Rwanda Wetlands Ecological Integrity Rapid Assessment Report

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Rwanda Wetlands Ecological Integrity Rapid Assessment Report

Report produced by the Albertine Rift Conservation Society (ARCOS)

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The Assessment team is presented on the page 15, they contributed much on field data collection and reporting on different taxa

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I. General Introduction

I.1 Wetlands Coverage in Rwanda

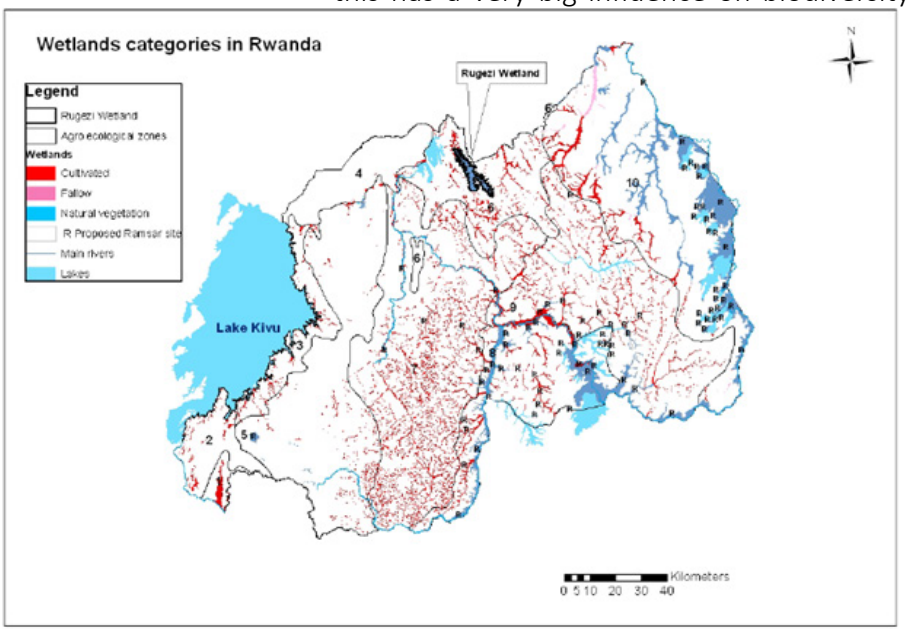
Rwanda is a small landlocked country in east-central Africa covered by a dance hydrological network of 101 lakes, 861 rivers and 860 wetlands (Singh et al. 2015). Wetlands cover a total of 10.6 per cent of Rwanda's territory, of which 53 per cent has been converted to agriculture and 41 per cent remains covered by natural vegetation. Wetlands are often referred as marshes and are some of its most threatened ecosystems (Singh et al. 2015).

The definition of a wetland as adopted by the Ramsar Convention under Article 1.1 (marine water exclused for Rwanda): "wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres."

Rwanda wetlands constitute a hydrological network subdivided into 9 main catchments: Lake Kivu, Rusizi, Nyabarongo upper, Mukungwa, Nyabarongo lower, Akanyaru, Akagera upper, Akagera lower, and Muvumba (Singh et al. 2015). They support various species of aquatic vegetation and perform multiple crucial ecosystem services including storing and purifying water, helping to control flooding by releasing water gradually to allow year-round stream flow; absorbing sediments; and helping to regulate the climate by recirculating moisture that cools the surroundings. They also contain large valuable peat deposits that help store and release water, store carbon and have energy production potential (Kabalisa, 2012).

I.1.1 Ecological Zones, Land Use and Impact on Wetlands Biodiversity in Rwanda

The Rwanda Irrigation Master Plan (2010) classifies the country's marshlands according to their altitude, as high-altitude marshes, medium-altitude marshes, and low-altitude marshes. They fall within different agro- climatic zones and this has a very big influence on biodiversity and ecosystem services distribution.



(REMA 2008-2009 cited in Nabahungu et al 2012)

Figure 1: Spatial distribution of wetland categories and proposed Ramsar sites in Rwanda, Numbers 1- 10 represent Agroclimatic zone explained in Table 1

Table 1: Wetland types in Rwanda: altitude, soil type, functions and corresponding agroclimatic zones

Wetland types	Altitude	Soil type	Vegetation	Function	Agroclimaticzon
High altitude wetlands	>1800	Histosols	Miscanthus, Violaceus, Cyperus, Latifolus, Lobelia, Ericaceae, Sphagnum Reclaimed-under crop	Water reserve, Water Source, Biodiversity reserve	Crete Z/N (5) Buberuka HL**(6) Volcanic land (4)
Mid altitude Impala wetlands	1550- 1800	Histosols	Cyperus Papyrus, Syzygium	Water reserve, Water source, filter	Impala 2
Mid altitude wetlands along lake Kivu	1400- 1500	Inceptisol, Nitosol	Cyperus, Papyrus Cyperus, Latifolius Typha	Biodiversity	Kivu Lake Border (3)
Mid altitude central plateau wetland	1400- 1800	Inceptisols	Cyperus latifolius,	Water reserve, Agriculture	Central Plateau (7)
Low altitude wetlands of Kanyaru, Nyabarongo and Akagera	12001500-	Histosols	Cyperus, papyrus Phoenix, Reclinata, Syzygium, cordatum	Water Reserve, Water source, Dam, Biodiversity	Mayaga, Bugesera(8)
Low altitude wetlands in the East	12001500	Vertisol	Typha Domingensis Polygonum pulchrum	Water reserve	Eastern Plateau (9) Eastern savannah (10)
Low altitude Wetlands of Imbo	<1000	Vertisol	Typha, Pragmites, maurritianum	Agriculture	Imbo(1)

REMA 2008-2009 cited in Nabahungu et al 2012

I.1.2 Pressure on Rwanda Wetlands

Over the last four decades, different protected areas mainly the Volcanoes National Park, Akagera National Park, Nyungwe National Park and Gishwati-Mukura Forest reserve have been degraded to the extent of reducing their size by more than 65% (Rutagrama et al 2006). This is due to high population densities near protected areas and resettlement strategy of the Government of Rwanda as well as continuous claims for agriculture land whereby more than 80% of the population depends on agriculture for their household economies (IPAR 2009, RAB 2013)[1]. Rwanda wetland ecosystems served as soft refuge for biodiversity and genetic resources. Consequently, different non-wetland animal species like Blue Monkey (Cercopithecus mitis) and different plant species like water hyacinth (Eichhornia crassipes) and giant sensitive tree (mimosa pigra) have invaded wetland ecosystems and are currently causing huge threats to native wetland species ecosystem services and people's livelihoods.

[1]http://www.institutions-africa.org/filestream/20130725-presentation-rwanda-agricultural-sector-and-its-impact-on-food-security-and-economy

In addition, the increased demographic pressures: 9.708 million in 2008 and 12.63 million in 2018 with high population densities near wetland areas because of their high agriculture production potential, and availability of water especially in the eastern part of the country, Climate change and related hazards (prolonged drought and severe floods) as well as high siltation rate coursed by erosion and unsustainable mining from mountainous zones of the country, regular fire burning of wetlands vegetation for expending agriculture land, overharvesting of wetland resources and pollution are the main threats affecting wetland biodiversity and ecological integrity.

I.1.3 Rwanda Wetlands Management and Policy Response

The increasing concern to protect wetlands from overuse led Rwanda to categorize them according to their potential for sustainable development. In 2010, the Government established a list of the country's swamps or wetlands, mapped their geographic limits and undertook to regulate their management and use. Wetlands were assigned to three types of categories according to types of prescribed use.

Figure 2: Wetland classification according to types of prescribed use. Source: (Rugege 2012 cited in Singh et al. 2015).

Specifically, The Prime Minister's Order No THE PRIME MINISTER'S 006/03 OF 30/01/2017 draws up a list of swamp lands, their characteristics and boundaries and determining modalities of their use, development and management. The National Environment and Climate change policy[2] sets forth provisions to promote sustainable management of wetlands, through 8 policy actions proposed including the development of wetland master plan and implementation strategies as well as intensification of wetland protection and restoration and rehabilitation of degraded wetlands.

