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EXECUTIVE SUMMARY

As commissioned by Rwanda Environmental Management Authority (REMA), the main objective of this survey was to make a rapid inventory of Kivu islands biodiversity and a socio-economy assessment particularly in Karongi District. In total, seven islands have been surveyed: Nyamunini, Mukondwe, Shegesha, Amahoro, Nyenyeri, Mpangara and Nyarugaba. The thematic groups studied were birds, plants, invertebrates, small mammals, reptiles, amphibians and socio-economy. Research methods are detailed in the report and vary according to the thematic area.

Results obtained for birds indicate that 80 species of birds were recorded in all islands surveyed 142 plant species, 52 invertebrates, 6 mammals, 6 reptiles and 5 species of amphibians. Some species of particular interest such as endemic, rare or useful species were described in the text.

Socio-economic findings revealed that various human activities are still taking place extensively in the islands. There is a lot of farming, animal grazing, and handcraft making using raw materials collected from the forest; there is also fishing, charcoal burning and firewood and medicinal plants collection which invariably indicates strong relatioship between ecosystems of the area and human activities.

It was also discovered that the main drivers of biodiversity change in Kivu islands are disturbance level, the location of island vis-a-vis the main land and the size of the island.

In order to protect the great richness of bird species and all other fauna and flora species found at those islands, there is an urgent need for conservation of Kivu islands so as to maintain its rich biodiversity. A new management system of should therefore be established as those islands constitute key zones for biodiversity conservation, tourism and recreation, and the best way to do this should be based on the creation of a *biosphere reserve*. In addition, Kivu islands have high potential of income generation and sustainable enhancement of local community livelihood.

CHAPTER I. INTRODUCTION

1.1. Kivu Lake

1.1.1. General information

Kivu Lake is a mountain lake which present characteristics are resulting from volcanic activity in the region. Originally flowing northwards into Lake Albert and the Nile system, the eruption of Birunga's volcanoes created a volcanic dam in the north and after the level rose by 50 to 70 meters the flow was reversed southwards into lake Tanganyika through the Rusizi river (Peeters, 1957 and 1959). Kivu Lake occupies an area of 2370 km^2 of which about 1000 km^2 (42%) belong to Rwanda. A total of 250 islands representing 315 km^2 are present. Idjwi island in DRC is the biggest with 200 km^2. In Rwandan part, 56 islands have been recorded.

Regarding depth, Kivu Lake has an average of depth of 240 m and a maximum depth of 490 m can be found (Degens *et al*., 1972). Due to its great depth and very steep shores, the littoral area of Kivu Lake having access to oxygenated waters only represents 12% (Beadle, 1981).

Geologically, this lake differs from the other large lakes in Central and East Africa by some characteristics. Kivu Lake is geologically young when compared to other large lakes, especially to the oldest Lake Tanganyika. It is about 15,000 years old and was formed during the Pleistocene volcanic events of the Virunga Mountains which blocked the connection between the south and the basin of the Nile River to the north (Beauchamp, 1964 *in* Isumbisho, 2006). Waters having lacked outlet northwards, found it toward the southern part of the lake by the Ruzizi River which now links Kivu Lake to Lake Tanganyika. It is thus possible to think about an old Kivu Lake that would even be in connection with Lake Victoria. The fact that Haplochromine fishes of Lake Victoria derive from those of Kivu Lake (Verheyen *et al*., 2003 *in* Isumbisho, 2006) tends to support this hypothesis.

The region enjoys a continental tropical humid climate, characterized by alternating dry and humid seasons. A small dry season takes place in December-January, followed by the great rainy season in February-May, the great dry season in June-September and the small rainy season in

October-November. Average rainfall over the lake during the dry season goes together with a decrease in maximum temperature. Average monthly temperature is around 20°C, it does not vary much throughout the year but can show considerable day-night variations.

Regular wind blows (Van Derben, 1959) mainly from south-east to east, crossing the lake in an oblique way or laterally. During the night, cold winds coming down from the volcanoes modify this system after sun set, they last up to 7 to 8 o' clock or and sometimes later.

Kivu Lake is a meromictic lake characterized by a partial movement of the first upper 70 m. A thermal stratification separates two layers which do not mix. Below 70 m there is a deoxygenated layer, and below 200 m presence of methane gas in big quantities (50 km^3) is characteristic of Kivu Lake (Degens *et al*., 1971, 1972).

Because of its relatively high altitude (1463 m), the surface waters of Kivu Lake are 2 to 4°C colder than those of other large lakes of the region: 23 to 24.5 °C against 26 to 29°C in lakes Tanganyika, Mobutu and Edward (Spigel and Coulter 1996).

Surface temperatures vary between 22°C and 24°C a steep thermocline of 1°C amplitude is located between 20 and 30 m (Damas, 1937; Van Derben, 1959).

pH is quite high in surface waters (9.45), this is the result of alkaline salts rich in soda coming from bottom lavas. The pH is constant in epilimnion, reaches 9 at 50 m and decreases to reach 7.2 at 100 m. Below 100 m, waters are slightly acid (6.85 to 6.75) probably as a result of the presence of high concentrations of carbon dioxide in deeper waters (Van meel, 1954).

1.1.2. The biological environment

1.1.2.1. Fish fauna

Kivu Lake is of a great poverty in terms of fauna, it is a result of its ecological youth. Prior to the introduction of *Limnothrissa miodon*, the fish fauna was related to that of Lake Albert being a restricted version of the species which had survived from the volcanic eruption turmoil and could adapt to the consecutive changes in environment. This fauna however did not show any relation with that of Lake Tanganyika. According to the various authors, it is considered that 16 to 19 species representing 3 families (Cichlidae, Claridae and Cyprinidae are represented). With the introduction of *Limnothrissa miodon* in 1959 (Collart, 1960; Splienthof *et al*., 1983), another

family the Clupeidae was added. However some authors indicate existence of 26 fish species of which 15 are endemic haplochromines (Snoeks *et al*., 1997 in Isumbusho *et al*., 2006).

1.1.2.1. Plankton fauna

Primary production in Kivu Lake is relatively low, considerable seasonal variations influence the zooplankton biomass, reaching a maximum in April-December (Verbeke, 1957; Kiss, 1959). This plankton bloom results from recirculation of nutriments from the mixolimnion. Primary production varies between 240 and 375 g C/m^2/year in the northern part of the lake (Jannash, 1975). Phytoplankton data from March 1975 have shown that the phytoplankton biomass in Kivu Lake was more abundant in the same period than in Lake Tanganyika and Lake Malawi (0.12 g C/m^3) Hecky et Kling, 1987). Two groups Cyanophycae and Chlorophycae represent 70 to 90% of the biomass. During the stratification period, phytoplankton in Kivu Lake is similar to that of Lake Tanganyika. In the coastal zone, sediments are encrusted by calcium carbonate, preventing colonisation by benthic invertebrates. Areas close to estuaries or in shallow bays are populated by Hirudinea, Chironomidae, Trichoptera, Ephemeroptera, Hemiptera, Coleoptera and Mollusca where encrusted areas as well as rocky areas are colonized by *Cladophora sp., Navicula sp., Cimbella sp., and Synodra sp., Cyanophicae* are not very common (De Iongh and Splienthof, 1981).

According to a recent study carried out by Isumbisho et *al.* (2006), zooplankton composition and relative abundance of different taxa showed that: three species of cyclopoid copepods were observed: *Mesocyclops aequatorialis* (Kiefer), *Thermocyclops consimilis* (Kiefer) and *Tropocyclops confinis* (Kiefer). Cladocerans were represented by *Alona rectangula* (Sars), *Ceriodaphnia cornuta* (Sars), *Diaphanosoma excisum* (Sars) and *Moina micrura* (Kurz), whereas rotifers were more diversified and represented by the following taxa: *Anuraeopsis fissa* (Gosse), *Brachionus calyciflorus* (Pallas), *Brachionus caudatus* (Barrois and Daday), *Brachionus falcatus* (Zacharias), *Brachionus quadridentatus* (Hermann), *Colurella sp., Keratella tropica* (Apstein), *Lecane sp., Trichocerca sp., Polyarthra sp., Hexarthra sp.* and unidentified Bdelloids.

Total biomass of mesozooplankton in Kivu Lake is lower than in lakes Tanganyika and Malawi. This may be related to the disappearance of a large grazer that existed before the sardine introduction, whereas the large lakes of the same region have a more complex pelagic food web,

with piscivorous fish, and with calanoid copepods, which can more efficiently exploit phytoplankton production (Isumbisho et *al.* 2006).

1.2. Kivu Lake islands

1.2.1. General information

With analogy to island biogeography, Kivu islands can be considered as continental islands. It means that before the lake was created, Kivu islands were physically and biologically similar to the surrounding main lands of western Rwanda. In fact, Kivu Lake is a mountain lake for which present characteristics result from volcanic activity in the region. Originally, flowing northwards into Lake Albert and the Nile system, the eruption of Birunga's volcanoes created a volcanic dam in the north and after the level rose by 50 to 70 meters, the flow was reversed southwards into Lake Tanganyika through the Rusizi River (Peeters, 1957 and 1959 in A. Mutamba & A. Mulindabigwi , 1987). This means that 15, 000 years ago, all actual islands were connected to the main land. For this reason, biodiversity from surrounding mainland should have many similarities with close islands. However, isolation of many islands could conduct to speciation.

1.2.2. Study sites

The islands to be covered by this consultation were Mukondwe, Shegesha, Amahoro, Mpangara, Nyarugaba and Sejema (Figure 1). After consultation with REMA, Sejema was replaced by Nyenyeri Island which is a very rich island in terms of biodiversity. In order to produce a comprehensive status of Kivu island inventories, the report also included data and findings from preliminary inventories carried out at Nyamunini Island. At each island, the survey was carried out on 6 different thematics: birds, plants, invertebrates, birds, Mammals, Reptile and Amphibians coupled with a socio-economy survey.

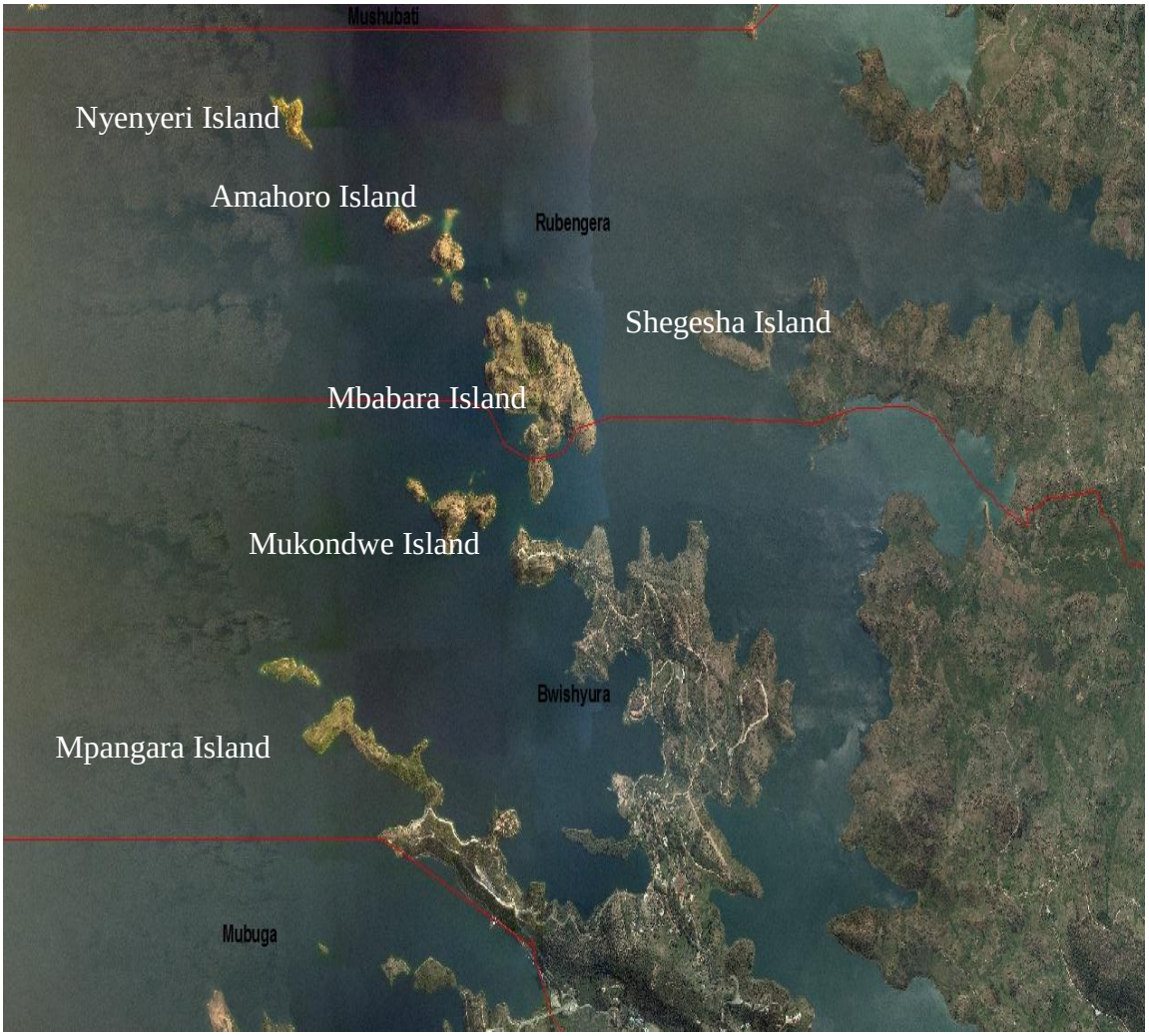

Figure 1 : Aerial photograph of some Kivu islands located in Karongi District

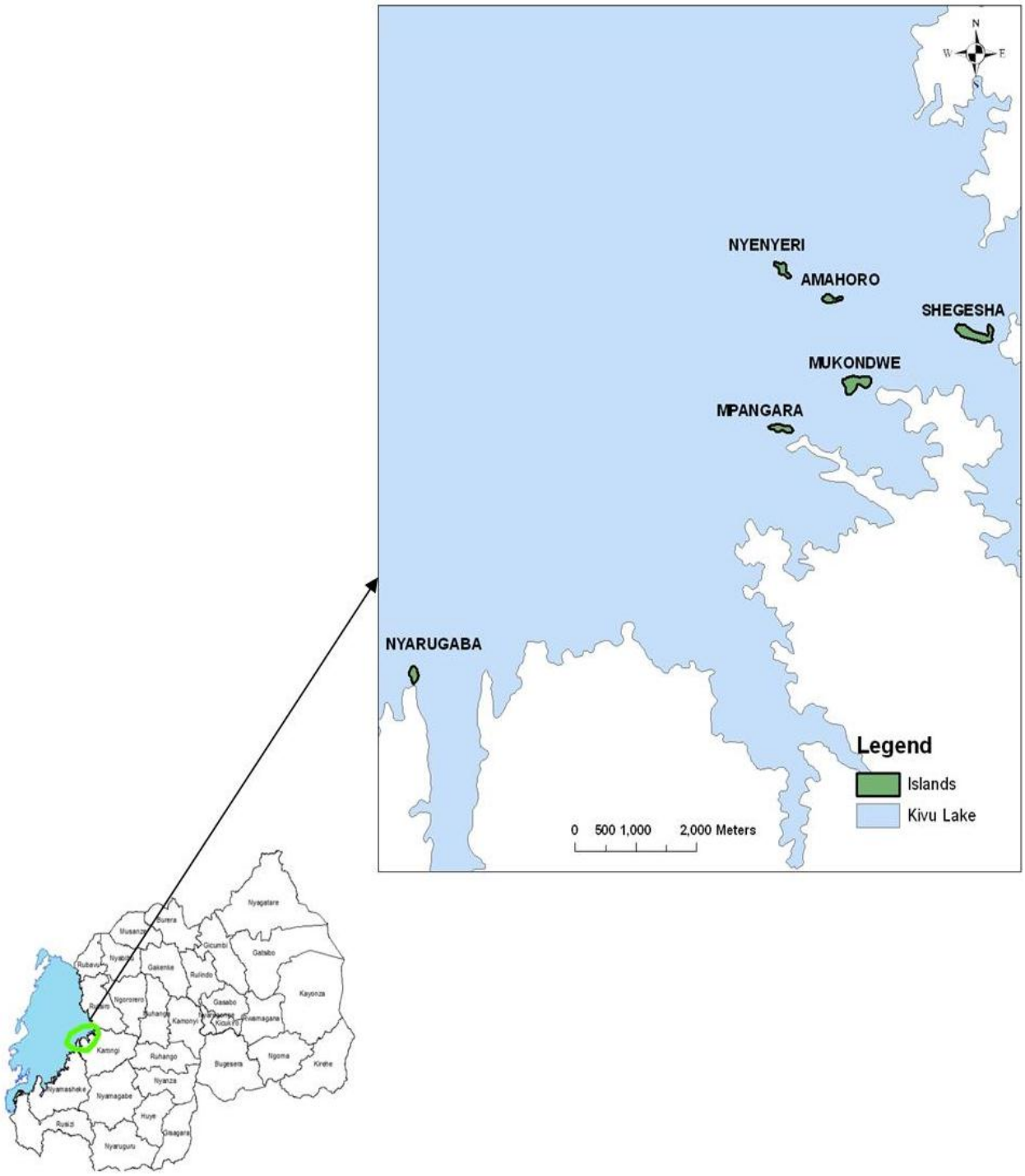

Figure 2: General map of surveyed islands

1.3. Scope of the study

The biodiversity of an island is dynamic. On islands, when separated from the mainland, species composition includes the original suite of species that have persisted plus those species that have been dispersed to the island. Mechanisms that bring species to islands include air and animal transport (e.g., seeds carried to the island via birds or bats), swimming from the mainland, deliberate anthropogenic introductions, and wind (Morton and Hogg 1989).

Every island has equilibrium for the optimum number of species it can support. Species diversity on an island mainly depends on three things:

- Extinction: the number of species that die out over time
- Immigration: the number of new species moving to the island from neighboring islands or landmasses
- Emigration: the number of species leaving the island to settle elsewhere

Other things that affect species diversity include time, isolation, and climate. The distance of an island from other habitats is an important factor to the levels of immigration and emigration. For example, an island close to a large mainland will have more animals arriving from the mainland to colonize the island than an island located many miles away from others will.

All actual Kivu islands were connected to the main land. For this reason, biodiversity from surrounding mainland should have many similarities with close islands. However, isolation of many islands could conduct to speciation.

Till now, very few published data exist about Kivu islands, most of existing information is related to Kivu Lake (Peeters, L., 1957; Haberyan K.A. Hecky E.R., 1987; Degens, E.T. *et al*., 1971). Kivu islands have however a high touristic potential thanks to their entertaining attraction. They contain a relic biodiversity, and if nothing is done for its conservation and restoration it is damned to disappear.

For all these reasons, REMA has committed a team of NUR researchers to conduct a biodiversity and socio-economy survey on some islands located in Karongi District so as to get more information about the existing possibilities to include Kivu islands in the protected areas network.

1.4. Objectives of the study

The objectives of this survey are:

- to conduct the biodiversity inventory of Kivu Lake islands.
- to gather the information on local people livelihood and main threats on biodiversity as a part of an ecological gap assessment.

CHAPTER II. RESEARCH METHODS AND MATERIALS

2.1. Birds survey

Three methods have been used to survey birds. Mist-netting and Opportunistic sampling techniques have been used on Mukondwe and Shegesha Islands, Line transect and Opportunistic sampling on Amahoro, Nyenyeri, Mpangara and Nyarugaba Islands.

2.1.1. Line Transect

Point counts and point transects are used to estimate population density /abundance of bird population (Anderson et al. 1979; Douglas 1995). The walk around island and counting all bird species detected is simple and routes are selected in accordance with the aims of the study. However the survey is sometimes constrained by accessibility to different habitats types (Colin et al, 2000). A transect was set across different habitat types from littoral vegetation, shrub /forest and savanna vegetation. Along the transect, all birds seen or heard have been recorded and their relative abundances were estimated for each surveyed island.

2.1.2. Mist-netting technique used to capture birds

Advantages of mist-netting include variability in data when compared to procedures, which depend on extensive experience with sight and sound identification or personal judgment in compilation and field data analysis (Karr, 1981a). Besides, that mist-netting can provide a wealth of data in a relatively short period; moreover, mist nets are powerful tools for detecting the presence of undergrowth bird species, particularly secretive species or those that vocalize

infrequently. It should be noted, however, that the capture does not represent a strictly random sample of the avifauna since large species walking on the ground and less active species at levels above net operation are undersampled (Karr, 1981b).

The birds were monitored using 12 m mist-nets within 1 day field work on each island.

The nets were placed on the ground level depending on the topography of the site, often from 0-2.5 m. Four nets were erected on Shegesha Island and three on Mukondwe Island. Those nests of 12 meters length and 2.5 meters height were placed in oriented West-East. Thus, the mist net line was 48 meters long and 36 meters long respectively. The nests were opened at down (about 8:30) and checked at 30 minutes intervals until 12:00 when they were closed and removed for the next island. Identifications of captured birds were made with reference to Stevenson & Fanshawe (2002).

For each bird captured, coordinates (longitude, altitude and latitude), time, and number of nets were recorded. All captured birds were recorded on a paper data sheet and ringed. For unidentified species on field, photographs were taken for further identification.

2.1.3. Opportunistic observation

Nets sampled only the understory birds. Transects or routes of reconnaissance sampled birds that were singing and obviously moving near the route or transect line. To complete the sampling, a quantitative sampling through general observation was made. In that regards binoculars for species record along the trails.

2.2. Vegetation and plants survey

2.2.1. Sampling techniques

Sampling was made inside the two major types of vegetation found on the islands: riparian forest and dry savanna. To determine the vegetation structure and floristic composition of the study area, stratified sampling method were used.

The cover-abundance value of all species was recorded within plots using the phytosociological method outlined by Braun-Blanquet (1932) according to which the abundance is estimated by assessment of the coverage of each plant species as follow:

Index	*Coverage*	*Coverage mean*
+	0.5%	0.5%
1	1 and 5%	3%
2	5 and 25%	15%
3	25 and 50%	37.5%
4	50 and 75%	62.5%
5	75 and 100%	87.5%

Species identification was done with reference on Troupin 1978, 1983, 1985 and 1988, and East Tropical Africa Monographs. Unknown plant species were collected, photographed, numbered and preserved for later identification. Biological forms proposed by Raunkiaer (1935) were also noted. Raunkier classification allows the description of the structure of habitats via physiognomic information and the assessment of regeneration responses in relation to habitat disturbances. Raunkiaer's life form spectrum has been applied for the prediction of climate in many ecosystems of the world and considered to be a good predictor of disturbance (Raunkiaer, 1934; Cain, 1950; Mcintyre *et al.*, 1999).

The communities have been identified using the Principal Components Analysis (PCA) with MVSP 3.1 (Multivariate Statistical Package) software (Kovach, 1997). The study site mapping was done using Arc GIS.

2.2.2. Useful plants identification and analysis

The evaluation methodology included scoping interviews, site visits and direct observation of the area, in-depth interviews, and group discussions. Development of the methodology began with an evaluation matrix, wherein the main issues were defined, together with key questions for each issue, specific sub-questions, and the corresponding data sources. After receiving based information consent, a semi-structured and open-ended interview was conducted.

Data analysis was done using Microsoft Excel software. Using data collected by interviews and direct observations, values for different uses of plants were analyzed for different islands. Therefore, a total number of species of each island was compiled and the role and use of all plants from all islands were established. In all islands, we analyzed the frequency of uses of four categories of plants: timber woods handicraft; domesticated plants; medicinal plants and edible plants.

2.3. Invertebrates survey

A set of three transects were identified according to the vegetation of the islands and the surface area. The transect was placed across the island and passed through different biota (gallery forest, forest and savanna). These transects were 5 m wide and around the circumference of the entire island.

Invertebrates were collected using the population estimates methods from line transects. We used two different models for this method. The first model is the static model that assumes that the animals are not moving. Then, we collected animals by moving stones and dead vegetation in transect and collecting all living organisms found there. The second model is the dynamic model that assumes that both the observer and the animal are moving such as Lepidoptera. A net of 30 cm of diameter was used in transect (Southwood, 1991). The specimens were identified by using the keys of Davies (1988), Lepesme (1953) and Grasse (1949).

The mollusks were identified by the keys of Brown (1994), Needhan and Needhan, (1962), Pennak (1952) and Pilsbry (1919).

2.3.1. Quadrats method

We used the quadrats methods for estimating the density of various taxa. We chose first the size of plot (1 m x 1 m) considered as the minimum surface (1 m^2) (Soutwood, 1991). Quadrats were selected in the gallery forest, in forest and in savanna according to the size of each island investigated. In the quadrat, we collected all organisms living inside by moving stones and dead materials. The specimens found were put in bottles containing formalin 10 % solution.

2.3.2. Relative methods using observation technical surface of flying insects

Flying insects were observed at a transect line of 5 m X 15 m in a specific site (Southwood, 1991). The number of transects were chosen according to the size of the island. The specimen collected were kept in bottles containing formalin (10%) , sorted in various taxa they belong to and were identified in the laboratory using the identification keys as explained above in quadrats methods.

2.4. Small mammals

Surveying small mammals uses stratified sampling techniques. In fact, diversity of habitats was targeted for trapping so to get as many species as possible. Sampling effort was done for each habitat and each island when possible. Within habitat living traps (Sherman live trap) were positioned so to catch as many species as possible that could be found on the island.

Traps were set in square grids of 15m×15m along transect at 20 meters of interval, along islands perimeters and some on top and middle altitudes where and when possible. 4 trapping stations per grid had Sherman live trap hidden in tufted brushes, on the base of trees. Baits used were dry *Limnotrissa* and *Lampructus* known as "indagara" with peanuts butter.

Traps were set for only one night in different stations all around an island and 4 to 6 stations were placed on each island depending on the size of the island which is not typical to standard methods. Trapping was limited at 6 days period covering one day and night for each island. Every morning check up of the traps was done. Captured small mammals were measured (head, whole body, forelimb, tail), weighed, described for their identification. Later on, captured animals were released for conservation issues. GPS was also used to record traps' positions.

2.5. Reptiles and Amphibians

Reptiles and amphibians were inventoried using direct observation. Tracking was concentrated mostly on islands' edges, in tufted grass and in areas with many rocks because they constitute the main habitat of reptiles and amphibians. Observations were done alongside transects and every time 10 minutes were spent in each position looking around and noting observed species of reptiles and amphibians. Direct observations were completed by indirect ones in terms of signs

and sounds and other relevant information such as habitat characteristics. Sometimes, it was necessary to disturb some bushes with a long stick to see if any reptile or amphibian may show up as these animals are cryptic.

As local population is an important source of information, a questionnaire was addressed to fishermen and other surrounding people to enrich collected information from the field.

2.6. Socio-economy survey

This study consisted of multi-stage approaches to identify the relationships between the existing natural resources and people's livelihood in the six islands visited at lake Kivu. Basically, we explored in deep the practical benefits underpinning the biodiversity and human development.
Data collection was done in four major islands: Mbabara, Kabahizi, Nyenyeri, Amahoro, Nyarugaba and Mpangara. The investigations were conducted in these islands because they are the ones which are inhabited, but the information gathered concerned all the surrounding islands globally.

