because of their limited assets and access (Dowdeswell, 1997; UNDP, UNEP and World Energy Council, 2000).

### 6.1.6 The ongoing degradation of ecosystem services is a significant barrier to achieve the MDGs

Ecologically unsustainable use of ecosystem services raises the potential for serious and irreversible ecological change. This may occur on such a large scale as to have a catastrophic effect on the economic, social and political processes on which social stability, human well-being and good health depend. The MDGs give prominence to achieving reductions in malnutrition, infectious diseases, maternal mortality, exposure to unsafe drinking-water and, most importantly, poverty. All these goals are seriously jeopardized by continuing decline in the world's ecosystems (Dowdeswell, 1997; Wolfensohn *et al*, 2002).

This indicates strongly that a precautionary approach to environmental protection is the most effective way to protect and enhance health. Unavoidable uncertainties about aspects of the risks to well-being and health from environmental changes should not be an excuse for delaying policy

decisions (Sarukhan *et al.*, 2005). To sensitize Congolese decision- makers on the necessity of a potential Ramsar site, data on legally protected animals (waterbirds, crocodiles and hippopotamuses) in the Ruzizi Congolese wetland were urgent and very important.

## 6.2 Recommendations for conservation of the Ruzizi Congolese plain

Nile Crocodile has temperature-dependent sex determination (CSG, 1996). For this reason, among others, its breeding areas should be protected from human disturbances to avoid unbalanced sex population in the area. For example, the former human-eater crocodile in the Rusizi Burundian areas 2002-2005 called "Gustave", was male (see appendix 2).

Continued monitoring of the areas is also recommended to ensure that good practice is maintained and the environmental law as complied with local people, is respected to ensure legal 25 m (instead of 50 m) free for biodiversity conservation along ponds, rivers and along the Lake Tanganyika shore area.

In the Ruzizi Congolese plain, cattle numbers should be regulated so that their impacts on the habitats are not too destructive. There is a danger that with increased traffic of people to the area because of fishing activities, and numbers of cattle and other livestock species will increase dramatically to the detriment of the grazing land available especially during dry season. This in turn will lead to increased pressure for grazing within marshes, swamps and all areas around ponds.

There is a need to work with the communities in the Ruzizi Congolese plain to help them plan and manage their livestock as well as potentially benefiting from the income of a potential wise agriculture, planned fishing activities which are being developed in the area.

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**Appendix 1: Crocodiles of the Ruzizi plains**

| RCP | Sites/ | Nile Crocodile | | | Sharp-nosed Crocodile | | |
|---|---|---|---|---|---|---|---|
| | **Sample No** | **S1** | **S2** | **S3** | **S1** | **S2** | **S3** |
| | Kimanga | 3 | 2 | 4 | 4 | 3 | 5 |
| | Kilomoni 2 | 2 | 1 | 3 | 5 | 4 | 6 |
| | Kyamvubu | 0 | 0 | 0 | 0 | 0 | 0 |
| | SRR mouth | 0 | 0 | 0 | 0 | 0 | 0 |
| | Mwaba | 3 | 2 | 3 | 2 | 3 | 4 |
| | Ruzia | 0 | 0 | 0 | 0 | 0 | 0 |
| | Kimuka | 0 | 0 | 0 | 0 | 0 | 0 |
| | Kaberagule | 0 | 0 | 0 | 6 | 4 | 9 |
| | Kivira | 3 | 3 | 3 | 0 | 0 | 0 |
| RBP | Vugizo | 10 | 11 | | 17 | 21 | |
| | Mpundu | 3 | 5 | | 6 | 11 | |
| | GRR Bridge | 0 | 0 | | 3 | 2 | |
| | GRR mouth | 9 | 6 | | 5 | 7 | |

**S**: Sample; **RCP**: Ruzizi Congolese Plain; **RBP**: Rusizi Burundian Plain;
**SRR**: Small Ruzizi River; **GRR**: Great Rusizi River.

**Appendix 2: Questionnaire to assess the presence of crocodiles, hippopotami, and human factors that influenced conservation of biodiversity in the Ruzizi plain**

1. What is your occupation? (Farmer, Fisherman, Cow keeper, State worker)
2. How old are you?
3. Are there hippopotamuses/ crocodiles/birds here around?
4. How many are they?
5. When do you see them (morning, midday, evening, during rain fall, after rain fall, daily, at night)
6. Do they move away for long time (1 week, 2 weeks, 3 weeks, 1 month, 3 months, or 1 year)?
7. Do their number increase/ decrease from time to time?
8. Do they move somewhere else (for example to DRC)?
9. Do you kill them? (How, why, where, when)
10. 10. Do they attack/harm people (like"Gustave ", a human-eater crocodile 2002- 2005, injure people like hippopotamus in Ruzizi Congolese plain)?
11. Which factors influence bird, crocodiles and hippopotamus conservation in this area?