[2]http://www.fonerwa.org/sites/default/files/Rwanda%20National%20Environment%20and%20Climate%20Change%20Policy%202019.pdf

II. Project Rationale and Scope

II.1. Project Rationale

The threats mentioned in the section II.1.2 above are exacerbated by unavailability of wetland biodiversity information to guide wetland management decision making in Rwanda. A little biodiversity assessments and inventories that have been conducted do not reflect the current status, pressure and responses in place, and resulting data are very scattered even missing. There is Lack of biodiversity data sharing mechanisms, and little capacity on data use to inform decision making. There is also a strong need for effective and joint planning among key institutions in wetland management, and enhance informed Environmental Impact Assessment reports, to reduce continued overexploitation, reclamation and conversion to other uses, pollution, and biodiversity loss in wetlands of Rwanda.

In this framework, the Albertine Rift Conservation Society (ARCOS Network) in partnership with Rwanda Environment Management Authority (REMA), the International Union for Conservation of Nature (IUCN)'s Forest Landscape Restoration (FRL) Hub, the Centre for Geographic Information System (CGIS) and the Centre of Excellence in Biodiversity and Natural Resources Management (CoEB) at the University of Rwanda has secured funding from the JRS Biodiversity Foundation to implementing a two years project entitled **"Using Ecological Integrity Assessment and Advanced Information to Guide Wetlands Management Decision Making in Rwanda".**

The main goal of the project is to Avail information on Rwanda's wetland biodiversity, and ecological integrity, build the capacity of key players in biodiversity information management and use to guide good decision-making.

Wetland Ecological Integrity Assessment (WEIA) refers to "an assessment approaches that measures overall wetland condition with an emphasis on the structure, composition, and function of an ecosystem in reference to a natural habitat of the region" (Lindenmayer and Franklin 2002, Young and Sanzone 2002, Faber-Langendoen et al, 2006). It provides government agencies, and key stakeholders with critical information on factors that may be degrading, maintaining or helping to restore an ecosystem, therefore supporting decision making.

II.2. Project Scope

The WEIA in Rwanda consists of four main levels: 1) The development of a framework for wetland ecological integrity assessment a step that allowed project stakeholders to describe the levels of intensity needed for data collection, 2) Application of GIS and Remote sensing to a) analyze digital wetland mapping and summarize information on wetland abundance, type, extent, and functions across the watershed, and b) assess landscape characterization of the distribution of anthropogenic stressors such as roads and land use land cover change over time in relation to wetlands., 3) **Conduct a rapid field assessment to evaluate the general condition of wetlands using a suite of easily collected and interpreted metrics**., and then, 4) Conduct a full and intensive assessments following carefully the protocol to collect detailed quantitative data and this last is considered the most accurate measure of wetland condition.

II.3. Scope of the Rapid Wetland Assessment Report

For the rapid wetland assessment, we covered 6 biodiversity groups (Plants, Birds, Fish, Algae, Butterflies, and Odonata). The current status of Rwanda wetland ecological integrity based on the State-Pressure-Response model (Burkhard et al 2008). The report presents the findings on biodiversity at both species and ecosystem levels, characterization of wetlands importance at local, national, and international levels, discusses the findings and finally provides conclusions and recommendations to inform and guide the management of wetlands in Rwanda

II.4. Assessment Sites and Methodology

II.4.1 Assessment Sites

ARCOS and partners have had a 6 months (June-December 2018) planning phase through which they agreed to conduct a rapid wetland assessment in different wetlands focusing on 8 major wetland complexes namely (1) City of Kigali Wetland Complex, 2) Rweru-Mugesera Wetlands Complex,3) Akanyaru Wetlands Complex, 4) Muvumba Wetlands Complex, 5) Southern Kirehe Wetlands Complex 6) Eastern Kirehe Wetlands Complex, 7) Rugezi Wetlands Complex, and 8) Rusizi Wetlands Complex) as illustrated in the figure below:

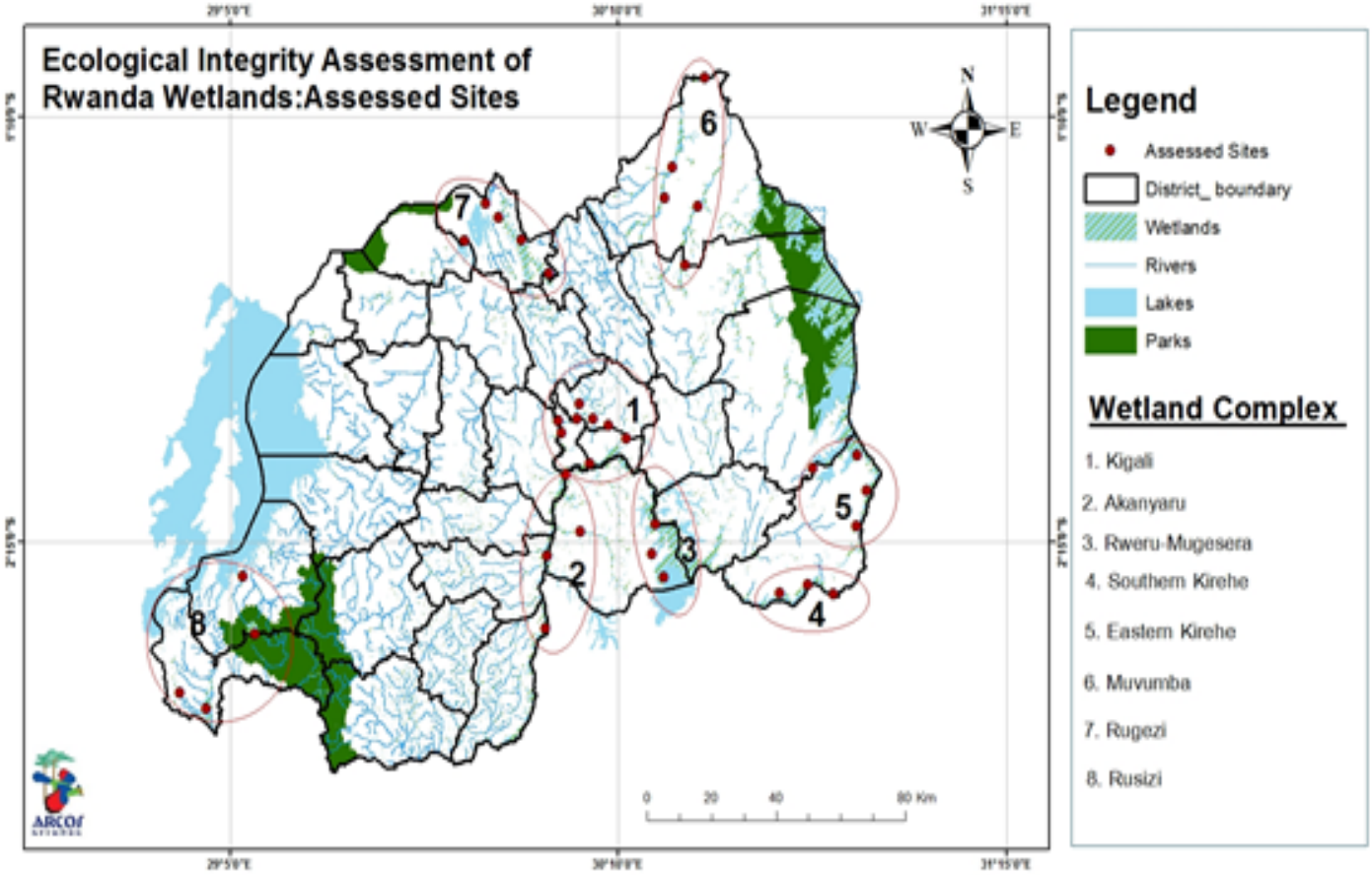


Figure 3: Wetland complexes in Rwanda Assessed for Ecological Integrity status

In each wetland complex, different team (taxa) have visited different wetlands to assess the status of ecological integrity by collecting data classified in three categories (Hydrology, Biota and landscape setting). The Framework for Wetland Ecological Integrity Assessment in Rwanda[3] was designed as a Biodiversity centered approach as the target is to use biodiversity information to inform wetland decision making and 16 indicators were measured. considered also the services provided as well as social economic benefits for the community within and around the ecosystem using the ILAM framework[4]