A standardized questionnaire was used to collect information from household. Among others, the questionnaire captured information on: general household information, access to infrastructure and services, household assets, land ownerships, use and location, farming practices, techniques of soil conservation, post harvest technologies, general awareness of and access to inputs, marketing of agricultural products, membership to cooperatives, livestock production and marketing, household income and expenditure, household food security, use and conservation of bio-physical and their changes observed over time. Arguably, it was designed to establish the benefits farmers accumulate from exploiting the surrounding environment, which was the basis for highlighting possible impacts that human beings activities would cause on the environment.
In order to capture the prevailing human activities in the islands, a transect walk for farm to farm and household to household was conducted. The transect walk was helpful for exploratory work that guided for observation of environment and socioeconomic features which could not be depicted in the formal questionnaire for data collection.
This part of the study had covered 100 respondents obtained from the six islands mentioned above. These were selected randomly to ensure representation and sample element was chosen in

consistent with analytical tools owing the characteristics of respondents and economics activities the household performs in a nutshell of human-environment nexus.

The data analysis was done through the use of SPSS, descriptive statistics and systems dynamic. Basically, descriptive analysis provided data for the baseline conditions of the islands and respondents. This type of analysis unveiled the living conditions of respondents, their dependence to the natural resources found in the islands, etc.

CHAPTER III. RESULTS

3.1. Biodiversity inventory

At each island surveyed, an inventory of biodiversity was conducted on 6 groups: birds, vascular plants, invertebrates, mammals, reptiles and amphibians. Total number of species recorded by group is as follows: 80 bird species, 142 plants, 52 invertebrates, 6 mammals, 6 reptiles and 5 species of amphibians (table 1). According to the results obtained, Nyamunini Island is the most diverse, followed respectively by Mukondwe and Shegesha. Among other explanations of this fact is the largest area of the first island with many various habitats compared to other islands investigated. It is also the less disturbed island like Mukondwe and Nyenyeri. Shegesha Island is the most disturbed but it is bigger that the latter. This shows that the diversity in the studied areas is correlated to island size and level of disturbance.

Table 1: Biodiversity inventory of the surveyed islands

Island	Birds	Plants	Invertebrates	Mammals	Reptiles	Amphibians	Total
Nyamunini	53	141	40	5	3	4	**246**
Mukondwe	51	57	28	4	5	3	**148**
Shegesha	27	46	18	5	4	1	**101**
Nyenyeri	24	50	17	3	4	2	**100**
Mpangara	20	34	17	5	5	3	**84**

Nyarugaba	19	20	30	6	5	3	**83**
Amahoro	14	40	24	2	2	0	**82**

However, considering the ratio: number of species/size of island, Nyamunini is no more the one with high diversity (figure 3).

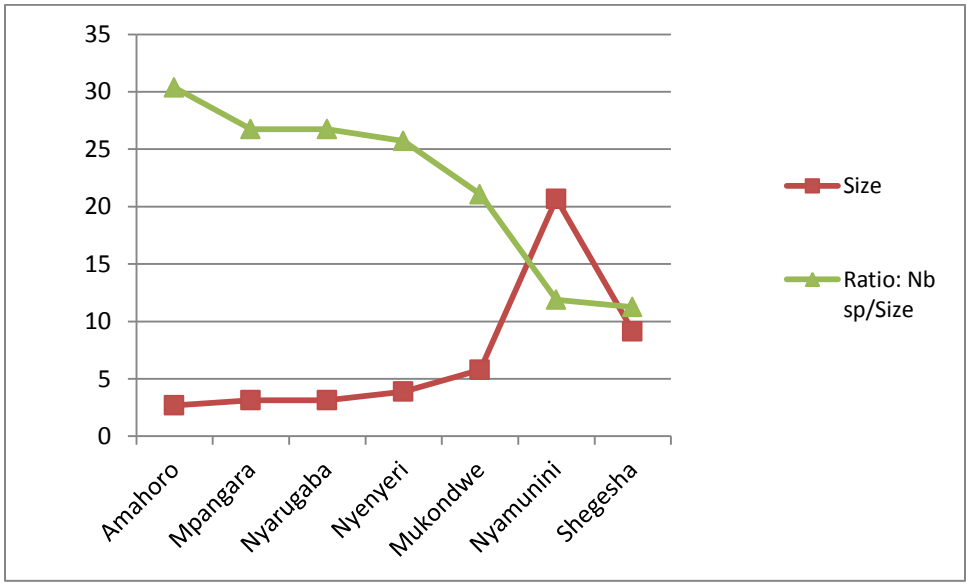

Figure 3 : Islands size and ratio between species richness and island size (Nb sp/Size)

The most diverse island in that case is Amahoro Island followed by Mpangara and Nyarugaba. The common feature of the three islands is that they are closer to the main land; a source of dispersal for many species especially plants. In fact, plants have less ability to dispersal compared to birds and they are subjected to be most abundant in islands closer to the source of dispersal: the main land.

Another fact highlighted by figure 3 is that Nyamunini and Shegesha niches are not completely occupied by species. According to field reality, at Shegesha many plants species have been removed because of intense disturbance by overgrazing. The situation is totally different at Nyamunini Island where plants species dominate the Southern part of the island because of a humidified wind blowing northwards. The Northern part of the island is therefore occupied by savanna vegetation with less species while the Southern part is forested. The particularity of

Nyamunini Island is that it is the most elevated of all islands studied with a maximum altitude evaluated to 1600m while the lowest point is located at 1470m high.

The same phenomenon has been demonstrated for plants where closer islands to the main land are the most diverse and the largest islands less diverse (figure 4).

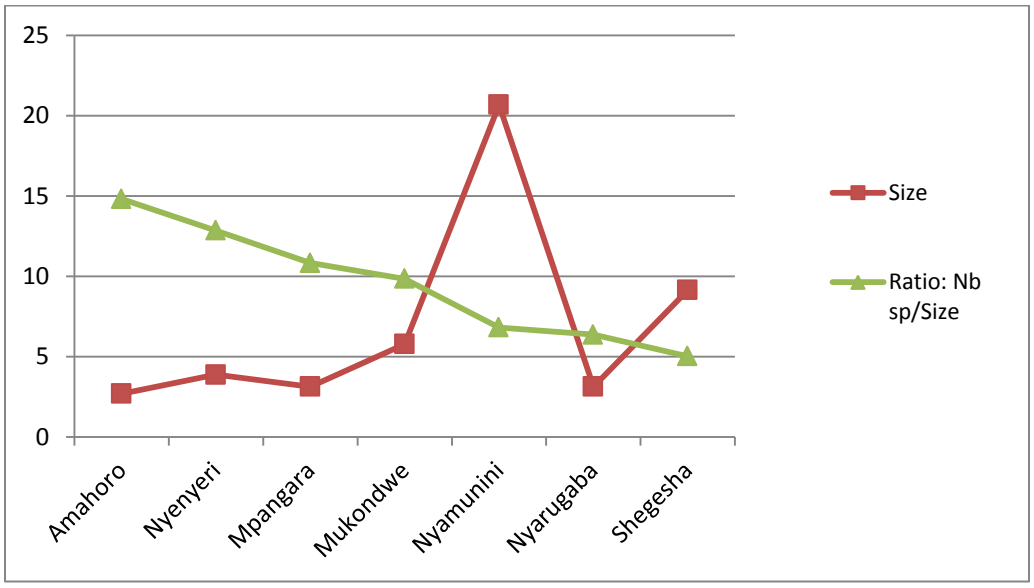

Figure 4 : Islands size and ratio between plants diversity and island size (Nb sp/Size)

With regard to species of higher ability to dispersal like birds, things are quite different. The factor influencing diversity the most is the quality of habitats (availability of food, zones for nesting, less predation….). The ratio between the number of species and the size of the island shows that Mpangara, Nyenyeri and Nyarugaba followed by Amahoro Island are the most diverse (figure 5). The common characteristic of the three islands is that they are relatively more forested. This kind of habitats allow many birds species to find easily food and zones for reproduction.

Birds have higher ability to move and disperse over all Kivu islands and they are concentrated into suitable habitats like those found on the three islands. They are the most sensitive to disturbance as it is demonstrated for the case of Shegesha Island. Nyamunini birds are mainly confined on small zone in the southern part of the island because it is the most forested area

offering suitable habitats to them. Despite the high variability of habitats on this island, its habitats seem to do attract many birds species as expected compared to three above mentioned islands.

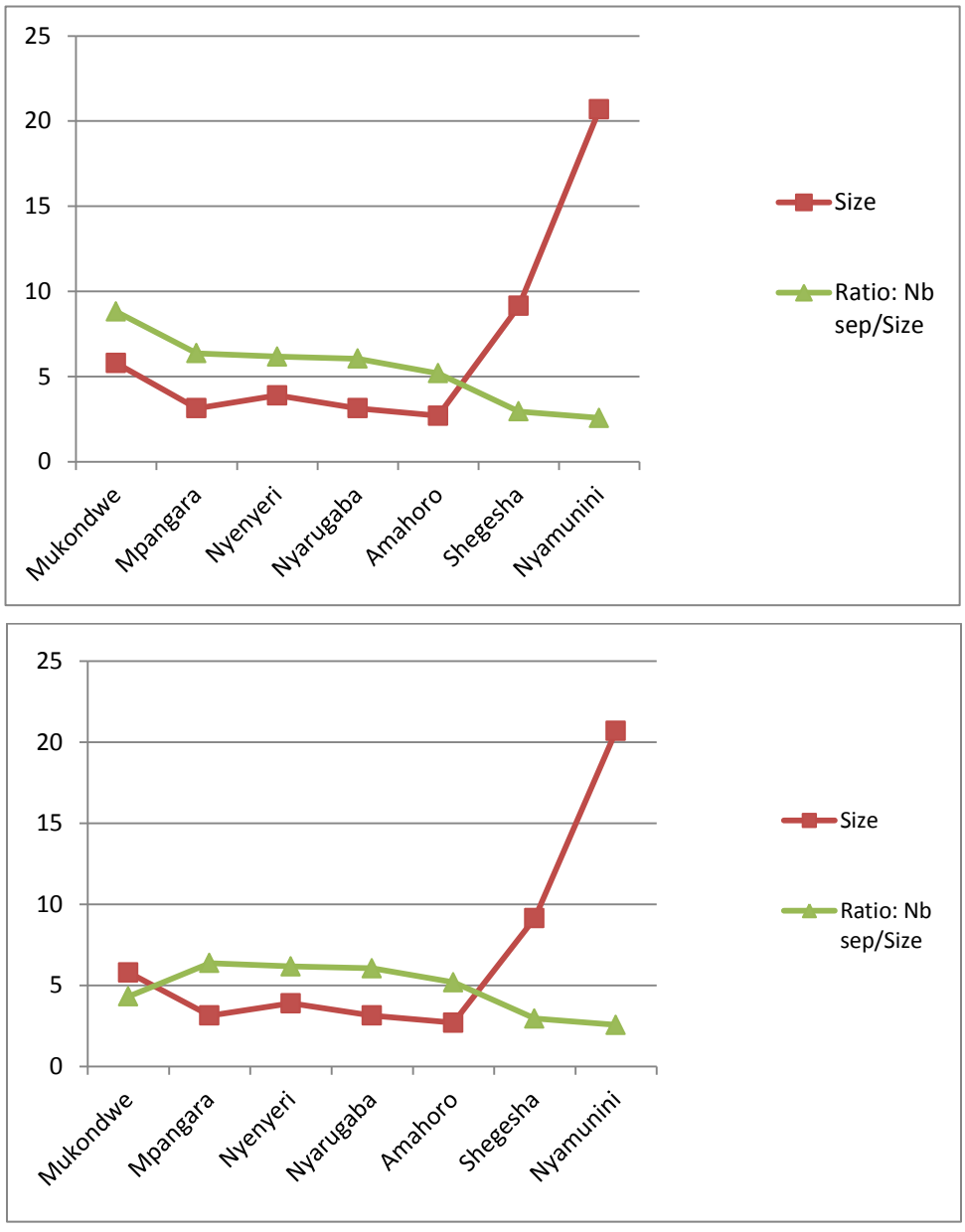

Figure 5 : Islands size and ratio between birds diversity and island size (Nb sp/Size)

3.1.1. Nyamunini Island

3.1.1.1. Geographic description

Nyamunini is a small island located in Kivu Lake, east of Rwanda, with a surface area estimated at ha 20,68. The elevation ranges between 1470 m and 1600 m. It is an island dominated by savanna vegetation in the northern part and forests along Kivu Lake shores and in the Southern part (figure 6).

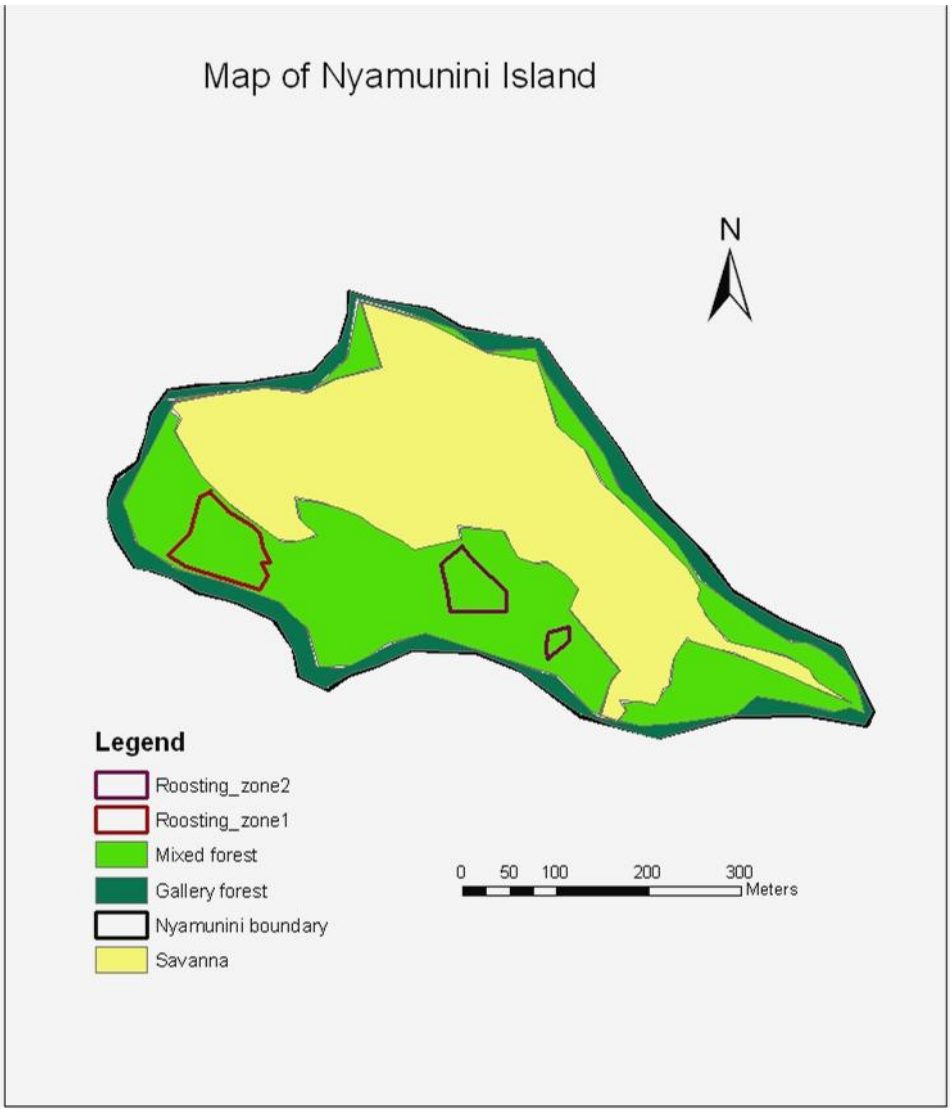

Figure 6: Map of Nyamunini Island

3.1.1.2. Birds

Prior to this study, a rapid inventory had been carried out at Nyamunini Island by the same team of researchers. A total of 53 bird species were recorded by sights and/or sounds during the line transect and opportunistic sampling at Nyamunini Island (Appendix, table 4).

Figure 7 shows the family abundance of bird species at that island. The families of Accipitridae (5), Nectarinidae (5) and Ploceidae (5) are more abundant at the Island. Of all 25 families recorded, 12 families are represented by only one species.
Among families represented by more than one species, the most abundant in terms of number of individuals are the families of Pycnonotidae followed by Estrilidae, Nectarinidae and Ploceidae. These families are on one hand abundantly represented mainly because of their wide ecological range in terms of feeding. On the other hand, Nyamunini Island is full of Psidium guajava tree plantations introduced by human beings especially during the period of genocide when that island has accommodated hundreds of people.

For instance, the Pycnonotidae species predominantly feed on fruits, and particularly on berries. However, some species of Bulbul also hunt for insects or look for worms and other small animals for food.

The basic food for most Ploceidae species is seeds of various wild grasses, supplemented with insects, spiders, freshwater snails, and fruits. They also help themselves to discarded scraps of human food.

Some remarkable bird species recorded at Nyamunini Island are briefly described below:

***Chlorocichla flavicollis* (Yellow-throated Greenbull)**
It is a species of songbird in the Pycnonotidae family. Its common names are Yellow-throated Greenbull in English and Grand Bulbul à Gorge Jaune in French. The species is found in Angola, Benin, Burkina Faso, Burundi, Cameroon, Central African Republic, Republic of the Congo, Democratic Republic of the Congo, Ivory Coast, Ethiopia, Gabon, Gambia, Ghana,

Guinea, Guinea-Bissau, Kenya, Mali, Nigeria, Rwanda, Senegal, Sierra Leone, Sudan, Tanzania, Togo, Uganda, and Zambia. Its natural habitats are subtropical or tropical dry forests, moist savanna, and subtropical or tropical moist shrub land (BirdLife International, 2009). The population size has not been quantified but this species and Common Bulbul *Pycnonotus barbatus* were mostly observed and abundant in Nyamunini Island.

Photo 1: Left: *Chlorocichla flavicollis*; Right: *Pycnonotus barbatus*

Nectarinia erythrocerca & Nectarinia senegalensis

The Red-chested Sunbird (*Nectarinia erythrocerca*) and the Scarlet-chested Sunbird (*Nectarinia senegalensis*) belong to the Nectariniidae family and inhabit savanna, grassland and wetlands. In Africa, they are mainly found in Burundi, Democratic Republic of the Congo, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, and Uganda. At Nyamunini Island, the species were mostly found feeding on flowers and their nests were found suspended in tree branches on the edge of the lake.

Photo 2: *Nectarinia erythrocerca* (Left), : *Nectarinia senegalensis* (Right)

***Dendropicos fuscescens* (Cardinal woodpecker)**

The Cardinal woodpecker is probably the most common and widespread of all African arboreal woodpeckers, with a range extending across sub-Saharan Africa, excluding dense equatorial lowland forest. The species is most common in woodland and savanna, avoiding arid areas. It is an extremely agile forager, gleaning ants and termites from bark and leaves, breaking open seed pods and even feeding on fruit (Hockey et al. 2005). At Nyamunini Island, invertebrates such as coleopteran, spiders, wasp larvae, some fruits and seeds have been recorded among its food items. No threat is recorded till now but, the species should be threatened by forest clearing on island because its breeding requires a nest which is a hole made in the underside of a tree branch.

Photo 3: *Dendropicos fuscescens* (Left), *Dendropicos fuscescens* nest (Right)

***Bostrichia hagedash* (Hadada ibis)**

This species inhabits wooded streams and river courses in open moist grassland and savanna woodland (Birdlife international 2009). It has been found on the edges of Kivu Lake feeding on invertebrates (Diptera, crustaceans, millipedes, spiders, earthworms, and snails) and small reptiles on island. The species is threatened by human activities such as logging (deforestation) for agriculture purpose which reduce food availability by extending droughts.

Photo 4: *Hadada ibis*

***Alopochen aegyptiaca* (Egyptian Goose)**

The species inhabits a wide range of freshwater wetlands in open country from sea level up to 4,000 m, including reservoirs, dams, pans, lakes, large ponds, rivers, marshes, sewage works, estuaries and offshore islands. It shows a preference for water-bodies with open shorelines and rich plant growth in close proximity to meadows, grassland and arable land for grazing generally avoiding densely forested areas (del Hoyo *et al*. 1992). This species is largely sedentary over much of its range, although it may make seasonal nomadic or dispersive movements related to water availability. It also undertakes annual post-breeding moult migrations to favoured waters. Its diet consists predominantly of vegetable matter such as the seeds, leaves and stems of grasses and other terrestrial plants, crop shoots (e.g. maize, wheat, oats, groundnuts and barley), potato tubers, algae and aquatic weeds, as well as some animal matter (worms, locusts and termite) (Kear 2005a). For breeding, nest sites on island were observed in dense vegetation on the ground near water on the edges of the lake. The species is persecuted by hunting and it is regarded as an agricultural pest.

Photo 5: *Alopochen aegyptiaca* (Egyptian Goose)

***Milvus migrans* (Black Kite)**

The Black Kite's range covers the majority of the Australian mainland, as well as Africa, Asia and Europe. The Black Kite is arguably the most numerous species of raptor in the world. The Black Kite is found in a variety of habitats, from timbered watercourses to open plains, and is often observed in and around outback towns. Despite being possibly the most common raptor in the world, the population has declined owing to poisoning, shooting, pollution of water and over-use of pesticides. Modernization of urban environments and agricultural improvements are also thought to be causing declines locally (Ferguson-Lees and Christie 2001). In Kivu islands the Black Kite preys on lizards, small mammals such as mice and insects.

Photo 6: *Milvus migrans* (Black Kite)

3.1.1.3. Flora and vegetation

a) Vegetation types

Three vegetation types are found at Nyamunini Island: A gallery forest (riparian forest) that covers 2.71 ha, a mixed forest that covers 8.18 ha, and a savanna that covers 9.79 ha. The most diverse community is the mixed forest followed respectively by the riparian forest and savanna.

b) Remarkable plant species

141 plant species were recorded at Nyamunini Island (Appendix, tables 5-7). Some remarkable plant species recorded at Nyamunini Island are briefly described below:

***Euclea racemosa* subsp. *schimperi* (A. DC.) F. White (Family: Ebenaceae)**
Local name: Umushikiri. **English names:** Sea guarri, Guarri-bush.
Ecology and distribution: *E. racemosa* is found in wooded grasslands, thickets, dry montane and dry lowland forests of East, Central and South Africa. In Rwanda, the species occurs in forest galleries and dry thickets in Mayaga, Bugesera, Umutara and Akagera National Park.
Uses: Firewood, tool handles, shade, antidote for poison, food (fruit), soil conservation, boundary marking, black dye (roots).

Photo 7: *Euclea racemosa* subsp. *schimperi*

***Anthocleista schweinfurthii* Gilg (Family: Loganiaceae)**

Local name: - **English name**: -

Ecology and distribution: It occurs in secondary forest, gallery forest, in thickets and sometimes in savanna or rainforest, usually not in moist localities. *Anthocleista schweinfurthii* occurs from Nigeria east to Ethiopia and south to Tanzania, Zambia and Angola. In Rwanda, the species is also found in Mashyuza, Bugarama.

Uses: The species is locally used to cure madness. In Congo a stem bark decoction is taken to treat hernia and female sterility. A root decoction is taken to treat stomach-ache in women, ovarian problems, venereal diseases, hernia, bronchitis and fever, and also as a purgative and to induce labour. In Tanzania a root decoction is taken to treat malaria, hard abscesses and as an anthelminthic. A bath is taken in a leaf decoction to treat vaginal prolapse. The plant is also used to prepare arrow poison.

Photo 8: *Anthocleista schweinfurthii*

***Psydrax parviflora* (Afzel.) Bridson (Family: Rubiaceae)**

Local names: Umugaja, Umubaruka, Umugomera, Umuyebe. **English names:** Giant canthium.

Ecology and distribution: It grows in lowland, submontane and montane forests, also found in thickets. It is widespread in East and Central Africa, also found in Malawi. In Rwanda, *P. parviflora* was recorded in Nyungwe and Volcano National Parks.

Uses: The fruits are used as medicine for coughs and influenza. Roots are cooked with animal soup (meat and bones) and taken for intestinal worms and generalized body pains. The wood is used for timber, firewood, charcoal, and tool handles. The tree is used for shade, amenity and bee forage.

Photo 9: *Psydrax parviflora*

***Entada abyssinica* Steud. ex A. Rich. (Family: Fabaceae)**

Local names: Umusange, Umusangasange. **English name:** Tree entada.

Ecology and distribution: It grows in wooded grassland, riverine forests and wet forest edges. Widespread in Sudanian and Guinean savannas to the South border of the Sahel, to East and South Africa. In Rwanda, this species was recorded at Bugarama, Umutara (Nyagatare), Akagera National Park and Bugesera.

Uses: Many medicinal and fetish uses: leaves; tonic tea, wound healing, contains rotenone and tannins, bark abortive, roots have antidotal effects against various toxic agents and fish poison (ichtyotoxic), nitrogen fixation, shade and live fence.

Photo 10: Pods of *Entada abyssinica*

***Solanecio mannii* (Hook.f.) C.Jeffrey (Family: Asteraceae)**

Local name: Umutagara. **English name:** -

Ecology and distribution: Montane rainforests, usually at edges or on clearings, also in grassland and on cultivated ground. Endemic to Central and East Africa. In Rwanda, it is widespread in Nyungwe National Park and abundant in Western and Southern Province.

Uses: Fence-posts, poles, sticks, used in traditional medicine against poisoning, splenic fever, leprosy and to treat snake bites. The roots are used against rheumatism.

Photo 11: *Solanecio manii*

3.1.1.4. Invertebrates

17 orders of invertebrates were identified at Nyamunini Island. The Diptera and the Coleoptera are the richest orders in terms number of families. Table 8 (Appendix) indicates the presence and absence of the arthropods and molluscs in 3 different habitats of Nyamunini Island.

3.1.1.5. Mammals

Mammals recorded during the survey are not restricted to Nyamunini Island. They were directly observed or confirmed by local people during the interviews. Therefore, these small mammals could occur in any island surveyed, and the description of the remarkable species is given below:

***Micropteropus pusillus* (Peters, 1867), Peter Dwarf Epauletted Fruit Bat**

This species is distributed in West Africa, Central Africa and East Africa and is native in many countries of those parts of Africa including Rwanda. This species is generally considered to be one of the most common African bats. Populations are typically found in savanna woodlands, but can be encountered in tropical moist forest, swamp forest, bushland, edaphic grasslands and

mosaics of these habitats. Animals usually roost in small numbers amongst dense vegetation.

Photo 12 : *Micropteropus pusillus*

***Congosorex polli* (Heim de Balsac & Lamotte, 1956), Greater Congo Shrew, Poll's shrew**

Congosorex polli is a species of mammal in the Soricidae family. It is endemic of Democratic Republic of the Congo. Its natural habitat is subtropical or tropical moist lowland forests. It is currently losing habitat to deforestation. The Greater Congo Shrew eats a wide variety of fruits and a few number of insects including ants. It is listed as data deficient by IUCN.

