RWANDA WETLAND BIODIVERSITY STATUS REPORT

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Rwanda Wetland Biodiversity Status Report

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I. Introduction

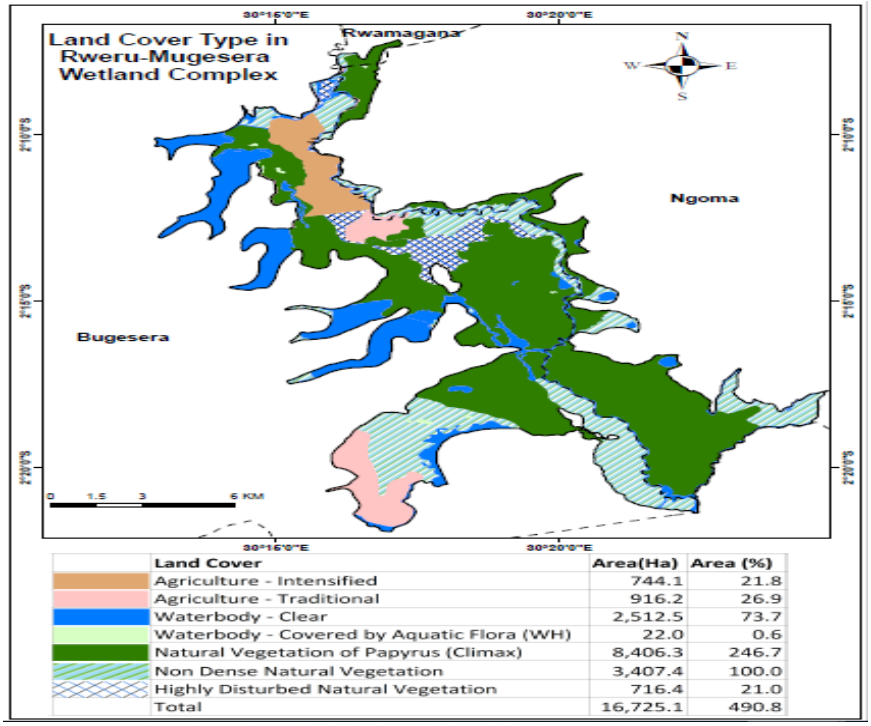
Conducting a new biodiversity status report every four years is one of the recommendations from the National Biodiversity Strategic Action Plan (NBSAP) for Rwanda, with the purpose to compare the results with the baseline ones and find different trends affecting biodiversity in different areas, and other issues relevant to biodiversity situation. Specifically, Rwanda develops a National State of Environment Outlook report, a strategic document that aims at informing strategic planning and decision making regarding the management of critical ecosystems and biodiversity in general. In this regard, a 6th National Environment and Outlook report is under development. The Albertine Rift Conservation Society (ARCOS), in partnership with Rwanda Environment Management Authority (REMA), discussed and approved the relevance of conducting a specific research on Rwanda Wetland Biodiversity status in 2018 and, with financial support from JRS Biodiversity Foundation, this report was developed; it provided information on the status of key functional wetland ecosystems and seven taxa, key ecosystem services, threats to wetland biodiversity in Rwanda and ongoing conservation actions to maintain wetland biodiversity and ecosystem integrity. This is an essential step toward enhancing wetland biodiversity conservation in Rwanda since apart from the technical report, all mobilized occurrence and checklist data were published on ARCOS biodiversity Information System (http://arbims.arcosnetwork.org/out.biodiversitydata.php) for free access to everyone and further use and value addition. Both data and a technical report are very important as they see the development of Rwanda Biodiversity Information System (RBIS) hosted and managed by the Center of Excellence in Biodiversity and Natural Resources Management. This technical report provides an in-depth evaluation of the current knowledge on wetland biodiversity in Rwanda, identifies data gaps that exist and highlights future priority actions and research requirements. In addition, it provides an important benchmark for future status assessments, and it is also a valuable reference document since it covers the range of wetland biodiversity levels (species, ecosystems) as well as examining current threats and issues. It is particularly timely and relevant given the need to inform the development of the country's critical wetland management plans and gazettement of those already proposed to be Ramsar sites, and specifically, the report reflects a strong commitment on the part of ARCOS and partners to contribute to wetland biodiversity conservation.

II. Status of functional wetland ecosystems

II.1 Rweru-Mugesera wetland complex

II.1.1 Location and land cover status

Rweru-Mugesera wetland complex was qualified as important at local, national and global level (ARCOS 20191). It is situated in the southeastern plateau at about 1300 m of altitude (Fischer at al 2011) within the Mayaga, Bugesera agroecological zone of Rwanda, one of the biggest semi dry areas and peat lands of the country, fed by Akagera river and connected to Rweru lake which are transboundary waters between Rwanda and Burundi but also Gaharwa, Kirimbi, Mirayi, Rumira and Gashanga lakes northward on the side of Bugesera District. It is composed of Jarama wetland toward southern east and a chain of lakes like Sake, Birira, and Mugesera toward the north in Ngoma District, this wetland complex constitutes a big part of the Nile Basin and contain so many lakes important in the great lake's region. With an area of 16,725.1 ha, the cropland cover is of 1,660.3 ha, the water body covers 2,534.5 ha, while natural vegetation covers 12,330.1 ha with 8,406.3 ha of natural and dense papyrus sp., 3,407.4 ha of non-dense papyrus sp., and 716.4 ha highly disturbed papyrus zone (ARCOS 20212).



Land Cover	Area(Ha)	Area (%)
Agriculture - Intensified	744.1	21.8
Agriculture - Traditional	916.2	26.9
Waterbody - Clear	2,512.5	73.7
Waterbody - Covered by Aquatic Flora (WH)	22.0	0.6
Natural Vegetation of Papyrus (Climax)	8,406.3	246.7
Non Dense Natural Vegetation	3,407.4	100.0
Highly Disturbed Natural Vegetation	716.4	21.0
Total	16,725.1	490.8

Figure 1: Map of Rweru-Mugesera wetland complex (ARCOS 2021)

1 Rapid wetland ecological integrity assessment
2 Rwanda Wetland cover change mapping report 2021

II.1.2 Ecosystem extent and quality

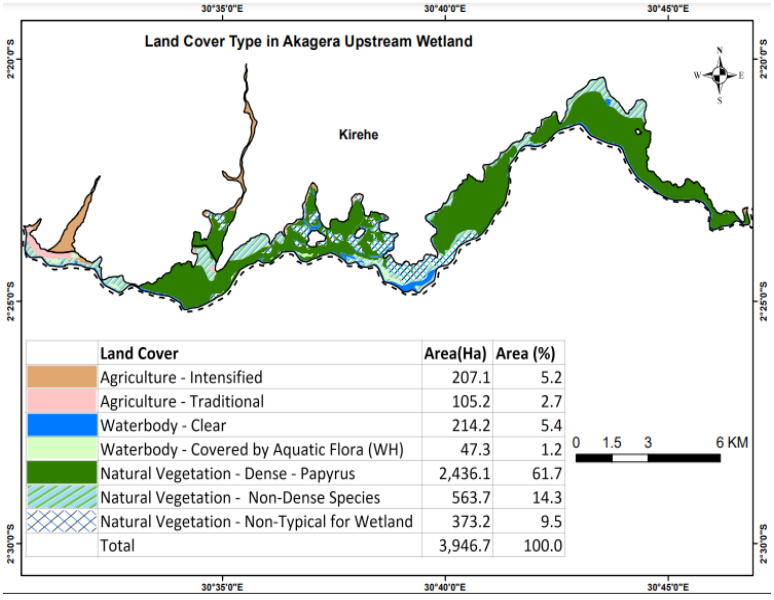
In terms of ecosystem extent, Rweru-Mugesera wetland complex was ranked medium (40-60%) as it still has large areas of natural vegetation and water body, and its connectivity was assessed high (60-80%) because of extended connection between Akagera river and different lakes. The overall population conservation was ranked very high because of high diversity of fish and water bird species but also the wetland hosts a high richness of species from other taxa.

II.1.3 Threats to Rweru-Mugesera wetland

The intensity and frequency of threats to Rweru-Mugesera was ranked very high. In addition to overfishing, overspread of invasive species (water hyacinth) and siltation from akagera river that diverted from its main path by 2015 to pass by Rweru lake before it continues toward Ngoma District in Jarama Sector, the wetland complex is overexploited for agriculture whose activities extend even in buffer zones.

II.2 Akagera wetland complex

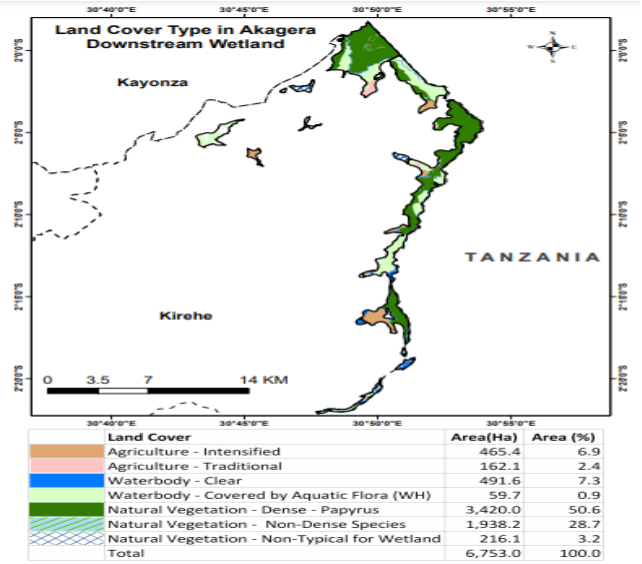
II.1.1Location and land cover status



Land Cover	Area(Ha)	Area (%)
Agriculture - Intensified	207.1	5.2
Agriculture - Traditional	105.2	2.7
Waterbody - Clear	214.2	5.4
Waterbody - Covered by Aquatic Flora (WH)	47.3	1.2
Natural Vegetation - Dense - Papyrus	2,436.1	61.7
Natural Vegetation - Non-Dense Species	563.7	14.3
Natural Vegetation - Non-Typical for Wetland	373.2	9.5
Total	3,946.7	100.0

Figure 2: the map showing the status of Akagera upstream cover

This wetland complex is comprised between in Southeastern part of Rwanda within Kirehe District. This eco-system is subdivided into two main complexes namely Akagera upstream (3,946.7 ha), composed of different wetlands within two administrative sectors (Musaza and Kigarama) including Rwagitugusa wetland that feed Nyagasenyi Natural remnant forest that connects to Cyunuzi wetland before it reaches Akagera river and limited to its end with Rusumo boarder.



Land Cover	Area(Ha)	Area (%)
Agriculture - Intensified	465.4	6.9
Agriculture - Traditional	162.1	2.4
Waterbody - Clear	491.6	7.3
Waterbody - Covered by Aquatic Flora (WH)	59.7	0.9
Natural Vegetation - Dense - Papyrus	3,420.0	50.6
Natural Vegetation - Non-Dense Species	1,938.2	28.7
Natural Vegetation - Non-Typical for Wetland	216.1	3.2
Total	6,753.0	100.0

Figure 3: The status of Akagera wetland downstream cover

Akagera downstream is composed of different wetlands within four administrative sectors (Nyamugali, Mahama, Mpanga, and Nasho). it starts upstream at Rusumo boarder and ends downstream at nyamwashama wetland and contains different lakes (Nasho, Cyambwe, Mpanga,……) as documented by Fisher at al (2011).

In general, the Akagera wetland complex is in the Eastern plateau agroecological zone, between 1200 and 1500 m of altitude, it has a vertisol soil type (soils with a high content of clay minerals that shrink and swell as they change water content), and its vegetation contains papyrus c and is dominated by Typha domingensis and Polygonum pulchrum.

Its hydrology depends on the Akagera river, surrounding mountains and different lakes. This is an important wetland that plays the role of water reservoir and connectivity between Akagera National Park in the north and other wetlands in the west towards Ngoma, Bugesera Districts and the city of Kigali. Almost seven main land use types determine the current wetland cover. They consist of Natural vegetation subdivided into dense papyrus, small patches of secondary papyrus species due to different disturbances, and highly disturbed patches colonized by species non typical to wetlands, a big part of water body (Akagera river) and small patches of water body covered with aquatic flora, Intensified and traditional agricultural land. The geological base consists mainly of Precambrian granitic and quarzitic rocks (Fisher at al 2011).

The status of key classes analyzed for wetlands in Kirehe District consist of 1,009.9 ha of crop land 11,340.1 ha of natural vegetation, 144.9 ha of water body making a total of 12,494.9 ha. Along the last 10 years (2008-2018), crop land class lost 27%, while the natural vegetation class lost 9%, and a considerable gain was detected on the water body class that increased up to 288%. Other classes (sand mining and quarry sites) in the wetlands) gained only 12% and this reflects the intactness of wetlands in Kirehe District. The lost 27 % of cropland highly correlates

with high gain in water body associated with recurring water because of the ongoing construction of Rusumo hydropower plant, in addition to the outflow of Rweru lake at the upstream due to the diversion of Akagera river's main pathway that occurred between 2014 and 2015, but also heavy rain that hit the region in the last 3 to 5 years which caused more floods (ARCOS 2021).

II 1.2 Ecosystem extent and quality

The habitat connectivity in the Akagera wetland ecosystem was ranked high (60-80%). There is a good communication of various habitats to mention the Akagera river, different lakes, and rivers especially during the flooding periods. It is covered with large areas of water body and natural vegetation. The overall population conservation was ranked very high because of high diversity of fish and water bird species, amphibians but also the wetland hosts a high richness of species from other taxa.

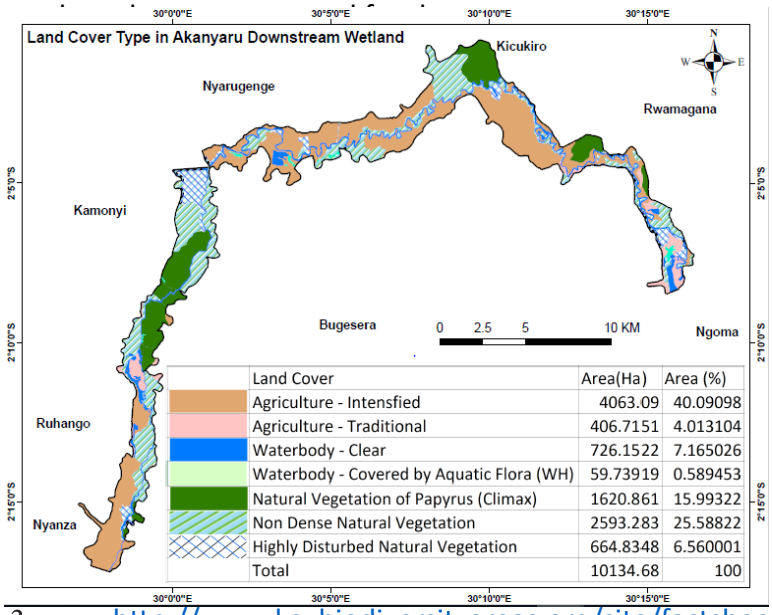
II.1.3 Threats to the Akagera wetland complex

The intensity and frequency of threats is medium (40-60%) and dominant threats include wetland conversion for agriculture expansion, sand mining, enrooting papyrus for manure production, overharvesting of papyrus for mulching crops and bricks making as well as burning wetlands as a solution to limit crop raiding by blue monkey and baboons, and invasive species.