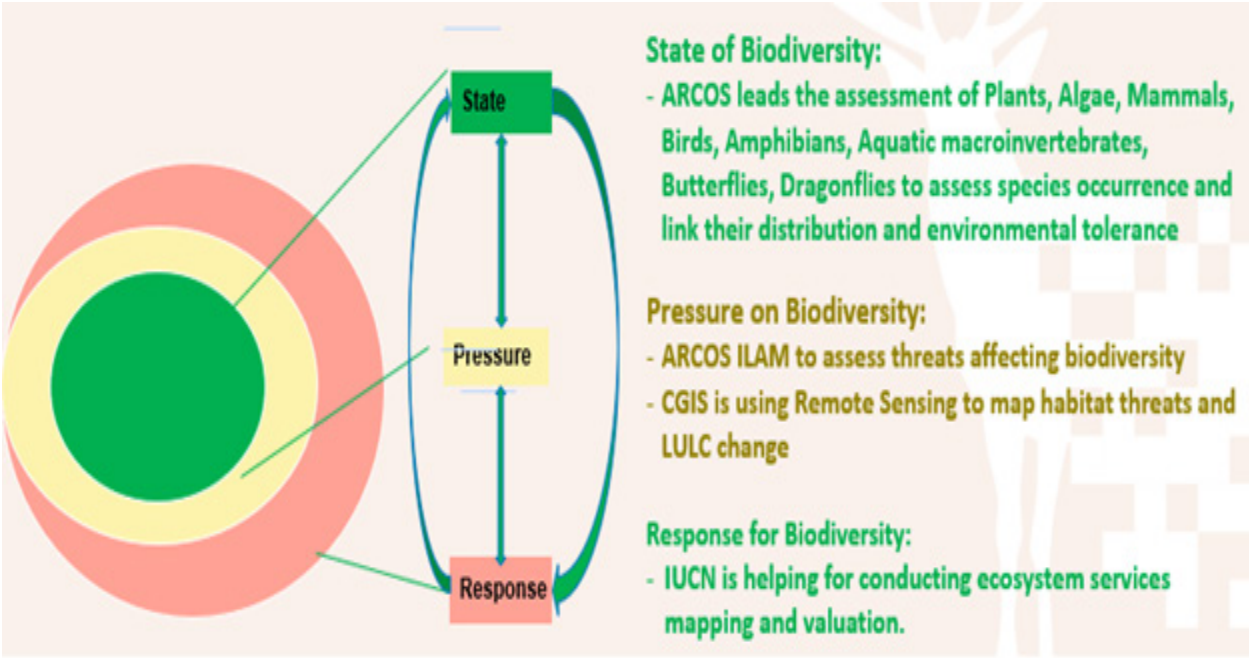


Figure 4: Design of the Framework for Rwanda wetland ecological integrity assessment

II.4.2 Assessment Team

A multidisciplinary team of experts in different domains was selected and facilitated to conduct the rapid assessment. The team formation based on expertise of people in different domains ranging from Biodiversity and Ecology, Ecosystem services mapping and valuation, GIS and Remote Sensing. The table below presents the members of the team their institutions, and responsibilities.

[3]Kubwimana J, Kanyamibwa S (2019): A Framework for Wetlands' Ecological Integrity Assessment in Rwanda. Biodiversity Information Science and Standards 3: e37918. https://doi.org/10.3897/biss.3.37918

[4]Gashakamba F (2018): Integrated Landscape Assessment and Monitoring (ILAM): A cost-effective approach towards informed decision-making for natural resources management. Biodiversity Information. Science and Standards 2: e26304. https://doi.org/10.3897/biss.2.26304

Table 2: Rapid Wetland Assessment Team Composition

No	Domain	Names	Institution	Role
1	GIS and Remote Sensing	Dr Elias Nyandwi	CGIS	Team leader
		Janvier Hitimana	ARCOS Network	Team member
2	Biodiversity and Ecology			
	Birds	Dr Sam Kanyamibwa	ARCOS Network	Team leader
		Martin Sindikubwabo	ARCOS Network	Team member
		Micomyiza Gilbert	ACNR	Team member
3	Plants	Uwitonze Narcisse	Master Student	Team leader
		Nyirambangutse Brigitte	GGGI	Team member
4	Fish	Rashid Mwimba	UR	Team leader
		Theodore Nshimyumuremyi	Student	Team member
5	Macroinvertebrates	Kubwimana Jean Paul	ARCOS Network	Team leader
		Christella Suavis Iradukuna	Nature Rwanda	Team member
		Umurungi Yvette	REMA	Team member
6	Algae	Nzarora Alphonse	UR	Team member
		Bertrand Uwimana	IPRC Kitabi	Team leader

III. Key Findings from the Rapid Wetland Ecological Integrity Assessment

III.1 Status of Rwanda Wetlands main Landcover Types in 2008 and 2018 Mapping

III.1.1 Introduction

The team has documented the status of wetlands landscape setting referring to to the National Wetlands Inventory of 2008 as baseline. The inventory documented-860 Swamps (278 536 ha)-10.5% of Rwanda area with 41% covered by natural vegetation, 53% covered by fields (148 344 ha), and 6% fallows (Jachères). 101 Lakes covering 149 487 ha and 861 Rivers covering 6 462 km. The mapping has also referred to the Rwanda's Wetlands Classification of 2011 (38 Swamps – 56 120 ha proposed for full Protection (20%), 475 Swamps – 206 732 ha proposed for exploitation under condition (74%) including: 182 Swamps covering 145 768 ha which are shared by several Districts; 365 Cultivated Swamps of > 100 ha covering 184 032 ha; with 130 873 ha cultivated and 347 Swamps covering 15 689 ha proposed for exploitation under a basic EIA (6%).

III.1.2 Methodology

The team has cleaned and conducted the topographical check-up of wetland boundaries and reestablished their characteristics according to four main cover type (Water body, natural vegetation, cropland and fallows) using the ortho-photographs (from the latest aerial mission in Rwanda) as background and layer of wetland in 2008. For the 2018 status the same exercise was done using data from different sources. Although the wish was to use data of similar resolution. The main source of data was cloud free Landsat-8 (optical, 30m) available for the period between 2016 – 2019. The output map readily available with Ministry of Environment (MoE/Water for Growth, June 2018), was cross-validated using UAV photos of 2019 for large part of City of Kigali wetlands, google earth and sporadic ground truth points generated from various CGIS projects during the period 2016 – 2019.

III.1.3 Land Cover Change Detection Between 2008 and 2018

Change detection helped to evaluate the pattern of wetland cover change and processes during last decade. Using both Land cover map under overlay function of spatial analyst tool from ArcMap 10.6, the change was detected, and result are well summarized table of wetland LCLU between 2008 and 2018

III.1.3.1 Classification Outputs

using different digitalization tools (create polygon, cut polygon, reshape….) Wetland cover map of 2008 was created. The four classes are distributed as summarized in table 3 bellow and detailed per district in of annex 1

Table 3: Summary of statistics of Rwandan Wetland cover in 2008

Cover type	Area (ha)	Proportion (%)
Agriculture	73,068	41.63
Natural Vegetation	88,848	50.62
Water Body	3,829	2.18
Others	9,787	5.58
TOTAL	**175,532**	**100**

The class called "others" is comprising all covers types which are not easily identifiable and would not be able to check from the ground since the ortho-photos shows the situation of 2008. The layer of wetlands, in GIS format, with new attribute of cover types is also submitted separately

III.1.3.2 Wetland Land Cover/Use Map of 2018

As explained under section the map comes from classified Landsat -8 images with similar cover types as in 2008 to easy to comparison. Wetland cover types are summarized with Table 3 bellow.