Photo 13: *Congosorex polli*

***Ruwenzorisorex suncoides* (Osgood, 1936), Ruwenzori shrew**

Ruwenzorisorex suncoides is listed as vulnerable by IUCN. This species is endemic to the Albertine Rift, occurring in the Ruwenzori Mountains (both in Uganda and the Democratic Republic of the Congo), additional parts of Uganda (Kasangaki *et al.*, 2003), eastern Democratic Republic of the Congo, Burundi (J. Kerbis pers. comm.) and Rwanda. This species is associated with damp and dense mossy vegetation in motane primary tropical moist forest. It appears to be a specialized semi-aquatic species that has been captured from shallow streams.

Photo 14: *Ruwenzorisorex suncoides* (Source: Myers, P., et atl. 2006)

***Atilax paludinosus* (G.[Baron] Cuvier, 1829). The marsh mongoose or water mongoose**

Mainly restricted to riparian habitats (rivers, streams, swamps, marshes and dams), wherever there is suitable vegetation cover and water in close proximity. They may also be found along estuaries and in coastal areas. Sometimes found away from watercourses, though only for limited periods. Diet comprises mostly aquatic prey with crustaceans usually dominating, which is unusual among herpestids. The species is widespread in Sub- Saharan Africa. Since it is dependent on riverine vegetation for shelter, the loss of this habitat may result in some localized declines where habitat loss is taking place.

Photo 15: *Atilax paludinosus*

***Oryctolagus cuniculus* (Linnaeus, 1758), Urukwavu, Rabbit**

Grey-brown fur and white-grey belly. Adults 1000-2000 g. Rabbits o**ccurs in** agricultural areas, desert, natural forests, planted forests, range/grasslands, ruderal/disturbed, scrub/shrublands, … Desirable features of ideal rabbit habitat include adequate cover close to feeding grounds kept closely grazed. Although rabbits can tolerate higher rainfall, they do so only on light soils and where other animals help to maintain a short sward. In wetter areas, rabbits favour dunelands, dry stony riverbeds, limestone hills with outcropping rocks, and sunny coastal slopes.

3.1.1.6. Reptiles

As for mammals, the inventoried reptiles occurred mainly in the waters around all islands, not at Nyamunini only. The following is the brief description of remarkable reptiles recorded:

***Trachylepis varia* (Petters, 1867), variable skink**

Trachylepis varia is widespread in East and South tropical Africa, typically inhabiting savanna and dry open forest habitats, eventually rain forest margins. It feeds on wide spectrum of small invertebrates, especially on insects.

Photo 16 : *Trachylepis varia*

***Trachylepis striata* (Peters, 1844), African Striped Mabuya, African Striped Skink**

The Striped Skink occurs in most of eastern Africa, its range extending from Ethiopia to the Democratic Republic of Congo, south to central and northern South Africa. The Striped Skink occupies a variety of habitats from forest clearings, coastal thicket, moist and dry savanna, to semi-desert and urban areas. This diurnal skink is essentially arboreal, and partial to human dwellings. It feeds on a variety of insects and other arthropods, particularly beetles, but also vegetable matter, fruit and carrion.

Photo 17: *Trachylepis striata*

Acanthocercus atricollis (Smith, 1849), Blue-headed Tree Agama, Black-necked agama

This species is found from Eritrea, south through East Africa to coastal KwaZulu-Natal, eastern Botswana and northern Namibia (Branch 1998). The western limit of the distribution is the western Democratic Republic of the Congo (Spawls *et al.* 2002). This species occurs from sea level to 2,400 m above sea level, although in East Africa it is most common from 1,300 to 2,000 m above sea level. This species inhabits open savanna.

Photo 18: *Acanthocercus atricollis*

3.1.1.7. Amphibians

Amphibians were not abundantly recorded during the survey, the main reason being that Kivu Lake, like other Rwanda lakes, is oligotrophic, therefore poor in nutrients to feed its fauna and phytoplankton.

***Hyperolius kivuensis* (Ahl, 1931)**

Found in Central and East Africa, the habitats of this frog are subtropical or tropical dry forests, moist savanna, subtropical or tropical seasonally wet or flooded lowland grassland, freshwater marshes, intermittent freshwater marches, and plantations.

***Afrixalus orophilus* (Laurent, 1947)**

Listed as Vulnerable by IUCN, the distribution of this species distribution is severely fragmented, and there is continuing decline in the extent and quality of its habitat in the Albertine Rift Mountains. This species occurs in Kivu Province in eastern Democratic Republic of Congo, western Rwanda, western Burundi, and south-western Uganda. Its habitat is not well known, but it has been found in montane grassland, bamboo forests, and in wetland areas in reeds and papyrus. It breeds in marshy areas.

Photo 19: *Hyperolius kivuensis* (Left); *Afrixalus orophilus* (Right)

***Phrynobatrachus versicolor* (Ahl, 1924)**

This species occurs in eastern Democratic Republic of Congo, western Rwanda, north-western Burundi and south-western Uganda. It is a leaf-litter species of mountain forest that is particularly associated with swamps and rivulets. The eggs are laid, and the larvae develop, in these waterbodies. It occurs only in undisturbed habitats. *Phrynobatrachus versicolor* is listed as vulnerable by IUCN.

***Hyperolius discodactylus* (Ahl, 1931)**

Hyperolius discodactylus is one of at least nine *Hyperolius* species endemic to the Albertine Rift, and it is distributed in Rwanda, Burundi, DRC and Uganda. It is found in high-elevation montane forest along streams.

Photo 20: *Phrynobatrachus versicolor* (Left), *Hyperolius discodactylus* (Right)

3.1.2. Mukondwe Island

3.1.2.1. Geographic description

Mukondwe is an island of about 5.8 ha, characterized by humid and rocky land in the northern part (figure 7 and 8). The soil becomes rocky on the slopes and the top of the hill. Mukondwe Island is made of 3 hills with one in the middle higher than others.

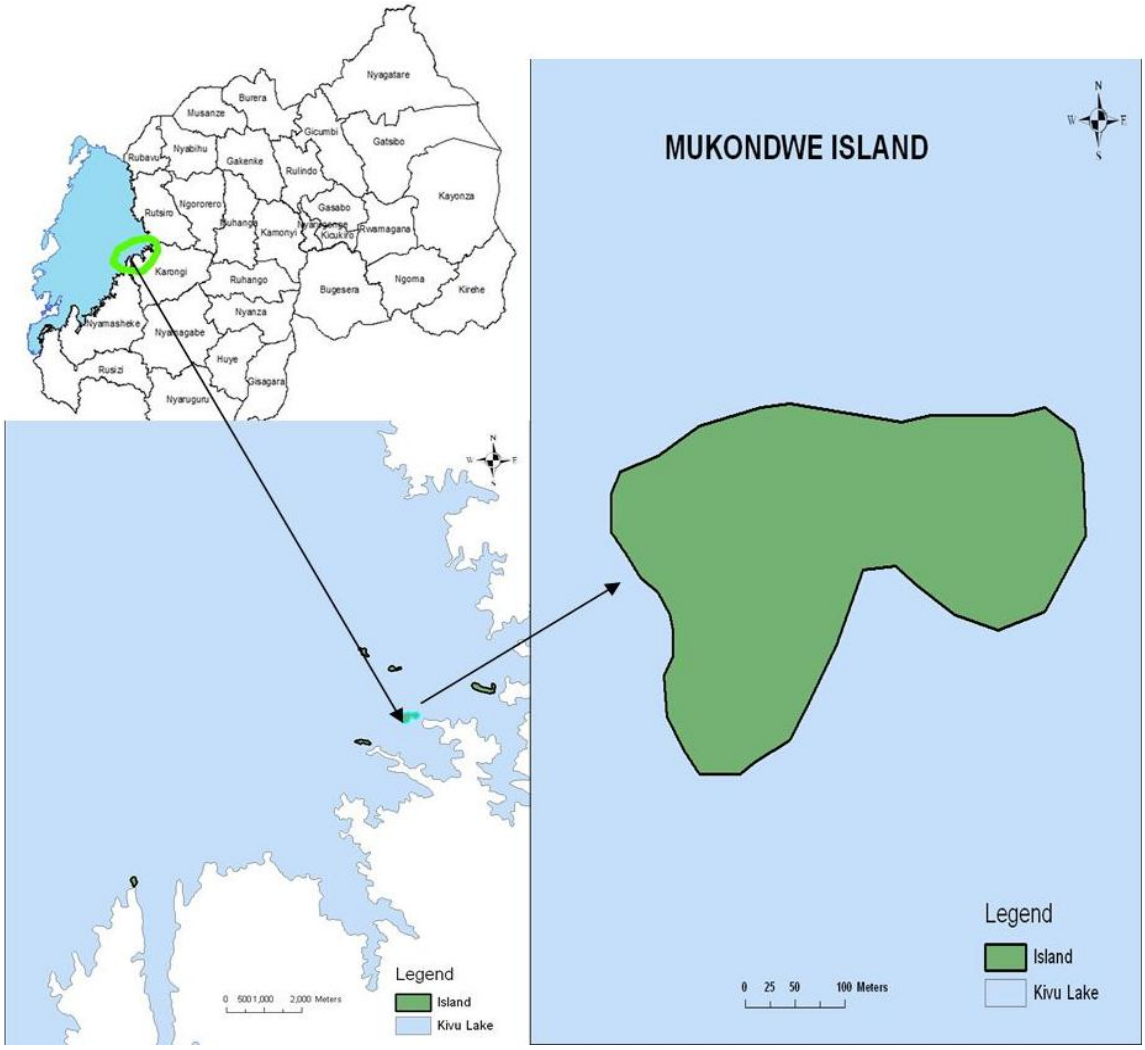

Figure 7: Map of Mukondwe Island

Figure 8: Mukondwe Island profile

3.1.2.2. Birds

A total number of 25 bird species was recorded by sights and/or sounds during the Mist-netting and opportunistic sampling. Among the recorded species *Pycnonotus barbatus* was the most abundant (Appendix, table 9). Some remarkable bird species recorded at Mukondwe Island are briefly described below:

***Phalacrocorax carbo* (Great Cormorant)**

The Great Cormorant is a water bird with an extremely large distribution, being found on every continent except South America and Antarctica. The species frequents both coastal and inland habitats (Birdlife international 2011). At Mukondwe Island, the Great cormorant was observed on rocks in the lake where its diet consists mainly of fish, crustaceans, amphibians, molluscs and nestling birds on the shore of the lake. This species is threatened by the clearing of riparian forest which is used as nesting sites. In addition to habitat disturbance, like all other ground nesting species, great cormorant is vulnerable to hunting and predation.

Photo 21: *Phalacrocorax carbo*

***Scopus umbretta* (Hammerkop)**

Occurs in south-western Arabia, Madagascar and sub-Saharan Africa. Within Africa it is locally common across much of the region, although scarce or absent in the arid western region. It generally favors the shallow margins of lakes, pans, swamps, rivers, marshes, streams, seasonally flooded ponds and even small puddles in gravel roads (Hockey et al. 2005). Its diet in Kivu islands is mainly made of frogs, small fish and insects, using a variety of foraging techniques, such as wading through the water and stabbing prey, still-hunting at the water's edge or pouncing on prey from the air. No threat is recorded but forest degradation should extirpate the species in islands because nests are made in tree branches.

Photo 22: *Scopus umbretta*

***Ceryle rudis* (Pied Kingfisher)**

It is a very beautiful species with 25cm length characterized by a black and white breast band (Stevenson 2002). It is very exciting to watch that species especially during its majestic diving while hunting fishes into the lake. The Pied kingfisher is one of the most common kingfishers in the world, being found in many areas of Africa and Eurasia, living in a wide range of aquatic habitats. It can live at any water body such as streams, rivers, lakes, temporary pans, estuaries, temporarily flooded areas and rocky coasts, and the nesting site is excavated into a vertical sandbank by both sexes (Hockey et al.2005). On Kivu islands, the species feeds mainly on fish and invertebrates such as dragonflies and their larvae, crickets and grasshoppers, water bugs and water beetles. No threat is recorded but the Pied Kingfisher population is impacted by poisonous used to kill fishes


Photo 23: Left: *Ceryle rudis*; Right: Pied kingfisher flying into its burrow

3.1.2.3. Flora and vegetation

a) Vegetation types

The vegetation is dominated by 3 main vegetation types: the riparian forest in the Northern part humid and rocky land with evergreen forest; the shrub layer of dry savanna on the slope of the hill; and the herbaceous layer of grass savanna on the hilltop with short and very dried herbs scattered on the rocky land. In the southern part of the island, many introduced plant species can be observed especially *Grevillea robusta* and *Psidium guajava.* Towards the top of the hill on a an eroded land, some Eucalyptus plantations can also be observed (see photo below).

Photo 24 : Mukondwe island *Eucalyptus* plantation

b) Remarkable plant species

57 plant species were recorded at Mukondwe Island (Appendix, table 10). Some key plant species recorded at the island are briefly described below.

***Cussonia arborea Hochst.* ex A. Rich. (Family: Araliaceae)**

Local names: Igitegamajanja. **English names:** Octopus cabbage tree.

Ecology and distribution: It is usually found in woodland, wooded grassland and bushland. It is widespread in Ethiopia, Sudan, East and Central Africa, south to South Africa. In Rwanda, the species is common in bushlands of Akagera National Park and Bugesera.

Uses: Timber (stoles), utensils (spoons), live fence, boundary marking, medicinal (venereal diseases, antidotes for venomous stings and bites, homeopathic, eye treatments, paralysis, epilepsy, convulsions, spasms) and bee forage.

Photo 25: Left: Plant of *Cussonia arborea*; Right: inflorescence of *Cussonia arborea*

***Phoenix reclinata* Jacq. (Family: Arecaceae)**

Local name: Umukindo. **English names:** Wild date palm, African wild date palm, Senegal date.

Ecology and distribution: It grows in dry lowland, montane and riverine forests and thickets. It is widespread in South Africa and Madagascar. In Rwanda, this species grows in many places particularly in eastern Rwanda and Kivu Lake shores.

Uses: Ornamental, shade, firewood, timber (local doors), food (fruit, it is a valuable source of nicotinic acid, vitamin C and potassium), sap and wines, soil and water conservation, fibres (leaves), roofing (leaves), basketry, ceremonial and religious purposes, mats (leaves) and bee forage.

Photo 26: *Phoenix reclinata*

***Ficus ingens* (Miq.) Miq. (Family: Moraceae)**

Local names: Umuvumu, umurehe, umurengarutare. **English names**: red-leaved fig, red-leaved rock fig, rock-breaker fig.

Ecology and distribution: *Ficus ingens* grows in various habitats but usually outside forest and prefers rocky outcrops and cliff faces throughout the bushveld, wooded grassland and coastal regions. It occurs in South Africa and further northwards into tropical Africa as far north as Ethiopia across into West Africa.

Uses: fence-posts, poles, sticks, hedges, markers, shade-trees, fibre, religion, superstitions, veterinary medicine, miscellaneously poisonous or repellent. It is also used in making canoes by local communities in Kivu Lake area.

Photo 27: *Ficus ingens*

3.1.2.4. Invertebrates

At Mukondwe Island, 5 plots were done. These plots were chosen to give the maximum of information about the invertebrates. It was observed that in recently occupied places the number of individual invertebrates is lower than in uninhabited places.

The order of Coleoptera is the most represented in this island. Many coleoptera found in this island are the first time to be identified in the region. The mollusk Pleuroprocta silvatica walikalensis is rare in the region. This species was identified by Plisbry (1919) in DRC but it is the first time to be identified in Rwanda. It is known that the distribution of tropical insect

diversity is poorly understood due to incomplete taxonomic knowledge that hinders identification of species and geographic distribution. Recent estimates of beta diversity, or change in species diversity among locations in Nyamunini Island in Rwanda challenged assumptions about geographic isolation and ecological specialization of insects. Dyer et al. (2007) found quite the opposite in a broader survey of caterpillars across a latitudinal gradient in the Americas. This situation in Mukondwe Island can be explained by the presence of more natural vegetation.

Figure 6 indicates that the insects are much more represented in Mukondwe. Other invertebrates are rare or inexistant in some plots. The Gasteropoda is located in one plot only, and plot 1 contains many species than all others.

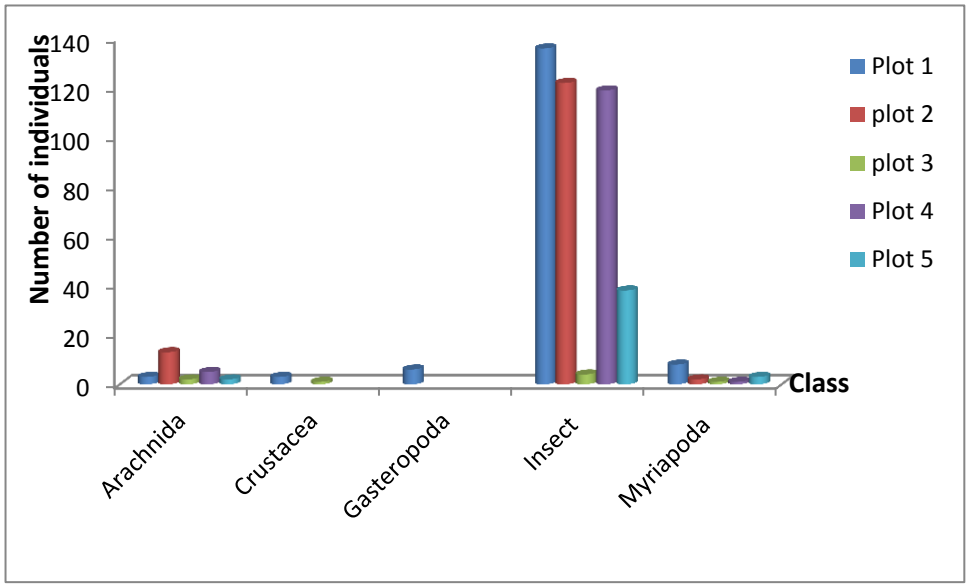

Figure 9: Invertebrates class distribution in Mukondwe Kivu Lake island

There were few flying insects found except Diptera and Lepidoptera (Butterfly); the other group was scarce (ex: Hymenoptera and Coleoptera). This situation was probably caused by the environmental degradation due to human activities. A comparison of the two transects shows that the difference is significative ($p>0.01$). The transect passed through bush and habited place is less colonized by insect then the one passed in scrub. This shows that the anthropogenic activities have impacted the presence of some species of invertebrates. The orders of Diptera, Lepidoptera and Hymenoptera are highly found in these transects.

3.1.2.5. Mammals

Most of mammals recorded at Nyamunini could also be found at Mukondwe Island. In total four Mammals species have been recorded at Mukondwe Island. The particularity of this island is the abundance of *Atilax paludinosus* according to information collected from local community.

3.1.2.6. Reptiles

At Mukondwe Island, 5 species of reptiles could be observed. The same species of reptiles recorded at Nyamunini could also be found at Mukondwe Island in addition of Forest Cobra and Black Mamba.

***Naja melanoleuca* HALLOWELL 1857), Forest Cobra**

A large and highly adaptable cobra found in various habitats throughout its large range. This is the most dangerous African snake. It is alert and moves quickly and can bite from a long distance. It lives in Africa from Sierra Leone to western Kenya and throughout Central Africa.

Photo 28: *Naja melanoleuca*

***Dendroaspis polylepis* (Günther, 1864), Black Mamba**

The Black Mamba snake also known as *Dendroaspis polylepis* is one of Africa's most dangerous and feared snakes. The black mamba is the largest venomous snake in Africa and the second largest snake in the world, after the King Cobra. The Back Mamba is also one of the fastest land snakes in the world. It has the capability to reach speeds in excess of 12 mph or 20km/hr. It mainly uses this speed the escape danger rather than capturing prey. This species is regarded as common in sub-Saharan Africa, it has been found as far north as Senegal and as far south as northeast South Africa (Spawls et al. 2002). Trape (2005) reports this species as far west as Senegal and Guinea. This species is most commonly found in well-wooded savanna or riverine forest, especially in areas with an abundance of rocky hills and big trees. It can also be found in coastal bush, moist and dry savanna and woodland.

Photo 29: *Dendroaspis polylepis*

3.1.2.7. Amphibians

Three species of amphibians were recorded at Mukondwe Island: *Afrixalus orophilus, Hyperolius kivuensis* and *Hyperolius discodactylus.*

3.1.3. Shegesha Island

3.1.3.1. Geographic description

Shegesha is an island of 9.1 ha located near Mukondwe Island, and is made of 3 hills as shown on the figure 10. The observed rocky land, dry soil covered by grass savanna and abundant Asteraceae species are characteristics of this disturbed area. This disturbance is mainly caused by grazing for cattle, cultivation of the land, uncontrolled tree harvesting, and habitat destruction/fragmentation due to the installation of small houses for shepherds and night watchmen.

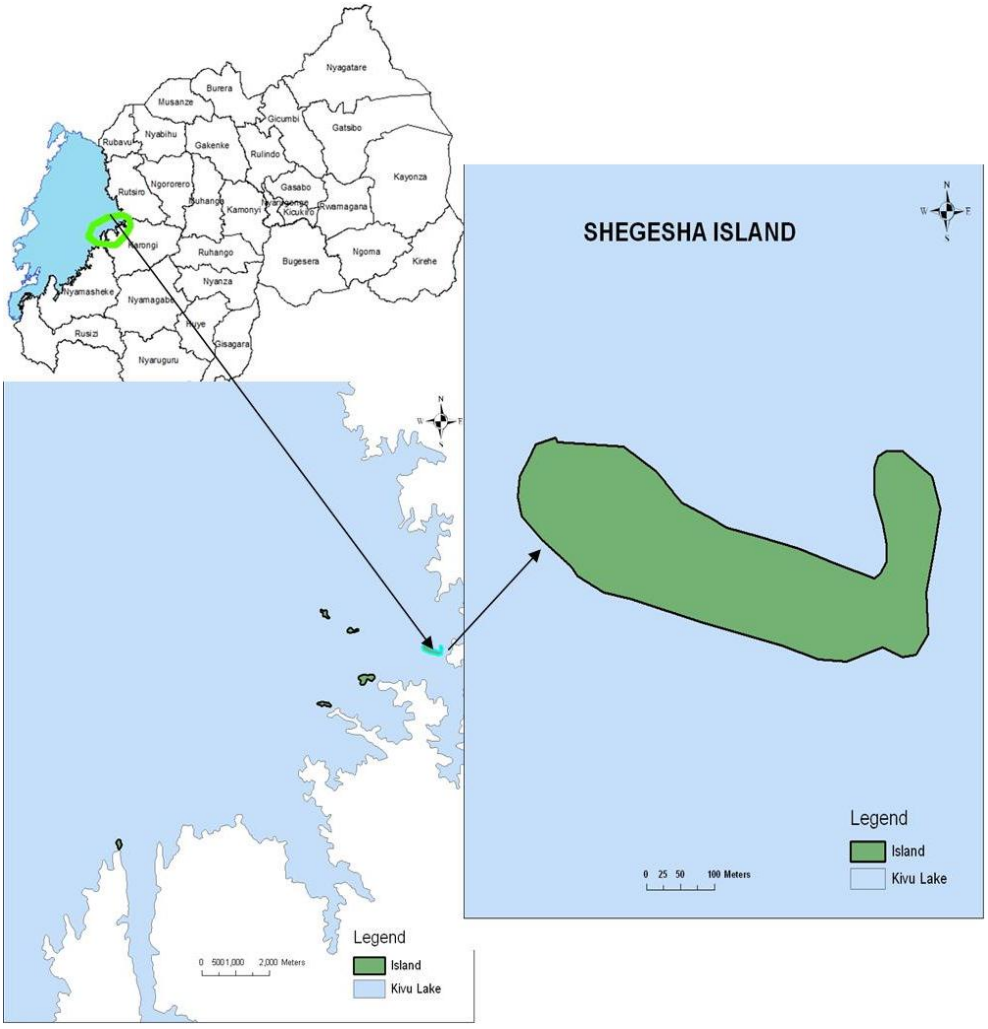

Figure 10: Map of Shegesha Island

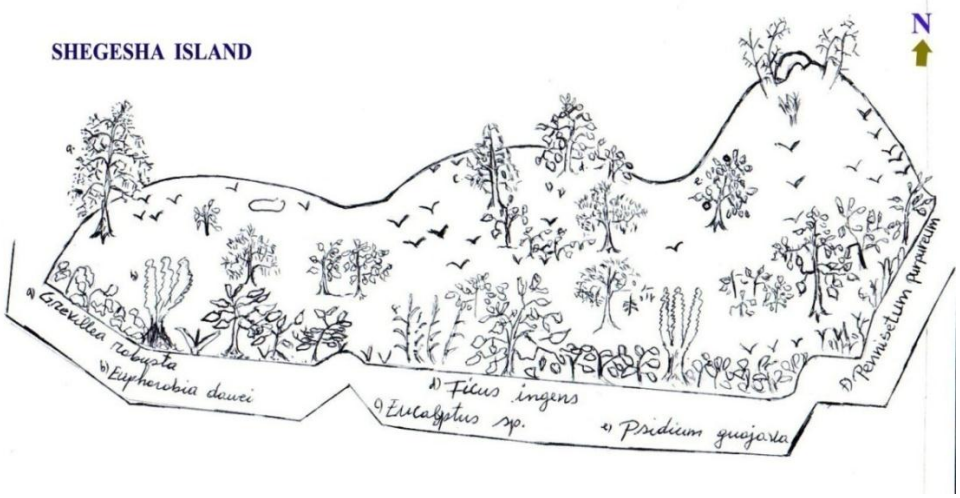

Figure 11: Shegesha Island profile

3.1.3.2. Birds

27 bird species were recorded by sights and/or sounds during the Mist-netting and opportunistic sampling. Among the recorded species *Euplectes franciscanus* (Northern Red bishop) and *Streptopelia semitorquata* (Red-eyed dove) were the most abundant (Appendix, table 11).

Photo 30: Left: *Streptopelia semitorquata* ; Right: *Euplectes franciscanus*

3.1.3.3. Flora and vegetation

a) Vegetation types

There are 3 main vegetation types from the North to the Southern part of the hill: the riparian forest which is much degraded; the shrubby layer and planted trees scattered in the middle part of the hill; and the grass savanna on the slopes and the top of the hills.

b) Remarkable plant species

46 plant species were recorded at Shegesha Island (Appendix, table 12). Some key plant species recorded at the island are briefly described below.

***Euphorbia candelabrum* Tremaux ex. Kotschy (Family: Euphorbiaceae)**

Local names: Umuduha. **English names:** Candelabra euphorbia, Tree euphorbia.

Ecology and distribution: It grows in thickets, bushlands and wooded grasslands especially on rocky hillsides and on termite mounds. It is *a* very common tree of very dry areas of East and Central Africa to South Africa. In Rwanda, this species grows naturally in Akagera National Park and Bugesera.

Uses: Ornament, firewood, timber (roofing, doors), shade, beehives, drums, carvings, ceremonial, night torches (dry branches), insect repellent (smoke of wood) and live fence.

Remarks: The latex is very poisonous and blinding if drops into the eyes.

Photo 31: *Euphorbia candelabrum*

***Acacia hockii* De Wild. (Family: Fabaceae)**

Local names: Umugenge, Umunyinya. **English names:** White thorn, Shittimwood.