II.3 Akanyaru Aval wetland complex

II.3.1 Location and land cover status

The Akanyaru aval wetland complex is defined as a wetland area extending from the border between Nyanza and Bugesera District at Rwabusoro bridge to Amasangano area within Ntarama sector. It includes an area drained by Cyohoha North Lake. With an area of 10,134.68 ha, 4,878.978 ha are covered by a natural vegetation dominated by regenerating/ non dense papyrus of 2,593.283 ha. Water body covers 785.891 ha while intensified agriculture covers 4,469.805 ha. The entire Akanyaru wetland3 covers 22,631 ha however the big part extending from Rwabusoro bridge toward upstream in Gisagara District were under peat mining /exploitation by the time of this



Land Cover	Area(Ha)	Area (%)
Agriculture - Intensfied	4063.09	40.09098
Agriculture - Traditional	406.7151	4.013104
Waterbody - Clear	726.1522	7.165026
Waterbody - Covered by Aquatic Flora (WH)	59.73919	0.589453
Natural Vegetation of Papyrus (Climax)	1620.861	15.99322
Non Dense Natural Vegetation	2593.283	25.58822
Highly Disturbed Natural Vegetation	664.8348	6.560001
Total	10134.68	100

3 http://www.keybiodiversityareas.org/site/factsheet/6777

Figure4: Map of Akanyaru aval wetland complex

The Akanyaru Aval wetland complex is on the list of Important Bird and Biodiversity Area, currently proposed as Key Biodiversity Area (KBA). It is an important water reservoir which serves for both agricultural production and both domestic and wildlife use.

II.3.2 Ecosystem extent and quality

In terms of ecosystem extent and habitat connectivity, the Akanyaru Aval wetland complex was ranked medium (40-60%) as the level of fragmentation is high even if some patches are still connected. The overall population status and trends of wetland taxa are high (60-80%).

This is because as Rweru-Mugesera and Akagera wetland complexes, Akanyaru wetland complex hosts a wide range of biodiversity and provide refuge for some species of mammals, birds, amphibians. It particularly exhibited a high species diversity for fish, amphibians, and water bird, and its importance was evaluated to be at both local, national, and international levels.

II.3.3 Threats to Akanyaru Aval wetland complex

The intensity and frequency of threats is very high (80-100%) mainly because of habitat fragmentation, conversion of wetland to agricultural land mainly for sugar cane plantation, sand mining and bricks making, peat mining activities from Rwabusoro bridge in Nyarugenge sector towards the southwestern part in Gisagara district and overspread of invasive species (water hyacinth) everywhere in the wetland complex.

III.4 Muvumba wetland complex

III.4.1 Location and land cover status

In the context of Rwanda wetland ecological integrity assessment project, Muvumba wetland complex was defined as an area embedded within the entire Muvumba catchment within Nyagatare (16,229.2 ha), and Gatsibo (17,471.9 ha) districts excluding the part of the Akagera National Park in the East. Four main classes of land cover including crop land (10,246.6 ha), Natural vegetation (17,751 ha), water body (1183.9 ha) and others (4,519.6 ha) characterize the current land use within Muvumba wetland complex (ARCOS 2021). It is drained with Muvumba4 River and its tributaries from the entry point on the Ugandan border which drains into the Kagitumba River which follows the border between Rwanda and Uganda to finally join the Akagera.

III.4.2 Ecosystem extent and quality

In terms of ecological characteristics, the status and trends in wetland ecosystem extent and habitat connectivity for Muvumba wetland complex were ranked very low (0-20%) as the complex was highly fragmented and dominated by agriculture intensification with monoculture vegetation (Rice). Its natural vegetation of Acacia vegetation was degraded and only about 15% remains (ARCOS 2019).

4 https://waterportal.rwb.rw/catchment-level-1/28

III.4.3 Threats to Muvumba wetland complex

The intensity and frequency of threats was ranked very high (80-100%) as there is continuous/permanent claiming of wetland for rice and soja cultivation despite the effort for preservation of the small patch of the gallery forest along Muvumba river toward Nyagatare District.

III.5 Rugezi wetland complex

III.5.1 location and land cover status

Rugezi wetland complex is a network of marshlands, rivers and lakes covering an area essentially administered by Burera, Musanze and Gicumbi districts. The total surface area for Rugezi wetland complex was estimated at 12,427.2 ha and is characterized by four main land use classes whereby crop land occupies 4,275.9 ha, Natural vegetation covers 6,224.1 ha, water body covers 136.8 ha, while other land use types cover 1,790.3 ha. Rugezi-Burera-Ruhondo is the core area but there are other important lakes and rivers associated to this from volcanoes national park, and in Gicumbi District. It covers an area of 6,736 ha and was designated as a Ramsar site on 12 January 2005.

III.5.2 Ecosystem extent and quality

In terms of its ecological character, the status and trends in wetland ecosystem extent and habitat connectivity Rugezi wetland complex were ranked high (60-80%) mainly because of the connectivity between the components of the core area (Rugezi wetland, Burera and Ruhondo lake) and the presence of a consistent mat of peat and water body.

III.5.3 Threats to Muvumba wetlands

The intensity and frequency of threats were ranked very low (0-20%) as the core still benefits from measures put in place by the Government of Rwanda through its gazettement for full protection as a Ramsar site but collection of papyrus and other grasses for domestic use is still done but illegally. Other threats are linked with wetland desiccation and reduction in size for those inside volcanoes national park (Yntze5 at al 2019).

III.6 Rusizi wetland complex

III.6.1 Location and land cover status

The team has defined Rusizi wetland complex as a network of lakes, rivers and marshlands within the administrative boundaries of Rusizi district and Nyamashe district from the border between Congo and Rwanda to the edges of Nyungwe National Park in addition to Kamiranzovu wetland inside Nyumngwe National Park. Kamiranzovu is a large swamp situated on the eastern slope of the Congo-Nile watershed at about 1950 m. It is part of the Nyungwe National Park and forms the largest peat bog in Continental Africa. It represents a large flat basin of about 850 hectares of surface area surrounded by hills covered with montane forest. The swamp is the source of the Kamiranzovu River which flows into Lake Kivu and the Congo basin (Fisher at al 2011). Apart from Kamiranzovu river between Nyungwe and Lake Kivu at Nyamasheke side, other key wet areas of the complex include Gishoma, lake Kivu, and Bugarama.

5 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6468056/

III.6.2 Ecosystem extent and quality

The Kamiranzovu wetland benefits from the protection status of Nyungwe National Park. However, the outside part towards the showers of lake Kivu is transformed into rice paddies, while it could serve for connection between the intact wetland and the Lake Kivu for aquatic species movement and reproduction sites. Gishoma wetland was totally converted for peat mining while Bugarama is used for rice farming. So, the quality of the ecosystem was ranked high (60-80%) inside Nyungwe national park, while it was low (20-40%) outside.

III.6.3 Threats to Rusizi wetland complex

The intensity and frequency of threats in Rusizi wetland complex was ranked medium in general. Peat mining in Gishoma wetland affected much the soil and habitat composition. Apart from the agriculture intensification within bugarama wetland poor waste management at the exits of Cimerwa plant induces water pollution in the Gikundamvura site in addition to high intensity of erosion and floods that affect the lowest altitudinal gradients within Bugarama wetland.

II.7 City of Kigali wetland complex

III.7.1 Location and land cover status

This wetland complex is embedded within Gasabo, Kicukiro and Nyarugenge districts. It consists of an area drained mainly by Nyabarongo river at its boundaries with other districts like Kamonyi and Bugesera in the southwestern part, Nyabugogo river and some regular ponds and small rivers fed by runoff water from hill sides mainly at the side of Mwanana-Mulindi-Kanombe as well as Ayabaraya, currently covering 7,838.2 ha distributed in 4 main classes. Crop land occupies 2,808.3 ha, natural vegetation covers 2,763.4 ha, water body covers 308.1 ha while other land use types cover 1,958.4 ha (ARCOS 2021).

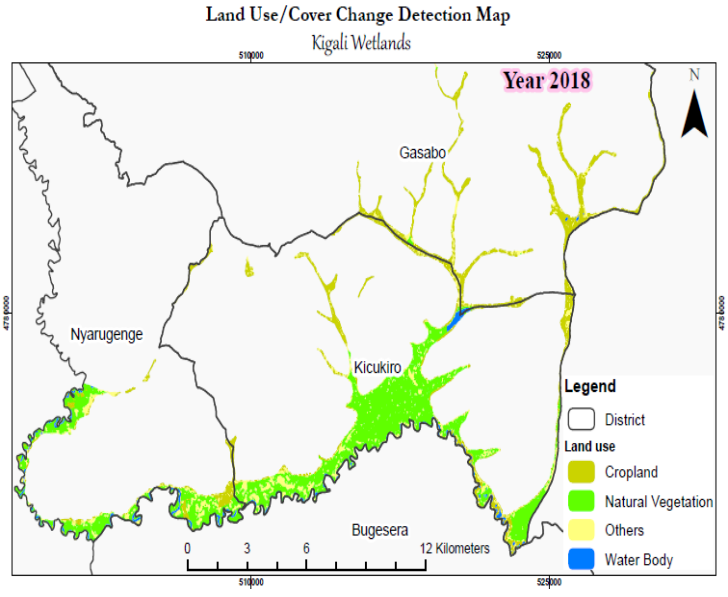


Figure 5: Map of City of Kigali wetland complex land use by 2018

III.7.2 Ecosystem extent and quality

In terms of its ecological characteristics, the status and trends in wetland ecosystem extent and habitat connectivity of the City of Kigali wetland are low (20-40%) as the natural vegetation has been altered except in few sites (ARCOS 2019). The ecosystem and habitat connectivity are very low (0-20%). Habitat fragmentation is very high the same as for Muvumba wetland complex. However, the overall population status and trends of wetland taxa are medium (40-60%) due to its high diversity and richness in birds especially water birds and fish species recorded there (ARCOS 2019).

III.7.3 Threats to the City of Kigali wetland complex

The intensity and frequency of threats to the city of Kigali wetland complex was ranked very high (80-100%) due to identified cases of waste dumping, burning wetlands grasses for agricultural expansion mainly sighted on the side of Ruliba clay plant, wastes from industries and mostly construction materials remaining after relocation of Gikondo industrial park, …

IV. Taxonomy/species

IV.1 Plants and Algae

IV.1.1 Plants

There is a great diversity of wetland plants. We have evaluated the distribution and abundance of plant species in eight wetland complexes, including Akanyaru, Rweru-Mugesera, city of Kigali, Akagera wetlands in Kirehe district, Muvumba, Rugezi and wetlands in Rusizi district. Apart from the primary data collected between June 2019 and May 2021, we have used secondary data from different literatures to document the status of wetland pants in Rwanda. However, we focused on wetlands outside protected areas except Kamiranzovu inside Nyungwe National Park.

Summary on the species status

127 different plant species classified into 51 families whereby Polygonum senegalens was frequently found in sampling spots (25), followed by Cyperus latifolius (24), Cyperus papyrus (18), Juncus oxycarpus (14) and Leonitis neputifolia (14).

5 invasive plant species were recorded including Eichornia crassipes (dominant), Mimosa pigra, Lantana camara, Tithonia diversifolia and Caesalpinia decapetala. Invasiveness of E. crassipes and M.pigra is too high in the wetlands, so special concern (application of all measures possible for the control of Alien Invasive Species) should be taken on those species for sustainable wetlands management (ARCOS 2019).

In general, plant distribution is also characteristics of different wetland complexes assessed. Muvumba wetland presented 36 plant species in 20 families, dominated by Polygonum senegalens and Leonitis neputifolia invaded by Lantana camara and Caesalpinia decapetala especially in Gatsibo side. For Kigali wetlands, 139 plant species within 50 families were recorded dominated by Cyperus latifolius, Cyperus papyrus, Polygonum senegalens and Typha domingensis, invaded by Mimosa pigra (mainly in Ruliba site within Nyabarongo amont), Eichornia cras-

sipes, Tithonia diversifolia. Rweru-Mugesera wetland complexes is characterized by 36 plant species from 18 families dominated by Cyperus papyrus, Ipomoea involucrata and Polygonum senegalens and highly invaded by Eichornia crassipes, Mimosa Pigra, Tithonia diversifolia. In Rugezi wetland 43 plant species from 28 families were recorded dominated by *Miscantus violaceous* and only *E. crassipes* was recorded as invasive species. Fisher et al 2011, recorded 94 species of vascular plants with two *Vaccinium stanleyi and Hypericum humbertii endemic to the Albertine Rift while E. crassipes was not recorded that time.* For **Rusizi wetlands, Kamiranzovu** inside Nyungwe National Park was assessed as the outside toward Lake Kivu was converted into rice paddies. 36 plant species were recorded from 26 families against 326 species recorded by Fisher et al (2011). However, this does not represent the decline in plant species rather the difference may be due to location of samples and time spent to the field by the team.

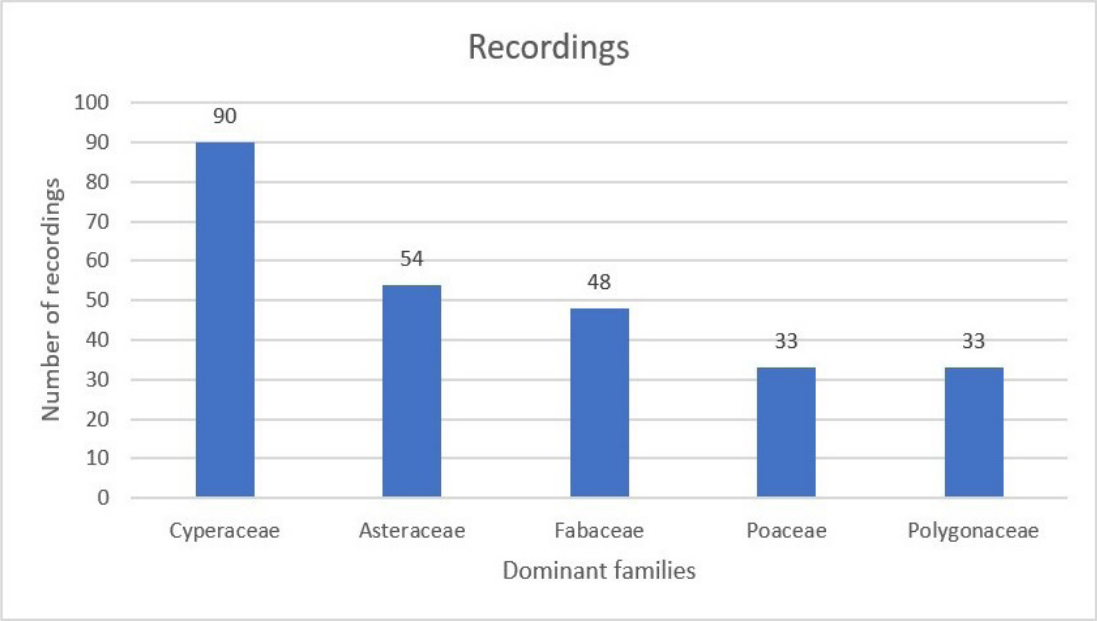


Figure 6: Dominance of plant species recorded per familiy

Actually, there is no dominancy here as such due to the fact that the sampled areas showed mosaic plants richness of Nyungwe National Park. **No invasive species recorded there**. We instead recorded 2 plant species endemics to the Albertine rift *Harungana montana*, *Impatiens warburgiana (Note that Fisher et al 2011 recorded* 56 species endemics to the Albertine Rift) and 3 species of orchids namely *Satrium trinerve*, *Satrium crassicaule* and *Eulophila horsfalli. Lastly* ***Akanyaru wetland complex*** presented 37 plant species from 18 families dominated by *Cyperus latifolius*, *Polygonum senegalens* and *Cyperus papyrus. 4 Invasive Alien Species were recorded. They include Eichornia crassipes, Mimosa Pigra, Tithonia diversifolia* and *Lantana camara where, Eichornia crassipes and Mimosa pigra are highly abundant in amasangano area (the junction between Akanyaru and Nyabarongo rivers)*

Discussions

The wetland complexes in which the study was conducted, the Cyperus papyrus is dominant, which means most of the wetlands have a lot of excess of water through the year (Kanyarukiga 2021). The Polygonaceae family also is frequently found in the visited wetlands, which can be justify wetland pollution (contamination by heavy metals) (Khan,2019) and some other members have the ethnobotanical importance in terms of food as well as

medicinal importance. Convolvulaceae were found associated to the *Cyperus papyrus, but some members were in cultivated area* (Ipomea *batatas*). Most of the Asteraceae family members were bound to the cultivated area. The pontederiaceae family members (*Eichornia crassipes)* are abundantly found in most of all wetlands, which is a great sign of water pollution of most of the wetlands in which the research was carried out and lead to water poor quality, specifically hypoxia (N. J. Waltham, 2017). *Spartina alternaflora,* is the key family member of the Poaceae in the wetlands of Rwanda and is most liked by the livestock.