Table 4: Summary of statistics of Rwandan Wetland cover in 2018

Cover type	Area (ha)	Proportion (%)
Agriculture	68,131	39
Natural Vegetation	77,024	44
Water Body	10,802	6
Others	19,574	11
TOTAL	**175,532**	**100**

III.1.3.3 Wetland Cover/Use Changes Between 2008 and 2018

Both LCLU maps show big change of all covers which is surprising for cropped wetland, there is a slight decrease instead of increasing. Water body also has increased, with 6% decrease of natural vegetation. Other uses or undefined uses (which need collection of field data) almost doubled during last ten years. The table below summarizes the status of wetland LULC change and shows that in some districts wetland cover types either have increased (green colour) or decreased (red colour) over the last 10 years.

Wetlands cover types during last ten years (situation of 2008 and 2018) has known a lot of changes due to human activities, especially irrigation and food security measures with increased rice paddy accompanied by water dams' construction. But the situation was not very alarming compare to people's perceptions on wetland reclamation during last two decades. Reason why, evaluating wetland covers change using different RS data, should be considered with caution, although it provides a general trend which reflect the reality. Therefore, the way forward is to revisit the wetland cover map of 2018 after acquiring access to worldview imagery (request is being submitted to National Institute of Statistics of Rwanda (NISR). Also, geographical coordinates collected by our research team will be used for accuracy assessment of 2018/9 situation and this will be important to produce the Land Use Land Cover status mainly in five wetland complexes selected for the full assessment.

Table 5: Status of Rwanda wetland Land Use Land Cover change over the last 10 years (2008 and 2018)

Land Cover Type Province and District	Cropland		Natural Vegetation		Water Body		Other		
	Coverage (ha)	Coverage (%)	Coverage (ha)	Coverage (%)	Coverage (ha)	Coverage (%)	Coverage (ha)	Coverage (%)	Total (Ha)
Kigali City									
Nyarugenge District	-715.7	-57.0	344.1	55.8	-30.8	-16.9	406.4	740.6	4.0
Kicukiro District	-664.3	-61.0	251.9	17.2	14.6	17.2	402.0	170.7	4.2
Gasabo District	-745.9	-28.8	-8.7	-9.1	26.2	86.0	735.2	591.7	6.9
Sub-Total Kigali	**-2,125.9**	**-43.1**	**587.2**	**27.0**	**10.1**	**3.4**	**1,543.7**	**372.3**	**15.1**
Northern Province									
Burera District	-732.1	-45.8	-101.7	-1.8	-2.8	-9.2	850.0	3,949.5	13.4
Gakenke District	-477.0	-31.0	-21.8	-50.0	-29.7	-11.6	533.5	982.7	5.1
Gicumbi District	-284.5	-8.7	-105.9	-16.8	17.6	52.7	379.4	178.5	6.5
Musanze District	-309.3	-42.5	-24.5	-55.3	53.4	1,139.8	281.6	620.5	1.2
Rulindo District	-293.8	-9.4	-184.3	-91.5	0.0	0.0	484.4	325.6	6.3
Sub-Total North	**-2,096.7**	**-20.4**	**-438.2**	**-6.5**	**38.5**	**10.0**	**2,528.9**	**524.1**	**32.4**
Western Province									
Karongi District	-368.6	-38.1	25.1	162.9	99.2	228.7	244.5	931.2	0.2
Ngororero District	-269.3	-35.0	-60.9	-100.0	85.4	46.1	244.5	681.4	-0.2
Nyabihu District	-156.2	-26.0	-19.6	-5.8	124.9	160.4	50.7	63.2	-0.2
Nyamasheke District	-934.7	-49.9	-178.5	-21.4	104.5	3,271.1	1,005.5	4,230.4	-3.2
Rubavu District	-139.0	-29.6	-0.4	-100.0	-4.5	-100.0	143.7	143.7	-0.3
Rusizi District	-1,416.0	-45.2	312.1	170.9	48.9	3,697.0	1,056.4	2,988.3	1.5
Karongi District	-302.0	-45.7	-40.7	-100.0	45.4	1,891.3	296.3	835.8	-1.0
Sub-Total West	**-3,585.8**	**-42.3**	**37.1**	**2.5**	**503.9**	**158.4**	**3,041.6**	**1,283.8**	**-3.2**
Eastern Province									
Bugesera	-2,062.9	-62.9	-2,245.9	-14.1	1,156.4	57.0	3,202.8	2,281.7	50.5
Gatsibo	671.2	19.8	-2,293.3	-17.6	607.6	1,098.5	1,067.6	111.5	53.1
Kayonza	-611.9	-24.4	-3,628.0	-18.9	1,306.2	1,623.7	3,080.7	963.5	147.1
Kirehe	-269.2	-26.7	-982.7	-8.7	416.7	287.6	1,239.5	1,239.5	404.4
Ngoma	-627.7	-39.2	-1,580.3	-19.1	318.1	767.5	1,989.3	28,046.8	99.5
Nyagatare	3,522.7	132.3	-1,199.8	-14.6	521.0	521.0	-2,570.2	-50.7	273.8
Bugesera	-972.2	-38.9	-44.6	-6.2	1,026.3	4,640.2	880.9	880.9	890.5
Sub-Total East	**-349.9**	**-2.1**	**-11,974.5**	**-15.6**	**5,352.5**	**225.6**	**8,890.7**	**137.0**	**1,918.9**
Southern Province									
Gisagara	-4,794.9	-52.7	1,000.7	1,184.6	45.5	61.0	3,685.5	172,596.3	-63.2
Huye	-1,151.5	-26.8	0.0	0.0	-43.7	-33.8	1,203.3	455.3	8.1
Kamonyi	-424.1	-16.1	494.8	35.2	202.3	202.3	-263.7	-27.9	9.3
Muhanga	-369.2	-19.3	0.0	0.0	214.6	1,106.7	163.6	25.5	9.0
Nyamagabe	-338.7	-20.1	-45.4	-100.0	-98.9	-77.3	482.4	7,091.5	-0.6
Nyanza	-1,883.3	-34.5	400.8	244.4	630.4	1,825.5	861.0	1,060.5	8.9
Nyaruguru	-1,048.0	-26.7	-98.8	-100.0	23.0	58.2	1,127.2	1,902.4	3.3
Ruhango	-859.0	-25.0	157.6	10,791.5	94.7	295.2	614.0	374.7	7.3
Sub-Total South	**-10,868.9**	**-33.5**	**1,909.7**	**106.1**	**1,067.9**	**233.5**	**7,873.4**	**364.0**	**-17.9**
Overall Total	**-19,027.2**	**-26.0**	**-9,878.7**	**-11.1**	**6,972.8**	**182.1**	**23,878.3**	**244.0**	**1,945.2**

III.2 Biodiversity Status

IV.2.1 Plants

IV.2.1.1 Methodology

For the rapid assessment, we spent 2 days for each site, and site have different number of sampling spots based on the size of the wetland covered for each site. After reaching on the wetland, we identified the sampling spot no1, we wrote down the GPS point, and start recording every plant species available by looking in all angles of the wetlands. We did not make a plot for demonstrating the distribution of each plant species, we will do it for intensive assessment where we will be having enough time to sample in plots. Once finished to record the plants species available, we move along the wetland to reach other sampling spot, it happened that we get other new plant species along the way, we ensured that we collected it too for maximizing the sampling effort to get all wetland plant species (opportunistic sampling) in short time available. For the plants, we did not able to identify immediately on the field, the team took pictures for further identification with other botanist experts.