Ecology and distribution: It occurs in wooded grassland and bushland, especially in areas where people have been living A. hockii is widespread in Africa, and in Rwanda, this species is found in Bugesera, Umutara (Nyagatare) and Akagera National Park.

Uses: Gums, resins, fiber, fodder, medicinal (pain-killers, stomack troubles, vermifuges, dropsy, swellings, oedema, gout, febrifuges)

Photo 32: *Acacia hockii*

***Erythrina abyssinica* Lam. ex DC (Family: Fabaceae)**

Local names: Umuko, Umurinzi. **English names:** Red-hot-poker coral tree, Flame tree, Lucky-bean tree.

Ecology and distribution: It grows in grassland, open woodland, Zambezian miombo woodland, bushland and forest edges especially on rocky places. It is endemic to Eastern-South Africa. In Rwanda, the species is common in many places around the country.

Uses: *Erythrina abyssinica* has interesting applications in traditional medicine: the bark is most commonly used in traditional medicine, to treat snakebites, malaria, sexually transmittable

diseases such as syphilis and gonorrhoea, amoebiasis, cough, liver inflammation, stomach-ache, colic and measles. Roasted and powdered bark is applied to burns, ulcers and swellings. Pounded flowers serve to treat dysentery. Leaves are applied externally to wounds and painful joints. *Erythrina Abyssinica* produces also firewood, carvings, utensils, mortars, drums, beehives, (bark, flower and roots), fodder (leaves), mulch, soil conservation, nitrogen fixation, ornament, shade, live fence, necklaces (seeds), curios (seeds). Traditionally, this species was used in cultural rituals known as Kubandwa.

Photo 33: *Erythrina abyssinica*

3.1.3.4. Invertebrates

The results of the inventory at Shegesha Island show that plot 1 was highly diversified than others investigated. In fact, it was located at the place undisturbed by human activities. The canopy was close and many dead materials were found at that place. This can be confirmed by the presence of the species *Lumbricus terrestris*. The difference between plots is very

significative (p>0.01). Plot 2 was located at a recently habited area and where the vegetation started growing. Plot 3 was located near the Lake with a poor soft soil. The soil is composed by stone and small sandy soil. These reasons can influence the presence of invertebrates in these plots. The class of Insects is highly represented in the sample in plot 1, and there are classes missing in some plots (figure 12).

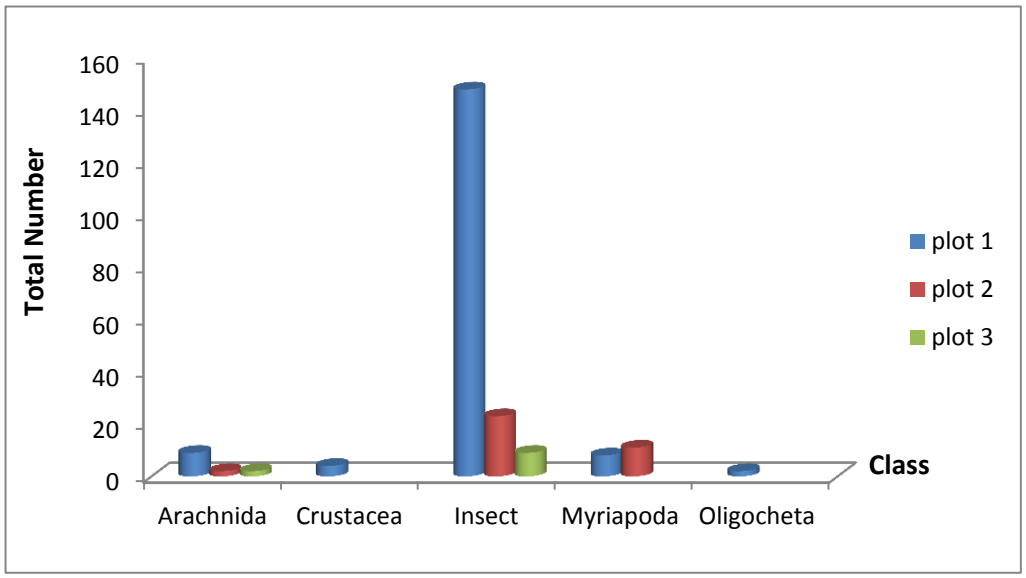

Figure 12: Invertebrates class distribution in Shegesha Island

The distribution of invertebrate species in all plots is shown in figure 13. The species *Cryptocercus punctutatus* was the most representative in Shegesha Island.

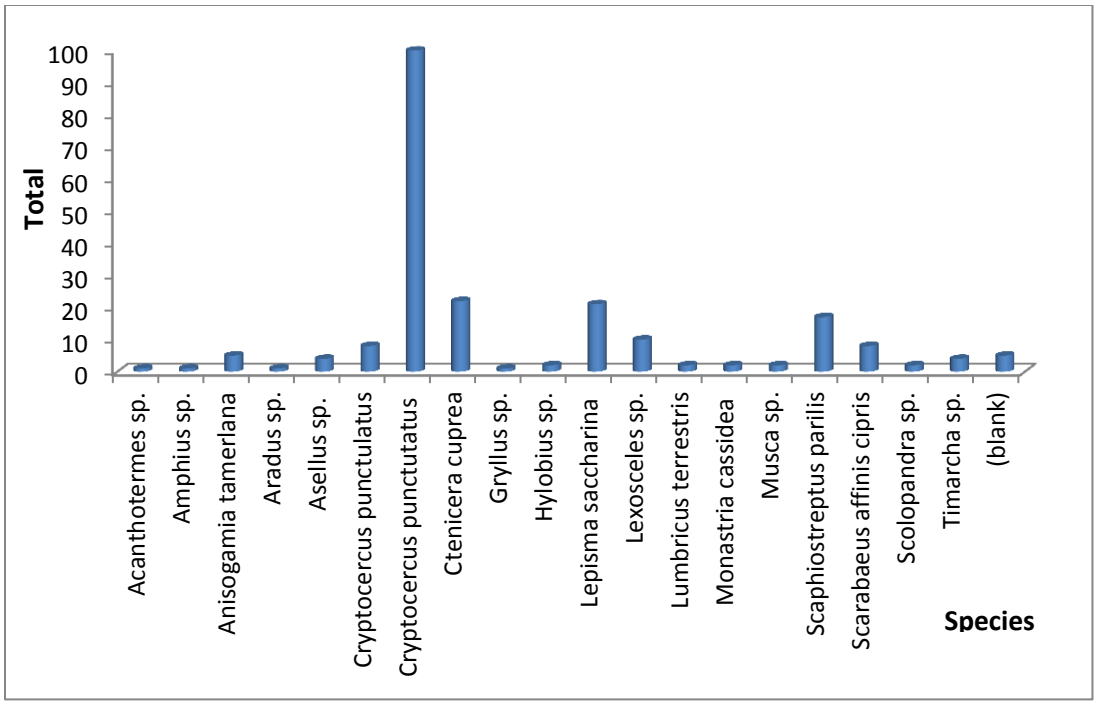

Figure 13: Species abundance at Shegesha Island

blank = No identified species.

The distribution of orders in transect of the Shegesha Island is presented in figure 14. The orders Diptera, Hymenoptera and Lepidoptera are the most representative orders. The analysis of total data using Khi quare shows no difference between transects.

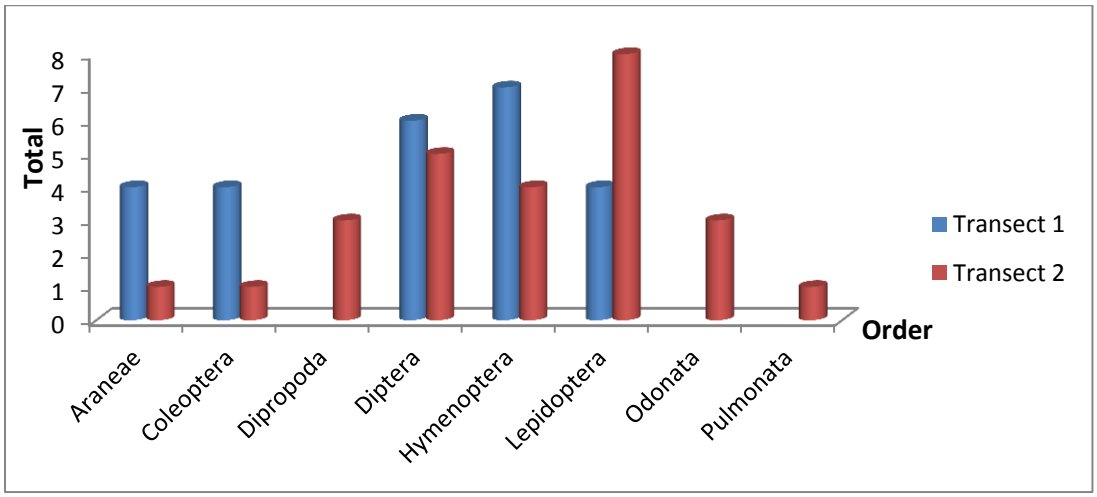

Figure 14: Order distribution within transects at Shegesha Island

3.1.3.5. Mammals

At Shegesha Island, all five species observed and at Nyamunini were also observed at Shegesha.

3.1.3.6. Reptiles

At this island, 6 species of reptiles could be observed including *Naja melanoleuca, Dendroaspis polylepis, Acanthocercus atricollis, Trachylepis varia* and *Trachylepis striata*.

3.1.3.7. Amphibians

Only one species could be observed at Shegesha Island: *Bufo maculatus*

***Bufo maculatus* (Hallowell, 1854)**

A medium sized toad (body 40–65 mm) known both from moist savanna and forest. The females lay their eggs in puddle pools or small ponds. The paratoid glands are flat, often inconspicuous. The skin is very warty. Tympanum 0.6–0.9 of the eye diameter. Tubercles on the hind-feet always very prominent. The color and pattern vary greatly: dark blackish brown to yellowish.

Photo 34 : *Bufo maculatus*

3.1.4. Amahoro Island

3.1.4.1. Geographic description

Amahoro is an island of 3 ha, and there is a businessman who lives there and who established a resort and changed it into a tourist place. Considering the morphology and the size of planted trees found, this island has been settled approximately since 30 years ago.

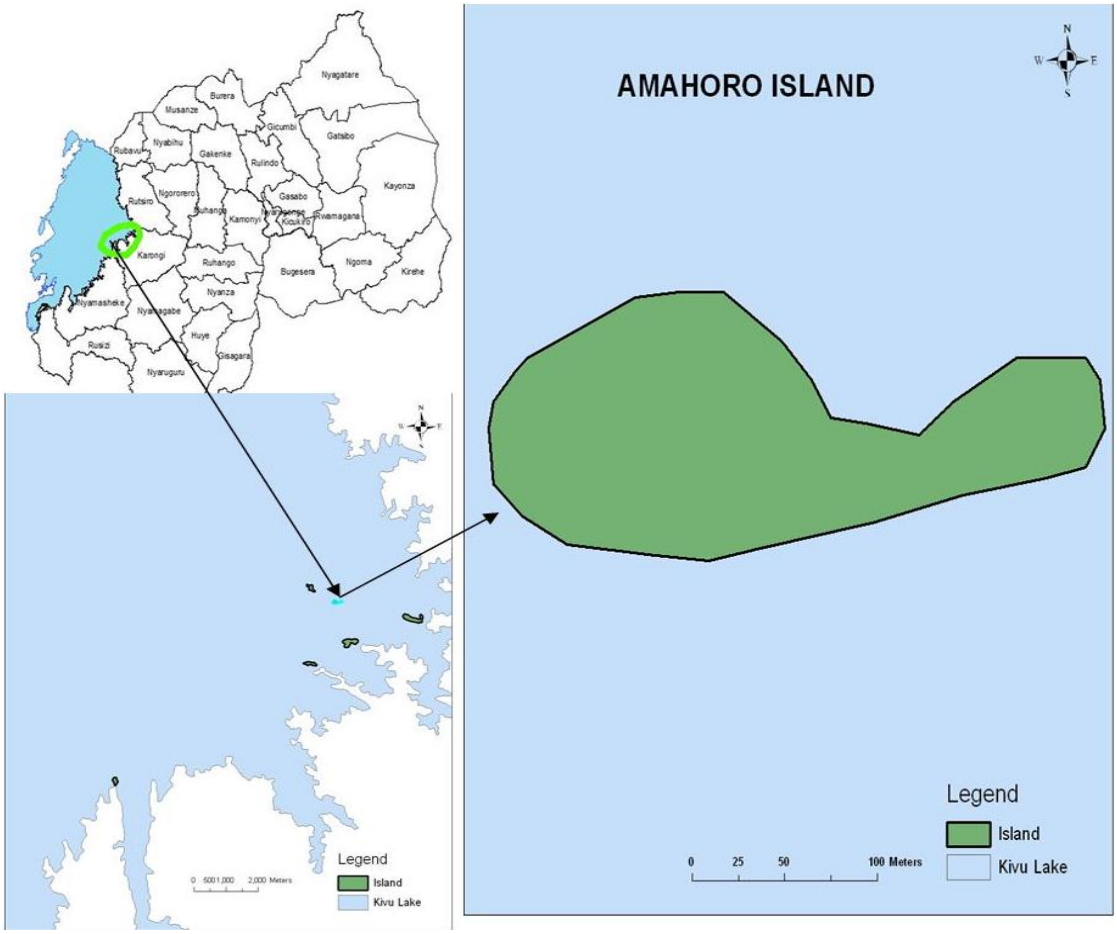

Figure 15: Map of Amahoro Island

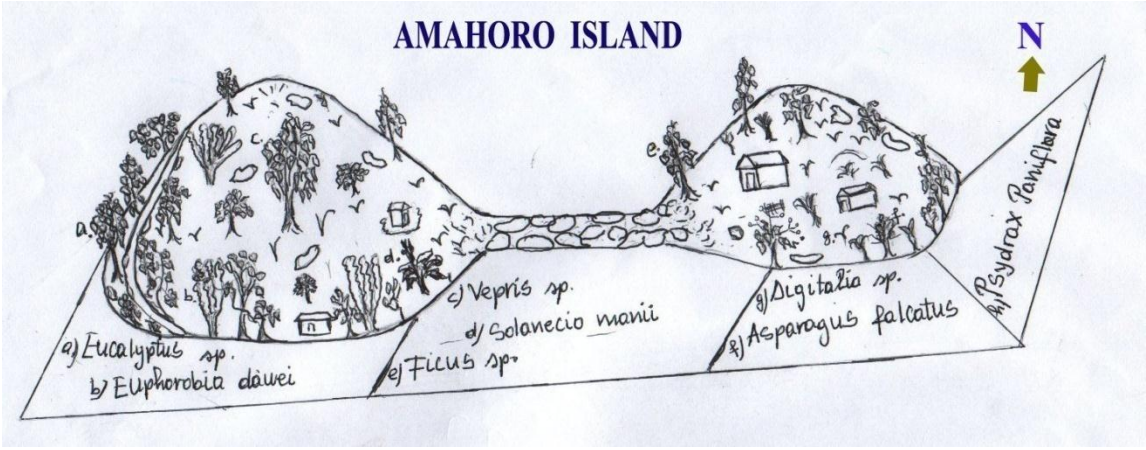

Figure 16: Amahoro Island profile.

3.1.4.2. Birds

A total number of 14 bird species was recorded by sights and/or sounds during the line transect and opportunistic sampling. Among the recorded species, *Merops oreobates* (Cinnamon-chested Bee-eater) and *Chlorocichla flavicollis* (Yellow-throated Greenbul) were the most abundant (Appendix, table 13).

Photo 35: Left: *Merops oreobates;* Right: *Chlorocichla flavicollis*

3.1.4.3. Flora and vegetation

a) Vegetation types

The main types of vegetation found on Amahoro Island are the Eucalyptus plantation on rocky soil in the middle part of the hill; the grass savanna on the hilltop in the North and Eastern part of the island; and the mixed riparian forest on rocky soil in the coastal land alongside the Lake.

b) Remarkable plant species

40 plant species were recorded at Amahoro Island (Appendix, table 14). Some key plant species recorded at the island are briefly described below.

***Euphorbia dawei* N.E. BR. (Family: Euphorbiaceae)**

Local name: Umurara. **English name:-**

Ecology and distribution: The species of lowland savannas in the Lake Victoria Mosaic Center of endemism. It grows in wooded ravines. It is an endemic species of Albertine Rift.

Remarks: E. dawei is a rare species found in Rwanda only in Kivu islands. It was recorded in Rusizi plain in Burundi, but now it is completely extinct. This species is listed in appendix II of CITES.

Photo 36: *Euphorbia dawei*

***Capparis tomentosa* Lam. (Family: Capparaceae)**

Local names: Umukorokombe, Umutugunguru, Umuhokera. **English names:** Capparis, Wag-'n-bietjie-climber, Wag-'n-bietjie-tree.

Ecology and distribution: It occurs in bushland, thickets, grassland with scattered trees, riverine vegetation, sometimes on termite mounds. It is widespread in Tropical Africa from Senegal

though Central and East Africa to South Africa and Mascarene islands. In Rwanda, this species has been recorded in Bugesera (Gako military camp), Akagera National Park and Umutara (Karukwanzi and Mimuli hills).

Uses: The plant is used to cure madness, snakebite, headache, impotence and sterility (in women). It is also used to treat fever. Roots are sometimes used as a love charm. It produces fodder (leaves), firewood, hedge and bee forage. **Remarks:** Roots and fruits are known to be very poisonous.

Photo 37: *Capparis tomentosa*

3.1.4.4. Invertebrates

The Amahoro Island is dominated by the class of insects. The distribution of insects in the plots shows a significative difference. Plot 2 is less dominated by invertebrates. The distribution of orders is presented in figure 17.

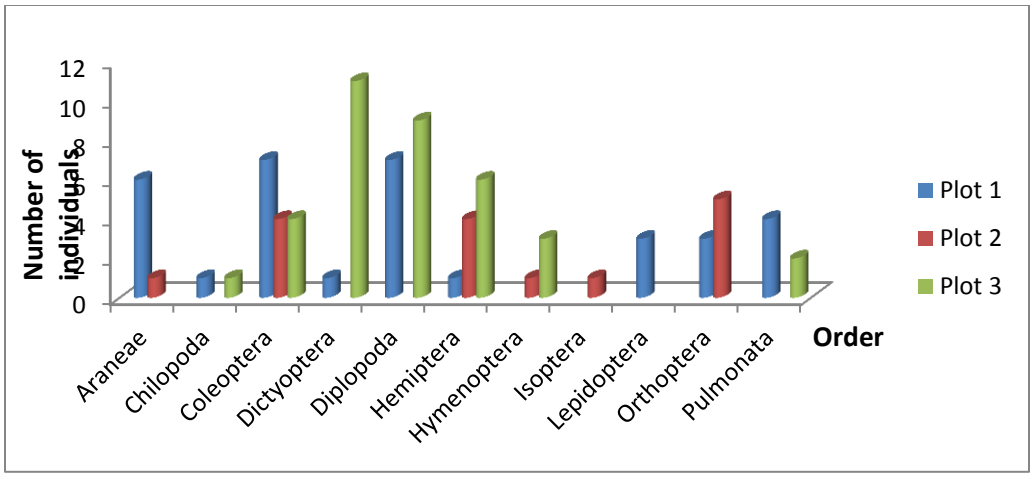

Figure 17: Distribution of orders at Amahoro Island

Similarly to other islands analyzed before, the distribution of orders at Amahoro Island is correlated to the topography, vegetation type and soil quality. Some orders are not represented in some plots and the number of specimen is fewer than in other islands. This situation is due to the anthropogenic activities at that island. That island undergoes many activities related to tourism and farming. Some recorded species are rare and others are abundant at the island among which *Scaphiostreptus parilis* is the dominant one.

The order of Diptera is the most found in the 2 transects at Amahoro Island (figure 18). Other orders are found only in one transect. The difference between the number of specimens of invertebrates collected is significant ($p>0.01$). The high number of invertebrates was recorded in the grassland where the canopy was open.

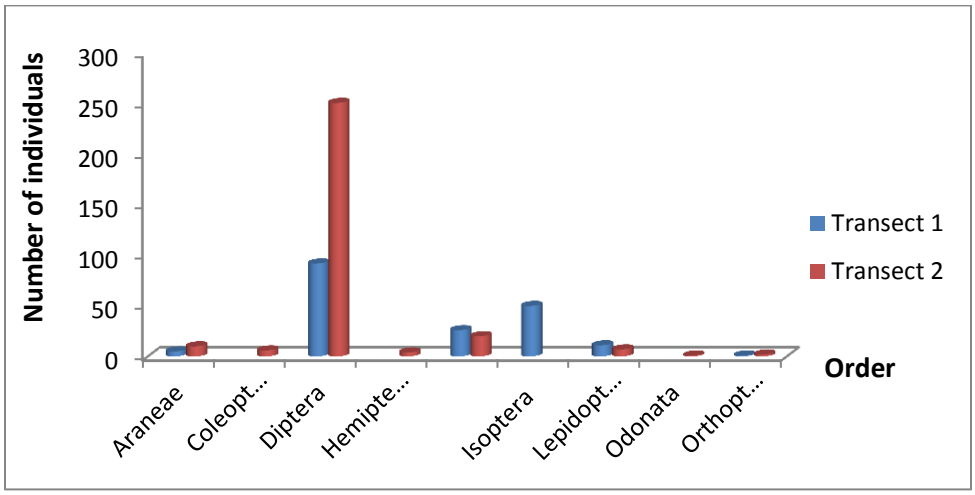

Figure 18 : Distribution of orders of invertebrate within transect at Amahoro Island.

3.1.4.5. Mammals

Amahoro Island is poorer in terms of mammals species than other islands surveyed. Only two species were recorded: *Congosorex suncoides* and *Surdisorex norae.*

3.1.3.6. Reptiles

Only two species of reptiles could be found at Amahoro Island: *Trachylepis varia* and *Trachylepis striata*.

3.1.3.7. Amphibians

During the survey, no amphibian species could be recorded at this island.

3.1.5. Nyenyeri Island

3.1.5.1. Geographic description

Nyenyeri Island covers 4 ha of area. It is located behind Amahoro Island and is formed by 3 hills with the big one in the middle (figure 19-20).

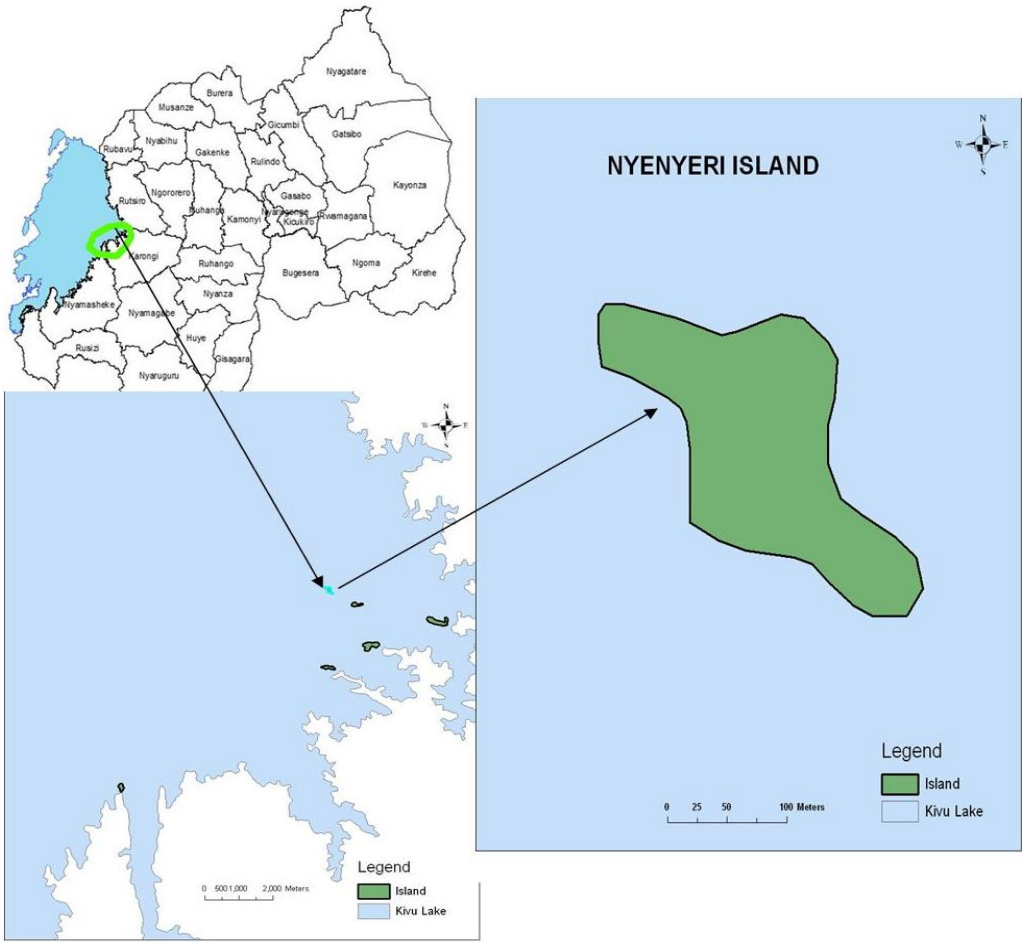

Figure 19: Map of Nyenyeri Island

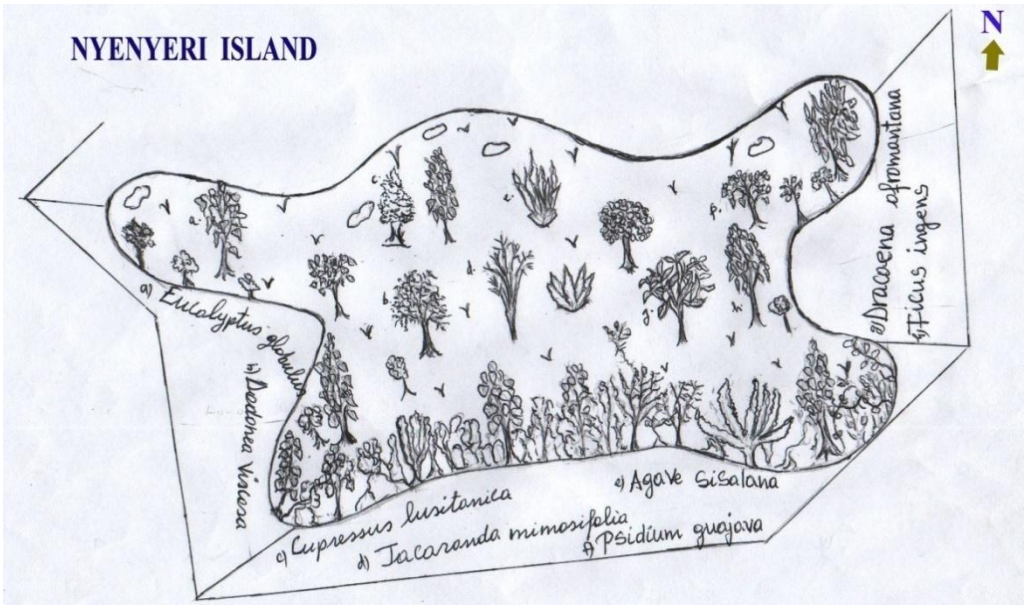

Figure 20: Nyenyeri Island profile

3.1.5.2. Birds

A total of 14 bird species was recorded by sights and/or sounds during the line transect and opportunistic sampling (Appendix, table 15). Among water bird recorded, species *Nettapus auriatus* (African Pygmy-goose*)* was the most abundant.