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IV.1.2 Algae

Summary on the species status

Among 55 phytoplankton taxa identified in all wetlands, Kigali was dominated by *Trachelomonas* spp. (27.58%), *Microcystis aeruginosa* (18.04%), *Synedra ulna* (13.14%), *Cryptomonas* spp. (12.63%); Bugesera was dominated by *Synedra ulna* (26.54%), *Trachelomonas* spp. (14.19%), *Microcystis aeruginosa* (9.35%), *Monoraphidium* spp. (8.85%), *Gomphonema* spp. (8.35%), *Chroococcus* spp. (8.18%); Kagera mid-upstream was dominated by *Cyclotella* spp. (16.03%), *Trachelomonas* spp. (12.66%), *Navicula* spp. (11.81%), *Cryptomonas* spp. (11.39%), *Synedra ulna (10.55%), Euglena spp. (9.7%); Kagera downstream was dominated by Synedra ulna (30.86%), Nitzschia spp. (20.58%), Microcystis aeruginosa (10.29%), Gomphonema spp. (10.29%); Akanyaru was dominated by Merismopedia spp. (44.24%) Trachelomonas spp. (15.07%), Cryptomonas spp. (13.7%); Northern Wetlands were*

dominated by Microcystis aeruginosa (39.42%), Synedra ulna (23.65%), Trachelomonas spp. (12.45%); Kamiranzovu was dominated by Trachelomonas spp. (29.51%), Synedra ulna (24.59%), Navicula spp. (18.03%), Cryptomonas spp. (16.39%).

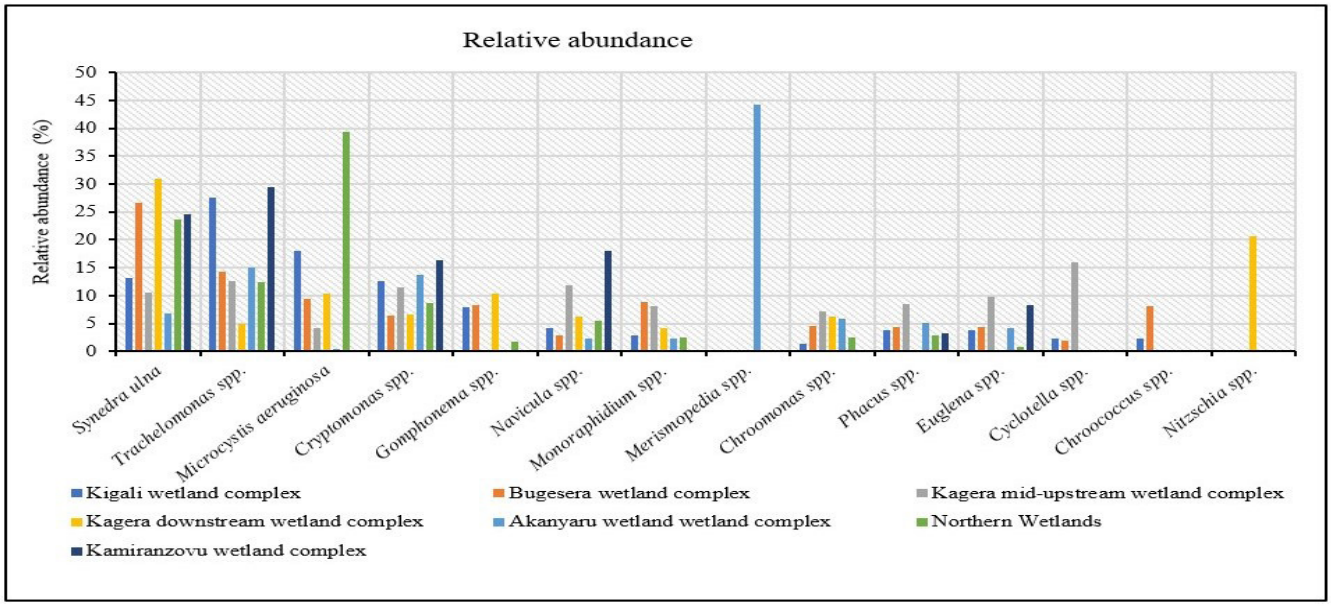

Figure 7 Relative abundance of taxa above 2% identified per wetland complex

All the identified taxa were classified into Reynold Functional Group (RFG). In fact, the dominantphytoplankton of Kigali belong to the group **W2** (20.82%), **MP** (15.56)and **H1** (13.62); The dominant phytoplankton of Bugesera belong to the group **D** (22.11%), **MP** (16.97), and **W2** (11.82); The dominant phytoplankton of Kagera mid-upstream belong to the group **MP** (23%), **W1** (14.06%) and **W1** (9.58%); The dominant phytoplankton of Kagera downstream belong to the group **MP** (34.08%) and group **D** (28.09%); The dominant phytoplankton of Akanyaru belong to the group **Lo** (33.92%) **W2** (11.54%) **,** and **Y** (10.49%); The dominant phytoplankton of Northern Wetlands belong to the group **W2** (29.51), D (24.59%) and **MP** (18.03%); The dominant phytoplankton of Kamiranzovu belong to the group **H1**(36.68%) and **D** (22.01%).

Table 1: Description of the main phytoplankton RFGs (with more than 3% contribution)

RFGs	Habitat	Representative phytoplankton	Tolerance	Sensitivity
MP	Frequently stirred up, inorganically turbid shallow wetlands.	*Gomphonema* spp. *Navicula spp.*	–	–
D	Shallow enriched turbid waters, including rivers	*Synedra ulna*	Flushing	Nutrient depletion
W2	Meso-eutrophic shallow wetland.	Bottom dwelling Euglenoids namely *Trachelomonas* spp.	High BOD	Grazing
H1	Eutrophic, both stratified and shallow wetland with low nitrogen content.	*Microcistis* spp.	Low nitrogen, low carbon	Mixing, poor light, low phosphorus
Y	Usually, small, enriched wetland	*Cryptomonas* spp.	low light	Phagotrophs, grazing
W1	Small organic ponds; Ponds rich in organic matter from husbandry or sewages.	*Euglena* spp., *Phacus* spp.	High BOD	Grazing
Lo	Summer epilimnia in mesotrophic lakes	*Merismopedia* spp. *Peridinium* spp	Segregated nutrients	Prolonged or deep mixing

X1	Shallow mixed layers in enriched conditions	*Monoraphidium* spp	Stratification	Nutrient deficiency filter feeding
X2	Shallow, clear mixed layers in meso-eutrophic wetland	*Chroomonas* spp.	Stratification	Mixing, filter feeding

Source: Reynolds et al., 2002; Padisák et al., 2009.

Discussion

The wetlands in which the study was conducted, Synedra ulna and Trachelomonas spp. were almost everywhere. Reynolds et al. (2002) reported that the dominance of Synedra ulna is associated with the nutrient-enriched and well-ventilated waters liable to be turbid; while the dominance of Trachelomonas spp. might be associated with their flagella dependent motility and facultative heterotrophy in the area rich in organic matter as reported by Gebrehiwot et al. (2017). The Cyanobacteria, especially Microcystis spp., is reported abundant because of anthropogenic eutrophication where it expresses a preference for high-phosphorus conditions (Reynolds, C.S., 2006).

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IV.2 Animalia

IV.2.1 Mammals

There are several benefits of wetlands to local communities, including dry season grazing and transportation facility. in Rwanda, some papyrus from wetlands is used to produce fuel briquettes (Kabii, 1996). Some wetland

mammal species like the African freshwater otters are threatened by human activities that change the structure and function of wetlands (Veron et al., 2008). Major anthropogenic threats that were observed in the past at Rweru-Mugesera and Akagera wetlands include agriculture, cattle grazing, production of loam bricks, fodder for livestock and construction purpose (Fischer et al. 2011). There is a need for collaborative and consultative aspects for the overall conservation program of wetlands since they are in critical situation while providing critical environmental resources to the society (Nyagatare 2000). The level of water in wetlands define the characteristics of the wetland and the animal species occurrence and distribution (May 2001). The wetlands can host more diversity of small mammals than surrounding dry habitats (Bowland and Perrin 1993; Hails 1997). Different species of mammals occur in wetlands and, based on their foraging habits include herbivorous, omnivorous, and carnivorous; such species include shrews, rodents, and marsh otters (May 2001). However, there are insufficient data to support the taxonomy of mammals existing in the wetlands of Rwanda. Especially, wetland small mammals have not been surveyed for many years. Fischer et al. (2011) reported that small mammals were recorded in four key wetlands of Rwanda only through random observations and literature survey.

An ARCOS team conducted a biodiversity survey between June 2019 and May 2021 in different wetland complexes outside protected areas in Rwanda. Four categories or groupings of wetlands were considered for the full and rapid assessment of mammal diversity in selected wetlands, namely Kigali wetlands complex (10 sites), Rweru-Mugesera wetlands complex (4 sites), Akanyaru wetlands complex (3 sites), and Kirehe wetlands complex (5 sites in its Southern zone and 5 sites in the Northern zone). While a combination of direct observation, live-trapping, refuge-searches, transect walks, and interviews have been suggested effective in surveying mammals (Attuquayefio et al., 2005), live-trapping was applied once on a special occasion in some wetlands in Kigali in September 2020 to target small mammals, such as rodents and shrews. On the other several sites, trapping techniques were not applied in the surveys of mammals.

We walked around the contours of the wetlands (including lakes) at accessible riparian zones, and focused on interviews, mammal sign surveys, and occasional sightings. Interviews inquired the type of mammals, when each type was last seen, how many of each type, their locations, their behavioral activity and other characteristics. To ascertain the reported mammals, cross-checking was done using the field guidebook for African mammals, an identification source we carried in the field. Besides the interviews, we considered opportunistic sampling of mammals through observation of signs and some direct sightings. Indirect signs of presence of mammals included observation of droppings (dungs), claws or footprints in trails, and vocalization. As we were walking around the periphery of each wetland, we could advance further in any wetland's accessible habitat. We observed closely inside and around wetland or used binoculars to ensure possible sightings of mammals. People could also indicate the places and identify timing mammals were likely to be observed or detected, directly or indirectly. Photographs were taken for any mammal seen during sampling and for indirect signs of the presence of mammals, particularly dung signs and footprints.

Summary on the species status

The results from the surveys of mammals in the selected wetlands of Rwanda have been presented for each wetland complex. The number of sites where a species was recorded is indicated. The mammals that live inside the wetland, papyrus, or other wetland vegetation are indicated; some mammals not indicated here were reported in the surroundings and their relations with the wetland were not documented.

Table 2: List of all mammals that were inventoried in the wetlands of Rwanda

	Mammal scientific name	Mammal common name	scientific name	Family	Kigali	Rweru-Mugesera	Akanyaru	Southern Kirehe	Northern Kirehe	IUCN status
1	*Sylvicapra grimmia*	Bush duiker	Artiodactyla	Bovidae				1		LC
2	*Tragelaphus spekii*	Sitatunga	Artiodactyla	Bovidae	2	3	1	3	2	LC
3	*Hippopotamus amphibius*	Hippopotamus	Artiodactyla	Hippopotamidae	4	2	1	3	2	**VU**
4	*Phacochoerus africanus*	Common warthog	Artiodactyla	Suidae		1	1	3	2	LC
5	*Canis adustus*	Side-striped jackal	Carnivora	Canidae	1			1	1	LC
6	*Civettictis civetta*	African civet	Carnivora	Viverridae				1		LC
7	*Aonyx congicus*	Congo clawless otter	Carnivora	Mustelidae	2	2	2	3	2	**NT**
8	*Hydrictis maculicollis*	Spotted-necked otter	Carnivora	Mustelidae	4	1	1	1		**NT**
9	*Leptailurus serval*	Serval	Carnivora	Felidae	1				1	LC
10	*Felis silvestris*	Wild cat	Carnivora	Felidae					1	LC
11	*Atilax paludinosus*	Marsh mongoose	Carnivora	Herpestidae	4	3	3	3	2	LC
12	*Galerella sanguinea*	Slender mongoose	Carnivora	Herpestidae	3	1			1	LC
13	*Cercopithecus mitis doggetti*	Blue monkey	Primates	Cercopithecidae	3	3	1	4	2	LC
14	*Chlorocebus pygerythrus*	Vervet monkey	Primates	Cercopithecidae		1	1			LC
15	*Crocidura jacksoni*	Jackson's shrew	Soricomorpha	Soricidae	1					LC
16	*Lemniscomys griselda*	Griselda's grass mouse	Rodentia	Muridae	1					LC
17	*Arvicanthis niloticus*	Nile grass rat	Rodentia	Muridae	1					LC
18	*Rattus rattus*	House rat	Rodentia	Muridae	1					LC
19	*Thryonomys gregorianus*	Lesser cane-rat	Rodentia	Thryonomyidae	2					LC

Discussions

Nineteen species were found, which are distributed into 12 families and five orders of mammals. This survey is important mainly as it has covered a large geographical scale over the country and provided some species that were missed in previous studies. Comparatively, only interviews and literature were used to provide the list of all mammals existing in some wetlands of Rwanda from Fischer et al. (2011), and Nsabagasani et al. (2008), unlike other groups of vertebrates like birds and amphibians. Besides, small mammals could not attract attention in those surveys. Wetlands are very important ecosystems, but they are threatened by encroachment. Indeed,

they are areas of rich biodiversity and support livelihoods of large populations of humans (Kabii, 1996). Otters and hippopotamus require typical wetland habitat to live. Besides, wetlands provide a refuge for many large mammals during periods of droughts (Keddy et al., 2009). Also, the marsh mongooses need wetland habitats to survive. However, not all of the reported mammals are normally wetland specialists; it is possible that blue monkeys, jackals, serval, and wild cat found refuge in the wetland following their normal habitat fragmentation and disturbance. At some sites, some large mammals had existed in the past but have today disappeared due to different anthropogenic threats.

The main threats facing the mammals in freshwater ecosystems include wetlands habitat loss, habitat degradation due to pollution and dumping, hunting and trapping, industrial effluents and agricultural pesticides, siltation from upland sources, and introduction of alien species (Kabii, 1996; Veron et al., 2008). For example, in addition to trapping and hunting, African freshwater otters are threatened by the effects of pollution and the different human activities that change the structure and function of wetlands (Veron et al., 2008). It appears that the two types of otters can be used as indicators of wetland quality among mammals, based on the information about their sensitivity to wetland pollution. Overall, three of the reported species are critical to conservation because the depend on wetlands and have their IUCN conservation status in the endangered, vulnerable and/or near threatened ranges: the two types of otters (NT) and the hippopotamus (VU). We did not find an endemic species of East Africa, Albertine Rift, or Rwanda in our survey. However, the Nile grass rat Arvicanthus niloticus and the lesser cane rat Thryonomys gregorianus are endemic to Africa and have some patchy distribution (Kingdon et al. 2013). The two species are not wetland specialists but are often associated partially or completely with wetlands.

Many agricultural activities will require absolutely the wetlands such as rice agriculture. Areas of wetland are also much productive with other crops such as Irish potatoes, sweet potatoes and corn than other surrounding lands. There are other roles of wetlands for local communities including dry season grazing and transportation facility (Kabii, 1996). There are not many significant threats that wetland mammals cause to local people, even if some problems of crop damages are caused by hippopotamuses and blue monkeys at some localities. Thus, the main strategy is to manage the negative impacts that people cause due to their dependence on wetlands, with finding incentive strategies.