III.2.1.2 Distribution and Abundance of Plant Species by Family

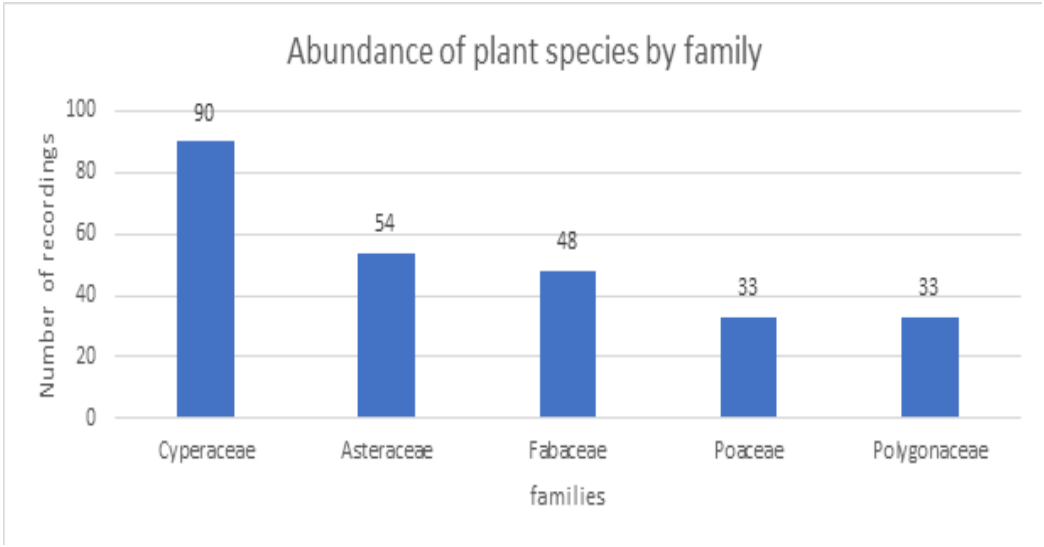


Figure 5: Abundance of plant species by family within sampled wetland complexes

A total of 492 georeferenced records with 127 different plant species classified into 51 families was identified. Polygonum senegalens was frequently found in sampling spots (25), followed by Cyperus latifolius (24), Cyperus papyrus (18), Juncus oxycarpus (14) and Leonitisneputifolia(14),andIpomoeainvolucrata(11).

4 invasive wetlands plant species were recorded including Eichornia crassipes, 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

We were able to find out that most of the wetland databased have been cleared for agriculture with very small wetlands remained as pristine areas. For restoring those wetlands, there are some which require replanting with some wetland plant species, whereas others can exhibit self-restoration. We identified too the higher level of the invasiveness whereby most of the wetlands visited showed at least one Invasive Alien species. For some wetlands, we found higher level of industrial pollution and house hold wastes including plastic bottles.

Key recommendation from the plant team

Be selective while selecting the plant species to grow for wetland restoration or for buffer zone making. Instead of using bamboo for river banks, it is much better to use the following: Hallea ribulo stipulata, Erythrina abyssinica, Euphorbia trucalli, Euphorbia candelabrum, Acacia sp. It is very important to use our native species for enhancing even other diversity to coexist, otherwise we will be losing many other associated species like birds and small pollinators, due to the introduction of exotic plants.

III.2.2 Birds

III.2.2.1 Introduction

Different authors (Block et al 1984, Morrison 1986, Croonquist and Brooks 1991) have demonstrated how bird communities are good indicators of ecosystem health for instance they indicate ecological conditions, including water quality, productivity, vegetation structure and composition, and landscape integrity (Adamus et al. 2001). Therefore, bird community has been determined as an effective tool for the wetland assessment (Noson and Hutto 2005).

III.2.2.2 Methodology

For the rapid assessment, bird species were recorded using stratified random sampling method. This has allowed the team to cover or reach different types of the habitat in the sampled wetland complexes. Opportunistically, all birds heard or seen were recorded and a GPS way point was taken to georeferenced the record and produce the checklists of birds in the specific wetland complex (Cohen& Crabtree 2006). Additional information like dominant plant species, threats to the habitat, hydrology and on ground interventions to restore the habitant was recorded and was used to describe wetland characterization and importance. We took photos of the ecosystem and any bird accoutered for subsequent identification. Recorded data was treated in excel to deduct statistical information on the status of bird species and ecological integrity of the assessed sites.

III.2.2.3 Distribution of Bird Species

Table 6: Summary on bird species distribution and their conservation status on IUCN red list

Wetland complex	No of Records	No of Species	Families	No of Endemic sp	IUCN Status		
					EN.	Vu.	N T
1 City of Kigali	222	97	43	0	0	1	1
2 Rweru-Mugesera	94	64	33	0	0	1	1
3 Southern Kirehe	115	66	32	0	0	1	1
4 Eastern Kirehe	57	42	26	0	0	0	1
5 Akanyaru	85	58	28	0	0	0	1
6 Rugezi	73	52	31	1	1	1	0
7 Rusizi	50	46	27	9	1	0	0
8 Muvumba	32	29	21	0	0	1	0

Overall, there was 721 georeferenced records of birds with 175 species from 56 families corresponding to 17,5% of all birds of Rwanda were recorded during this assessment. The highest number of species was recorded within Kigali wetlands complex (97 species from 43 families), followed by Southern Kirehe (66 species from 32 families) and Rweru-Mugesera wetlands complex (64 species from 33 families) while the lowest number was recorded within Muvumba wetlands complex.

It is important to note that 10 species are endemic to the Albertine Rift region with 2 endangered (Grauer's Swamp Warbler: Bradypterus graueri and Grey Crowned Crane: Balearica regulorum), 1 nearly threatened (Papyrus Gonolek: Laniarius mufumbiri), and above all, 31 species (17.7%) of all recorded bird species are water birds. Water birds depend very much to wetland for survival and are known as indicators of the quality of certain types of wetlands (Wetlands International 2010).

Table 7: The list of water bird species recorded from all 8 wetland complexes

Family	Common names	Scientific name	Endemic	IUCN
Anatidae	Spur-winged Goose	*Plectropterus gambensis*	NO	LC
Anatidae	White-faced Whistling-Duck	*Dendrocygna viduata*	NO	LC
Anatidae	Yellow Billed Duck	*Anas undulata*	NO	LC
Ardeidae	Black Heron	*Egretta ardesiaca*	NO	LC
Ardeidae	Black-headed Heron	*Ardea melanocephala*	NO	LC
Ardeidae	Cattle Egret	Bubulcus ibis	NO	LC
Ardeidae	Grey Heron	*Ardea cinerea*	NO	LC
Ardeidae	Intermediate Egret	*Mesophoyx intermedia*	NO	LC
Ardeidae	Little Egret	*Egretta garzetta*	NO	LC
Ardeidae	Purple Heron	*Ardea purpurea*	NO	LC
Charadriidae	Long-toed Lapwing	*Vanellus crassirostris*	NO	LC
Charadriidae	Spur-winged Lapwing	*Vanellus spinosus*	NO	LC
Charadriidae	Three-banded plover	*Charadrius tricollaris*	NO	LC
Charadriidae	Wattled Lapwing	*Vanellus senegallus*	NO	LC
Ciconiidae	African Openbill	*Anastomus lamelligerus*	NO	LC
Ciconiidae	Marabou Stork	*Leptoptilos crumeniferus*	NO	LC
Ciconiidae	Opened-billed Stork	*Mycteria ibis*	NO	LC
Ciconiidae	Yellow-billed Stock	*Mycteria ibis*	NO	LC
Gruidae	Grey Crowned Crane	Balearica regulorum	NO	LC
Jacanidae	African Jacana	*Actophilornis africanus*	NO	LC
Pelecanidae	Great White Pelican	*Pelecanus onocrotalus*	NO	LC
Pelecanidae	Pink-backed Pelican	*Pelecanus rufescens*	NO	LC
Phalacrocoracidae	Long tailed Cormorant	*Phalacrocorax africanus*	NO	LC
Rallidae	Black crake	*Amaurornis flavirostris*	NO	LC
Rallidae	Eurasian Moorhen	*Gallinula chloropus*	NO	LC
Rallidae	Lesser Moorhen	*Gallinula angulata*	NO	LC
Rallidae	Red-knobbed Coot	*Fulica cristata*	NO	LC
Scopidae	Hamerkop	*Scopus umbretta*	NO	LC
Threskiornithidae	Hadada Ibis	*Bostrychia hagedash*	NO	LC
Threskiornithidae	Sacred ibis	*Threskiornis aethiopica*	NO	LC