Nettapus auriatus inhabits permanent or temporary swamps, marshes, inland deltas, shallow lakes, pools, farm impoundments, flood-plains, slow-flowing rivers and occasionally coastal lagoons (del Hoyo *et al.* 1992). It shows a preference for deep clear waters with abundant emergent and aquatic vegetation, especially water-lilies (Brown *et al.* 1982). Its diet consists predominantly of the seeds of water-lilies (*Nymphaea* spp.), although the seeds and vegetative parts of other aquatic plants (e.g. pondweeds *Potamogeton* spp.), aquatic insects and small fish (Hockey et al. 2005). Breeding sites on island are preferably the vegetation stands closer to the edge of the lake. The species is threatened by hunting, habitat degradation around the lake and the destruction of aquatic plant communities through the introduction of exotic fish.

Photo 38: *Nettapus auriatus*

***Ispidina picta* (African pygmy-kingfisher)**

The African pygmy-kingfisher is beautiful species for bird watching. It is a small dark blue crown not extending down to the eye and orange cheeks with a purple pink to ear-coverts (Stevenson 2002). It is widespread across sub-Saharan Africa, partly due to its ability to live in a wide range of woodland types. The African pygmy-kingfisher feeds mainly in insects and fish. It is an intra-African breeding migrant. Not threatened, but its population is impacted by deforestation (Hockey et al. 2005).

Photo 39: *Ispidina picta*

***Burhinus vermiculatus* (Water Thick-knee)**

The Water Thick-knee has an extremely large range. It inhabits riverbanks, lake shores, estuaries, mangrove swamps, undisturbed sheltered beaches and islands, showing a preference for habitats with bushes or shrubs providing cover (Hayman et al. 1986; del Hoyo et al. 1996). Its diet on Kivu islands consists of insects such as aquatic beetles, grasshoppers, and termites; small crustaceans, mollusks, earth worms, frogs, millipedes and grass seeds. In Kivu island, the species breeds by making the nest on the ground close to water. This makes the species to be

vulnerable to hunting and predation. In addition to hunting and predation Water thick-knee is threatened by human disturbance of the habitat.

Photo 40: *Burhinus vermiculatus*

3.1.5.3. Flora and vegetation

a) Vegetation types

The main vegetation types are the riparian forest on fertile soil in the coastal land alongside the Lake and the grass savanna on the slopes and hilltop.

b) Remarkable plant species

50 plant species were recorded at Nyenyeri Island (Appendix, table 16). Some key plant species recorded at the island are briefly described below:

***Dodonaea viscosa* Jacq. (Family: Sapindaceae)**
Local name: Umusasa. **English names:** Hopbush, switch sorrel, sand olive
Ecology and distribution: It occurs in coastal bushland, on the landward side of mangrove forest, on sand dunes and coral rock mostly just above the high water mark. It is found in West

Africa, East Africa and Madagascar. In Rwanda, it was recorded in Kivu islands and in Nyungwe National Park

Uses: It is a traditional medicine worldwide, administered orally or as poultice to treat a great variety of ailments: sore throats, colds, fever, rheumatis, itching,digestive system disorders, stimulate milk production after giving birth and to treat dysmenorrhoea and irregular menstruation.

Photo 41: *Dodonaea viscosa*

***Rubia cordifolia* L. (Family: Rubiaceae)**

Local name: Umukarakambwe. **English names:** Indian madder, munjeet

Ecology and distribution: It is found in forest edges and clearings, scrub vegetation and dune forest, less commonly in grassland or open, rocky areas. In Africa it is found from Sudan and Ethiopia to South Africa. In Rwanda, it was recorded in Mayaga.

Uses: *Rubia cordifolia* is widely used in African traditional medicine. In Rwanda a root decoction is used to treat women who experience weight loss during pregnancy (‘ifumbi’), urethral leak, giddiness, tingling sensations and kidney problems. In Burundi a leaf decoction is administered to newly born calves with haemorrhagic diarrhoea (‘amacikire’) and also to treat external parasites such as fleas, ticks and mites in animals. In Uganda and Tanzania the leaves are used as a poison antidote and to treat mouth sores and intestinal problems such as diarrhoea; a drink prepared from crushed and boiled leaves is administered to patients. Roots are credited with astringent and antidysenteric properties. In South Africa the root is used to treat impotence and as an aphrodisiac. In Tanzania and Kenya a wound dressing (‘kiraara’) is made by rubbing the leaves between the hand palms into a ball, which is then applied to a wound or cut to stop bleeding and as an antiseptic. A root decoction is used as an emetic in cases of stomach problems. In DR Congo the leaves are burnt and the ashes are used to treat inflammation of the mammary glands (mastitis) in cattle and also to treat itchy skin in humans. In Ethiopia the leaves are used to treat malaria, itches and to stop bleeding, the roots to treat amoebic dysentery, cancer and cough.

Photo 42: *Rubia cordifolia*

***Cadaba farinosa* FORSK. (Family: Capparaceae)**

Local name: Umuryanka, Umuvutavuta. **English names: -**

Ecology and distribution: Common in large depressions, but also found on sandy silts of valleys, around temporary pond. It is native of Central West and East Africa. In Rwanda, it was recorded in Bugesera and Akagera National Park.

Uses: The young leaves are edible and are used in spicing and flavouring food. Leaves are used as a medicine against coughs. The species protects the soil from wind and water erosion.

Photo 43: *Cadaba farinosa*

***Asystasia gangetica* (L.) T.Anderson (Family: Acanthaceae)**

Local name: Urusogo. **English names:** Tropical primrose, Chinese violet

Ecology and distribution: *Asystasia gangetica* is found along roadsides and river banks, in more or less waterlogged areas as well as well-drained cultivated areas. It occurs throughout tropical Africa.

Uses: Edible leaves, forage, medicinal (used to ease pain during childbirth, and the sap is applied to sores, wounds and piles, and in embrocations to treat stiff neck and enlarged spleen in children; powdered roots are used in treating stomach-ache and snakebites; the sap is applied to swellings; it is also used as a vermifuge and to treat rheumatism).

Photo 44: *Asystasia gangetica*

3.1.5.4. Invertebrates

The inventory of invertebrate fauna in Nyenyeri Island is summarized in figure 21. The class of insect is mainly represented in the 3 plots followed by Myriapoda, andsome classes are missing in some plots.

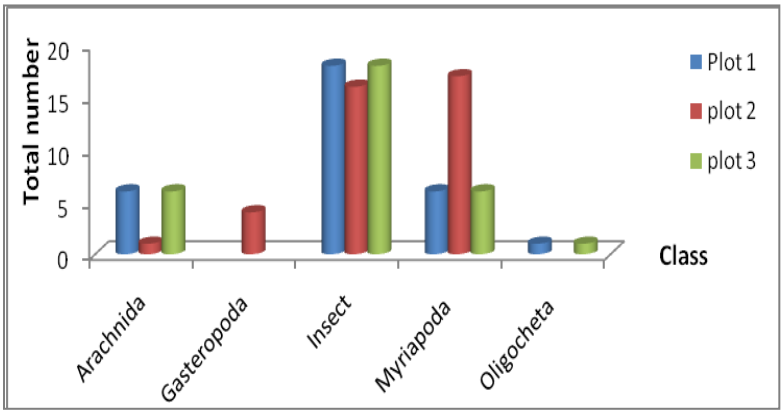

Figure 21: Invertebrates class distribution in Nyenyeri Island

The presence of insects is due to land cover of this island and soil characteristics. This can be explained by the presence of the class of Oligocheta and Myriapoda whose species live in dead vegetation and soft soil.

The species diversity in Nyenyeri Island is presented in figure 22. In this figure, the species *Redividius* sp is the most representative in the second plot. It is important to note that many species still need to be identified.

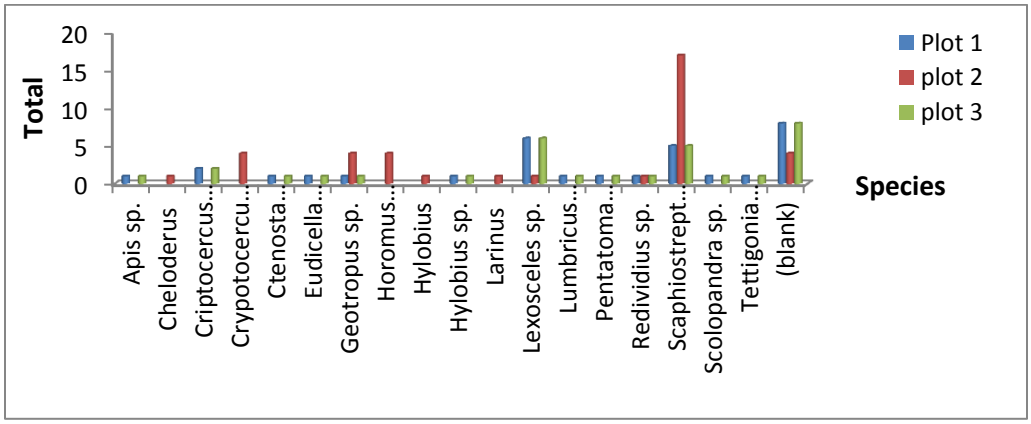

Figure 22: Species abundance at Nyenyeri Kivu Lake island

The abundance of orders in the Nyenyeri Island is presented in the figure 23. The Coleoptera and Diplopoda are the mainly represented orders in the sampling. As seen before, some orders are represented by one species only. The order Pulmonata was found only at the second plot.

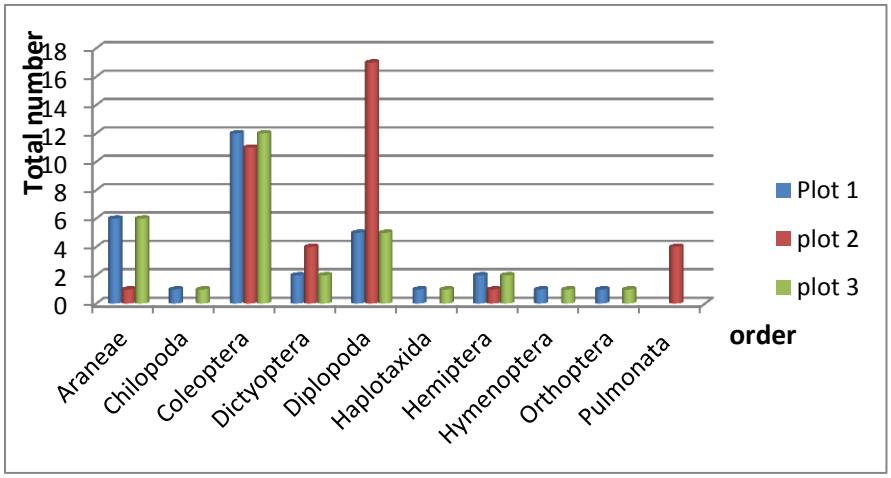

Figure 23: Order distribution within the plots (Nyenyeri)

3.1.4.5. Mammals

Three mammal species were recorded at Nyenyeri Island. The most particular one is *Surdisorex norae*. The two others are *Ruwenzorisorex suncoides* and *Oryctolagus cuniculus*.

***Surdisorex norae* (Thomas, 1906), Aberdale mole shrew**

Surdisorex norae is a species endemic to the Aberdare Mountain Range in central Kenya. It is listed as vulnerable by IUCN. Its natural habitat is tropical high-altitude bamboo and grassland. This species inhabits dense montane grassland above the treeline.

Photo 45: *Surdisorex norae*

3.1.3.6. Reptiles

At Nyenyeri Island, the same species of reptiles recorded at previous islands could also be found there. 4 particular species are *Acanthocercus atricollis*, *Naja melanoleuca*, *Trachylepis varia* and *Trachylepis striata*.

3.1.3.7. Amphibians

Two species were recorded at Nyenyeri Island, and these include *Bufo maculatus and Afrixalus orophilus*.

3.1.5. Mpangara Island

3.1.5.1. Geographic description

Mpangara Island is composed by two small hills, with a total area of 3 ha (figure 24-25). The land is constituted of rocky, shallow and dry soil.

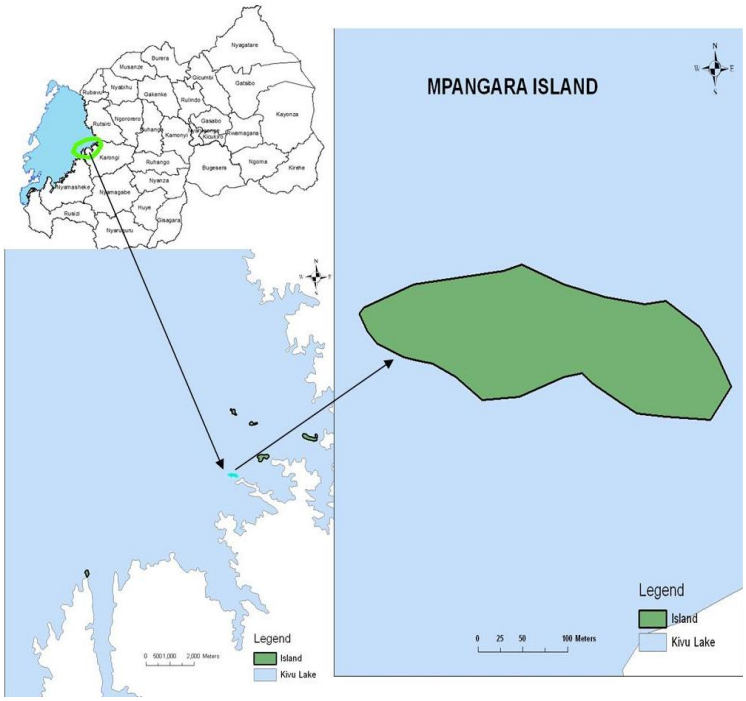

Figure 24: Map of Mpangara Island

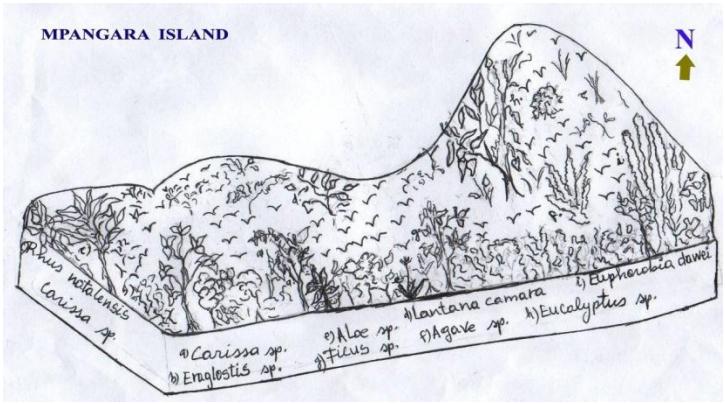

Figure 25: Mpangara Island profile

3.1.5.2. Birds

A total number of 20 bird species was recorded by sights and/or sounds during the line transect and opportunistic sampling. Among the recorded species *Vidua* macroura (Pin-tailed whydah) and *Streptopelia semitorquata* (Red-eyed dove) are the most abundant (Appendix, table 46).

Photo 46: Left: *Vidua macroura (*male); Right: *Vidua macroura (*female)

3.1.5.3. Flora and vegetation

a) Vegetation types

The main vegetation types are the riparian forest at the lower part densely populated by native trees; the shrub layer from medium altitude to the hilltop dominated by spiny plants; and the grass savanna.

b) Remarkable plant species

34 plant species were recorded at Mpangara Island (Appendix, table 17). Some key plant species recorded at the island are briefly described below.

***Rhus natalensis* Krauss (Family: Anacardiaceae)**

Local name: Umusagara. **English name:** Natal rhus.

Ecology and distribution: It grows in wooded savannas, forest edges and riverine forest. It is widespread in Tropical Asia, also found in Africa from Guinea to Somalia, Eastern and Central Africa, south to South Africa. In Rwanda, this species is found in low and medium altitude areas including Akagera National Park, Bugesera, Umutara and Mayaga.

Uses: Edible fruits, fodder, firewood, charcoal, timber, farm tools, medicinal (root used to treat diarrhea, leaves used in treating coughs and stomachaches).

Photo 47: *Rhus natalensis*

***Carissa spinarum* L. (Family: Apocynaceae)**

Local name: Umunyonza. **English names:** Simple-spined carissa.

Ecology and distribution: It grows in Zambezian Miombo woodland, bushland, riverine forest or thickets and upland forest, especially in rocky places. This species is widespread in Tropical Africa, Asia and Australia. In Rwanda, it was recorded in Bugesera, Umutara and in Akagera National Park.

Uses: Edible fruits, medicinal: the boiled leaves are applied as poultice to relieve toothache; ground-up roots are used as a remedy for venereal diseases, to restore virility, to treat gastric ulcers, cause abortion, and as an expectorant.

Photo 48: *Carissa spinarum*

***Cyphostemma adenocaule* (Steud. ex A.Rich.) Wild & R.B.Drumm. (Family: Vitaceae)**

Local name: Umubombwe. **English name:** -

Ecology and distribution: *Cyphostemma adenocaule* is widespread in savanna and is found in gallery forests and fallow land as well. It is widespread in tropical Africa from Senegal east to Eritrea and south to Angola, Malawi and Mozambique. In Rwanda, the species was recorded in Akagera National Park.

Uses: The leaves and fruits eaten as a vegetable or in soup in Ghana, DR Congo, Kenya and Uganda. Leaves are used to remedy a sore throat, cough reduce swellings. Water in which roots have been boiled is drunk to treat syphilis, abdominal pain (related to pregnancy or not) and to prevent abortion.

Photo 49: *Cyphostemma adenocaule*

3.1.5.4. Invertebrates

At Mpangara Island, the orders of Dictyoptera and Coleoptera are the mainly distributed orders in the plots. At this island, the anthropogenic activities are less than in other islands presented before. The Coleoptera was found in all plots at a high rate (figure 26).

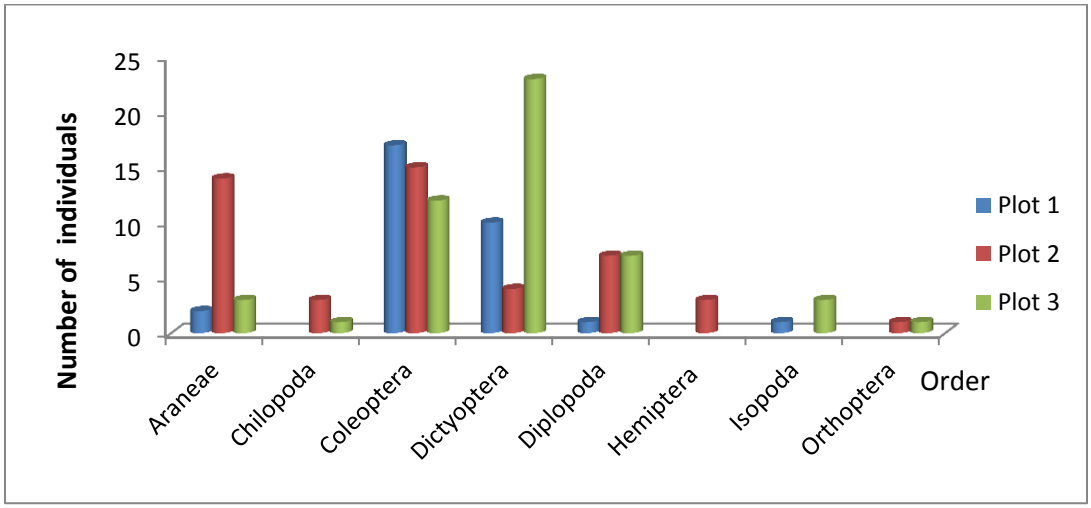

Figure 26 : Distribution of orders at Mpagara island

At this site, a total of 128 specimens were collected and the species *Anistogamia tamerlana, Cryptocercus punctutatus* and *Scaphiostreptus parilis* were dominant. The analysis of the orders indicates that the Hymenoptera order is mainly represented in the two transects studied. The number of species in transect 2 is higher than in transect 1 (figure 27).

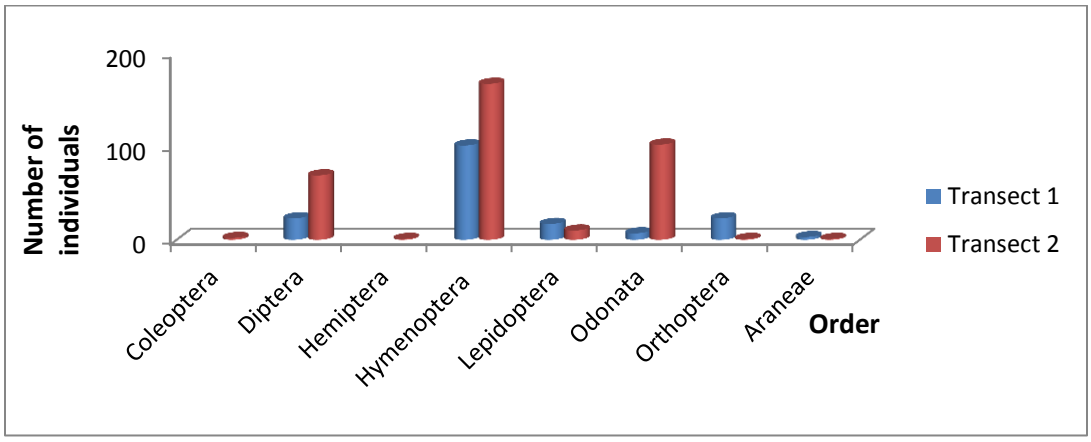

Figure 27: Distribution of order in Transect at Mpagara island.

3.1.5.5. Mammals

The same species of mammals recorded at Nyamunini could also be found at Mpangara Island, with the particularity of abundant *Congosorex suncoides*.

3.1.5.6. Reptiles

Reptiles that could be observed at Mpangara Island include *Trachylepis varia, Trachylepis striata, Acanthocercus atricollis, Naja melanoleuca* and *Dendroaspis polylepis.*

3.1.5.7. Amphibians

Three species were recorded: *Bufo maculatus*, *Phrynobatrachus versicolor* and *Hyperolius kivuensis.*

3.1.6. Nyarugaba Island

3.1.6.1. Geographic description

With an area of 3 ha, Nyarugaba Island is located in Nyamasheke District. This island is located at few meters from Munanira Sector, and there is a connection (like a bridge) between this island and that nearest peninsula (figure 28-29).

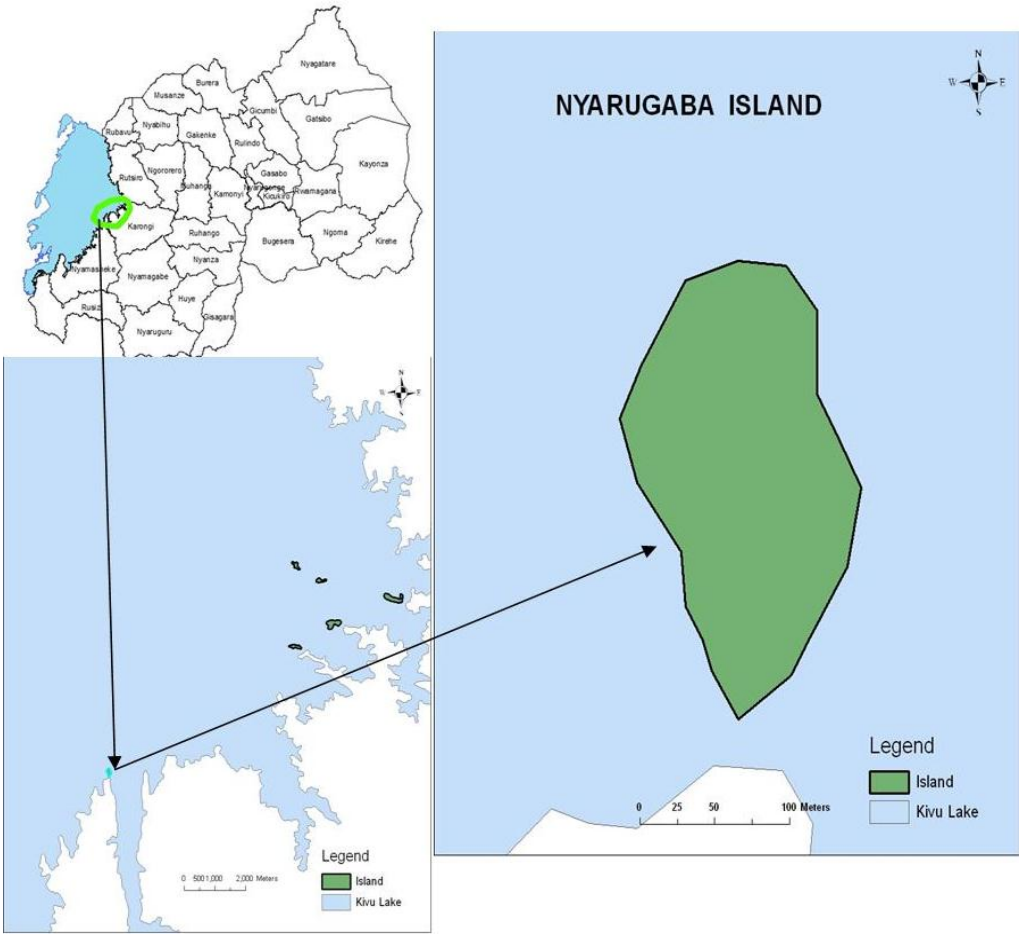

Figure 28: Map of Nyarugaba Island

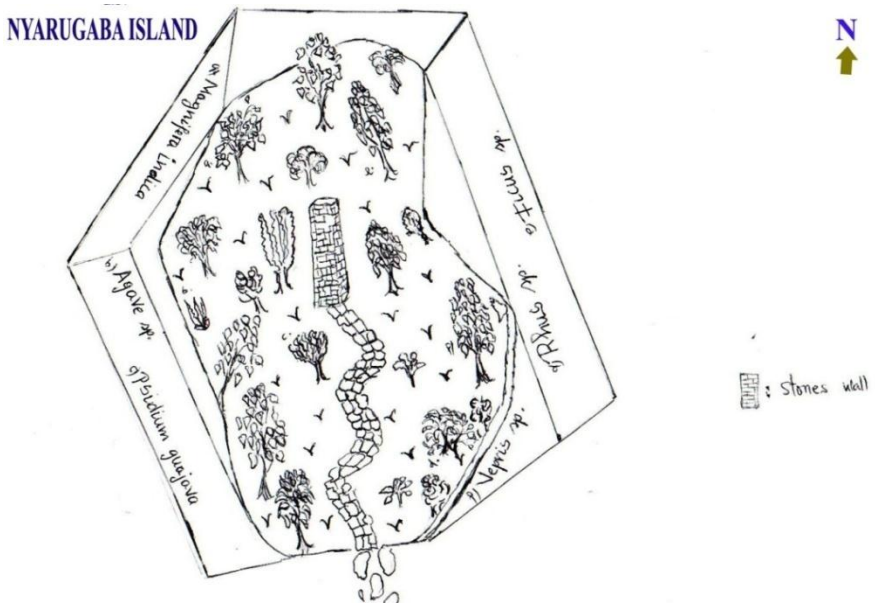

Figure 29: Nyarugaba Island profile

3.1.6.2. Birds

At Nyarugaba, 19 bird species were recorded by sights and/or sounds during the line transect and opportunistic sampling. Among the recorded species *Phalacrocorax carbo* (Great Cormorant) was the most abundant (Appendix, table 19).