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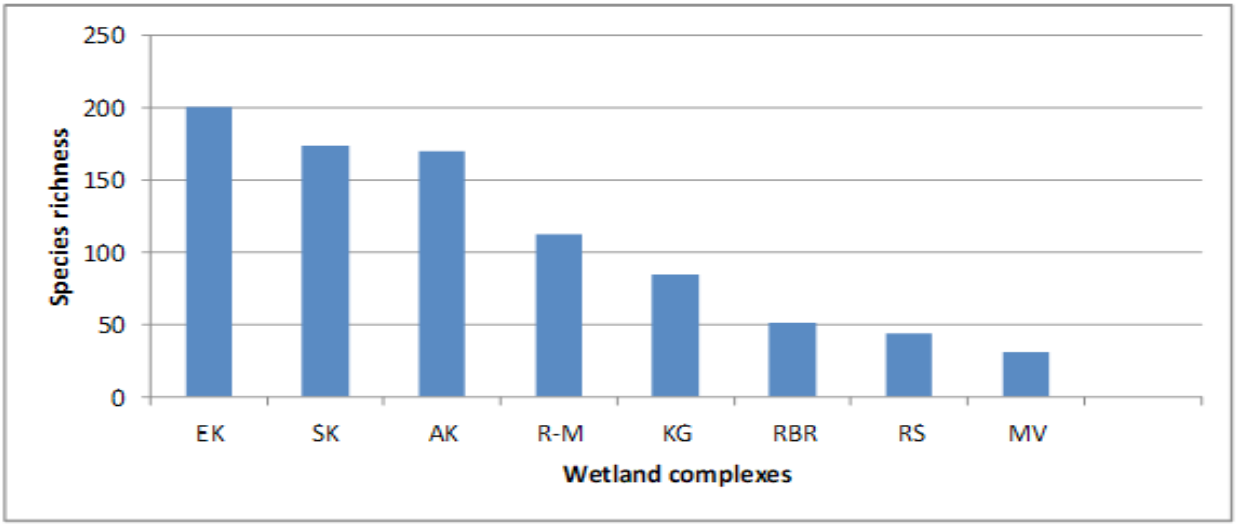
IV.2.2 Birds

Avian community has been used in different assessment and monitoring as bio-indicators of the status and trend of ecological integrity of the wetlands (Furness and Greenwood, 1993). In addition, in some developed countries like UK have been using birds as indicators of sustainable development (DEFRA, 2007). Some wetlands in Rwanda were assessed in the past for bird community but the studies covered only a small part like the one Nsabagasani et al (2008) on Akanyaru wetland, and Fisher et.al (2011) that covered Kamiranzovu, Rweru-Mugesera, Rugezi

and Akagera wetland complexes. ARCOS team extended the study to cover the wetlands mentioned above in addition to City of Kigali, Muvumba , and Rusizi outside protected areas. A 2-km transect was designed to cover different habitats including marshlands, peat lands, lake shores, natural vegetation, under regeneration and cultivated areas, and point counts were established at every 200 meters. At each point, the team recorded all bird species heard and seen for a period of 10 minutes and then moved to the next point and replicated the same method until to the end of the transect (Colin et al., 2000). Each point was visited once between 7:00 and 12:00 and later evening between 3:00 and 6:22 pm to increase the coverage. Species were identified using binoculars and HELM FIELD GUIDE: Birds of East Africa Kenya, Tanzaniya, Uganda, Rwanda and Burundi. Terry Stevenson John Fashawe. GPS waypoints were captured at the point of observation to georeferenced the species records. To maximize the records in wetlands sampled and to avoid leaving out any species present on the site. Opportunistic sampling was used, were, all bird's species heard or seen between point counts and outside of transects were recorded and were used to produce the checklists of the wetlands covered (Cohen& Crabtree 2006).

Summary on the species status



EK :	Eastern Kirehe wetland complex	RBR	Rweru-Burera-Ruhondo
SK:	Southern Kirehe wetland complex	RS	RS : Rusizi : Rusizi wetland complex
AK	Akanyaru wetland complex	MV	Muvumba wetland complex
R-M:	Rweru-Mugesera Wetland complex		

Figure 8: Species richness in assessed wetland complexes

Overall, Akagera wetland (Eastern and Southern Kirehe wetands) exihibited the highest species richness comparatively to other assessted sites while Muvumba wetland complex presented the lowest species richness.

Water birds

Water birds are good indicators for ecological integrity of the wetlands due to their ecological dependency on wetlands. They link people with wetlands for different purposes such as eco-tourism. Water birds were identified based on Wetlands International criteria.

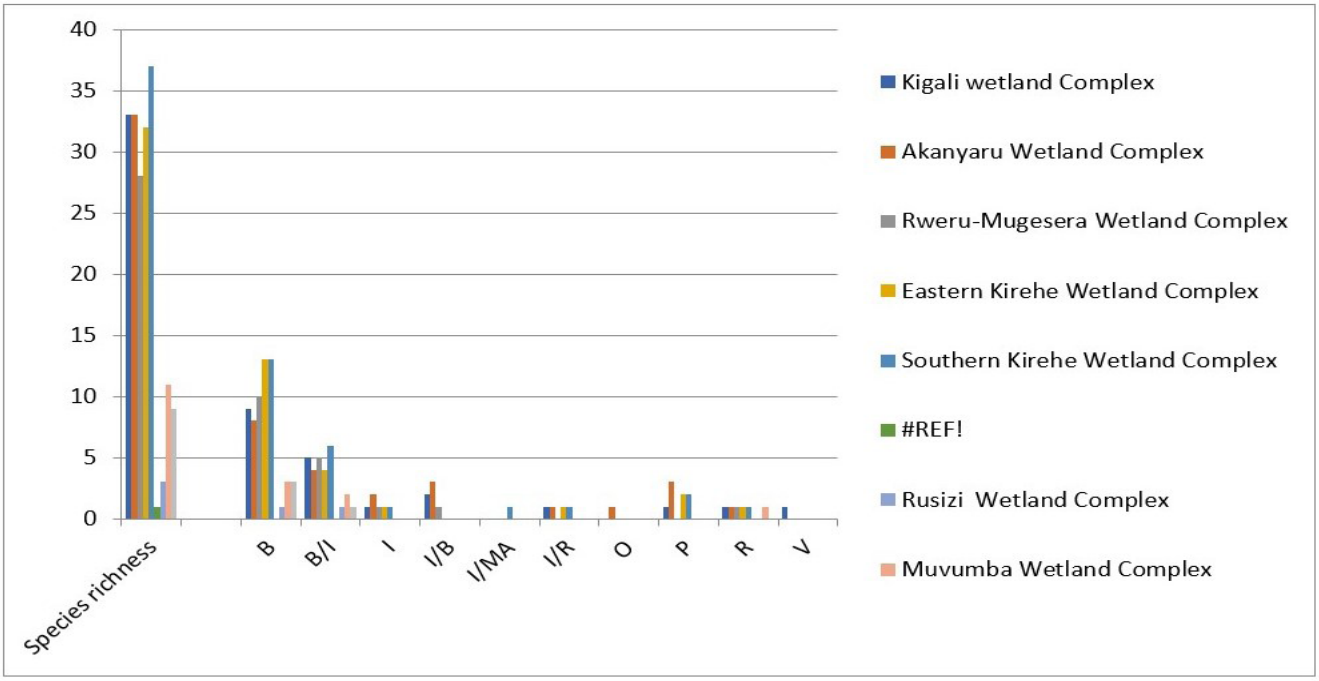


Figure 9: Species richness of water birds in covered wetland complex.

Southern Kirehe Wetland complex presented the highest waterbird species richness (37) followed by both City of Kigalia and Akanyaru wetland complexes. Akanyaru and city of Kigali wetland complexes were highly disturbed and affected by agriculture and pollution but still have pristine sites that can host bird species hance special attention should be taken to insure their protection and conservation.

Table 3: *Status and distribution of water bird species per assessed wetland*

***NT:** Near Threatened. **E**: Endangered, **L**: Least Concern, **V**: Vulnerable. **B:** resident breeding or likely breeding, present all year-round. **R:** nonbreeding resident, present all year-round but without any indication of breeding. **M:** migrant species, present only parts of the year. **I:** Intra-african migrant, breeding in sub-saharan Africa. **MA:** non-breeding visitors breeding in Madagascar. **P:** non-breeding visitors breeding in the palearctics. **Ir:** Irregular visitor, not occurring every year. **O:** occasional visitors.*

Family/ Common Names	Scientific Names	IUCN	City of Kigali	Akanyaru	Rweru-Mugesera	Eastern Kirehe	Southern Kirehe	Nyamwashama	Rusizi	Muvumba	Rugezi
Alcedinidae											
African Pygmy Kingfisher	*Ispidinia picta*	L							V		
Grey-headed Kingfisher	*Halcyon leucocephala*	L	V	V	V	V	V				
Half-collared Kingfisher	*Alcedo semitorquata*	L		V							
Malachite Kingfisher	*Corythornis cristatus*	L	V	V	V	V	V				
Pied kingfisher	*Ceryle rudis*	L	V	V	V	V	V				
Woodland Kingfisher	*Halcyon senegalensis*	L			V	V	V	V		V	

Anatidae											
African Black Duck	*Anas sparsa*	L			V	V	V				
Egyptian Goose	Alopochen aegyptiaca						V				
Spur-winged Goose	*Plectropterus gambensis*	L					V				
African Pygmy-Goose	Nettapus auritus	L				V	V				
Knob-billed Duck	Sarkidiornis melanotos	L		V							
Spur-winged Goose	*Plectropterus gambensis*	L	V	V	V	V	V	V			
White-faced Whistling-Duck	*Dendrocygna viduata*	L	V	V		V	V			V	
Yellow Billed Duck	*Anas undulata*	L		V	V	V	V				
Anhingidae											
African Darter	*Anhinga rufa*	L	V			V					
Ardeidae											
Grey Heron	*Ardea cinerea*	L	V	V	V	V	V				
Black Heron	*Egretta ardesiaca*	L	V	V		V	V				
Black-headed Heron	*Ardea melanocephala*	L	V	V	V	V	V	V		V	V
Cattle Egret	*Bubulcus ibis*	L	V	V	V	V	V	V	V	V	
Common squacco Heron	*Ardeola ralloides*	L	V		V	V					
Goliath Heron	Ardea goliath	L		V							
Grey Heron	*Ardea cinerea*	L	V	V	V	V	V	V			
Intermediate Egret	*Ardea intermedia*	L	V	V	V		V				V
Little Egret	*Egretta garzetta*	L	V		V	V	V				
Purple Heron	Ardea purpurea	L				V	V				
Rufous-bellied Heron	Ardeola rufiventris	L		V			V				
Malagasy Pond Heron	Ardeola idea	E					V				
Charadriidae											
African Wattled Lapwing	*Vanellus senegallus*	L	V								
Common Ringed Plover	Charadrius hiaticula	L		V							
Crowned Lapwing	*Vanellus coronatus*	L	V								
Long-toed Lapwing	*Vanellus crassirostris*	L	V	V	V	V	V			V	
Spur-winged Lapwing	*Vanellus spinosus*	L	V		V	V					
Three-banded plover	*Charadrius tricollaris*	L	V	V							
Wattled Lapwing	Vanellus senegallus	L	V			V		V			
Ciconiidae											
African Openbill	Anastomus lamelligerus	L	V	V	V		V	V		V	V
Marabou Stork	*Leptoptilos crumeniferus*	L					V				
Yellow-billed Stork	*Mycteria ibis*	L	V							V	V
Grey Crowned Crane	*Balearica regulorum*	E	V	V	V	V	V			V	
African Jacana	*Actophilornis africanus*	L	V	V	V	V	V				
Phalacrocoracidae											

Great Cormorant	*Phalacrocorax carbo*	L			V		V				
Reed Cormorant	*Microcarbo africanus*	L		V	V	V	V				
Rallidae											
Black Crake	*Amaurornis flavirostris*	L	V	V	V	V	V				V
Common Moorhen	Gallinula chloropus	L	V		V	V	V				
Lesser Moorhen	*Gallinula angulata*	L	V	V	V						
Red-knobbed Coot	*Fulica cristata*	L	V	V	V	V	V				V
Scolopacidae											
Common sandpiper	*Actitis hypoleucos*	L	V	V		V	V				
Marsh Sandpiper	*Tringa stagnatilis*	L		V		V	V				
Wood Sandpiper	*Tringa glareola*	L									
Scopidae											
Hamerkop	*Scopus umbretta*	L	V	V	V	V	V	V		V	
Threskiornithidae											
African spoonbill	Platalea alba	L	V	V						V	V
Glossy Ibis	Plegadis falcinellus	L		V							
Hadada Ibis	*Bostrychia hagedash*	L	V	V	V	V	V		V		V
Sacred ibis	*Threskiornis aethiopica*	L	V	V	V	V	V			V	V

Migrant species.

Ecological Integrity of the wetlands is very important to the survival of migratory species. They provide habitats for breeding, nesting, rearing of young, feeding, staging, and roosting. They are also good indicators of the status of the wetlands.

Table 4: Migrant species

Family/ Common Names	**Scientific Names**	IUCN	Waterbird	City of Kigali	Akanyaru	Rweru-Mugesera	Eastern Kirehe	Southern Kirehe	Nyamwashama	Rusizi	Muvumba	Rugezi
Accipitridae												
Yellow-billed Kite	*Milvus migrans*	L		v	v	v	v	v			v	
Grey-headed Kingfisher	*Halcyon leucocephala*	L	v	v	v	v	v	v				
Half-collared Kingfisher	*Alcedo semitorquata*	L	v		v							
Anatidae												
Knob-billed Duck	Sarkidiornis melanotos	L	v		v							
White-faced Whistling-Duck	*Dendrocygna viduata*	L	v	v	v		v	v			v	
Black Heron	*Egretta ardesiaca*	L	v	v	v		v	v				
Cattle Egret	*Bubulcus ibis*	L	v	v	v	v	v	v	v	v	v	
Common squacco Heron	*Ardeola ralloides*	L	v	v		v	v					
Intermediate Egret	*Ardea intermedia*	L	v	v	v	v		v				v
Little Egret	*Egretta garzetta*	L	v	v		v	v	v				

Rufous-bellied Heron	Ardeola rufiventris	L	v		v			v				
Malagasy Pond Heron	Ardeola idea	E	v					v				
Common Ringed Plover	Charadrius hiaticula	L	v		v							
Crowned Lapwing	*Vanellus coronatus*	L	v	v								
Three-banded plover	*Charadrius tricollaris*	L	v	v	v							
Broad-billed Roller	Eurystomus glaucurus	L						v				
Cuculidae												
Black Coucal	*Centropus grillii*	L				v						
Red-chested Cuckoo	*Cuculus solitarius*	L			v		v	v				
Fringillidae												
Western Citril	*Crithagra frontalis*	L		v	v			v				
Hirundinidae												
Barn swallow	Hirundo rustica	L		v			v	v	v			
Meropidae												
European Bee-eater	*Merops apiaster*	L			v	v	v	v	v			
Motacillidae												
Grey Wagtail	*Motacilla cinerea*	L					v					
Yellow Wagtail	*Motacilla flava*	L						v				
Oriolidae												
African Golden Oriole	Oriolus auratus	L			v		v					
Pelecanidae												
Great White Pelican	*Pelecanus onocrotalus*	L		v		v	v	v				v
Phalacrocoracidae												
Great Cormorant	*Phalacrocorax carbo*	L	v			v		v				
Ploceidae												
Fan-tailed Widowbird	*Euplectes axillaris*	L		v	v	v	v	v	v	v		v
Red-billed Quelea	*Quelea quelea*	L		v	v	v	v	v	v			
Rallidae												
Lesser Moorhen	*Gallinula angulata*	L	v	v	v	v						
Scolopacidae												
Common sandpiper	*Actitis hypoleucos*	L	v	v	v		v	v				
Marsh Sandpiper	*Tringa stagnatilis*	L	v		v		v	v				
Wood Sandpiper	*Tringa glareola*	L	v									
Threskiornithidae												
Glossy Ibis	Plegadis falcinellus	L	v		v							
Viduidae												
Cuckoo-finch	Anomalospiza imberbis	L			v							
Pin-tailed Whydah	*Vidua macroura*	L		v	v		v	v				
Village indigobird	*Vidua chalybeata*	L					v					