III.2.2.4 Water Bird Species Richness per Assessed Wetland Complex

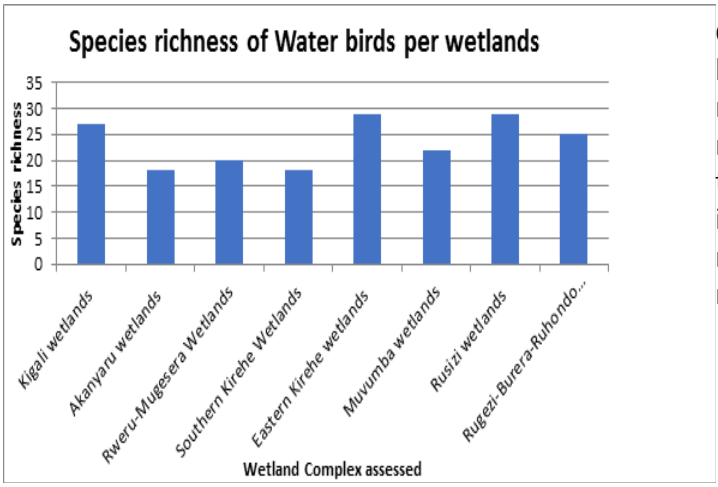


Figure 6:water bird species richness per assessed wetland complex

Overall, the eastern Kirehe, Rusizi and City of Kigali wetlands exhibited the highest water bird species richness followed by Rugezi, Muvumba and Rweru Mugesera wetlands respectively. It is important to conduct a deep study to understand ecological implications associated with this status as the dynamics of water bird populations depends on surrounding wetland environment (Rehan et al 2018).

III.2.2.5 Summary of the Status of Bird Species in Sampled Wetland Areas

Table 8: Summarised information on bird species status-pressure and responses

Status	Pressures	Responses in place	Recommendations
· 175 species of birds with 31 water birds recorded.	· Habitat fragmentation and burning natural vegetation for agriculture land expansion (case of Ruliba site in Kigali Gashora wetland in Rweru-Mugesera, Gaharwa and Amasangano sites in Akanyaru wetlands).	· National burning of single use plastic bottles in Rwanda should benefit specifically the city of Kigali wetlands.	· Enhance the restoration of the papyrus vegetation within and around Rweru-Mugesera and Akanyaru wetland to enhance the conservation of critical species like Papyrus gonolek and Barearica regulorum
· A good buffer zone around Rweru lake but cultivated during the dry season	· Damping industrial wests including plastic bottles in wetlands (case of rwezangoro site in City of Kigali wetlands).	· Relocation of industries and other settlement from wetlands in the city of Kigali wetlands	· Enhance law enforcement to stop regular burning of papyrus for agriculture
· NT species (Papyrus gonolek) recorded in Rweru-Mugesera and Akanyaru)	· Peat mining and agriculture intensification in Gisagara, Gishoma, and Rwabusoro Sites of Akanyaru)	· Development of the City of Kigali wetland master plan	· Rehabilitate the normal path of the Akagera river and stop its flow to Rweru lake
· Remaining important sites include Nzove, Nyarutarama pond, Kitaguzirwa and Nyandungu sites in city of Kigali	· Sand mining in Nyakerera – rusumo site of Southern Kirehe	· Special attention to conserve and restore the population of the Gray Crown Crane	· Gazztement of Rweru-mugesera as a ramsar site for its habitat to benefit from regal protection
· Southern and eastern Kirehe wetlands, Rugezi as a control site	· Clay extraction and bricks making in most of the sites.	· Demarcation and establishment of buffer zone in some of the wetlands	
· Cyohoha site in Akanyaru	· Buffer zones made of bamboo in Gaharwa-Cyohoha site of Akanyaru and along nyabarongo river		
	· Agriculture activities in different buffer zones		
	· Prolonged drought in Rweru and diversion of Akagera river into Rweru lake		
	· Erosion and siltation into Nyabarongo and Akanyaru river.		
	· Large areas open for sugar cane plantation (Case of Nyabarongo amont and aval)		
	· Use of exotic species in buffer zones and city beautification and overspread of water hyacinth in the entire Akanyaru wetlands ecosystem		

III.2.3 Fish

III.2.3.1 Introduction

In Rwanda, the ichthyological fauna is not much diversified owing to the youth of lakes and the existence of natural obstacles (falls) which 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. 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 (Devos L et al., 2001).

III.2.3.2 Methodology

The sampling was based on visits conducted on various fishing sites, direct identification of fish collected by fishermen, and interviews to local fishermen. Interview questions focused on daily fish capture, fishing devices used and fruitfully fishing seasons. Fish identification and classification was done using the field guide (Check list of fishes of Rwanda by Luc Devos et al 2001) It involved examining the color pattern, morphology, lateral lines, fins and mouth, and character of the teeth and scales. We took photos of all species captured and samples of unidentified fish species conserved in a solution of formaldehyde for subsequent identification in the laboratory of University of Rwanda. A total of 26 fish species distributed in 9 families were recorded from all 8 assessed wetland complexes from January to June 2019.

Photos of some fish species identified

III.2.3.3 Distribution of Fish Species in Different Assessed Sites

Table 9: List of fish species recorded from assessed Wetlands complexes during the rapid assessment

Family	Species name	IUCN status	Occurrence in the wetlands 'complex							
			City of Kigali	Rweru-Mugesera	South-Kirehe	East-Kirehe	Akanyaru	Rugezi	Rusizi	Muvumba
Protopteridae	Protopterus aethiopicus	LC	R	R	R	R	R	R	NR	NR
Cyprinidae	Cyprinus carpio	LC	NR	R	NR	R	R	NR	NR	NR
	Barbus cercops	LC	R	R	NR	R	NR	NR	NR	NR
	Barbus apleurogramma	LC	R	NR	NR	NR	NR	NR	NR	NR
	Labeo victorianus	LC	NR	NR	R	R	NR	NR	NR	NR
	Varicorhinus ruandae	LC	NR	NR	NR	R	NR	NR	NR	NR
	Ctenophary-ngodon idellus	LC	NR	NR	NR	R	NR	NR	NR	NR
Cichlidae	Oreochromis niloticus	LC	R	R	R	R	R	R	NR	NR
	Tilapia rendalli	LC	NR	R	R	NR	R	NR	NR	NR
	Haplochromis vittatus	LC	R	R	NR	NR	NR	NR	R	NR
	Haplochromis crebidens	LC	R	R	NR	NR	R	NR	R	NR
	Haplochromis insidiae	LC	R	NR	NR	NR	R	NR	R	NR
	Haplochromis kamiranzovu	LC	NR	NR	NR	NR	NR	NR	R	NR
	Haplochromis erythromaculatus	EN	R	NR	NR	R	NR	R	NR	NR
	Haplochromis burtoni	LC	NR	NR	R	R	NR	NR	NR	NR
	Pseudocrenilabrus multicolor	LC	R	R	R	NR	R	NR	NR	NR
Clariidae	Clarias gariepinus	LC	R	R	R	R	R	NR	NR	NR
	Clarias liocephalus	LC	R	R	R	R	R	NR	NR	NR
Aplocheilich thyidae	Aplocheilichthys centralis	LC	R	R	NR	NR	R	R	R	R
Schilbeidae	Shilbe intermedius	LC	R	R	R	R	R	NR	NR	NR
Mochokidae	Synondontis ruandae	EN	NR	NR	NR	R	NR	NR	NR	NR
Bagridae	Bagrus docmac	LC	NR	NR	NR	R	NR	NR	NR	NR
Mormyridae	Gnathonemus longibarbis	LC	NR	NR	NR	R	NR	NR	NR	NR
	Petrocephalus catostoma	LC	NR	NR	NR	R	NR	NR	NR	NR
	Pollimyrus nigricans	LC	NR	NR	NR	R	NR	NR	NR	NR
	Marcusenius victoriae	LC	NR	NR	NR	R	NR	NR	NR	NR
			13	12	9	18	11	4	5	1

Keys: R: Recorded.

NR: Not Recorded.

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

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.