3.1.6.3. Flora and Vegetation

a) Vegetation type

3 main vegetation types found on the island are the riparian forest which occupies a small part (0-5m from the lake); the shrub layer found in few meters from the coastal to the middle part; and the grass savanna on the hilltop with dry soil and rocks.

b) Remarkable plant species

20 plant species were recorded at Nyarugaba Island (Appendix, table 20). Some key plant species recorded at the island are briefly described below.

***Vepris nobilis* (Delile) Mziray (Syn: *Teclea nobilis*) (Family: Rutaceae)**

Local names: Umuzo. **English names:** Small-fruited Teclea.

Ecology and distribution: It is found in evergreen forest, riverine forest and woodland. It is endemic of Eastern and Central-East Africa. In Rwanda, this species was recorded in Akagera National Park, Bugesera and Nyagatare.

Uses: Medicine: The leaf or root decoction mixed with honey is used against pneumonia, the roots are used as an anthelminthic and the steam inhalation of the leaves reportedly cures fever. Fruits are edible. Source of firewood, charcoal, timber, poles, posts, tool handles, building poles, wooden spoons, spear shafts, bows, clubs, walking sticks, shade, amenity and bee forage.


Photo 50: *Vepris nobilis*

***Ficus cyathistipula* Warb. (Family: Moraceae)**

Local name: Imvubuvubu. **English name:-**

Ecology and distribution: Moist soil and hillsides. Widespread from West to Central and East Africa. In Rwanda, it is found in Kivu islands (Gwanuma, Ikihe, Nyarugaba and Nyamunini)

Uses: Used for shade and for ornamental purposes because of its aerial roots.


Photo 51: *Ficus cyathistipulata*

***Gomphocarpus fruticosus* (L.) W.T.Aiton (Family: Asclepiadaceae)**

Local name: Gasaho. **English names:** Milkweed, Wild cotton

Ecology and Distribution: It is often found in abandoned fields. *G. fruticosus* is widely distributed in the southern African region. In Rwanda, it was recorded in Mubyanka island (Kibuye)

Use: A root or plant decoction is taken to treat liver troubles, malaria and abdominal pains. Infusion of the leaves, roots and fruit is taken orally to treat diarrhoea. Roots are used to treat backache, diabetes, gonorrhoea, to stop vomiting of bile, to treat infertility, asthma, and nerve pain. Leaves are applied to sores. Fresh powdered leaves are soaked in water and the liquid is drunk to induce vomiting in case of hepatitis. In Uganda and Madagascar the latex applied to teeth to treat toothache and a decoction of the seeds is taken as a cough medicine.

Photo 52: *Gomphocarpus fruticosus*

***Commiphora africana* (A. Rich.) Engl. (Family: Burseraceae)**

Local names: Umudahwera. **English names:** African myrrh, Poison-grub commiphora.

Ecology and distribution: It grows in bushland and wooded grassland on rocky sites, clay or sandy soils. It is widespread in drier parts of Africa, from Senegal east to Somalia and south to South Africa. In Rwanda, the species was recorded in Akagera National Park and Bugesera.

Uses: Firewood, utensils, medicine (fruits are chewed or pounded and used against toothache and diseases of the gum), gum extracted from the stem is used in making arrows.), live fence, carvings and edible tubers from young plants.

Photo 53: *Commiphora Africana*

***Rumex abyssinicus* Jacq. (Family: Polygonaceae)**

Local name: Umufumba. **English name:** Sorrel, dock, Spanish rhubarb

Ecology and distribution: *Rumex abyssinicus* occurs along paths and water, in secondary scrub, grassland and margins of rain forest, up to 3300 m altitude. *Rumex abyssinicus* is widespread in tropical Africa, most commonly in the highlands, particularly in central and eastern Africa, and Madagascar. In Rwanda, it can be found in many places including Nyungwe and Ruhande arboretum.

Uses: Shoots and leaves edible, rhizomes yield a yellow and red dye, sap of the aerial parts is applied as a treatment for pneumonia and cough, the plant is used to treat jaundice and related liver diseases, an extract of the rhizome is taken to control mild forms of diabetes in eastern Africa and, with water, to cure stomach-ache. In Rwanda and Tanzania crushed plants are used to scour clean cooking pots blackened over the fire and to remove grease.

3.1.6.4. Invertebrates

The statistic analysis of the total number of collected data in the 3 plots shows a significative difference between the plots ($p>0.01$). Plot 2 at Mpangara has a soft soil that can be the reason to have high density of species. The distribution of orders at Mpangara shows also that plot 3 is more diversified than others (figure 30).

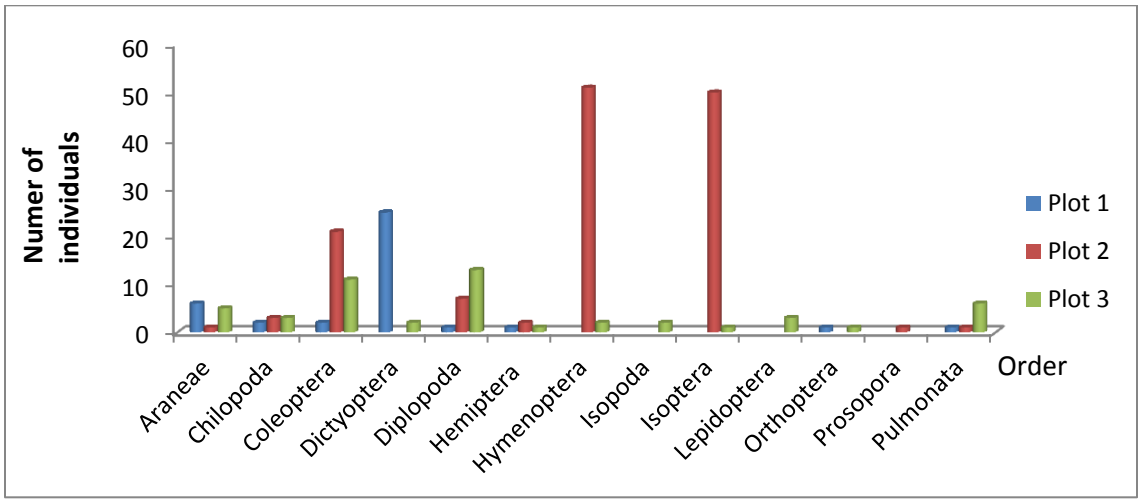

Figure 30 : Orders Distribution in Nyarugaba plots

The study in the transect shows that the transect 2 has many individuals than the transect 1. The Khi quare analysis shows a difference between the transects. The order of Diptera is largely represented in the Mpangara Island followed by Orthoptera, Hymenoptera and Lepidoptera (figure 31).

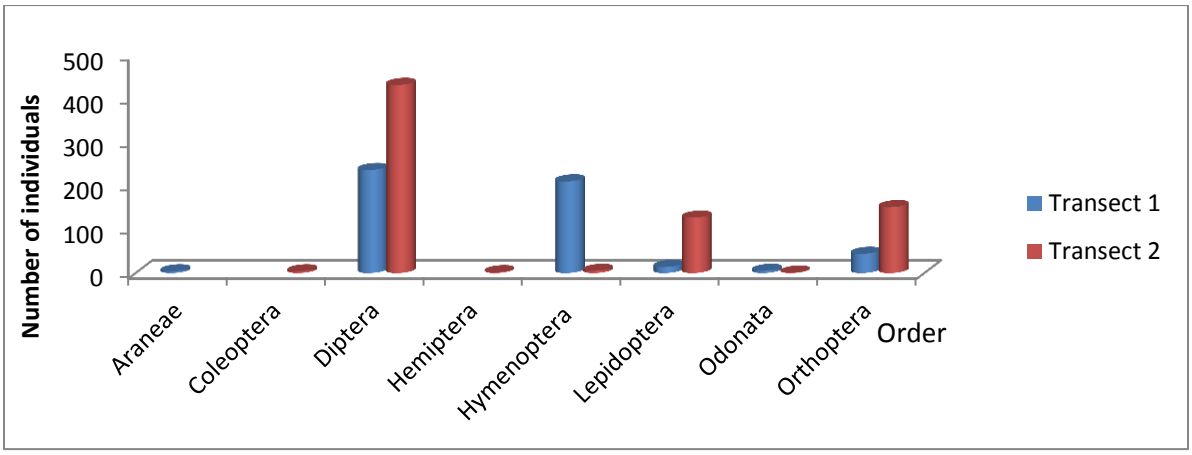

Figure 31 : Nyarugaba order distribution in transect

3.1.6.5. Mammals

Six species could be found at Nyarugaba Island, according to direct observations and from the information provided by interviewed people: *Micropteropus pusillus, Congosorex polli, Ruwenzorisorex suncoides, Atilax paludinosus, Oryctolagus cuniculus* and *Surdisorex norae.* The information related to these species was provided in previous islands.

3.1.6.6. Reptiles

All 5 species of reptiles recorded at Nyarugaba are the same as those recorded at the previously islands. However, there is the particularity of the presence of *Bitis nasicornis*:

***Bitis nasicornis* (Shaw, 1792), River Jack**

It can be found in the tropical forests throughout Central and Western Africa. *Bitis nasicornis* lives often near water, or some sort of swampy environment. Because of this habitat preference it is often called the River Jack. It has, however, been reported in relatively dry forest areas. Mainly terrestrial, it will climb trees, in search of food.

Photo 54 : *Bitis nasicornis*

3.1.6.7. Amphibians

At this island, two species of amphibians could be observed. They include *Phrynobatrachus versicolor* and *Hyperolius kivuensis.*

3.2. Socio-economy survey

This part explores and presents the socioeconomic conditions of respondents in the study areas. A general discussion on natural resources exploitation is done in order to shade light on policy implications. Respondents were found in their residents in places where they are inhabited following Government's policy to evacuate the islands but also keep people close to social and economic infrastructures. However, some respondents were found in the islands during field data collection as they were working in their farms located in the island. This means that some farmers walk everyday from their residences to islands for farming and harvesting. The following is the brief description of the respondents:

3.2.1. Description of the Households

The marital status and gender aspects of the household heads determine the household composition, working capacity and socioeconomic conditions.

Table 2: Head of household and Sex

			Household size							Total
			1	2	3	4	5	6	7	
Head of household (sex)	Male (Head)	% of Total	4%	2%	6%	10%	15%	15%	17%	69%
	Female (Head)	% of Total	2%	4%	4%	8%	4%	8%	2%	31%
Total		% of Total	6%	6%	10%	17%	19%	23%	19%	100%

According to the table above most of household are male headed with 69% while only women headed household account for 31% of the total sample. The table further shows that the highest family size is made by 7 which is 17% that headed by men and 2% of the same size are female headed while the smallest family size is 1 which 4% headed by men and 2% by women. The family size in any case has implications on consumption patterns within the household and may influence production capacity. The resources exploitation may also vary within the family as they strive to satisfy their needs. It was reported by respondents that due to large families, they tend to exploit excessively other resources like natural forests for energy production, handicraft making, etc in order to satisfy household needs. While analyzing the education level of local

communities, results showed that the proportion of women who have never been at school is smaller with 10% compared to 17% for men (figure 32). There are 29% of male who did not complete primary school, and only 2% attained vocational training. On the other hand, there are 6% female who completed primary school, but none of them attained vocational training nor completed secondary school.

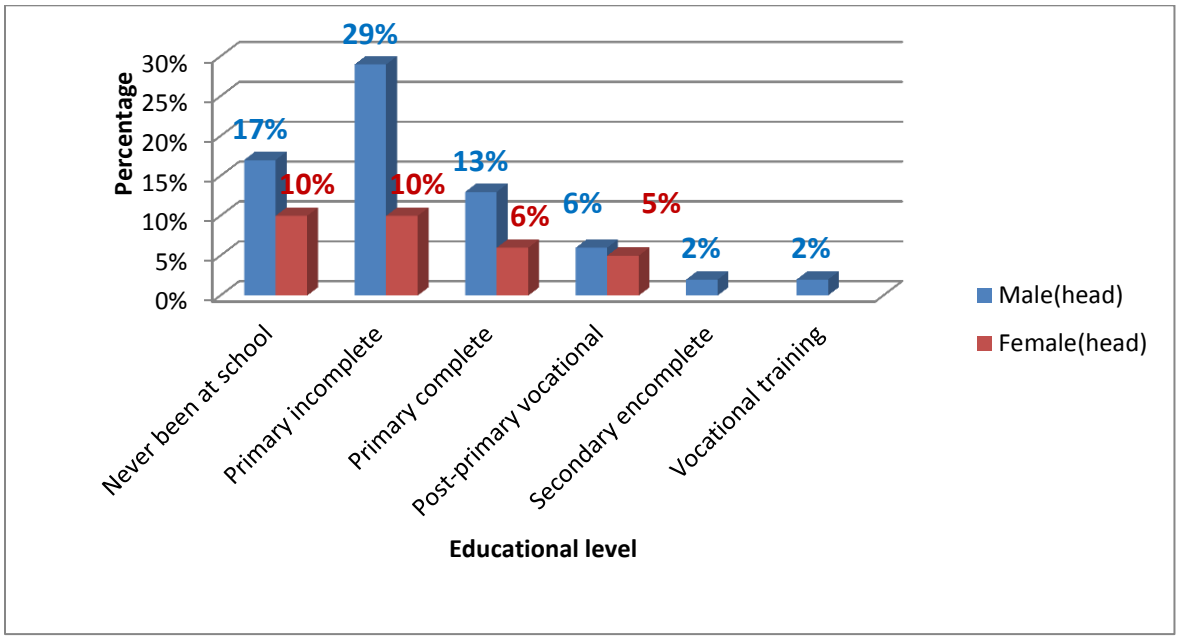

Figure 32: Education level of the Respondents

The respondents have explicitly shown that lack of considerable higher education limits their choice and they rely on farming, fishing and handicraft making. Proponents have shown that lack of formal education may impede the capacity of people to adopt to new development policies. The underlying assumption here is that, the lower education level has refrained families in the area to enhance viable off-farm activities that may improve the living standards of the community without putting pressure on biodiversity.

3.2.3. Energy used for Cooking

How and where does people get cooking energy in the study areas was paramount to determine the impact of the energy needs and environment protection. Table 3 indicates that 85% of the respondents uses fire wood for cooking in which 67% of the respondents collected wood from natural forest, 15% collects them from their own forests, and 2% collect them nearby bushes.

Furthermore, 7% of the respondents' uses charcoal for cooking which they buy from vendors, and 8% uses both firewood and charcoal.

Table 3: Source of energy used for cooking

Source of firewood used	Energy used for cooking			Total
	Firewood	Charcoal	Firewood and charcoal	
Own forest	15%	-	4%	19%
Natural forest	67%	-		67%
Others	2%	7%	4%	14%
Total	85%	7%	8%	100%

As explained by the respondents natural forests include trees planted and owned by the government, academic and research institutions, and those grew naturally. Additionally, few respondents have their own forests and can harvest wood from their forests. However, regardless of the ownership of the forest which produces wood, the importance of forest on sustainable development are enormous and there is an obligation to handle them properly for the proper management of environment. Several studies link the current environment harzads such as continous soil erosion, prolonged drought in some areas of the global, etc with irrational cutting of trees mainly caused by increasing demand of energy by the population. And, (elliot, 2004) contend that, the overwhelming dependence on biomass fuels for energy may greatly contribute to environmental degradation through deforestation and soil erosion. The recent studies show that rural areas in Rwanda have experienced continous land slides and rain water washing fertile soil, thus affecting agricultural production. Thus imperative to mention the protection of Lake Kivu islands calls a sepcial attention in order to avoid continous encroachment that may deteriorate the existing natural resources in order tourism in the area.

3.3.3. Description of Major Economic Activities carried out in the Islands

Various economic activities are carried out by people from different places near or far from the location of the islands. The activities include crop farming, livestock keeping, fishing, water transportation and boat manufacturing, handicraft making, charcoal burning and wood collection, etc.

3.3.3.1. Crop farming

More than 63% of the respondents depend only on agricultural farming for their livelihood and food security. There is land segmentation where 61% of the respondents reported their plots are located on the islands only, 25% of the respondents having their lands on the islands and mainland, and 14% their lands located in the mainland only. The agricultural farming is carried out mainly in Mbabara Island and Kabahizi Peninsula. Generally, the main crops grown include maize, beans, banana, sweet potatoes, Irish potatoes, cassava, coffee and fruit tree. There is limited agricultural trade because there is little surplus for commercialization.

In Kabahizi, there is habitation and people practice farming near to their homes. On the other hand, farmers in Mbabara have been removed and settled in the mainland where the District allocated them a land. Arguably, these people have settled on Mbabara Island for many years and it is difficult for them to abandon their lands. In this regard, they are still undertaking farming activities in the island, but they have to cover the distance every day from their new settlement to the island which is about 12km.

Some crops are grown in the islands due to land shortage in the mainland and plays pivotal role in the livelihood of people. For example, some respondents acknowledged having small plots of land on the mainland but own another plot on the islands for growing fruits which cannot be planted alongside other food crops since their land is small. On the other hand communities living in the nearby areas go to the islands to harvest/collect fruits which grow there naturally for commercialization and home use. Growing fruits or collecting them from islands has become a prominent source of income to the communities and it is regarded as prospective mechanism to offset losses incurred from crop production and sales. Indeed, fruits plantation serves twin purposes: first as an added value to food security and then as mechanism to control soil erosion. Fruits are planted mainly along the shores of the Lake (50m) to prevent further human activities like farming but also as a motivation to smallholder farmers that their land is used for other productive purposes.

Due to fertile soil in Mbabara, the government has identified the importance of the Mbabara Island on livelihood of people and food production. In this regard the government has introduced

crop intensification and land consolidation programme. There are also various soil erosion control mechanisms in the island that have improved soil fertility. These include the plantation of fruit tree which provide fruits and protect soil against erosion. Mostly these trees are planted along 50m at the lake off-shore and farmers are being assisted by DEP project under REMA.

3.3.3.2. Livestock Keeping

Farmers have indicated that they own livestock which help them to raise income as supplement from crop sales. Livestock keeping in the areas has increasingly created synergitic attractions between animals and crop farming where cows produces manure and in-turn crop residues used as forages.

The results obtained show that there is still existence of open grazing in islands especially Amahoro, and Nyarugaba where 47% of the respondents graze their cows in an open space as well as 87% of the respondents who owns goats do the same practice especially in natural forests/bushes. In any case, proponents have shown that the tendency to collect forages from bushes or to graze animals in an open spaces gradually deteriorate the forests in the islands. Local Government should strengthen the zero grazing policy and farmers encouraged to keep their animals (especially cattle) into shades and also entice farmers to grow forages along terraces and on their plots.

The importance of natural resources to living conditions of human being can not be underestimated. However, the rational exploitation of these resources in the pursuit of development of human species is of great concern and constitutes the determining factor for how long and how much it will contribute sustainably. According to (Gowdy and McDaniel, 1995), biodiversity loss is the most irrevisable environmental crisis threatening the long-run prospects for the human species. It is therefore important and ugent to revise livestock keeping mechanisms in the islands in order to avoid any depletion of natural resources.

3.3.3.3. Fishing

Fishing is also an important activity carried by the majority of respondents in the islands and those living near to the Lake. Notably 24% of the respondents practice fishing, whereas 46% of the respondents practice fishing along with other activities like agricultural farming, small

business, handicraft making. It is a well organized activity and practitioners are organized in cooperatives that facilitate them to organize their production, marketing and other related economic benefits. Indeed, fishing is organized by the cooperative and each member is obliged to contribute to the cooperative a certain of his/her daily income. Some of the cooperatives include UCOPEVEKA (Union des Coopératives de Pêcheurs de Karongi), TWUZUZANYE KU MWUGA COOPERATIVE and DUHARANIRE INYUNGU COOPERATIVE. On average the respondents earn between 35,000 Rwf and 85,000 Rwf per month from fish sales. Basically, the income varies according to quantity obtained and on wether conditions.

It was reported that fishing is a high labor demanding activity that involves looking for feeds to catch fish, drying and packaging fish. Fishermen use trees and other biomass products to dry their fish which is their traditional mechanism to preserve their fish. In this regard, they will collect wood from the forest or cut trees for that purpose.

3.3.3.4. Water transportation

Lake provides comfortable transportation of people and goods by linking islands and mainland. The boats used in the lake for transportation are either made in wood or imported. The category of the boat the owner depends on initial investment cost and purpose of the activity.

Photo 55: Transportation in Lake Kivu using locally made boats (from the timber)

Lake Kivu transportation is increasingly becoming a source of job opportunity to many people especially youths. The people in this business are grouped in cooperatives as mechanism to professionalize their activity as well as income sharing. Some cooperatives are COTRALAKI (Coopérative du transport sur le Lac Kivu) and COOPERATIVE ABAJYAMBERE.

The importance of transportation in Lake Kivu cannot be undermined, because it is promoting both trade and employment in the area. However, there is excessive use of trees (wood) for manufacturing new boats, rehabilitating the old ones and performing other related activities. Therefore, transporters should be encouraged to buy modern boats which are relatively environmentally friendly and which may improve transport and reduce losses.

The findings indicate that plants are used for other various purposes including traditional medicine. The figure below shows that the leaves constitute the main part of the plants used in traditional medicine on all the islands (above 80%). Referring to the plant physiology, leaves pray a great role in the surviving of plants, the high rate of using leaves in medicine may harm the vegetation of the island.

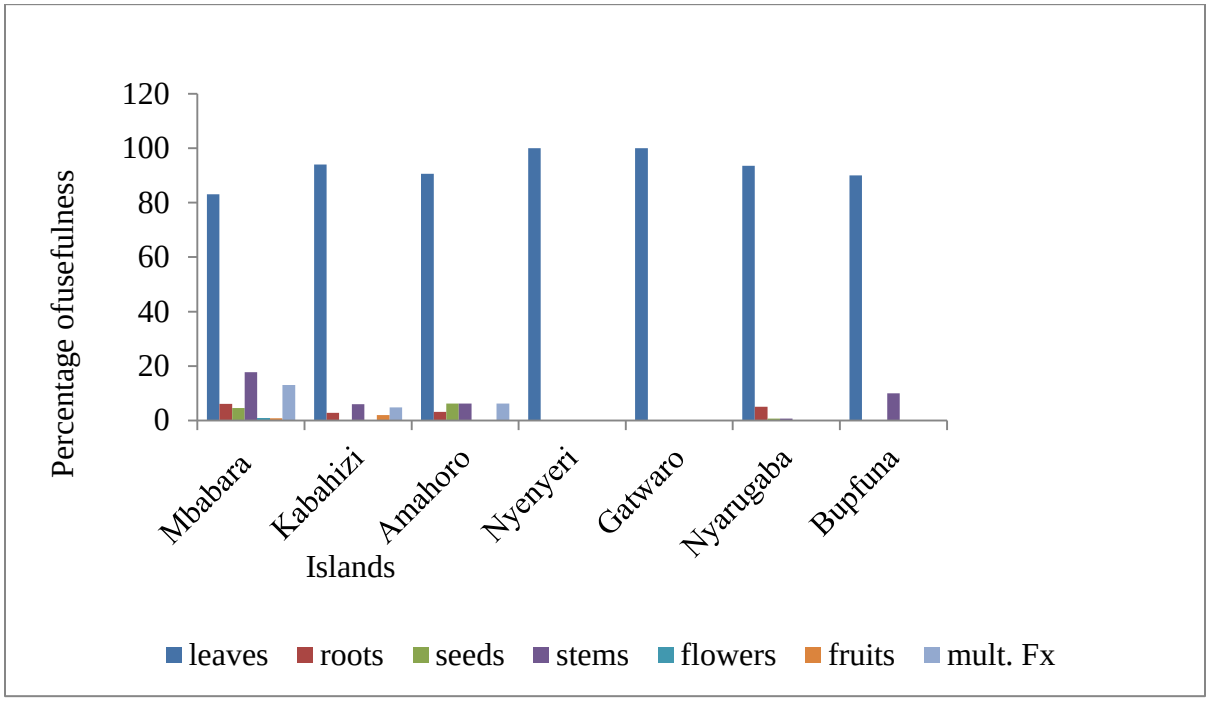

Figure 33: Graphical representation of plant parts used in traditional medicine.

The use of medicinal plants increasingly adds substantial income to people involved in this type of healing but also helps to cure diseases which might otherwise damage the health of the communities in the areas. It is a labor intensive activity that healers to walk a long distance in an intense forest looking for appropriate plants. However, some healers have reported the continous loss of some useful plants to treat certain diseases. The majority are not even recognized by the national health systems thus they working informally. Despite such limitations the number of patients and frequency to attend their clinic is high. This is because some rural people still rely and believe in traditional healing to cure certain diseases and it is even affordable by poor. However, the extent to which these treatments cure the disease accurately is not well known. Furthermore, the impact of traditional medicine on sustainability of plant sepcieas is not known.

Therefore further studies are needed to assess the impact of tradtional healing on human health and on biodiversity.

3.3.4. Land ownership in the islands

The ownership of land in the Kivu islands varies according to the nature of provision and activities. For example in Mbabara people are allowed to carry their farming activities in the island though they have been removed. It has been revealed that the land on this island is an indigenous resources belonging to these people since the time of their ancestors. On the other hand, the islands like Nyarugaba, Amahoro and Mukondwe which are owned by individuals either claim that they bought them or are exploiting them because their parents have been exploiting them before. These islands are completely owned by individuals and common activities cannot be carried without permission from owners. There is resort facilities built there like on Amahoro and Nyarugaba where there is hotel that receives tourists.

However, the issue of land ownership in the islands must be stipulated clearly in order to define the exploitation mechanisms. For example the article 27 of decree of 31 July 1912 of the civil code on property and various changes of ownership states that "The island or islands that in the bed of a lake or navigable stream, floatable belongs to the colony (Rwanda)". In any case this law was designed many years back but it is still valid since seems there is no new law or decree in regard to land ownership in the islands. However, it is possible that the current owners of the islands are not familiar with the law. It is thus important to observe the law and guide the decision in regard to land ownership in the islands for proper resources exploitation.

CHAPTER IV: KIVU ISLANDS CONSERVATION ISSUES

4.1. Introduction

The importance of islands goes far beyond their striking beauty. Islands are the earth's great repositories of biological diversity. Thanks to their favorable climates and historic isolation, islands are home to thousands of species that do not exist elsewhere.

Nevertheless, island ecosystems are threatened as never before; their ecosystems are extremely vulnerable to damage caused by introduced species like the exotic plants which have been introduced, overexploitation of their resources, habitat loss/degradation, fragmentation, etc.

Actually, all studied islands are not settled because people have been removed from some previously habitated islands like Mbabara to the main lands surrounding Kivu lake. This means that all islands in Karongi district belong to the governement. It is therefore easy to take conservation measures as far as this will not conflict with local people interests.