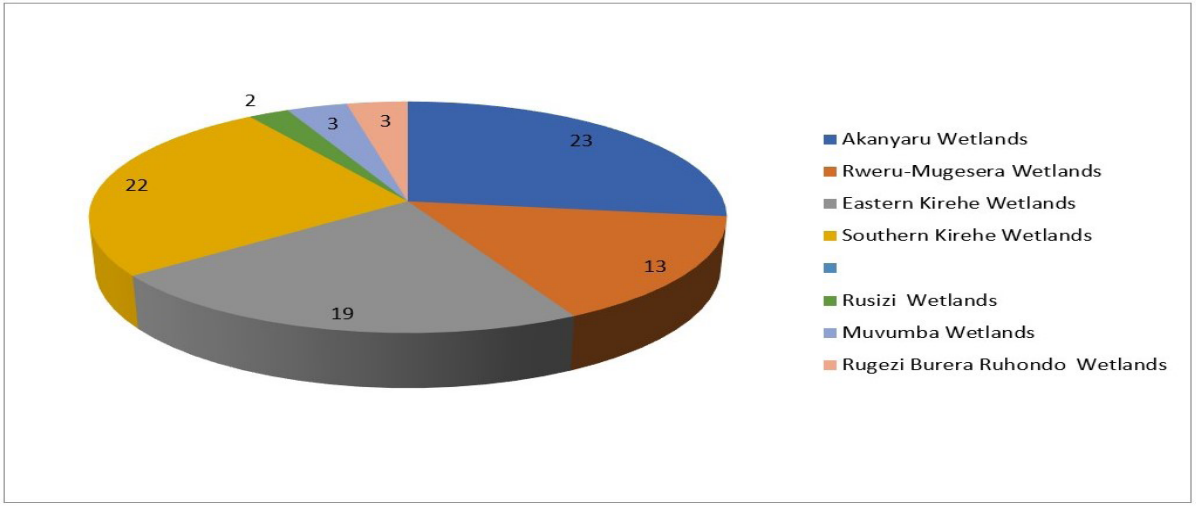


Figure 10: Species richness of migrant species in covered wetland complex

Akanyaru wetland complex presented the highest Alpha diversity (23) followed by southern Kirehe wetland complex (22) and Eastern Kirehe wetland complex.

Table 5: Over all species richness of all wetland complex

***NT:** Near Threatened. **E**: Endangered, **L**: Least Concern, **V**: Vulnerable. **B:** resident breeding or likely breeding, present all year-round. **R:** nonbreeding resident, present all year-round but without any indication of breeding. **M:** migrant species, present only parts of the year. **I:** Intra-african migrant, breeding in sub-saharan Africa. **MA:** non-breeding visitors breeding in Madagascar. **P:** non-breeding visitors breeding in the palearctics. **Ir:** Irregular visitor, not occurring every year. **O:** occasional visitors.*

No	Family/ Common Names	Scientific Names	IUCN	Status	Water bird	Endemic	City of Kigali	Akanyaru	Rweru-Mugesera	Eastern Kirehe	Southern Kirehe	Nyamwashama	Rusizi	Mulumba	Rugez
1	**Accipitridae**														
1	African Fish Eagle	*Haliaeetus vocifer*	**L**	**B**			ü	ü	ü	ü	ü				
2	African Harrier-Hawk	*Polyboroides typus*	L	B			ü	ü			ü				
3	African Marsh Harrier	*Circus ranivorus*	L	B			ü	ü			ü				
4	Augur Buzzard	*Buteo augur*	L	B			ü	ü	ü		ü				ü

5	Bateleur	*Terathopius ecaudatus*	NT	B						ü	ü				
6	Little Sparrowhawk	*Accipiter minullus*	L	R			ü			ü	ü				
7	Long-crested Eagle	*Lophaetus occipitalis*	L	B			ü	ü		ü	ü			ü	
8	Martial Eagle	*Polemaetus bellicosus*	V	R				ü							
9	Palm-nut Vulture	*Gypohierax angolensis*	L	B					ü						
10	Yellow-billed Kite	*Milvus migrans*	L	P			ü	ü	ü	ü	ü			ü	
2	**Acrocephalidae**														
11	Dark-capped Yellow Warbler	*Iduna natalensis*	L	B						ü					
12	Lesser Swamp Warbler	*Acrocephalus graciliros-tris*	I	B			ü	ü	ü	ü	ü				
13	Papyrus Yellow-Warbler	*Calamonastides gracil-irostris*	v	B			ü	ü		ü					
3	**Alcedinidae**														
14	African Pygmy Kingfisher	*Ispidinia picta*	L	B	ü								ü		
15	Grey-headed Kingfisher	*Halcyon leucocephala*	L	I	ü		ü	ü	ü	ü	ü				
16	Half-collared Kingfisher	*Alcedo semitorquata*	L	O	ü			ü							
17	Malachite Kingfisher	*Corythornis cristatus*	L	B	ü		ü	ü	ü	ü	ü				
18	Pied kingfisher	*Ceryle rudis*	L	B	ü		ü	ü	ü	ü	ü				
19	Woodland Kingfisher	*Halcyon senegalensis*	L	B	ü				ü	ü	ü	ü		ü	
4	**Anatidae**														
20	African Black Duck	*Anas sparsa*	L	B	ü				ü	ü	ü				
21	Egyptian Goose	*Alopochen aegyptiaca*		B	ü						ü				
22	Spur-winged Goose	*Plectropterus gambensis*	L	B	ü						ü				
23	African Pygmy-Goose	*Nettapus auritus*	L	B	ü					ü	ü				
24	Knob-billed Duck	*Sarkidiornis melanotos*	L	I/B	ü			ü							
25	Spur-winged Goose	*Plectropterus gambensis*	L	B	ü		ü	ü	ü	ü	ü	ü			
26	White-faced Whistling-Duck	*Dendrocygna viduata*	L	B/I	ü		ü	ü		ü	ü			ü	
27	Yellow Billed Duck	*Anas undulata*	L	B	ü			ü	ü	ü	ü				
5	**Anhingidae**														
28	African Darter	*Anhinga rufa*	L	B	ü		ü			ü					
6	**Ardeidae**														

29	Grey Heron	*Ardea cinerea*	L	B	ü		ü	ü	ü	ü	ü				
30	Black Heron	*Egretta ardesiaca*	L	I/R	ü		ü	ü		ü	ü				
31	Black-headed Heron	*Ardea melanocephala*	L	B	ü		ü	ü	ü	ü	ü	ü		ü	ü
32	Cattle Egret	*Bubulcus ibis*	L	B/I	ü		ü	ü	ü	ü	ü	ü	ü	ü	
33	Common squacco Heron	*Ardeola ralloides*	L	B/I	ü		ü		ü	ü					
34	Goliath Heron	*Ardea goliath*	L	B	ü			ü							
35	Grey Heron	*Ardea cinerea*	L	B	ü		ü	ü	ü	ü	ü	ü			
36	Intermediate Egret	*Ardea intermedia*	L	B/I	ü		ü	ü	ü		ü				ü
37	Little Egret	*Egretta garzetta*	L	B/I	ü		ü		ü	ü	ü				
38	Purple Heron	*Ardea purpurea*	L	B	ü					ü	ü				
39	Rufous-bellied Heron	*Ardeola rufiventris*	L	B/I	ü			ü			ü				
40	Malagasy Pond Heron	*Ardeola idea*	E	I/MA	ü						ü				
7	**Bucerotidae**														
41	Crowned Hornbill	*Lophoceros albotermi-natus*	L	B							ü		ü		
8	**Capitonidae**														
42	Yellow-rumped Tinkerbird	*Pogoniulus bilineatus*	L	B									ü		
9	**Caprimulgidae**														
43	Swamp Nightjar	*Caprimulgus natalensis*	L	B							ü				
10	**Charadriidae**														
44	African Wattled Lapwing	*Vanellus senegallus*	L	B	ü		ü								
45	Common Ringed Plover	*Charadrius hiaticula*	L	P	ü			ü							
46	Crowned Lapwing	*Vanellus coronatus*	L	V	ü		ü								
47	Long-toed Lapwing	*Vanellus crassirostris*	L	R	ü		ü	ü	ü	ü	ü			ü	
48	Spur-winged Lapwing	*Vanellus spinosus*	L	B	ü		ü		ü	ü					
49	Three-banded plover	*Charadrius tricollaris*	L	I/B	ü		ü	ü							
50	Wattled Lapwing	*Vanellus senegallus*	L	B	ü		ü			ü		ü			
11	**Ciconiidae**														
51	African Openbill	*Anastomus lamelligerus*	L	B	ü		ü	ü	ü		ü	ü		ü	ü
52	Marabou Stork	*Leptoptilos crumeniferus*	L	B	ü						ü				
53	Yellow-billed Stork	*Mycteria ibis*	L	B	ü		ü							ü	ü

12	**Cisticolidae**														
54	Carruthers's Cisticola	*Cisticola carruthersi*						ü							
55	Banded Prinia	*Prinia bairdii*	L	B									ü		
56	Black-throated Apalis	*Apalis jacksoni*	L	B									ü		
57	Chestnut-throated Apalis	*Apalis porphyrolaema*	L	B									ü		
58	Chubb's Cisticola	*Cisticola chubbi*	L	B			ü						ü	ü	ü
59	Grey-capped Warbler	*Eminia lepida*	L	B			ü	ü					ü	ü	ü
60	Ruwenzori Apalis	*Oreolais ruwenzorii*	L	B		ü							ü		
61	Tawny-Flanked Prinia	*Prinia subflava*	L	B				ü	ü	ü				ü	
62	Trilling Cisticola	*Cisticola woosnami*	L	B			ü								
63	white-chinned Prinia	*Schistolais leucopogon*	L	B						ü					
64	Winding Cisticola	*Cisticola marginatus*	L	B			ü	ü	ü	ü	ü	ü		ü	ü
65	Zitting Cisticola	*Cisticola juncidis*	L	B			ü	ü			ü				
13	**Coliidae**														
66	Speckled mousebird	*Colius striatus*	L	B			ü	ü		ü	ü		ü	ü	ü
14	**Columbidae**														
67	African Green Pigeon	*Treron calvus*	L	B			ü	ü	ü	ü	ü	ü		ü	
68	Blue-Spotted Wood Dove	*Turtur afer*	L	B			ü	ü	ü	ü	ü			ü	
69	Laughing Dove	*Streptopelia senegalensis*	L	B			ü	ü	ü	ü	ü	ü			
70	Red-Eyed Dove	*Streptopelia semitorquata*	L	B			ü	ü	ü	ü	ü	ü		ü	
71	Ring-necked Dove	*Streptolia capicola*	L	B			ü	ü	ü	ü	ü				
15	**Coraciidae**														
72	Broad-billed Roller	*Eurystomus glaucurus*	L	B/I							ü				
73	Lilac-breasted Roller	*Coracias caudata*	L	B					ü		ü	ü			
16	**Corvidae**														
74	Pied Crow	*Corvus albus*	L	B			ü	ü	ü						ü
17	**Cuculidae**														
75	Barred Long-tailed Cuckoo	*Cercococcyx montanus*	L	B									ü		
76	Black Coucal	*Centropus grillii*	L	B/I					ü						
77	Blue-headed Coucal	*Centropus monachus*	L	B			ü		ü	ü	ü		ü		

78	Red-chested Cuckoo	*Cuculus solitarius*	L	B/I				ü		ü	ü				
79	White-Browed Coucal	*Centropus superciliosus*	L	B			ü	ü	ü	ü	ü	ü			ü
18	**Dicruridae**														
80	Fork-tailed Drongo	*Edolius adsimilis*	L	B				ü	ü	ü	ü	ü			
19	**Emberizidae**														
81	Crimson-rumped Waxbill	*Estrilida rhodopyga*	L	R			ü	ü		ü	ü		ü		ü
20	**Estrildidae**														
82	African Firefinch	*Lagonosticta rubricata*	L	B			ü		ü	ü					ü
83	Black-and-white Mannikin	*Lonchura bicolor*	L	B			ü	ü	ü						
84	Black-crowned Waxbill	*Estrilda nonnula*	L	B											ü
85	Bronze Mannikin	*Spermestes cucullata*	L	B			ü	ü	ü	ü	ü				ü
86	Common Waxbill	*Estrilda astrild*	L	B			ü	ü	ü	ü	ü				ü
87	Fawn-breasted Waxbill	*Estrilda paludicola*	L	B											ü
88	Red-billed Firefinch	*Lagonosticta senegala*	L	B			ü	ü	ü	ü	ü				
89	Red-cheeked Cordon-bleu	*Uraeginthus bengalus*	L	B			ü		ü	ü	ü				
21	**Falconidae**														
90	African Hobby	*Falco cuvierii*	L	B			ü	ü		ü	ü				ü
22	**Fringillidae**														
91	Western Citril	*Crithagra frontalis*	L	B/I			ü	ü			ü				
92	Papyrus Canary	*Crithagra koliensis*	L	B			ü								
93	Streaky Seedeater	*Crithagra striolata*	L	B			ü								ü
94	Thick-billed Seedeater	*Crithagra burtoni*	L	B			ü								
95	Yellow-fronted Canary	*Serinus mozambicus*	L	B			ü	ü		ü	ü				ü
96	Yellow-crowned Canary	*Serinus flavivertex*	L	B											ü
23	**Gruidae**										ü				
97	Grey Crowned Crane	*Balearica regulorum*	E	B	ü		ü	ü	ü	ü	ü			ü	
24	**Hirundinidae**														
98	Angola Swallow	*Hirundo angolensis*	L	B			ü	ü	ü	ü	ü	ü			
99	Barn swallow	*Hirundo rustica*	L	P			ü			ü	ü	ü			
100	Black Saw-wing	*Psalidoprocne pristoptera*	L	B			ü	ü	ü	ü					ü

101	Brown-throated Martin	*Riparia paludicola*	L	B			ü	ü							
102	Lesser Striped Swallow	*Cecropis abyssinica*	L	B			ü	ü		ü					ü
103	Little Swift	*Apus affinis*	L	B				ü							
104	Brown-throated Martin	*Riparia paludicola*	L	B			ü						ü		ü
105	Red-rumped Swallow	*Hirundo daurica*	L	B				ü		ü	ü				
106	White-headed Saw-wing	*Psalidoprocne albiceps*	L	B			ü	ü		ü					
107	Wire-tailed Swallow	*Hirundo smithii*	L	B						ü	ü				
25	**Indicatoridae**														
108	Greater honeyguide	*Indicatoridicator*	L	B				ü							
26	**Jacanidae**														
109	African Jacana	*Actophilornis africanus*	L	B	ü		ü	ü	ü	ü	ü				
27	**Laniidae**														
110	Grey-backed Fiscal	*Lanius excubitoroides*	L	R			ü		ü	ü	ü	ü		ü	
111	Northern Fiscal	*Lanius humeralis*	L	R			ü			ü	ü		ü		ü
28	**Leiothrichidae**														
112	Arrow-marked Babbler	*Turdoides jardineii*	L	B			ü	ü	ü	ü	ü			ü	
29	**Locustellidae**														
113	Cinnamon Bracken Warbler	*Bradypterus cinnamomeus*	L	B			ü			ü			ü		ü
114	Grauer's Swamp Warbler	*Bradypterus graueri*	E	B		ü							ü		ü
30	**Lybiidae**														
115	Yellow-rumped Tinkerbird	*Pogoniulus bilineatus*	L	B						ü					
31	**Macrosphenidae**														
116	Grauer's Warbler	*Graueria vitata*	L	B		ü				ü					
32	**Malaconotidae**														
117	Mountain Sooty Boubou Laniarius holomelas	*Laniarius holomelas*	L	B		ü							ü		
118	Black-headed Gonolek	*Laniarius erythrogaster*	L	B			ü	ü	ü	ü	ü	ü			
119	Marsh Tchagra	*Bocagia minuta*	L	R						ü	ü				
120	Papyrus Gonolek	*Laniarius mufumbiri*	NT	B			ü	ü	ü	ü	ü				
121	Slate-coloured Boubou	*Laniarius funebris*	L	B					ü						