III.2.3.3 Fish Species Abundance and Richness

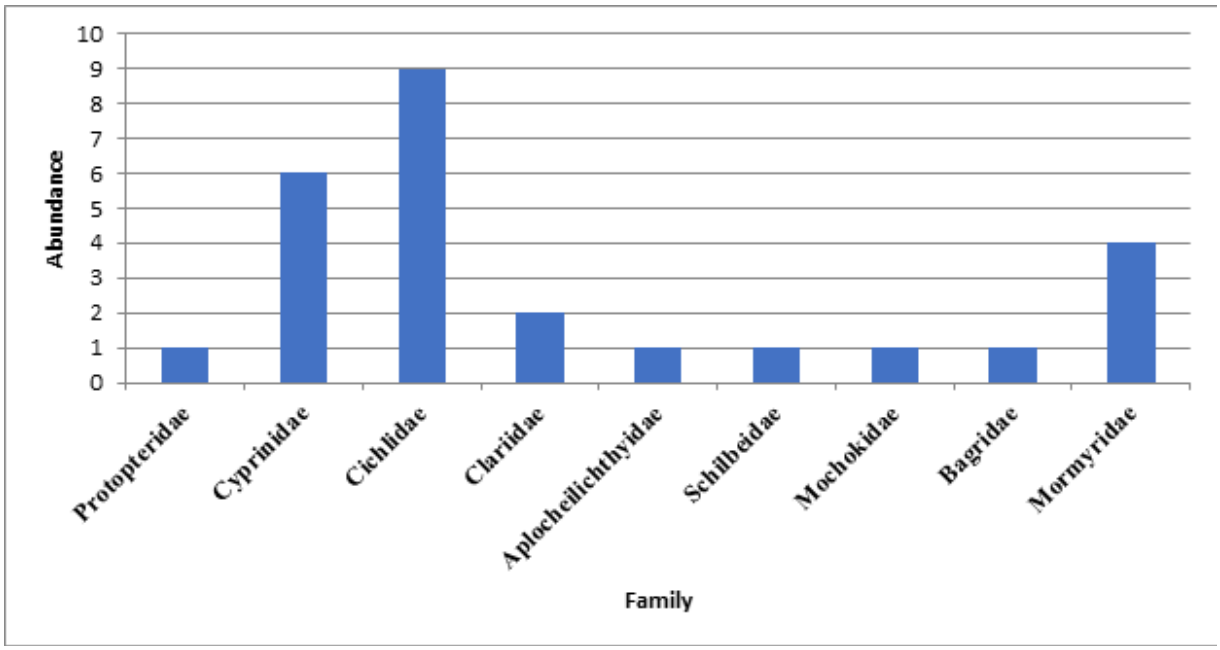


Figure 7: Abundance of fish species identified by family from all 8 wetland complexes

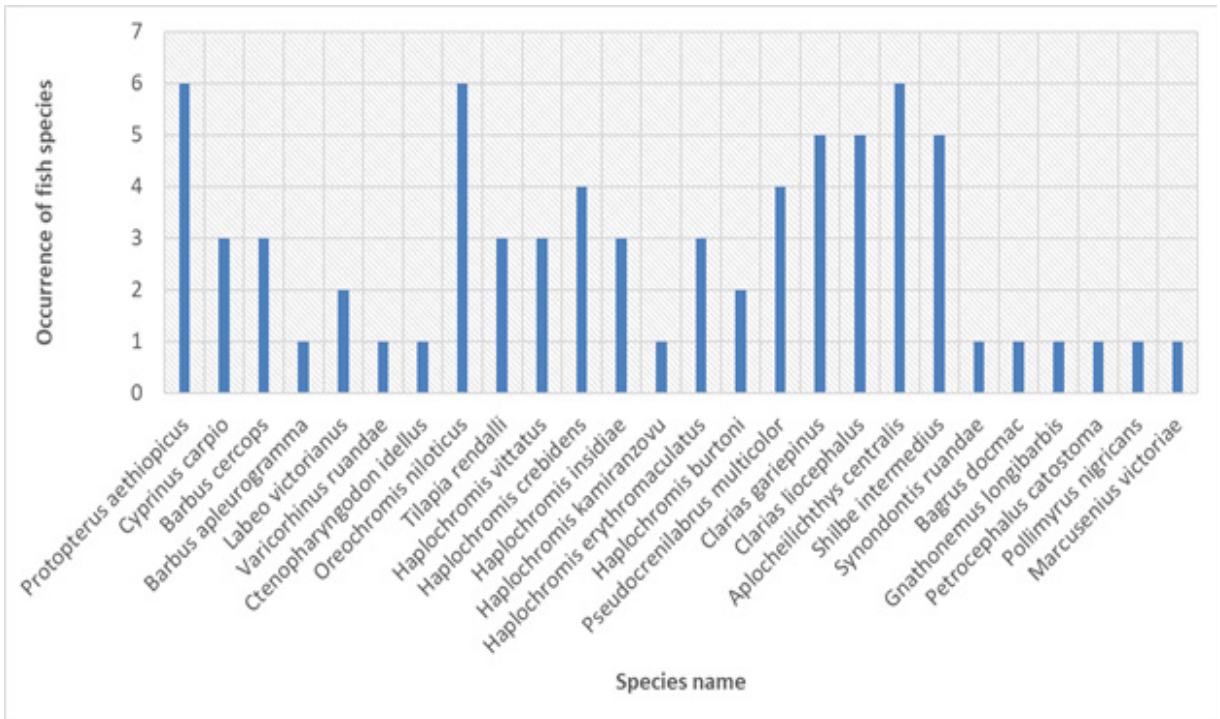


Figure 8: Occurrence of fish species recorded from all 8 wetland complexes

Protopterus aetiopicus, Oreocchromis niloticus, and Aplocheilichthys centralis were highly recorded within six over eight wetland complexes followed by Clarias gariepinus, Clarias liocephalus and Shilbe intermedius that were highly recorded in five over eight assessed wetland complexes.

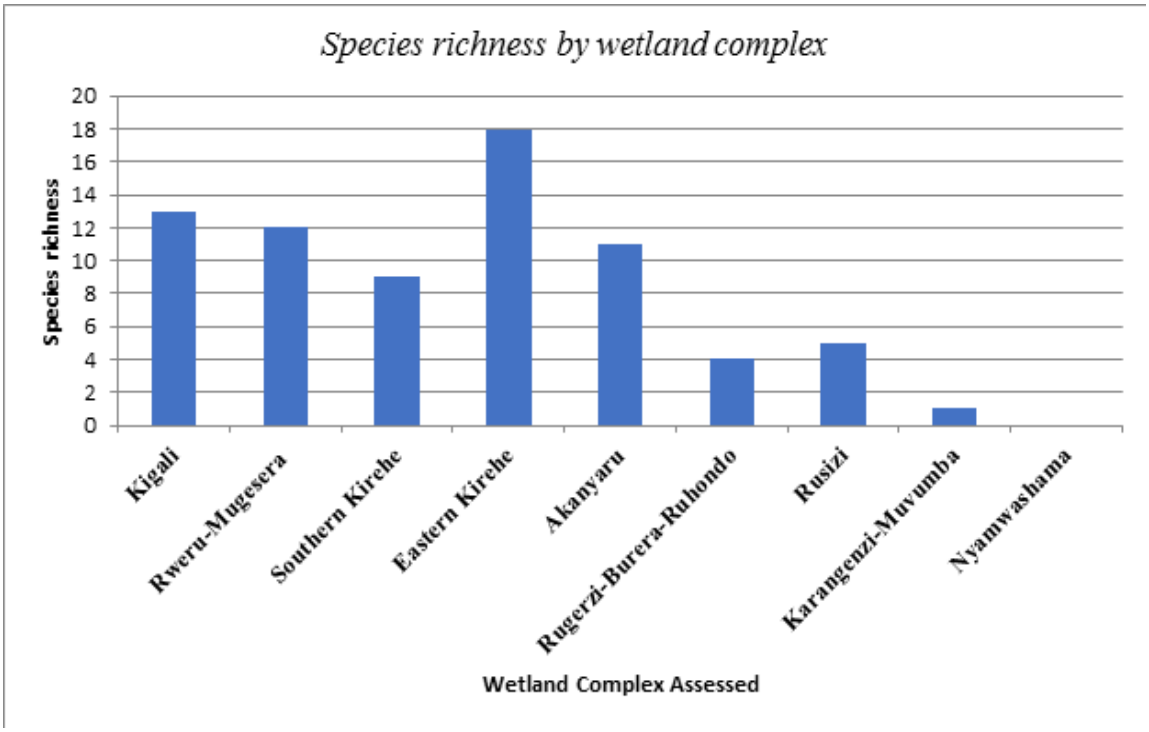


Figure 9: Abundance of fish species recorded by wetland complex

The Eastern Kirehe wetland complex exhibited a high species richness (18 fish species over 26 fish species recorded from all 8 wetlands complexes hence representing 70%. Specifically, it is in this wetland complex that Haplocromis erythromaculatus and Synodontis rwandae, the two fish species classified as endangered on the IUCN red list were recorded. This shows the importance of this ecosystem and its possible connectivity to the entire hydrological system of Rwanda as they were first identified from the northern part of the country

III.2.3.4 Estimated Total Fish Capture

The fish capture varied largely form an area to another. It is significantly higher in wetlands with wide open waters such as around rivers, lakes and natural ponds. The average value being: 150-200kg/day per wetland complex assessed for wetlands with large open water, and 10-20kg/day per wetland complex assessed on wetlands without large open waters. According to local fishermen, the total fish capture varies depending on th seasons of the year whereby the capture increases considerably during the rain season and decrease during the dry season.