4.2. Reasons for conservation

4.2.1. Hotspot of biodiversity

Kivu islands is located within Albertine Rift ecoregion, a recognized hotspot of biodiversity in the world. As mentionned above, islands do normally host a particular fauna and flora. However, due to their limited area they do not host as many species as the main lands do.

According to the results of our study on “inventories of lake kivu islands biodiversity in support to their inclusion into the protected areas network in Rwanda”, seven islands surveyed (Nyamunini, Mukondwe, Nyenyeri, Shegesha, Amahoro, Mpangara and Nyarugaba) accommodate a very rich biodiversity. It the case of plants with 142 species of flowering plants and 54 birds species distributed only on an area of less than 30 ha. Many birds species known to be in decline or extincted else where in Rwanda can be observed abundantly within the studied

islands. It is the case for *Euphorbia dawei*, *Ceryle rudis*, *Scopus umbretta*, *Atilax paludinosus*…. *Euphorbia dawei* is indeed a very rare species restricted in Kivu islands. So many other plants and animals species are also becoming very rare in Rwanda and even in Albertine Rift but remain abundant within Kivu islands. For plants wild *Ficus* species from which local people use for boats manifacture are almost exclusively found in Kivu Islands.

Natural fauna and flora remaining for the lowlands of western Rwanda is now almost restricted to Kivu islands which are less disturbed compared to the surrounding main lands. Kivu islands host Rwandan heritage in terms of biodiversity which can be loss for ever as far as they are colonized by a majority of species already disappeared elsewhere in Rwanda or in very small populations.

For the above mentionned reason, Kivu islands are a specific biodiversity reservoir of Albertine Rift in general and Rwanda particularly.

Among the islands surveyed, Nyamunini island alone host about 141 flowering plant species and 53 bird species (UNESCO, 2009). With reference to islands biogeography, this can be explained by the size and habitat variability of Nyamunini island. In fact, Nyamunini island is the largest island in Karongi district after Mbabara island. The latter is however less diverse because of heavy disturbances due to human settlements in the past.

When we consider the main lands surrounding kivu islands, they accommodate almost exclusively non native plant species, generalists birds species and some vertebrates escpecially small mammals and reptilia adapted to anthropogenic conditions.

Kivu islands can therefore be considered as refugia of biodiversity due human settlements in the neighboring main lands.

It is also the case of many birds species whose habitat is associated to Lake Kivu organisms.
Some of the above mentioned species depend on Lake kivu for their feeding but for reproduction, they need safe habitats like the one found on less disturbed islands. This situation

has been met on less disturbed islands like Mukondwe where many birds species have found refugia.

Briefly, there is a need to conserve kivu islands because they constitute a refugia area of already exploited zones of the main land. They are also very good areas for speciation of organisms with low capacity of dispersal like small mammals, reptilia, some amphibians and invertebrates because of they isolation over time and space.

4.2.2. Kivu islands are home of endangered species

Some species invetoried on Kivu islands are already registered on IUCN redlist and therefore need more attention for their conservation at least at the national level. It the case of the Marsh Mongoose (*Atilax paludinosus*: inzibyi), some waterbirds and snakes like *Bitis nasicornis* and *Naja melanoleuca.*

Atilax paludinosus is a wetland small mammal that have been signaled by respondents every where in the region of Karongi close to Kivu lake. It is a species ranked on the IUCN redlist and therefore needs attention for conservation. Moreover, local people living in the surroundings of Kivu lake eat the meat from that species.

The Marsh Mongoose *Atilax paludinosus* recorded in Kivu islands is normally known a voracious carnivore, consuming any form of meat it can catch, as well as a wide variety of fruit found either inside water or on islands. Some accounts from local people in Karongi claim that the Marsh Mongoose will sometimes lay very still, its tail up, and that in this position, the pink anal region makes a startling contrast against the dark fur, which induces birds to come near and peck at it; when the birds or hens come near, they are killed and consumed.

The Marsh Mongoose is solitary, nocturnal, and crepuscular. That is why it has been difficult to meet it during our survey on the six islands but was previously seen on the shores of Nyamunini island.

Beside *Atilax paludinosus*, more than half of birds' species recorded in Kivu islands are on the IUCN redlist. **This means that those islands deserve a particular attention.**

4.2.3. Kivu islands: potentially international important area

With reference to Ramsar conditions of sites acceptance as internationally important, waterbirds density and diversity is taken into account. In fact, according to criteria 5 of Ramsar Information Sheet (RIS), a wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds.

A site can also be recognized as internationally important when according to criterion 6 of the same RIS if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.

According to data collected of Kivu islands, it has been identified many waterbirds species (12 waterbirds species), more than one fifth of all species recorded. They use islands for reproduction and Kivu Lake for feeding and resting. Those islands are very important for the survivorship of the above mentioned waterbirds.

The Criterion 3 of the RIS states also that a site should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region. This criterion is totally met on Kivu islands. In fact, Kivu islands accommodate essential species for Albertine Rift biodiversity maintenance as far as that area is a refuge of so many species extinct or declining in the surrounding lands and in Albertine Rift.

Furthermore, if we take into account the *"biosphere reserve"* admission criteria, Kivu islands respond also totally to them. In fact, it is stated that to be a biosphere reserve, a site should fulfill the following conditions: biodiversity conservation, recreation, education and population well being.

A biosphere reserve is defined as an area of land or water that is protected by law in order to support the conservation of ecosystems, as well as the sustainability of mankind's impact on the environment. This means that each biosphere reserve aims to help scientists and the

environmental community figure out how to protect the world's plant and animal species while dealing with a growing population and its resource needs.

There are three main parts to a biosphere reserve. The first part is called the core zone. This zone is strongly protected for the conservation of biological diversity — to make sure that different types of plants and animals are safe from human impact. The second part is called a buffer zone. These zones surround the core zones and provide a space for environmental research, recreation, and tourism.
The last part is called a transition zone. A transition zone is for local communities that have a hand in managing the resources of the area through farming, fisheries, and other non-governmental activities.

4.2.4. Threats to biodiversity conservation in kivu islands

It has been demonstrated that Island biodiversity has suffered from a high degree of extinction in the past and many threatened species are island endemics, principally due to invasive species, climate change, natural and environmental disasters, land degradation and pollution. For the case of Kivu islands, there has been inevitably severe biodiversity loss over time since the lake was established about 15000 years BP. This was mainly due to human activities within the islands. Because those islands were not protected, the most vulnerable species were the one exposed to hunting, predation and those with fewer requirements in terms of space. Actually, the remaining species are those high capacity of dispersal over the lake like birds while Mammals and reptiles are in a very low number.

Currently, invasive species are considered to be the main threat to island species although climate change is predicted to be a major threat to islands in the future. The most invasive species recorded on Kivu islands are *Lantana camara* and *Caesalpinia decapetala*. Some islands could be shortly invaded if no conservation measure is undertaken. **Conservation and restoration of Kivu islands should therefore not only contribute to biodiversity conservation but also to mitigation of impacts of climate change.**

Lantana camara is progressively becaming a serious threat to vegetation as they cover very large parts of some islands especially at Mukondwe, Shegesha and Mbabara islands while Caesalpinia decapetala is now spreading at Mbarara island.

Human activities like farming and animal rearing in the islands have also been recorded at almost all the large islands like Shegesha Mbabara (agriculture and husbandry), Nyamunini and Shegesha (husbandry). It is known that Kivu islands like the main land part have unfertile soils and very sensitive to erosion. Rocks are very closer to the surface and if the vegetation is removed, erosion should likely make the land farmable only for a short time and farmers will be obliged to leave their degraded plots. Restoration costs at that time will be more expensive than if immediate conservation measures were taken.

4.2.5. The CBD and Kivu islands biodiversity conservation

Islands are microcosms of the processes of threat and extinction and may provide insights into effective management approaches. They also offer an opportunity for practical conservation as they are self-contained ecosystems that it should be possible to isolate from many threat factors (Gerlach, J., 2008).

The 8th Conference of the Parties to the Convention on Biodiversity (COP8) in 2006 agreed a "Programme of Work for Island Biodiversity" to protect and manage the island natural resources that support people. The Working Plan aims to Conserve the world's unique island biodiversity, significantly reduce the rate of biodiversity loss and advance sustainable livelihoods on islands.
Among other targets developed, "at least 10% of each of the island ecological regions must be effectively conserved" (target 1.1.) and "Areas of particular importance to island biodiversity are protected through comprehensive, effectively managed and ecologically representative national and regional protected area networks" (target 1.2.).

Within Kivu islands, Rwanda is in possession of more than 50 islands and none among them is protected. **As a country which has ratified the CBD, Rwanda is therefore encouraged to conserve and restore at least 10% of the extent of Kivu islands.**

4.3. Measures and priorities for Kivu islands conservation

As demostrated in the paragraphs above, many Kivu islands are intensively degraded. This is the case of Shegesha, Amahoro and Mbabara islands. To conserve them, there is first all a need of ecological restoration followed by taking appropriate conservation measures.

Till now, Kivu islands are the property of the governement. However, conservation measures should be as participatory as possible so as to get long lasting results. In fact, there still some interactions between local communities and Kivu islands resources including pastures for cattle grazing, stones for various constuctions, medicinal plants, wild meat (mainly from *Atilax paludinosus*), timber….

One and easiest stragetic way should be to create a biosphere reserve in that part of the country. With reference to the survey commissioned by UNESCO in 2009 and this study especially in its components related to socio-economy and biodiversity, core conservation zone should integrate less disturbed areas with minimum of human activities like Mukondwe, Amahoro, Nyenyeri, Nyamunini, Mpangara, Rwanuma and all close islands. This list can be extended to other islands after they will be investigated as well.

Islands for tourism should be those with already intense human activities like Mbabara, Pininsulas like NUR peninsula, Kabahizi peninsula etc… Transitional zone should consider islands closer to the main land like Shegesha, Nyarugaba etc..

Tourism in the islands should be promoted in order to create other employement opportunities and this should provide alternative activities of local community and reduce pressure on natural resources. The development of tourism will increasingly lead to more off-farm employements thus improving the living standards of people.

The people who were shifted from the islands for better access to economic and social infrastructure should be compensated for new lands to stop them from going back into islands to practice their farming.

The Government and other development partners should scale-up the biogas project to reach people who were evacuated from the islands or still using islands to sastisfy home energy needs. The use of this renewable energy will reduce pressure on forests where people gather their firewood for energy production. It is important to mention that the cattle owned by the people in the islands can be used to produce dung useful for biogas energy production. This can be used for cooking and lighting thus increasing more hours for working especially for women and provisioning of clean energy that lead to reduction of unnecessary illness like respiratory diseases which mostly attack women and children involved in cooking.

People in visited areas should be encouraged to keep their animals in shade rather than grazing them in an open space.

Moreover, these islands are occupied by cattle coming from Kibuye and the nearest areas and that contributes to the disturbance of the flora and the vegetation ,affects the canopy structure and consequently decreases the fauna and flora biodiversity.

The people who were shifted from Mbabara should settled permanently and supported to cop with land use at the mainland as well as increasing technical supports in their farming on the island. The efforts to stop them to practice farming along 50m offshores should be increased to avoid land slides. These people should also assisted to form competitive cooperative structures which ease the dissimination of technologies and marketing their produce.

In short term, priority should be given extend the survey a representative number of islands within Kivu lakes so as to get an overview of the stutus of biodiversity in that area and take global conservation measures. Meanwhile, process regarding conservation of the six islands should start as soon as possible to avoid current land degradation on those islands. A particular attention should be given to less disturbed islands like Mukondwe, Nyenyeri, Nyamunini, Rwanuma and Mpangara.

Additionnaly, priority should also be oriented to the definition, development, enacting and enforcement of law in relation to Kivu islands ownership and land use. This is because Kivu islands are very attractive for tourism, hotels establisment and other recreative activities.

CHAPTER V. CONCLUSION

The importance of islands goes far beyond their striking beauty. Islands are the earth's great repositories of biological diversity. Thanks to their favorable climates and historic isolation, islands are home to thousands of species that do not exist elsewhere.

Kivu islands are one of key zones in Rwanda for biodiversity conservation, tourism and recreation. They have high potential of income generation and sustainable enhancement of local community livelihood. Actual management of Kivu islands should be reformed so as to alleviate proverty of local community and contribute to environment restoration and conservation.

Lake Kivu islands are homes for many bird species (Index 1) and hold three migratory species (*Cossypha natalensis* on Mukondwe island, *Milvus migrans* on Nyenyeri and Mpangara islands and *Bulbucus ibis* on Shegesha island). *Cossypha natalensis* seems to use the Kivu islands as one of its stopover as it was also recorded at Idjwi and Nyamunini islands (UNESCO, 2009). Also, these islands seem to be a good area for birds breeding.

The species breeding like *Nettapus auriatus* and many nests of Ploceidae were observed.

The presence of a high number of bird species, according to its area, and the presence of these three migratory species, in addition to all other fauna and flora species found at those islands, show the importance of the islands in terms of biodiversity conservation.

Briefly, Kivu islands can become a relevant income generation source for Rwanda when combining touristic activities and biodiversity conservation in that area.

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APPENDIX

Table 4: Recorded bird species at Nyamunini Island.

Common names	Scientific Names	Order	Families	R. A.	A. A.
Great Cormorant	*Phalacrocorax carbo*	Galliformes	Phalacrocoracidae	1	0
Hadada Ibis	*Bostrychia hagedash*	Passeriformes	Threskiornithidae	10	0
Egyptian Goose	*Alopochen aegyptiaca*	Coraciadiformes	Anatidae	5	0
Palm-nut Vulture	*Gypohierax angolensis*	Accipitriformes	Accipitridae	4	0
African Harrier-hawk	*Polyboroides typus*	Accipitriformes	Accipitridae	1	0
Augur Buzzard	*Buteo augur*	Accipitriformes	Accipitridae	7	0
African Fish-eagle	*Haliaeetus vocifer*	Accipitriformes	Accipitridae	1	0
Black Kite	*Milvus migrans*	Accipitriformes	Accipitridae	9	0
Grey Kestrel	*Falco ardosiaceus*	Falconiformes	Falconidae	1	0
Red-eyed Dove	*Streptopelia semitorquata*	Columbiformes	Columbidae	3	0
Blue-spotted Wood-dove	*Turtur afer*	Columbiformes	Columbidae	22	3
Ring-necked Dove	*Streptopelia capicola*	Columbiformes	Columbidae	4	0
Pied Kingfisher	*Ceryle rudis*	Passeriformes	Alcedinidae	7	0
African Pygmy-kingfisher	*Ceyx pictus*	Passeriformes	Alcedinidae	4	2
Grey-headed Kingfisher	*Halcyon leucocephala*	Passeriformes	Alcedinidae	1	1
Little Bee-eater	*Merops pusillus*	Coraciiformes	Meropidae	1	0
Double-toothed Barbet	*Lybius bidentatus*	Buceroformes	Capitonidae	5	1

Cardinal Woodpecker	*Dendropicos fuscescens*	Piciformes	Picidae	1	0
Wire-tailed Swallow	*Hirundo smithii*	Passeriformes	Hirundinidae	3	0
Blue Saw-wing	*Psalidoprocne pristoptera*	Passeriformes	Hirundinidae	1	0
Angola Swallow	*Hirundo angolensis*	Passeriformes	Hirundinidae	1	0
African Pied Wagtail	*Motacilla aguimp*	Passeriformes	Motacillidae	1	0
Grassland Pipit	*Anthus cinnamomeus*	Passeriformes	Motacillidae	5	0
Common Bulbul	*Pycnonotus barbatus*	Passeriformes	Pycnonotidae	76	1
Yellow-throated Greenbul	*Chlorocichla flavicollis*	Passeriformes	Pycnonotidae	127	2
Red-capped Robin-chat	*Cossypha natalensis*	Passeriformes	Turdidae	5	2
Olive Thrush	*Turdus olivaceus*	Passeriformes	Turdidae	1	0
White-browed Robin-chat	*Cossypha heuglini*	Passeriformes	Turdidae	8	1
Grey-capped Warbler	*Eminia lepida*	Passeriformes	Sylviidae	8	1
Red-faced Cisticola	*Cisticola erythrops*	Passeriformes	Sylviidae	8	0
Tawny-flanked Prinia	*Prinia subflava*	Passeriformes	Sylviidae	6	0
White-eyed Slaty-flycatcher	*Dioptrornis fischeri*	Passeriformes	Muscicapidae	1	0
African Paradise-flycatcher	*Terpsiphone viridis*	Passeriformes	Muscicapidae	1	0
Brown-throated Wattle-eye	*Platysteira cyanea*	Passeriformes	Platysteiridae	13	1
Scarlet-chested Sunbird	*Nectarinia senegalensis*	Passeriformes	Nectarinidae	8	2
Bronze Sunbird	*Nectarinia kilimensis*	Passeriformes	Nectarinidae	7	0

Red-chested Sunbird	*Nectarinia erythrocerca*	Passeriformes	Nectarinidae	25	3
Olive-bellied Sunbird	*Nectarinia chloropygia*	Passeriformes	Nectarinidae	1	1
Variable Sunbird	*Nectarinia venusta*	Passeriformes	Nectarinidae	1	0
Common Fiscal	*Lanius collaris*	Passeriformes	Laniidae	6	0
Tropical Boubou	*Laniarius aethiopicus*	Passeriformes	Laniidae	4	0
Pied Crow	*Corvus albus*	Passeriformes	Corvidae	6	0
Violet-backed Starling	*Cinnyricinclus leucogaster*	Passeriformes	Sturniidae	1	0
Red-collared Widowbird	*Euplectes ardens*	Passeriformes	Ploceidae	19	0
Spectacled Weaver	*Ploceus ocularis*	Passeriformes	Ploceidae	3	0
Holub's Golden-weaver	*Ploceus xanthops*	Passeriformes	Ploceidae	2	0
Grosbeak Weaver	*Amblyospiza albifrons*	Passeriformes	Ploceidae	1	1
Baglafecht Weaver	*Ploceus baglafecht*	Passeriformes	Ploceidae	5	0
Common Waxbill	*Estrilda astrild*	Passeriformes	Estrildidae	63	1
Fawn-breasted Waxbill	*Estrilda paludicola*	Passeriformes	Estrildidae	34	0
African Firefinch	*Lagonosticta rubricata*	Passeriformes	Estrildidae	5	0
Bronze Munia	*Lonchura cucullata*	Passeriformes	Estrildidae	1	0
Yellow-fronted Canary	*Serinus mozambicus*	Passeriformes	Fringillidae	12	0

Table 5: Phytosociological table of *Rhoicissus revoilii* and *Euclea schimperi* community (Nyamunini)

Species name	R13	R15	R16	R17	R19	R20	R21	RM (%)
Rhoicissus revoilii	3	3	4	4		+	4	24.98
Euclea schimperi	1	+	4		5	5		22.89
Ficus ingens	+	2	2	4	1	3	3	16.24
Rhus natalensis		4					2	7.36
Vepris nobilis	2	1	3	+		1	2	7.03
Psydrax parviflora	1	2	1	1	3	1	1	6.41
Pteris preussii	+	3		+	+	1	1	4.27
Entada abyssinica			2			1		1.71
Euphorbia candelabrum	2		+				+	1.52
Cussonia holstii			2					1.42
Plectranthus barbatus	1	+		+			+	0.43
Solanecio mannii	+	+	+	1				0.43
Asystasia gangetica	+	+			1			0.38
Justicia flava	+	+	+	+	+	+	+	0.33
Psidium guajava			1			+		0.33
Triumfetta cordifolia	+	+	+		+	+	+	0.28
Euphorbia dawei				1				0.28
Hyparrhenia variabilis		1						0.28
Arthraxon quartinianus	1							0.28
Commelina africana	+	+	+		+		+	0.24
Cyanotis foecunda	+	+	+	+	+			0.24
Kalanchoe crenata	+	+	+			+	+	0.24
Ocimum gratissimum	+	+	+				+	0.19
Biophytum helenae	+		+			+		0.14
Clausena anisata	+	+	+					0.14
Conyza sumatrensis	+		+			+		0.14
Rumex usambarensis		+			+	+		0.14

Ageratum conyzoides					+		+	0.09
Indigofera congesta	+	+						0.09
Kyllinga bulbosa	+					+		0.09
Mariscus sumatrensis	+					+		0.09
Pavetta urundensis						+	+	0.09
Phyllanthus odontadenius		+	+					0.09
Rhynchosia orthobotrya		+		+				0.09
Solenostemon platostomoides		+	+					0.09
Tragia brevipes		+	+					0.09
Abutilon mauritianum			+					0.05
Allophyllus chaunostachys				+				0.05
Asparagus falcatus var. falcatus		+						0.05
Caesalpinia decapetala			+					0.05
Sarcostemma viminale	+							0.05
Cyphostemma bambuseti			+					0.05
Eragrostis olivacea	+							0.05
Eulophia orthoplectra	+							0.05
Jasminum pauciflorum		+						0.05
Lactuca inermis						+		0.05
Microglossa pyrifolia			+					0.05
Phyllanthus maderaspatensis							+	0.05
Rubia cordifolia			+					0.05
Senna septemptrionalis		+						0.05
Vernonia lasiopus	+							0.05
Vernonia brachycalyx		+						0.05

Table 6: Phytosociological table of *Hyparrhenia variabilis* and *Conyza pyrrhopappa* community (Nyamunini)

Species name	R29	R30	R33	R34	R35	R36	R37	R38	R39	R40	R41	R42	RM (%)
Hyparrhenia variabilis				5	5	1	+	5	2				24.06
Conyza pyrrhopappa	2	+	1		+	+		3	4		+		10.27
Eragrostis racemosa	4	3									+		8.6
Acacia hockii												5	7.49
Hyparrhenia filipendula			5										7.49
Phoenix reclinata										5			7.49
Rytigynia bridsoniae							4		+				5.39
Entada abyssinica											4		5.35
Euclea schimperi							2			3			4.49
Ocimum gratissimum	3											+	3.25
Psidium guajava	+		+					+	2	1			1.67
Triumfetta cordifolia	2		+		+			+		+	+		1.5
Clematis hirsuta											2		1.28
Ficus ingens							2						1.28
Hyparrhenia filipendula				+		1			1				0.56
Hyparrhenia lecomtei						1			1				0.51
Biophytum helenae	+	+	+		+		+	+	+	+	+	+	0.43
Ageratum conyzoides							+		1	+	+	+	0.43
Solenostemon platostomoides	+	+	+	+	+	+	+		+			+	0.39
Cyanotis barbata	+	+	+	+	+			+	+			+	0.34
Fimbristylis complanata	+	+	+	+	+		+	+	+				0.34

Psydrax parviflora			+				1		+				0.34
Oldenlandia herbacea		+			+		+	+	+		+	+	0.3
Spermacoce pusila		+	+	+	+		+	+	+				0.3
Carissa spinarum							1			+			0.3
Digitaria abyssinica										+	1		0.3
Solanecio mannii	+						1						0.3
Conyza sumatrensis	+				+			+	+	+		+	0.26
Bidens grantii					1								0.26
Capparis tomentosa							1						0.26
Plectranthus barbatus							1						0.26
Vernonia brachycalyx		1											0.26
Commelina africana	+			+			+			+	+		0.21
Aechynomene schimperi		+	+		+					+		+	0.21
Rhynchosia orthobotrya			+	+	+	+		+					0.21
Vernonia lasiopus			+		+		+	+	+				0.21
Asystasia gangetica	+						+				+	+	0.17
Crassocephalum sarcobasis				+				+		+		+	0.17
Hibiscus noldae	+						+	+	+				0.17
Justicia flava	+						+			+	+		0.17
Englerastrum djalonensis			+					+	+		+		0.17
Mariscus sumatrensis	+			+			+			+			0.17
Commelina benghalensis							+		+	+			0.13
Desmodium									+		+	+	0.13

setigerum													
Alectra sessiliflora		+						+					0.09
Antherotoma naudinii								+	+				0.09
Polygala melilotoides			+					+					0.09
Drymaria volkensii								+	+				0.09
Kalanchoe crenata											+	+	0.09
Kyllinga appendiculata	+						+						0.09
Ocimum lamiifolium										+		+	0.09
Phyllanthus odontadenius	+	+											0.09
Pteris preussii							+			+			0.09
Vepris nobilis										+	+		0.09
Aeolantus repens					+								0.04
Albizia adianthifolia						+							0.04
Anthericum laurentii							+						0.04
Anthocleista schweinfurthii								+					0.04
Asparagus falcatus var. falcatus							+						0.04
Brachiaria decumbens										+			0.04
Centella asiatica											+		0.04
Ceropegia nilotica var. nilotica							+						0.04
Clausena anisata										+			0.04
Commiphora madagascarensis							+						0.04
Cyphostemma bambuseti										+			0.04

Erythrococca bongensis										+			0.04
Euphorbia dawei							+						0.04
Polygala melilotoides		+											0.04
Gynura scandens							+						0.04
Hyparrhenia lecomptei		+											0.04
Leonotis nepetifolia	+												0.04
Dissotis brazzae						+							0.04
Melinis repens		+											0.04
Microglossa pyrifolia										+			0.04
Ocimum basilicum											+		0.04
Panicum repens							+						0.04
Peperomia fernandopoiana var. butanguensis	+												0.04
Senna septemptrionalis	+												0.04
Triumfetta pilosa var. nyasana												+	0.04

Table 7: Phytosociological table of *Psydrax parviflora* and *Solanecio mannii* community (Nyamunini)

Species name	R1	R10	R11	R12	R14	R18	R2	R22	R23	R24	R25	R26	R27	R28	R3	R31	R32	R4	R5	R6	R7	R8	R9	RM (%)
Psydrax parviflora	4	4	1	4	3	1	2	2	1	3			1	2	2	2	2			2		3	1	12.56
Solanecio mannii	+	1	3	4	+	3	4	+		+	2	+	2	4	+	+	1	3	+	2	1	2	+	11.17
Rhus natalensis		4	2	+	3	1	3	3	+				4	2	1	2				+				8.67
Justicia flava	1		+		1	1		+	1	1	2	3			1	+	+	4	3		4	1	1	7.21
Rytigynia bridsoniae										3	1	5	2		2	+	2			3				6.31
Carissa spinarum					+	5				+	2					4								4.96
Cussonia holstii					4	1					1								2	1	4			4.46
Microglossa pyrifolia	1		+				1	+	4	+	+	+	+	1	1				+	1		2	3	3.99
Anthocleista schweinfurthii	1						3	1	4											1		1	1	3.44
Vepris nobilis			2	1	+	1		+	1	+	1	+	+	+		+		1	+	4	1	1	1	3.16
Plectranthus barbatus	+	1	1	1	+			1	+	1	1	1	1	2	3	1			+	1	1	1	1	2.8
Opuntia vulgaris																	5							2.62
Entada abyssinica	+							+	1	1	1				1							1	4	2.35
Bridelia micrantha	2							1	1	+								2				3	1	2.3