122	Sulphur-breasted Bushshrike	*Chlorophoneus sulfureo-pectus*	L	B							ü				
123	Tropical Boubou	*Laniarius major*	L	B			ü	ü		ü	ü			ü	ü
33	**Meropidae**														
124	Blue-breasted Bee-eater	*Merops variegatus*	L	RO			ü								
125	Cinnammon-chested Bee-eater	*Merops oreobates*	L	B			ü								
126	European Bee-eater	*Merops apiaster*	L	P				ü	ü	ü	ü	ü			
127	Little Bee-eater	*Merops pusillus*	L	B											ü
34	**Monarchidae**														
128	African Paradise Flycatcher	*Terpsiphone viridis*	L	B			ü	ü	ü	ü					
35	**Motacillidae**														
129	African Pied Wagtail	*Motacilla aguimp*	L	B			ü	ü	ü	ü	ü		ü	ü	ü
130	African Pipit	*Anthus cinnamomeus*	L	B			ü	ü		ü	ü	ü			
131	Cape Wagtail	*Motacilla capensis*	L	B			ü	ü			ü		ü	ü	ü
132	Grey Wagtail	*Motacilla cinerea*	L	P						ü					
133	Yellow Wagtail	*Motacilla flava*	L	P							ü				
134	Yellow-throated Longclaw	*Macronyx croceus*	L	B			ü	ü	ü	ü	ü	ü			
36	**Muscicapidae**														
135	African Dusky Flycatcher	*Muscicapa adusta*	L	B			ü			ü					
136	African Stonechat	*Saxicola torquata*	L	B			ü	ü	ü	ü		ü	ü		ü
137	Archer's Robin-Chat	*Cossypha archeri*	L	B		ü							ü		
138	Snowy-crowned Robin-Chat	*Cossypha niveicapilla*	L	B			ü								
139	Southern black Flycatcher	*Metaenormis pammelaina*	L	B					ü						
140	Swamp flycatcher	*Muscicapa aquatica*	L	B			ü	ü	ü	ü	ü			ü	ü
141	White-fronted Black Chat	*Oenanthe albifrons*	L	B							ü				
142	White-Eyed Slaty Flycatcher	*Melaenornis fischeri*	L	B											ü
143	White-starred Robin	*Pogonocichla stellata*	L	B									ü		
144	Yellow-eyed black Flycatcher	*Malaenormis ardesiacus*	L	B									ü		
37	**Musophagidae**														
145	Bare-faced Go-away-bird	*Corythaixoides personatus*	L	B			ü		ü	ü					
146	Black-billed Turaco	*Turaco schuetti*	L	B									ü		

147	Eastern Grey Plantain-eater	*Crinifer zonurus*	L	B							ü				
148	Ruwenzori Turaco	*Gallirex johnstoni*	L	B		ü							ü		
38	**Nectarinidae**														
149	Blue-headed Sunbird	*Cyanomitra alinae*	L	B		ü							ü		
150	Bronzy Sunbird	*Chalcomitra kilimensis*	L	B			ü	ü		ü	ü				ü
151	Purple-banded Sunbird	*Chalcomitra bifasciata*	L	B							ü		ü		
152	Purple-banded Sunbird	*Chalcomitra bifasciata*	L	B		ü							ü		
153	Red-chested Sunbird	*Nectarinia erythrocerca*	L	B			ü	ü	ü	ü	ü				
154	Scarlet-chested Sunbird	*Chalcomitra senegalensis*	L	B			ü	ü		ü	ü				
155	Variable Sunbird	*Cinnyris venusta*	L	B			ü	ü		ü	ü				ü
39	**Oriolidae**														
156	Black-headed Oriole	*Oriolus larvatus*	L	B				ü		ü					
157	African Golden Oriole	*Oriolus auratus*	L	I				ü		ü					
158	Mountain Oriole	*Oriolus percivali*	L	B									ü		
40	**Passeridae**														
159	House Sparrow	*Passer domesticus*	L	B			ü				ü			ü	ü
160	Northern Grey-headed Sparrow	*Passer griseus*	L	B			ü		ü	ü	ü				
41	**Pelecanidae**										ü				
161	Great White Pelican	*Pelecanus onocrotalus*	L	I			ü		ü	ü	ü				ü
162	Pink-backed Pelican	*Pelecanus rufescens*	L	B			ü		ü						
42	**Phalacrocoracidae**										ü				
163	Great Cormorant	*Phalacrocorax carbo*	L	B/I	ü				ü		ü				
164	Reed Cormorant	*Microcarbo africanus*	L	B	ü			ü	ü	ü	ü				
43	**Phasianidae**														
165	Red-necked Spurfowl	*Pternistis afer*	L	B						ü					
44	**Phylloscopidae**														
166	Red-faced Woodland Warbler	*Seicercus laetus*	L	B		ü							ü		
45	**Picidae**														
167	Cardinal Woodpecker	*Dendropicos fuscescens*	L	B			ü			ü	ü				
168	Grey woodpecker	*Dendropicos goertae*	L	B						ü					
46	**Platysteiridae**														

169	Chinspot Batis	*Batis molitor*	L	B									ü		
47	**Pellorneidae**														
170	Mountain Illadopsis	*Illadopsis pyrrhoptera*	L	B									ü		
48	**Ploceidae**														
171	Baglafecht Weaver	*Ploceus baglafecht*	L	B			ü	ü	ü	ü				ü	ü
172	Black-billed Weaver	*Ploceus melanogaster*	L	B			ü								
173	Black-headed Weaver	*Textor melanocephalus*	L	B			ü	ü	ü	ü			ü		ü
174	Dark-backed Weaver	*Malimbus bicolor*	L	B									ü		
175	Fan-tailed Widowbird	*Euplectes axillaris*	L	B/I			ü	ü	ü	ü	ü	ü	ü		ü
176	Thick-billed Weaver	*Amblyospiza albifrons*	L	B			ü	ü	ü	ü	ü				
177	Holub's Golden Weaver	*Ploceus xanthops*	L	B			ü			ü					
178	Northern Brown-throated Weaver	*Textor castanops*	L	B				ü			ü				
179	Red-billed Quelea	*Quelea quelea*	L	B/I			ü	ü	ü	ü	ü	ü			
180	Slender-billed Weaver	*Ploceus pelzelni*	L	B			ü	ü	ü	ü	ü		ü		
181	Southern Red Bishop	*Euplectes orix*	L	B			ü	ü			ü				
182	Spectacled Weaver	*Textor ocularis*	L	B			ü			ü	ü				
183	Strange Weaver	*Ploceus alienus*	L	B		ü									
184	Thick-billed Weaver	*Amblyospiza albifrons*	L	B			ü	ü	ü	ü	ü				
185	Yellow-backed Weaver	*Ploceus melanocephalus*	L	B			ü	ü	ü	ü	ü				ü
49	**Psittacidae**														
186	Brown-necked Parrot	*Poicephalus fuscicollis*	L	R			ü								
187	Red-headed Lovebird	*Agapornis pullarius*	L	B						ü					
188	Meyer's Parrot	*Poicephalus meyeri*	L	B											
50	**Pycnonotidae**														
189	Dark-capped Bulbul	*Pycnonotus tricolor*	L	B			ü	ü	ü	ü	ü		ü	ü	ü
190	Yellow-whiskered Greenbul	*Eurillas latirostris*	L	B									ü		
51	**Rallidae**														
191	Black Crake	*Amaurornis flavirostris*	L	B	ü		ü	ü	ü	ü	ü				ü
192	Common Moorhen	*Gallinula chloropus*	L	B	ü		ü		ü	ü	ü				
193	Lesser Moorhen	*Gallinula angulata*	L	I/B	ü		ü	ü	ü						
194	Red-knobbed Coot	*Fulica cristata*	L	B	ü		ü	ü	ü	ü	ü				ü

52	**Scolopacidae**														
195	Common sandpiper	*Actitis hypoleucos*	L	P	ü		ü	ü		ü	ü				
196	Marsh Sandpiper	*Tringa stagnatilis*	L	P	ü			ü		ü	ü				
197	Wood Sandpiper	*Tringa glareola*	L	P	ü										
53	**Scopidae**														
198	Hamerkop	*Scopus umbretta*	L	B	ü		ü	ü	ü	ü	ü	ü		ü	
54	**Cettiidae**														
199	Neumann's Warbler	*Urosphena neumanni*	L	B		ü							ü		
55	**Stenostiridae**														
200	White-tailed Blue Flycatcher	*Elminia albicauda*	L	B							ü				
56	**Strigidae**														
201	Pearl-spotted Owlet	*Glaucidium perlatum*	L	B						ü					
57	**Sturnidae**														
202	Greater Blue-eared Starling Lamprotornis	*Lamprotornis chalybaeus*	L	B			ü	ü	ü	ü	ü	ü	ü		
203	Rüppell's Starling	*Lamprotornis purpurop-terus*	L	B			ü	ü	ü	ü	ü	ü			
204	Waller's Starling	*Onychognathus walleri*	L	B									ü		
58	**Sylvidae**														
205	Grey capped Warbler	*Eminia lepida*	L	B			ü	ü	ü	ü	ü				
59	**Threskiornithidae**														
206	African spoonbill	*Platalea alba*	L	B	ü		ü	ü						ü	ü
207	Glossy Ibis	*Plegadis falcinellus*	L	I	ü			ü							
208	Hadada Ibis	*Bostrychia hagedash*	L	B	ü		ü	ü	ü	ü	ü		ü		ü
209	Sacred ibis	*Threskiornis aethiopica*	L	B	ü		ü	ü	ü	ü	ü			ü	ü
60	**Timaliidae**														
210	Black-Lored Babbler	*Turdoides melanops*	L	B			ü	ü		ü	ü				
61	**Trogonidae**														
211	Bar-tailled Trogon	*Apaloderma vittatum*	L	B											
62	**Turdidae**														
212	Abyssinian Thrush	*Turdus abyssinicus*	L	B			ü	ü							
213	African Thrush	*Turdus pelios*	L	B			ü	ü	ü	ü	ü				ü
214	White-browed Robin-Chat	*Cossypha heuglini*	L	B			ü	ü	ü	ü	ü			ü	ü

63	**Viduidae**														
215	Cuckoo-finch	*Anomalospiza imberbis*	L	I				ü							
216	Pin-tailed Whydah	*Vidua macroura*	L	B/I			ü	ü		ü	ü				
217	Village indigobird	*Vidua chalybeata*	L	B/I						ü					

Discussions

This assessment generated 2.447 georeferenced records of bird species. It demonstrated that wetlands of Rwanda are still very important for the conservation of bird species as almost 217 species (31% of all birds of Rwanda) distributed in 63 families were identified, including species threatened to extinction as per the IUCN Red list 2021-2 available at **https://www.iucnredlist.org/**. 3 species are endangered, 2 are vulnerable and 2 near threatened. Specifically, the study identified 53 water bird species belonging to 11 families with Akagera wetland complex presenting the highest species richness followed by Akanyaru and Kigali city and Rweru-mugesera wetland complexes. 36 migrant bird species were identified with Akanyaru exhibiting the highest species richness followed by Akagera wetland complex. This correlates with the findings of ARCOS 2019 on the status of ecological integrity as Akagera, and Rweru-Mugesera wetland complees ranked high and Akanyaru ranked medium comparatively to other wetlands in the country. Parrish etall., 2003 and Hilty et al., 2020 stressed on the linkage between healthy bird community and the status of the ecological integrity of its habitat and for this, Muvumba wetland complex exhibited the lowest species richness.

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IV.2.3 Fish

Introduction and methods

In Rwanda, the ichtyological fauna is not much diversified owing to the fact that lakes are young and the existence of natural obstacles (falls) has prevented the colonization of the upper party of hydrographic network by various species characteristic of the Nile basin. Currently 82 species belonging to 12 families are known from Rwandese waters (Devos L et al., 2001). With at least 37 species, cichlids are by far the largest fish family in the country followed by Cyprinidae, Mormyridae and Mochokidae, respectively represented by 24, 6, and 4 species. The other eight families are represented by one or two species only. The presence of at least 12 species is the result of introductions by man (Devos L et al., 2001). However, the numbers evoked here are not conclusive since the taxonomic status of several Rwandan fishes is still unresolved and several species still await formal description. Besides, at present, some hydrographic sub-units are insufficiently explored. Probably a dozen or so Haplochromine species of the Middle and Upper Akagera currently remain undescribed (Devos L et al., 2001).

ARCOS team conducted an intensive assessment of fish species in eight (8) key wetland complexes (City of Kigali, Akanyaru, Rweru-Mugesera, Muvumba, Rugezi, RUsizi and Akagera wetlands in Kirehe District) from June 2019 to May 2021 to document the current **distribution, diversity, and abundance** of fish species within major wetland complexes of Rwanda. With the help of local fishermen, interviews were conducted at different fishing sites and mostly information was collected about vernacular names of fish, daily fish capture, fishing devices used, and fishing pick along the year. The same sample sites were visited during the dry season from June to October 2019 and during the rainy season from March to May 2021.

Fish species identification was done by morphometrical analysis and using the field guide directly from the field. This involved the measurement and counting of characteristic external organs of sampled fish and examining the color pattern, morphology, lateral lines, fins and mouth, and character of the teeth and scales. In addition, all unidentified fish on the field were photographed and some samples were collected, conserved in a solution of

formaldehyde for subsequent identification in the laboratory. For identification, the classification of sampled fish followed the taxonomic keys and guides by Schneider, 1990, Dankwa et al.1999, Luc De Vos et al. 2001, Edwards et al.2001, Kwei and Ofori Adu 2005, (Lévêque, C. et al, 1984).

Summary on the species status

Overall, 26 fish species distributed in 9 families were recorded and their distribution and status on IUCN red list is demonstrated in the table below:

Table 6: Fish species distribution in 9 wetland complexes and their status on IUCN red list

Family	Species	IUCN RL	Occurrence in the wetlands 'complex								
			Kigali wetlands	Rweru-Mugesera	South-Kirehe Akagera	East-Kirehe Akagera	Akanyaru	Rugezi-Burera Ruhondo	Kivu and Rusizi	Karangazi-Muvumba	Nyamwashama
Protopteridae	*Protopterus aethiopicus*	LC	R	R	R	R	R	R	NR	NR	NR
Cyprinidae	*Cyprinus carpio*	LC	NR	R	NR	R	R	NR	NR	NR	NR
	Enteromius cercops	LC	R	R	NR	R	NR	NR	NR	NR	NR
	Enteromius apleurogramma	LC	R	NR	NR	NR	NR	NR	NR	NR	NR
	Labeo victorianus	LC	NR	NR	R	R	NR	NR	NR	NR	NR
	Labeobarbus ruandae	NT	NR	NR	NR	R	NR	NR	NR	NR	NR
	Labeobarbus altianalis	LC	NR	NR	NR	R	NR	NR	NR	NR	NR
Cichlidae	*Oreochromis niloticus*	LC	R	R	R	R	R	R	NR	NR	NR
	Tilapia rendalli	LC	NR	R	R	NR	R	NR	NR	NR	NR
	*Haplochromis vittatus**	LC	NR	NR	NR	NR	NR	NR	R	NR	NR
	*Haplochromis crebidens**	LC	NR	NR	NR	NR	NR	NR	R	NR	NR
	*Haplochromis insidiae**	LC	NR	NR	NR	NR	NR	NR	R	NR	NR
	*Haplochromis kamiranzovu**	LC	NR	NR	NR	NR	NR	NR	R	NR	NR
	Haplochromis erythromaculatus	EN	NR	NR	NR	R	NR	R	NR	NR	NR
	Astatotilapia burtoni	LC	NR	NR	R	R	NR	NR	NR	NR	NR
	Pseudocrenilabrus multicolor	LC	R	R	R	NR	R	NR	NR	NR	NR
Clariidae	*Clarias gariepinus*	LC	R	R	R	R	R	NR	NR	NR	NR
	Clarias liocephalus	LC	R	R	R	R	R	NR	NR	NR	NR
Poeciliidae	*Lacustricola centralis*	LC	R	R	NR	NR	R	R	R	R	NR
Schilbeidae	*Shilbe intermedius*	LC	R	R	R	R	R	NR	NR	NR	NR
Mochokidae	*Synondontis ruandae*	VU	NR	NR	NR	R	NR	NR	NR	NR	NR
Bagridae	*Bagrus docmac*	LC	NR	NR	NR	R	NR	NR	NR	NR	NR
Mormyridae	*Gnathonemus longibarbis*	LC	NR	NR	NR	R	NR	NR	NR	NR	NR
	Petrocephalus catostoma	LC	NR	NR	NR	R	NR	NR	NR	NR	NR
	Pollimyrus nigricans	LC	NR	NR	NR	R	NR	NR	NR	NR	NR
	Marcusenius victoriae	LC	NR	NR	NR	R	NR	NR	NR	NR	NR
			9	10	9	18	9	4	5	1	0

Key: R: Recorded in the area.

NR: Not Recorded in the area.

LC (Least Concern): the species is not considered near threatened or threatened.

NT (Near Threatened): the species is close to qualifying for a threatened category but is not currently considered threatened.

VU (Vulnerable): species that have a high risk of extinction in the wild, according to: observable reduction in numbers of individuals and the total geographical area occupied by the species.

EN (Endangered): species that have a very high risk of extinction in the wild, according to: observable reduction in numbers of individuals and the total geographical area occupied by the species.

***: Endemic to Rwanda** (in Lake Kivu)

The fish capture varied largely from one area to another. It was significantly higher in wetlands with wide open waters such as around rivers, lakes and natural ponds. The average value varying from **150-200kg/day** on open water to **10-20kg/day** on wetlands not surrounded with open waters. The main captured species were Nile Tilapia (*Oreochromis niloticus*) sold at 1200-1500Rwf/kg, the African catfish (*Clarias gariepinus*) sold at 700-1000Rwf/kg and the African lungfish (*Protopterus aethiopicus*) sold at 600-800Rwf/kg.

In Rwandan ichthyofauna, most of endemic species are found in Lake Kivu, these are (15) haplochromine species (Snoeks J, et al 1997:, Fishebase, all fishes reported in Rwanda). During this study, 4 endemic haplochromine species have been recorded in Kivu and Rusizi wetland complexes (see table 1). Three species have been recorded during this study and are mentioned in the IUCN Red List status: *Haplochromis erythromaculatus* (EN), *Synodontis ruandae* (VU) and *Labeobarbus ruandae* (NT). De Vos, L. et al 1990 (2) have observed *Haplochromis erythromaculatus* in Lake Burera and Ruhondo, the fish has been described as a new species. However, during this study the species has been observed and recorded in Kigali, Eastern Kirehe -Akagera, Rugezi-Burera-Ruhondo wetlands complex. The Mochokid *Synodontis ruandae*) has been observed and recorded at Eastern-Kirehe-Akagera. Indeed, the species is known from the Akagera River system in Rwanda and Burundi (De Vos, L., 1991, Banyankimbona, G., E. et al, 2012). The Cyprinid *Labeobarbus ruandae* is known from the Upper Akagera system in Rwanda (De Vos, L., et al 1990 (1), De Vos, L., et al 2001) and Burundi (Banyankimbona, G., E. et al, 2012). The introduction of tilapia and some *Haplochromis* may have been the reason for the decimation or extinction of the later species in Lake Ruhondo. For this study, the species has been observed and recorded only at Eastern-Kirehe-Akagera.

Discussion

Except for the cyprinid *Cyprinus carpio*, all recorded species during this investigation have native occurrence and are found in their natural geographic distribution. Cichlid family is more represented with nine (9) species that have been recorded and identified followed by Cyprinidae and Mormyridae with respectively six (6) and four (4) species. Lévêque C and Paugy D. (2017) state that Cyprinidae, Alestidae, and a few Siluriformes families constitute the bulk of the riverine fish fauna with Cyprinodontiformes and Mormyridae. The Cichlidae are by far

the most abundant with some 1,150 species (more than 2,000 estimated) and about 143 genera recorded, most of them endemic to East African lakes where many species remain to be described. In Rwandan Cichlid fauna, most of the Haplochromine species are known from Lake Kivu (Van Oijen, M.J.P., et al, 1991). Three sympatric haplochromine species in Lake Kivu (*Haplochromis kamiranzovu*, *H. insidiae*, and *H. astatodon)* recently have been studied on specificity and sexual dimorphism in tooth shape (Munyandamutsa et al, 2019). However, six haplochromine species have been recorded in wetlands. The Cichlid *Oreochromis niloticus* has high occurrence and has been observed at six sites. From interview with fishermen, the species is mentioned all over the country.

The Poeciliid fish; *Lacustricola centralis* has also a high occurrence in Rwandan waters where it was observed in six sites in clean stagnant shallow waters. According to Seegers, L., (1996), the species is generally found in quite shallow water between flooded grasses in East Africa. The African catfish; *Clarias gariepinus* was recorded in five sites. This species and the African lungfish; *Protopterus aethiopicus (recoreded in six sites)* are observed all over the country (BCEOM report, 2008). Note that the African catfish was translocated from Lake Ihema into Lake Muhazi by the Rwandan Ministry of Agriculture (Plisnier, 1989). A first translocation apparently was made already in 1982 by some anglers. In order to improve the genetic diversity of the introduced stock, more *Clarias* specimens were translocated later in the eighties from Lake Ihema to Lake Muhazi by V. Frank.

Cyprinidae and Mormyridae were abundantly recorded in Kirehe wetlands complex. The specific diversity and richness were significant in Eastern Kirehe Akagera, Kigali, Rweru Mugersera, Akanyaru and Southern Kirehe Akagera with respectively 18, 9, 10, 9, 9 species. The alpha-diversity values were not computed since the specimens recorded in some families and sampled areas were widely abundant. However, the Kirehe wetlands complex may show higher alpha-diversity value compared to others sampled areas. The reason for the recorded result should be that Kirehe wetlands complex are less degraded and anthropogenic pressure is negligible. Paradoxally, Kigali wetlands complex show higher specific diversity and richness despite higher degradation level observed in most of sampled sites.

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V.2.4 Amphibians

Amphibians are considered biological indicators for the changes in the quality of wetlands based on their diversity across spatial scale (Saber et al., 2017). Different studies have evaluated the indirect ecosystem services provided by amphibians such as food to human and other animals within a wide-ranging food web, control of pests, provision of medicine and seed dispersal (Hocking & Babbit,2014). Amphibians affect ecosystem structure through soil burrowing and aquatic bioturbation which enhance nutrients cycling (Anyelet et al., 2013). However, amphibians' populations are more threatened, and are declining more rapidly, than either birds or mammals (Stuart et al. 2005). Amphibians in Rwandan wetlands consist mainly of a large group of Frogs and Toads under the order Anura (Dehling, 2012; Fisher et al 2021; Mindje et al 2020; Roelke & smith, 2010; Sinsch et al 2012; Tumushimire et al 2020). Distribution, diversity, and richness of anuran communities within these wetlands depend on several factors such as the types and structure of wetlands' habitats in terms of water availability, vegetation, and predators (Moreno-Rueda & Pizarro, 2007). They encompass 53 anuran species and one Gymnophiona (Boulengerula fischeri) (Measey et al., 2011) with Callixalus pictus reported to have been extirpated from Rwanda due to heavy habitat destruction over the last 30 years in Rutsiro district, western province

of Rwanda (Sinsch et al.,2011).

There is a lack of updated information on anuran community in wetlands in Rwanda to guide decision making; the most recent comprehensive study was done by Fisher et al. (2011). ARCOS has invested efforts to assess the distribution, of anuran community within Akagera, Rweru-mugesera, city of Kigali, Akanyaru, and used information from other studies to update data on anuran species. Anuran sampling followed a night bioacoustics assessment at acoustic niches selected by the anurans for advertisement calling. Sampling period was from June to September 2019 and from April to May 2021. Advertisement calls are specific per species in both Frogs and Toads (reviewed by Schneider & Sinsch (2007). This encompasses, a recording of species vocalization per microhabitat and later advertisement call recordings were analyzed using ADOBE Audition for call structures (Call structure are characterized by measuring the anuran call duration [ms], pulses per call, pulse rate [Hz], pulse duration [ms], interpulse interval [ms] and dominant frequency [Hz]) which were identified based on previous literature (Kohler et al., 2017) Sinsch et al., 2012). Microhabitats were selected per each site based on the structure of the habitats that included meadows, mud holes, dammed lakes, long and tall grasses, Papyrus and Cyperus natural vegetation, irrigation channels with or without vegetation, ponds, and agriculture fields. For species like Xenopus spp. which calls under water, a hydrophone is usually requested to record the advertisement calls.

We used a LED torch pointed onto the ponds or lakes to stimulate the species to bring out its head on the water surface and a scoop net was used in small ponds to collect Xenopus spp known to live in mud holes or shallow ponds. The visual encounter surveys are also conducted sometimes during the nights to maximize species detection. Advertisement calls were recorded using a mobile phone (LG Q6 and Samsung J5 Prime) since there was no recorder available such as the Sony J PCM–D50 Linear PCM Recorder with stereo microphones, Sony Deutschland GmbH, Cologne. The search took into consideration the fact that the amphibians are often found amongst leaf litter and under natural cover objects (e.g., logs, stones) in the terrestrial environment as another strategy to recover anuran in the sampling site. At each sampling site, anurans were approached by homing in their microhabitats to capture calling specimens for identification by looking at the morphological and call structure corroboration. Photographs of calling specimen and alive caught specimen were later identified in the next morning based on literature by Sinsch et al., 2012 and Dehlign & Sinsch 2013, and when not certain an expert eye was used by sending the photographs to Prof. Dr. Ulrich Sinsch from University of Koblenz-Landau for further assistance in anuran identification.

Status of amphibian taxa

It was not surprising to find species restricted to near or natural wetlands such as *Hyperolius cinnamomeoventris* in the Rubilizi and Gahanga wetlands, *Hyperolius rwandae* in the Rweru-Mugesera, and Rubilizi wetland and *Hyperolius lateralis* in the Ruliba wetland. Moreover, a species of Hyperoliidae (*Hyperolius spp*) was found in Gatenga wetland and currently it seems to be an undescribed species. However, other species of Toads and Frogs were commonly distributed among the remaining wetlands, and these are potential indicators of disturbed wetlands.

These species were *Ptychadena nilotoca, P. porosissima, P. anchietae, Afrixalus quadrivittatus, Kassina senegalensis, Phrynobatrachus natalensis, P. kakamikro, Hyperolius kivuensis, H. viridiflavus, Sclerophrys regularis, Xenopus victorianus* and *Amietia nutti* that are known to coexist in heavily disturbed wetlands dominated by human activities (Mindje et al., 2020; Tumushimire et al., 2020).

Summary on the species status

Table 7: IUCN Status of identified anuaran species

Family	Anuran Taxa	Common name	IUCN Red list
Hyperoliidade	*Afrixalus quadrivitattus*	Four-lined Spiny Reed Frog	LC
	Hyperolius cinnamomeoventris	Cinnamon-bellied Reed Frog	LC
	Hyperolius kivuensis	Kivu reed frog	LC
	Hyperolius lateralis	Mottle-sided Reed Frog	LC
	Hyperolius rwandae	Rwanda Reed frog	LC
	Hyperolius viridiflavus	Common reed frog	LC
	Kassina senegalensis	Senegal land frog	LC
Pixycephalidae	*Amietia nutti*	Nutts' river frog	LC
Phrynobatrachidae	*Phrynobatrachus kakamikro*	Dwarf Puddle Frog	DD
	Phrynobatrachus natalensis	Natal or snoring Dwarf Puddle Frog	LC
Ptychadenidae	*Ptychadena anchietae*	Anchieta's or Plain grass frog	LC
	Ptychadena porosissima	Grassland ridged frog	
	Ptychadena nilotica	Nile grass frog	LC
Bufonidae	*Sclerophrys regularis*	African common toad	LC
Pipidae	*Xenopus victorianus*	Lake Victoria clawed frog or Mwanza frog	LC

LC: least concern; DD: Data deficiency.

Anuran taxa identified/recorded per wetland

Only anurans (Frogs and Toads) were sampled among amphibians. Among the surveyed anuran only one species (*Sclerophrys regularis*) is a Toad and remained anurans are Frogs.

Table 8: Anuran identified in each of the surveyed wetland

Species	Rweru	Gaharwa	Gashora	Chohoha North	Amasanga-no	Nyandungu	Mbabe	Don Bosco	Rwampara	Rwezangoro	Ruliba	Bumbogo	Rubilizi	Inyange	Gahanga
*Hyperolius viridiflavu*s	+	+	+		+	+	+	+	+	+	+	+	+	+	+
Afrixalus quadrivittatus								+	+	+	+		+		+
Hyperolius lateralis											+				
Hyperolius kivuensis	+		+	+	+	+	+	+	+	+	+		+	+	+
Hyperolius cinnamomeoventris													+		+
Hyperolius rwandae			+										+		

Amietia nutti	+					+		+		+	+		+		
Hyperolius spp (udescribed)								+							
Sclerophrys regularis	+		+	+	+	+		+	+		+	+	+		
Ptychadena nilotica	+	+	+	+	+	+	+		+	+	+	+	+	+	+
Kassina senegalensis			+			+									
Ptychadena anchietae	+	+					+		+	+	+		+	+	+
Ptychadena porosissima									+	+					+
Phrynobatrachus natalensis	+		+	+			+		+	+	+	+	+		+
Phrynobatrachus kakamikro			+	+	+	+	+	+					+	+	+
Xenopus victorianus	+						+	+	+					+	
Species richness (n)	**8**	**3**	**8**	**5**	**5**	**7**	**7**	**8**	**8**	**8**	**9**	**4**	**11**	**6**	**9**

Discussions

Based on the results of this study, the anuran species sampled from the surveyed wetlands indicate heavy wetlands alterations as all the species are those that coexist in strongly disturbed wetlands of Rwanda (Tumushimire et al., 2020). However, few wetlands in Kigali such as the Ruliba, Nyandungu, Rubilizi and Gatenga, in the easter province such as the Rweru-Mugesera, Akanyaru -Cyohoha and Gahanga wetlands still maintain species of natural or semi natural wetlands (*Hyperolius cinnamomeoventris* and *Hyperolius lateralis*) which still confirm their current status of partially disturbed wetlands. It was observed that wetlands with high degree of alterations had a higher richness of species than those with little alterations or semi natural wetlands. However, based on the species presence or absence data with comparison with literature in similar disturbed ecosystems comprised of agriculture, ornamental flowers selling and growing which and waste dumping, the species detected determine heavy wetlands alterations. The change in the wetlands natural state to altered ones favored the invasion of generalists' species of frogs and toads' species which out-competed species specific to natural wetlands. However, remnant patches of natural vegetation were rarely found in most wetlands of Kigali as natural wetlands have been cleared by human activities. This was confirmed by presence of anuran communities of altered wetlands (Sinsch et al., 2012) that were already detected in the wetland of Kigali, Akanyaru-Cyohoha and Rweru-Mugesera complex. However, wetlands that are still partially covered by natural vegetation have a high probability of regeneration once measures of rehabilitation become stringent since there is still a retention of natural vegetation with species of natural wetlands. There is a need to assess the diversity of species in those wetlands to confirm the status of the wetlands, complementing the presence/absence data for empirical scientific based evidence to guide decisions on the wetlands management and conservation.