Clausena anisata			+	+	+				+		+		+	1	1			4	+	+	1	+		2.27
Pteris preussii	4		+	+						+		+	+									+		1.96
Cissus quadrangularis											4													1.87
Pteridium aquilinum	4																							1.87
Gongronema angolense																			3		1		+	1.23
Ficus tremula											3	1												1.21
Secamone stuhlmannii																				3				1.12
Thelypteris confluens		2						+	+	1					+							2		1.03
Psidium guajava	1		+	+			1	1	1					1	+		+					2	+	0.97
Asystasia gangetica	+			+	+			1		+						+	+	+	2		+	+		0.67
Erythrococca bongensis				+							2		+	+	1	+			+	+	+		+	0.66
Discopodium penninervium				2										1						1		+	+	0.66
Tragia brevipes																			2	1	1	+	+	0.66
Commelina			1	1		+		+	+	+	+	+	+	+		1	1	+		+	+	+		0.54

africana																							
Commiphora madagascarensis																2	1						0.54
Capparis tomentosa						+										+			+		2		0.49
Jasminum pauciflorum			+															+				2		0.48
Albizia gummifera												2												0.45
Euclea schimperi																2								0.45
Commiphora africana		1								+	1				+			+			1	+		0.33
Cyanotis foecunda		+	+	+	+	+	1		+			+			+	+		+				+	+	0.27
Mariscus sumatrensis	+	+	+	1				+		+		+	+			+	+					+		0.24
Cissus quadrangularis			1	1				+		+			+									+		0.24
Conyza sumatrensis		+	1	+					+						+					+		+		0.18
Sarcostemma viminale		1														1								0.18
Ipomoea tenuirostris						+			+				+	+			+		1					0.16

Pavetta urundensis		1			+					+	+	+	+										0.16
Pentas longiflora		+	+	+				+	+	1													0.16
Kalanchoe sp.		+	+	+		+		+		+			+	+			+						0.13
Achyranthes aspera														+				+		+	1		0.13
Euphorbia candelabrum			+					1						+					+				0.13
Phyllanthus sp.	1							+	+				+										0.13
Rubia cordifolia			+	1				+												+			0.13
Ocimum gratissimum				+										1								+	0.12
Tarenna graveolens								+										1				+	0.12
Cyanotis barbata															1			+					0.1
Triumfetta cordifolia			+					+	+	+			+									+	0.09
Agave sisalana							1																0.09
Albizia adianthifolia																				1			0.09
Euclea schimperi																1							0.09
Commelina benghalensis							1																0.09

Hyparrhenia filipendula												1											0.09
Not yet identified															1								0.09
Ocimum basilicum															1								0.09
Sarcostemma viminale var. 2																1							0.09
Cyphostemma adenocaule				+			+								+		+					+	0.07
Panicum repens																+	+		+		+	+	0.07
Asparagus falcatus var. Falcatus										+						+			+		+		0.06
Aloe lateritia					+		+			+													0.04
Cyphostemma bambuseti			+		+									+									0.04
Ageratum conyzoides			+								+												0.03
Cissus petiolata					+	+																	0.03
Clerodendrum johnstonii			+											+									0.03
Dodonaea viscosa											+			+									0.03
Lantana trifolia			+					+															0.03
Phyllanthus			+																			+	0.03

odontadenius																								
Solenostemon platostomoides						+											+							0.03
Vernonia lasiopus				+																			+	0.03
Vernonia brachycalyx	+		+																					0.03
Abutilon mauritianum																			+					0.01
Euclea schimperi																+								0.01
Not yet identified								+																0.01
Aulera trifoliae	+																							0.01
Bidens grantii												+												0.01
Capparis sepiaria var. rivae																		+						0.01
Ceropegia nilotica var. nilotica																+								0.01
Celosia stulhmanniana														+										0.01
Cissampelos mucronata																						+		0.01
Coffea arabica															+									0.01
Conyza																	+							0.01

pyrrhopappa																							
Desmodium setigerum									+														0.01
Digitaria abyssinica	+																						0.01
Dovyalis macrocalyx															+								0.01
Eragrostis olivacea																						+	0.01
Eriosema erici-rosenii																					+		0.01
Eucalyptus globulus	+																						0.01
Lactuca capensis														+									0.01
Chamaecrista mimosoides								+															0.01
Desmodium intortus															+								0.01
Ficus ingens					+																		0.01
Helichrysum schimperi									+														0.01
Hibiscus noldae												+											0.01

Commelina benghalensis							+																0.01
Ipomoea cairica				+																			0.01
Ipomoea involucrata									+														0.01
Kalanchoe crenata															+								0.01
Kyllinga appendiculata																	+						0.01
Otiophora pauciflora	+																						0.01
Pentas schimperana	+																						0.01
Brachiaria eminii								+															0.01
Sansevieria cylindrica		+																					0.01
Whithania somnifera																		+					0.01
Solanum nigrum														+									0.01
Spermacoce pusila			+																				0.01
Vernonia brachyceras																				+			0.01

Table 8: Presence and abscence of invertebrates at Nyamunini Island

Taxa	Gallery forest	Forest	Savanna
Phyla Arthropoda Class Insects Order Coleoptera Family Curculionidae Family Tenebrionidae Family Coccinellidae Family Scarabaeidae	+	+	+
Order Diptera Family Muscidae Family Culicidae Family Tabanidae Family Similidae	+	+	+
Order Hemiptera Family Pentatomidae Family Naucoridae	+	+	+
Order Isoptera Family Termopsidae Family Termitidae	+	+	+
Order Homoptera Family Aphididae Family Cicadelidae	+	-	-
Order Dictyoptera Family Mantidae Family Blatidae	+	+	+
Order Orthoptera Family Acrididae Family Tettigoniidae Family Gryllidae	+	+	+

Order Odonata Family Coenagrionidae Family Gomphidae Family libellulidae	+	+	+
Order Lepidoptera Family Pieridae Family Paplionidae Family Nymphalidae	+	+	+
Class Cructacea Order Decapoda Family Potamonidae	+	-	-
Order Isopoda Family Aselludae	+	+	-
Class Myriapode Order Diplopode Family Iulidae	+	+	+
Order Chilopoda Family Scolopendroidae	-	+	+
Class Arachnida Order Araneida	+	+	+
Order Acarina Family Ixodidae	-	+	+
Phyla Molluscs Class Gasteropoda Order Basommatophora Family Lymnaeidae	+	-	-
Order Stylommatophora Family Limicoloria Family Subulina	-	+	-

Legend: +: Presence; -: Absence

Table 9: Recorded bird species at Mukondwe Island.

Scientific name	*Order*	*Family*	*Relative abundance*
Phalacrocorax carbo	Galliforme	Phalacrococidae	5
Streptopelia capicola	Columbiformes	Colombidae	1
Colius striatus	Passeriformes	Coliidae	1
Turtur afer	Columbiformes	Colombidae	1
Bostrychia hagedash	Passeriformes	Threskiornithidae	3
Camaroptera brachyuran	Passeriformes	Sylvidae	3
Pycnonotus barbatus	Passeriformes	Pycnonotidae	14
Chlorocichla flavicollis	Passeriformes	Pycnonotidae	3
Ploceus ocularis	Passeriformes	Ploceidae	2
Eminia lepida	Passeriformes	Sylvidae	2
Cossypha natalensis	Passeriformes	Turdidae	2
Cisticola erythrops	Passeriformes	Sylvidae	2
Cossypha heuglini	Passeriformes	Turdidae	1
Terpsiphone viridis	Passeriformes	Muscicapidae	1
Lybius bidentatus	Buceroformes	Capitonidae	4
Lagonosticta senegala	Passeriformes	Estrilididae	2
Lagonosticta rubricate	Passeriformes	Estrilididae	4
Ploceus baglafecht	Passeriformes	Ploceidae	4
Laniarius aethiopicus	Passeriformes	Laniidae	2
Aquila rapax	Acciptriformes	Acciptridae	1
Ceryle rudis	Passeriformes	Alcedinidae	1
Streptopelia semitorquata	Columbiformes	Colombidae	2
Platysteira cyanea	Passeriformes	Platysteiridae	1
Scopus umbretta		Scopidae	1
Phalacrocorax africanus	Galliformes	Phalacrococidae	1

Table 10: Phytosociological table of *Hyparrhenia variabilis* and *Psidium guajava* community (Mukondwe Island).

Species name	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	RM(%)
Hyparrhenia variabilis	2	4		4	+	+				3	17.5
Psidium guajava			1	2			+			5	10.39
Psydrax parviflora				+		1	3	2		+	5.54
Ficus ingens					1	+	3				4.02
Caesalpinia decapetala								2	+		1.52
Ooldenlandia herbacea		2									1.47
Rhoicissus revoilii						1		1			0.59
Vepris nobilis							1	1			0.59
Digitaria abyssinica				+	1		+			+	0.44
Clerodendrum rotundifolium			+		+	+	+		+	+	0.29
Cussonia arborea				1							0.29
Entada abyssinica				1							0.29
Euphorbia dawei								1			0.29
Clematis hirsuta				+	+	+					0.15
Commelina benghalensis	+	+							+		0.15
Euphorbia candelabrum					+	+	+				0.15
Alectra sessiliflora		+									0.05
Asparagus falcatus								+			0.05
Carissa edulis						+					0.05
Citrus lemon										+	0.05
Crotalaria laburnifolia					+						0.05
Comiphora africana								+			0.05
Grevillea robusta										+	0.05
Leucas deflexa						+					0.05
Macadamia integifolia										+	0.05
Melinis repens	+										0.05

Nephrolepis undulata		+									0.05
Ocimum basilicum									+		0.05
Pavetta ternifolia										+	0.05
Rubus apetalus										+	0.05
Rumex abyssinicus									+		0.05
Sarcostemma viminale								+			0.05
Senna siamea	+										0.05
Sida acuta					+						0.05
Cissus quadrangularis					+						0.05
Solanecio manii										+	0.05
Tragia brevipes									+		0.05
Ageratum conyzoides				+	+						0.1
Aloe lateritia						+		+			0.1
Asystasia gangetica				+		+					0.1
Biophytum corniculatus		+	+								0.1
Conyza sumatrensis			+	+							0.1
Indigofera circinella	+	+									0.1
Jasminum schimperi							+	+			0.1
Justicia flava						+				+	0.1
Kyllinga bulbosa	+	+									0.1
Lantana trifolia			+		+						0.1
Microglossa pyrifolia					+					+	0.1
Oldenlandia goreensis				+		+					0.1
Rubia cordifolia									+	+	0.1
Lantana camara						1			5		8.87
Agave sisalana							+	+		3	3.77
Eragrostis racemosa	+	+								3	3.77
Rhus natalensis					+	+		3			3.77
Phoenix reclinata					2	1					1.76

Acacia hockii			3	1	3	+				+	7.75
Triumfetta cordifolia					+				+	+	0.15

Table 11: Recorded bird species at Shegesha Island

Scientific name	Order	Family	Relative abundance
Francolinus afer	Galliformes	Phasianidae	1
Euplectes franciscanus	Passeriformes	Ploceidae	15
Lanius mackinnoni	Passeriformes	Laniidae	1
Streptopelia capicola	Columbiformes	Colombidae	4
Streptopelia semitorquata	Columbiformes	Colombidae	16
Pycnonotus barbatus	Passeriformes	Pycnonotidae	6
Cisticola erythrops	Passeriformes	Sylvidae	2
Colius striatus	Passeriformes	Coliidae	7
Cinnyris erythrocerca	Passeriformes	Nectariniidae	2
Cinnyris venusta	Passeriformes	Nectariniidae	1
Ploceus cuculatus	Passeriformes	Ploceidae	1
Laniarius aethiopicus	Passeriformes	Laniidae	5
Bostryshia hagedash	Passeriformes	Threskiornithidae	5
Chlorocichla flavicollis	Passeriformes	Pycnonotidae	2
Cossypha heuglini	Passeriformes	Turdidae	1
Chalcomitra senegalensis	Passeriformes	Nectariniidae	1
Ceryle rudis	Coraciiformes	Alcedinidae	4
Phalacrocorax carbo	Galliformes	Phalacrococidae	1
Nettapus auriatus	Anseliformes	Anatidae	8
Centropus monachus	Cuculiformes	Cuculidae	3
Saxicola torquata			2
Lagonosticta rubricate	Passeriformes	Estrilididae	1
Lybius bidentatus	Buceroformes	Capitonidae	1
Scopus umbretta	Ciconiformes	Scopidae	1

Hirundo angolensis	Passeriformes	Hirundinidae	1
Vidua chalybeate	Passeriformes	Viduidae	1
Bubulcus ibis	Ciconiformes	Arideidae	4

Table 12: Phytosociological table of *Lantana camara and Rhus natalensis* community (Shegesha Island)

Species names	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	RM(%)
Lantana camara	2	+	2	5	2	+	1	2		+	18.5
Rhus natalensis	+	3		+	+	3		3	+	3	18.5
Ficus ingens	+				2	4			4		17.1
Acacia hockii	+	4						+	2	1	9.9
Euphorbia Candelabrum								2		4	9.4
Tithonia diversifolia			4			+		+			7.7
Clerodendrum rotundifolium	+	1	1	1	+	2	+	+	+	+	3.3
Euphorbia tirucalli	2				+						1.9
Hyparrhenia variabilis									2	+	1.9
Justicia flava						2	+				1.9
Pennissetum purpureum							2				1.8
Rhoicissus revolii								2			1.8
Triumfetta rhomboidea	1		+				+		+		0.5
Conyza sumatrensis		+	+		+	+	+	+			0.4
Digitaria abyssinica	+			+		+	+	+	+		0.4
Eragrostis racemosa					1						0.4
Ricinus communis			1								0.4
Bidens pilosa	+	+	+			+	+				0.3
Commelina benghalensis	+	+			+	+				+	0.3
Hibiscus noldae			+		+	+		+		+	0.3
Microglossa pyrifolia					+	+				+	0.2

Psidium guajava	+							+	+	+	0.2
Rubia cordifolia	+				+	+					0.2
Ageratum conyzoides				+							0.1
Aloe lateritia								+			0.1
Arthropteris orientalis									+		0.1
Asparagus racemosus										+	0.1
Asystasia gangetica									+		0.1
Biophytum helenae									+		0.1
Cedrella serrata				+							0.1
Cissus quadrangularis									+	+	0.1
Crotalaria ochraleuca									+		0.1
Cupressus lusitanica									+		0.1
Cyphostemma adenocaule				+							0.1
Emilia caespitosa									+		0.1
Erythrina abyssinica							+				0.1
Grevillea robusta								+			0.1
Kyllinga bulbosa	+									+	0.1
Lantana trifolia	+			+							0.1
Leonotis nepetifolia		+					+				0.1
Melinis multiflora										+	0.1
Ocimum urticifolium						+	+				0.1
Panicum maximum						+			+		0.1
Rumex abyssinicus					+	+					0.1
Tagetes minuta	+			+							0.1
Vepris nobilis									+		0.1

Table 13: Recorded bird species at Amahoro Island

Scientific name	Order	Family	Relative abundance
Corbus albus	Passeriformes	Corvidae	3
Phalacrocorax carbo	Pelecaniformes	Phalacrocoracidae	1
Ceryle rudis	Passeriformes	Alcedinidae	2
Cinnyris erythrocerca	Passeriformes	Nectariniidae	2
Chalcomitra senegalensis	Passeriformes	Nectariniidae	2
Chlorocichla flavicollis	Passeriformes	Pycnonotidae	4
Streptopelia semitorquata	Columbiformes	Colombidae	1
Merops oreobates	Coraciiformes	Meropidae	4
Motacilla aguimp	Passeriformes	Motacillidae	2
Bostrychia hagedash	Passeriformes	Threskiornithidae	2
Lagonosticta rubricata	Passeriformes	Estrilididae	1
Pycnonotus barbatus	Passeriformes	Pycnonotidae	1
Laniarius aethiopicus	Passeriformes	Laniidae	2
Euplectes franciscanus	Passeriformes	Ploceidae	2

Table 14: Phytosociological table of *Psydrax parviflora and Asystasia gangetica* community (Amahoro Island)

Species names	P1	P2	P3	P4	P5	RM(%)
Psydrax parviflora		3		5	3	21.2
Asystasia gangetica		+	4	4		16.4
Hyparrhenia variabilis	5					11.4
Vepris nobilis		+	2	2	3	8.9
Euphorbia dawei		4	1	+		8.6
Euphorbia candelabrum					4	8.1
Ficus ingens					3	4.9
Rhus natalensis		3				4.9
Teclea nobilis		+		1	2	2.4

Cissus quadrangularis			2			2
Cyanotis barbata	1	+				0.5
Psidium guajava				1	+	0.5
Tetradenia riparia		+		1		0.5
Catharantus roseus	1					0.4
Clerodendrum rotundifolium		1				0.4
Cupressus arisonica	1					0.4
Eragrostis racemosa				1		0.4
Euphorbia pulcherima			1			0.4
Justicia flava				1		0.4
Asparagus falcatus		+		+	+	0.2
Commelina benghalensis	+	+		+		0.2
Hibiscus noldae		+		+	+	0.2
Aloe lateritia					+	0.1
Arthropteris orientalis				+		0.1
Capparis tomentosa		+				0.1
Carissa edulis				+		0.1
Conyza sumatrensis					+	0.1
Crotalaria laburnifolia				+		0.1
Cucurbita pepo			+			0.1
Digitaria abyssinica		+		+		0.1
Erythrococca bongensis		+				0.1
Gynura scandens		+				0.1
Macadamia integrifolia				+		0.1
Peperomia fernandopoiana					+	0.1
Phoenix reclinata					+	0.1
Rumex abyssinicus					+	0.1
Sarcostemma viminale				+		0.1
Solanecio manii			+			0.1

Tragia brevipes		+				0.1
Triumfetta rhomboidea					+	0.1

Table 15: Recorded bird species at Nyenyeri Island.

Scientific name	Order	Family	Relative abundance
Bostryshia hagedash	Passeriformes	Threskiornithidae	3
Chlorocichla flavicollis	Passeriformes	Pycnonotidae	13
Pycnonotus barbatus	Passeriformes	Pycnonotidae	3
Turtur afer	Columbiformes	Colombidae	2
Ceryle rudis	Passeriformes	Alcedinidae	2
Streptopelia semitorquata	Columbiformes	Colombidae	3
Cinnyris erythrocerca	Passeriformes	Nectariniidae	4
Lamprtornis purpuropterus	Passeriformes	Sturniidae	2
Cisticola erythrops	Passeriformes	Sylvidae	4
Nettapus auriatus	Anseliformes	Anatidae	8
Motacilla aguimp	Passeriformes	Motacillidae	2
Milvus migrans	Accipitriformes	Accipitridae	1
Merops oreobates	Coraciiformes	Meropidae	1
Terpsiphone viridis	Passeriformes	Muscicapidae	1
Scopus umbretta	Ciconiformes	Scopidae	1
Ploceus xanthops	Passeriformes	Ploceidae	1
Burhinus vermiculatus		Burhinidae	2
Streptopelia capicola	Columbiformes	Colombidae	2
Cinnyris venusta	Passeriformes	Nectarinidae	2
Hedydipina collaris	Passeriformes	Nectarinidae	2
Lagonosticta rubricata	Passeriformes	Estrilididae	1
Ispidina picta	Passeriformes	Alcedinidae	1
Laniarius aethiopicus	Passeriformes	Laniidae	2
Phalacrocorax carbo	Galliformes	Phalacrococidae	1

Table 16: Phytosociological table of *Psidium guajava and Agave sisalana* community (Nyenyeri Island)

Species names	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	RM(%)
Citrus lemon				1			+		2		0.89
Clerodendrum rotundifolium	1		1	1		1		+	+		0.62
Dodonaea viscosa					4		4				6
Erythrococca bongensis						1	+	+	2	+	0.93
Euphorbia tirucalli					+			2			0.74
Jasminum schimperi						2	+	+	+		0.79
Persea Americana									2		0.72
Rhus natalensis	3					5					6
Cissus quadrangulalis		2								1	0.86
Solanecio manii	2	+							1	2	1.61
Psidium guajava			4		2	2	5		4	+	11.67
Rubia cordifolia	1	+				3			2		2.69
Justicia flava	+	+	1		+		+		3	2	2.76
Jacaranda mimosifolia					+			3			1.83
Ocimum lamiifolium			+	4		1	+		2		3.91
Agave sisalana					2			4		5	7.93
Ficus ingens	3	1		4							4.95
Hibiscus noldae						+	+	+	+		0.1
Cadaba falinosa	+										0.02
Dracaena afromontana					+						0.02
Morus alba					+						0.02
Asparagus falcatus	+	1				+	+	1	1		0.5
Cyphostema adenocaule						+	+				0.05
Rumex abyssiniccus		+					+				0.05
Kalanchoe serrata	+	+						+			0.07
Kyllinga bulbosa		+	+		+	+	+				0.12

Sonchus luxurians	+	+				+			+	+	0.12
Arthropteris orientalis					1						0.14
Carissa edulis			1								0.14
Nerium oleander								1			0.14
Commelina benghalensis	+	+	+	+		+	+			+	0.17
Mangifera indica					+				1		0.17
Panicum maximum							1	+			0.17
Sarcostemma viminale	+	1									0.17
Tetradenia riparia	1	+									0.17
Tragia brevipes		1				+					0.17
Achyranthes aspera			+					+	1		0.19
Aloe lateritia					+	1				+	0.19
Catharanthus roseus				1		+	+				0.19
Lantana camara			1		+				+		0.19
Veprisnobilis		+	+	1		+	+				0.24
Microglossa pyrifolia									3		1.8
Crotalaria laburnifolia			+	+	1	+		1	2	1	1.22
Triumfetta rhomboidea		+	+	1	+		1	1	2		1.22
Asystasia gangetica	+	2				2			+		1.49
Clematis hirsuta									2	3	2.52
Cuperessus lusitanica					+			4			3.03
Psydrax parviflora	3	4			1	+		1			5.12
Euphorbia dawei	1	3				5					6.15
Cissus quadrangularis			+	4		3		2	2		6.27

Table 17: Recorded bird species at Mpangara Island.

Scientific name	Order	Family	Relative abundance
Pycnonotus barbatus	Passeriformes	Pycnonotidae	17
Colius striatus	Passeriformes	Coliidae	9
Turtur afer	Columbiformes	Colombidae	1
Ceryle rudis	Passeriformes	Alcedinidae	6
Lagonosticta rubricata	Passeriformes	Estrilididae	18
Phalacrocorax carbo	Galliformes	Phalacrococidae	2
Cossypha heuglini	Passeriformes	Turdidae	2
Platysteira cyanea	Passeriformes	Platysteiridae	2
Vidua macroura	Passeriformes	Viduidae	25
Streptopelia semitorquata	Columbiformes	Colombidae	20
Cinnyris erythrocerca	Passeriformes	Nectariniidae	2
Francolinus afer	Galliformes	Phasianidae	3
Laniarius aethiopicus	Passeriformes	Laniidae	1
Streptopelia capicola	Columbiformes	Colombidae	2
Bostryshia hagedash	Passeriformes	Threskiornithidae	1
Milvus migrans	Accipitriformes	Accipitridae	1
Corbus albus	Passeriformes	Corvidae	3
Turdoides jardineii	Passeriformes	Turdidae	5
Turdus olivaceus	Passeriformes	Turdidae	1
Chlorocichla flavicollis	Passeriformes	Pycnonotidae	1

Table 18: Phytosociological table of *Lantana camara* and *Carissa edulis* community (Mpangara Island)

Species names	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	RM(%)
Rhus natalensis	5		5	3	5		5	4	3	2	23.7
Carissa edulis	3	+	2	3	4	+	1	3	4	5	16.22
Lantana camara		5	1	3	4	3	+		2	1	11.62
Acacia hockii	1	1		+	3	4			2		5.73
Ocimum lamiifolium	+	4			3	1	+		1	1	5.19
Clematis hirsuta		1			3	1	+	+	4		5.05
Rhoicissus revoilii	1	1	3	+	3			+		+	3.89
Clerodendrum rotundifolium		1	+	1	3	1	+	+	+		2.29
Rubia cordifolia	+		+	+			3	1		1	2.12
Panicum maximum			1		3			+			1.93
Eragrostis racemosa			+	2	1	1	+		+	1	1.2
Psydrax parviflora	2	+	+	1	1			1			1.18
Crotalaria ochroleuca	+		+	+	1	2	+		1		1.08
Asparagus falcatus	2			+	1			+		1	1.04
Triumfetta rhomboidea	2	+	+		1		+	+	+		0.97
Jasminum schimperi			+	+	1			+	+	2	0.94
Microglossa pyrifolia							+			2	0.73
Rumex abyssinicus										2	0.71
Asystasia gangetica				1	1		+			1	0.45
Digitaria abyssinica	1	+	+	+		+		+		1	0.4
Hybiscus noldae			+	1	+	+			+		0.24
Justicia flava			1	+	+			+	+		0.24
Aloe lateritia				+		1	+				0.19
Psidium guajava		+					+		1		0.19
Commiphora africana								1			0.14
Euphorbia candelabrum			1								0.14

Hyparrhenia variabilis						1					0.14
Cyphostemma adenocaule	+	+	+	+	+		+	+			0.13
Commelina benghalensis	+					+	+		+		0.09
Kalanchoe serrata		+				+					0.05
Kyllinga bulbosa	+			+							0.05
Ageratum conyzoides						+					0.02
Gomphocarpus fruticosus						+					0.02
Spermacoce pusilla							+				0.02

Table 19: Recorded bird species at Nyarugaba Island.

Scientific name	Order	Family	Relative abundance
Scopus umbretta	Ciconiformes	Scopidae	2
Corbus albus	Passeriformes	Corvidae	2
Phalacrocorax carbo	Galliforme	Phalacrococidae	8
Colius striatus	Passeriformes	Coliidae	5
Pycnonotus barbatus	Passeriformes	Pycnonotidae	2
Ardea melanocecphala	Ciconiformes	Ardeidae	1
Ploceus xanthops	Passeriformes	Ploceidae	1
Tchagra senegala	Passeriformes	Malaconotidae	2
Eminia lepida	Passeriformes	Sylvidae	1
Cisticola erythrops	Passeriformes	Silvidae	3
Streptopelia capicola	Columbiformes	Colombidae	1
Serinus citrinelloides		Fringiliidae	1
Laniarius aethiopicus	Passeriformes	Laniidae	1
Chlorocichla flavicollis	Passeriformes	Pycnonotidae	2
Ceryle rudis	Passeriformes	Alcedinidae	2
Streptopelia semitorquata	Columbiformes	Colombidae	2
Lagonosticta rubricata	Passeriformes	Estrilididae	1
Phalacrocorax africanus	Galliformes	Phalacrococidae	1

Turtur afer	Columbiformes	Colombidae	1

Table 20: Phytosociological table of *Hyparrhenia variabilis and Ocimum lamiifolium* community (Nyarugaba Island)

Species names	P1	P2	P3	RM(%)
Hyparrhenia variabilis	4		5	22.5
Ocimum lamiifolium			5	13.1
Vepris nobilis	2	4		11.6
Ficus cyathistipula		4		9.4
Rhus natalensis	4			9.4
Clematis hirsuta		3		5.6
Psidium guajava	+	2	2	4.6
Justicia flava	2	2		4.5
Panicum maximum	2	+	1	2.8
Ficus ingens	2			2.2
Tetradenia riparia		2		2.2
Agave sisalana	+		1	0.5
Eragrostis racemosa	+		1	0.5
Clerodendrum rotundifolium	1			0.4
Lantana camara			1	0.4
Aloe lateritia			+	0.1
Bidens pilosa		+		0.1
Commelina benghalensis			+	0.1
Jasminum schimperi		+		0.1
Microglossa parviflora	+	+		0.1