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IV.2.5 Macroinvertebrates (Odonata and Butterflies)

For the assessment of Rwanda wetland biodiversity, ARCOS team studied the distribution, diversity and richness of macroinvertebrates, focusing on odonata (Dragonflies and damselflies), butterfly and Lepidoptera (butterflies) groups as indicators of healthier freshwater ecosystems and the relative ease of their identification. Dragonflies are well featured for nature management and are often used as indicators of environmental health, pollution indicators and conservation management (Uyizeye et al.,2021) but they also play a significant role in the food chain. Likewise, an abundance of butterflies is often an indication that an ecosystem is thriving. This is because butterflies are an important component of a food chain, as predators and prey. Butterflies are particularly sensitive to climate change, but they are also sensitive to other threats such as habitat destruction and changes in the behavior of butterflies can warn people of the future effects of habitat loss on other animals.

A transect of 1km along the wetland side in each site, was visited for three days from 9:00 am and 16:00pm. At each site, GPS waypoints were recorded. Sampling was based on adult individuals and all dragonflies, damselflies and butterflies observed within 1-3 m from the observer on every side of the riverbanks or wetland were directly identified using the handbook of odonatan for Eastern Africa by (Dijkstra et al 2013) and (Picker et al., 2004). We also used an aerial net to capture individuals, and mostly specimens were photographed using a high-resolution camera to help in subsequent identification. We released all individuals after the identification and documented vegetation structure at the sampling site (Dutra and Marco, 2015; Martins, 2015).

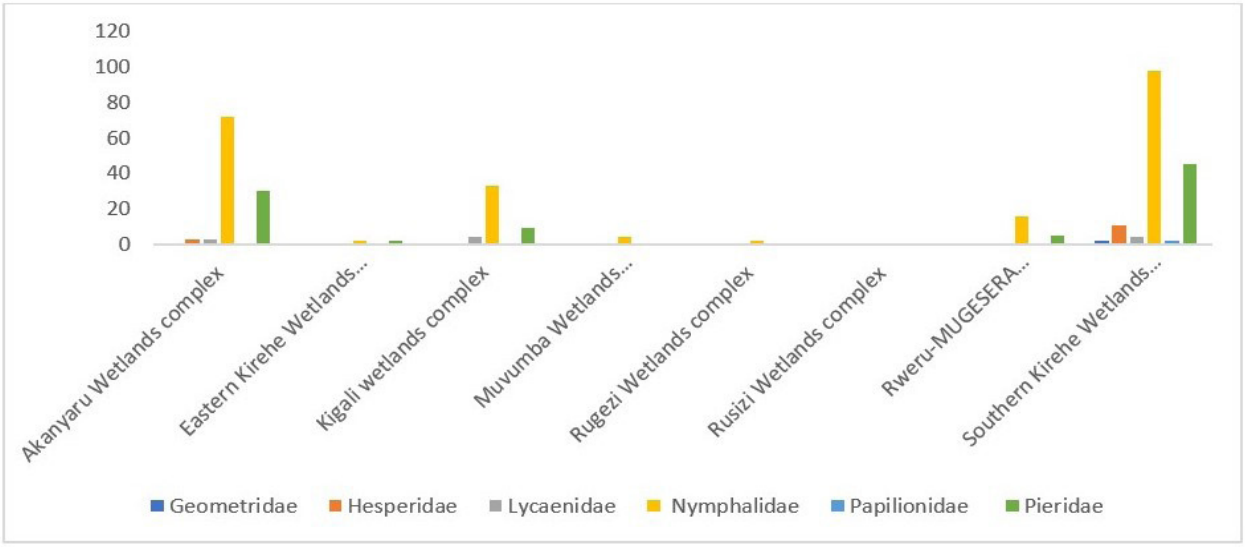

Figure 11: Abundance of butterfly species per family in different wetland complexes assessed.

Abundance of butterflies is often an indication that an ecosystem is thriving. The most populated wetlands were Southern Kirehe, Akanyaru and Kigali complex wetlands. No endemic species of butterfly was recorded. Identified butterfly species were in 6 families where the Nymphalidae family exhibited the highest abundance, highly

dominant in Akagera wetlands in southern part of Kirehe District, followed by Akanyaru north wetlands. Other families identified include Geometridae, Hespheridae, Lycaenidae, Papilionidae, and Pieridae. A total of 45 species (25.56% of all butterflies of Rwanda) were recorded. For odonatan group, 52 species were recorded with only *Parazyxomma flavicans* found in Nyandungu, Nyarutarama and Akagera wetland in the southern part of Kirehe is Endangered on IUCN red list. Others are in least concern category. They belong to 6 families Aeshnidae, Coenagrionidae, Gomphidae, Lestidae, Libellulidae, Platycnemidae where Libellulidae family was the most dominant. The Sensitivity-Based score (SBS) and Threat Based score (TBS) for each species recorded can be found in the annex 1.

Discussions

A total of 510 records from 87 species representing 6 families of butterflies were counted in studied wetlands. Similar studies found in Nepal (Subedi et al.,2021) and in Ghana (Jenber and Getu,2020). Butterflies respond quickly to environmental changes and these data can respond how particular species contend with alterations in land-use, and thus may play a valuable role in ecological monitoring (Daily and Ehrlich, 1995). Butterfly abundance varied among wetland this should have explanations taking account of variations in species compositions of the wetlands and impact of human activities or environmental stressors such as agricultural expansion and intensification, settlement expansion and pollution which according to Bonebrake et al. and Gardner et al. play significant roles in biodiversity decline.

High abundance and diversity were recorded in the southern Kirehe, which can be due to stability and availability of larval food. This result agrees with that of Sreekumar and Balakrishnan 2001a where the prevalence of butterfly species at a particular habitat depends on a wide range of factors, of which the availability food is the most important. In the butterfly diversity, out of the five butterfly families recorded, Nymphalidae was richest in terms of abundance next to Lycaenidae, the dominance of Nymphalidae can be due to the polyphagous habit that helped them to live in all habitats (Sreekumar and Balakrishanan, 2001b), which comprised the largest family of butterflies. The Pieridae were the third family in abundance. Pieridae are sun lovers seen basking in sun with wings partially open (Kehimkar, 2008), the presence of Hesperidae in most abundant families might be cause of time data were sampled, in general; their flight period is early morning hours at dawn and dusk (Kehimkar, 2008), this may result in collecting a diverse species as sometimes samples were conducted in the morning.

Lastly, Lycaenidae family which is abundant in Kigali wetlands is known to adapt to various climates and feeding on a variety of larval food plants (Kunte, 2001), this could be the reason for the dominance of Lycaenidae family as in sampled wetland we found large variety of abundant flowering plants which provides favorable habitat for the butterflies such as abundant flowering plants which provides favorable habitat for the butterflies. With odonatan, a total of 251 records from 52 species representing 6 families were counted in studied wetland complexes. As shown in appendix, recorded species have been branded according to the value of the Rwanda Dragonfly Biotic Index (RDBI), this practical tool lies in its ability to indicate sites that need priority for conservation and its biotic indices that are taxonomically and ecologically tailored at local scare (Uyizeye et al.,2021). The RDBI seeks as many facets as possible to characterize a habitat by using odonate assemblage sub-indices that reflect the status of threats to habitat; scores were distribution Based Scores (DBS); IUCN, Threat Based Scores (TBS)

and Sensitivity Based Scores (SBS) but in our case we only use SBS and IUCN/TBS because the distribution the research cited above sampled in were different with our case study. From recorded individuals, many species are Least Concern but live-in disturbed area, this explain how our wetlands are disturbed but also polluted, The only species, Parazyxomma flavicans found in Nyandungu , Nyarutarama and Kirehe is Endangered and conservation measures are needed to be taken in the said wetlands.

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15. V. Proportion of species threatened by extinction per taxa.

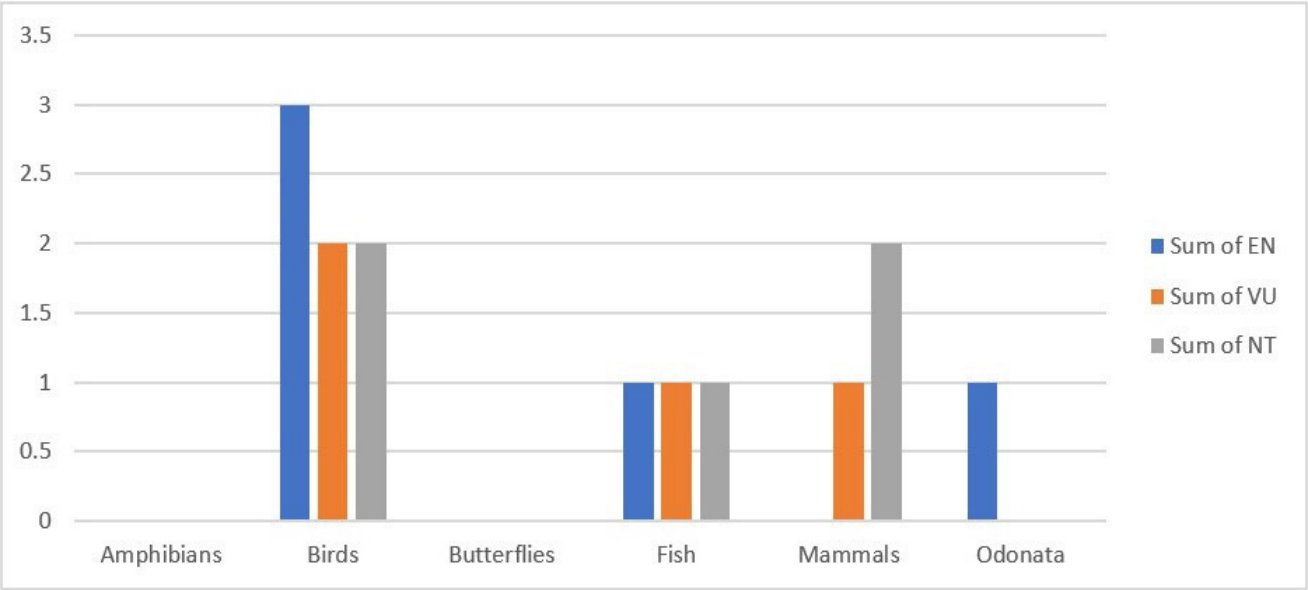

Figure 12: Number of threatened species per taxon assessed

Image: Papyrus gonolek

Summary distribution of threatened species per taxon and per wetland complex

Table 9: Distribution of threatened species per taxon in assessed wetlands

Taxon/species	IUCN Category	KGK	RWE	AKA	SKR	EKR	MUV	RGZ	RSZ
Birds									
Grauers's Swamp Warbler	EN							V	V
Grey Crowned Crane	EN	V	V	V	V	V	V	V	V
Malagasy Pond Heron	EN		V		V				
Martial Eagle	VU			V					
Marabou Stock	VU				V	V			
Shoebill	VU				V	V			
Madagascar Squacco Heron	VU		V	V	V	V			
Papyrus Gonolek	NT	V	V	V				V	
Mammals									
Hippopotamus	VU	V		V	V	V			
Congo clawless Otter	NT	V	V	V	V	V			
Spotted-necked Otter	NT	V	V	V	V	V			
Fish									
Synodontis rwandae	VU				V	V			
Haplocromis erythromaculatus	EN				V	V			
Labeobarbus ruandae	NT					V			
Amphibians									
Long Reed Frog	Endemic								V
Reptiles									
Three-Horned Chameleon	Endemic								V
Great Lakes Bush Viper	Endemic								V

KGK: Kigali wetland complex, **RWE**: Rweru-Mugesera wetland complex, **AKA**: Akanyaru wetland complex, **SKR**: Southern Kirehe wetlands, **EKR**: Eastern Kirehe wetlands, **MUV**: Muvumba wetland complex, **RGZ**: Rugezi wetland complex, **RSZ** : Rusizi wetland complex.

In general, the distribution of threatened species demonstrates that Southern and Eastern Kirehe sites in Akagera wetland complex possess the highest species richness for both mammals, birds, and fish in terms of species threatened and that need special conservation actions.

VI. Responses for wetland biodiversity conservation

A lot have been done to enhance wetland management in Rwanda, considering three main and needed actions: science and policy interface, species protection laws, environmental awareness and adaptation actions on the ground. The national biodiversity strategic action plan (NBSAP) provides about 4 targets that are aligned with wetland biodiversity conservation and protection, namely target 1, target 2, target 6 and target 8. The target 2 concerns the integration of the value of biodiversity and ecosystem services into national planning and poverty reduction strategies and into national economy. The national capital accounting recognizes the economic value of Akagera wetland complex, Rugezi wetland and currently completed economic value of Rweru-Mugesera and City of Kigali wetland complexes were captured in the 6th national state of environment and outlook report. The ecological study of the city of Kigali wetland complex informed the development

of the city of Kigali wetland master plan, and the recently developed national policy of environment and climate change considered wetland management and sustainable use. In this past decade, Rwanda has undertaken several legislative measures to enhance wetland management and sustainable utilization including but not limited to *1. Developing Wetlands Master Plan for City of Kigali (CoK) and Conservation Investment Plan, 2. Proposing 74% of wetlands to be exploited under conditional use based on Environmental Impact Assessment, 20% of wetlands to be totally protected, while 6% of wetlands can be used under certain conditions (REMA 2015, PM Order 2017);*

The Ministry of Environment has made a good progress with support from the Academia and NGOs in raising the awareness of citizens and decision makers about the importance of conserving wetlands and their biodiversity. The results are visible for emblematic species, such as gray crowned cranes (21-hectare nature reserve was set in Kigali) the endangered and yellow warbler in Rugezi wetland and Akagera National Park). The International Day of Wetlands is celebrated every year to raise the awareness of Rwandans and global community; however, much remains to be done to improve the conditions of less spectacular and/or ordinary species.

VII. Conclusion and Recommendations

A good strategy for protecting wild wetland habitants consists of having them designated as protected or used under certain conditions. The National Biodiversity Strategic Action Plan (NBSAP) targets to have 10.3 % of the national territory holding particular biodiversity and ecosystem services protected by 2020 and this includes wetlands. Particularly, the Prime Minister Order of 2017 proposes 74% of wetlands to be exploited under conditional use based on Environmental Impact Assessment, 20% of wetlands to be totally protected, while 6% of wetlands can be used under certain conditions. However, more effort is still needed especially for law enforcement and designing and funding adaptation projects for wetlands protection. Over the last decade, many efforts were invested in wetland monitoring but with little focus on biodiversity and ecosystem services. This report provides a comprehensive information on both biodiversity, ecosystem services, and ecological characters of major wetlands of Rwanda outside protected areas.

In general, natural wetland habitats are declining at an alarming rate at the expense of agriculture expansion as well as severe floods and invasive species and the issues will continue if nothing is done. Peat mining in Akanyaru wetlands in addition to intensification of chemical fertilizers use everywhere is increasing pollution of wetland waters putting in danger aquatic biodiversity especially fish species, small mammals, water birds, …

The following recommendations were drowned for improving the conservation status of wetland biodiversity:

- ✓ Given the importance of some wetlands like Rweru-Mugesera and Akagera wetland complexes, a wetland management plan and action plan are needed to guide their sustainable use.

- ✓ Wetland buffer zones demarcation and protection should consider the use of tree species that are adapted to wetland conditions, and which are both economically and ecologically important.

- ✓ Accelerate the process of protected area designation to incorporate areas recognized by the scientific community

as being important for biodiversity (IBAs, KBAs). Protection efforts need to be directed towards wetlands rich in endangered species: water courses, temporary marshes, damp grasslands, and peat bogs, including those with very small surface areas like Rweru wetlands.

- ✓ Develop and improve **monitoring and research** concerning the biodiversity of wetlands to fill the knowledge gaps that prevent better management and conservation of sites.

- ✓ Protection of catchments that feed into wetlands (non-point and point pollution)