The main captured species are: Nile Tilapia (Oreochromis niloticus) sold at 1200-1500Rwf/kg, African catfish (Clarias gariepinus) sold at 700-1000Rwf/kg and African lungfish (Protopterus aethiopicus) sold at 600-800Rwf/kg

IV.2.3.5 Summary of the Status of Fish Diversity in Sampled Areas

Table 10: Summarised information on bird species pressures-state-and response

Status	Pressures	Responses in place	Recommendations
• Our study fund 26 species of fish from all sampled wetland complexes. They represent 32% of the ichthyological fauna of Rwandan ecosystems which is 82 species (Devos et al 2001)	• Overfishing	• Implementation of cycling fishing method (opwtimum utilization).	• Strengthening of measures on fishing activities in Rwandan wetlands like
• High diversity and abundance in ichthyological fauna in wetlands with large open waters.	• Invasive plant species mainly Water hyancyth) → reduction of light penetration into water → reduction of primary production → decrease of DO level in water → disparition of oxyphile fish species.	• Implemtation of fishing reglementation in large open waters (lakes, rivers, …)	• Control of fishing devices (Prohibiting devices such as fishnets with small meshes),
• Low diversity and abundance in ichthyological fauna in wetlands without large open waters.	• Chemical pollution due to plastics discharge mainly in city of Kigali		• Extending the cycling fishing period (optimum utilization of resources) to 6 months or one year to allow the recovery of fish stock in water bodies.
• High productivity in fish within Eastern Kirehe, Rweru-Mugesera, Akanyaru and City of Kigali wetland complexes comparatively to Rusizi, rugezi and Muvumba wetland complexes that has low productivity in fish	• Runoff of sewage from both household and industries within city of Kigali,		• Conduct a full assessment to determining total fish catch per year. And inform regulations to limit overfishing, and properly determine the strategies for PES.
	• Peat mining all along Akanyaru and Rusizi wetland complexes.		• Enhance the protection of buffer zones and use the proper wetland plant and grasses.
	• Rapid Propagation of invasive predators species (African lungfish: Protopterus aethiopicus, African catfish: Clarias gariepinus).		• Control the propagation of water hyacinth.
	• Degradation of river banks and lake showers by agriclture		• Conduct a study on the impact of propagation of the Protopterus aethiopicus, and Clarias gariepinus).

III.2.4 Macroinvertebrates

IV.2.4.1 Introduction

The assessment focused on macroinvertebrates within the orders of Odonata (Dragonflies and damselflies) and Lepidoptera (butterflies). Odonata are divided into two suborders namely: Zygoptera or damselflies, and Anisoptera or true dragonflies. Due to their sensitivity to the quality of water (Moore 1997) (e.g. forest cover, water chemistry, rivers and bank structure), their amphibious habits (Sailendra et al. 2016), 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 (Cherry et al. 2015, Kantika et al. 2016) 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

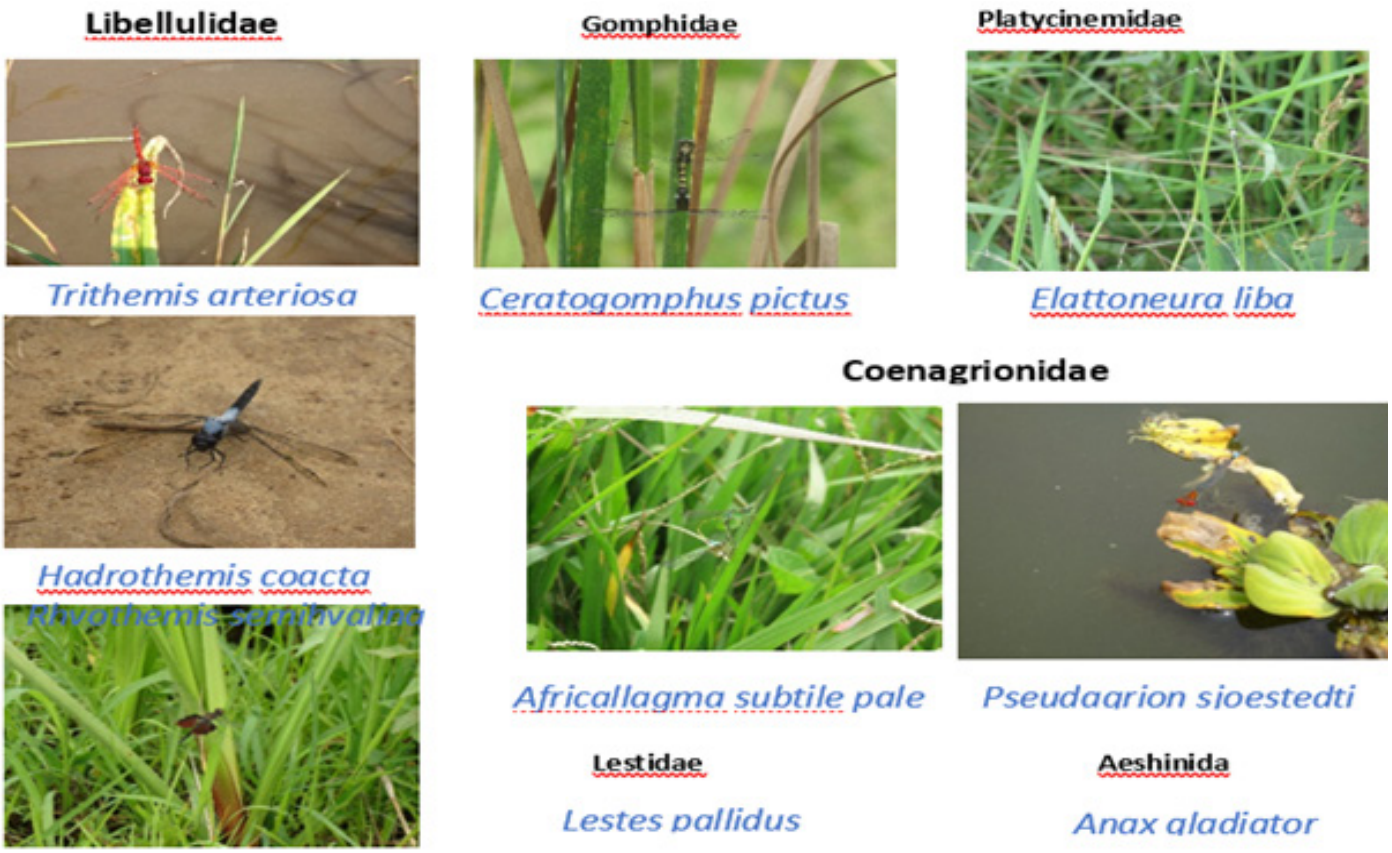
For this rapid assessment the team assessed the presence and distribution of odonata and butterfly species to inform the full assessment study that should look deeply on the ecological implication of their abundance and species richness and come up with information on factors that may be degrading (like alteration of wetland structure or pollution of running and standing waters) or restoring the ecological health of wetlands

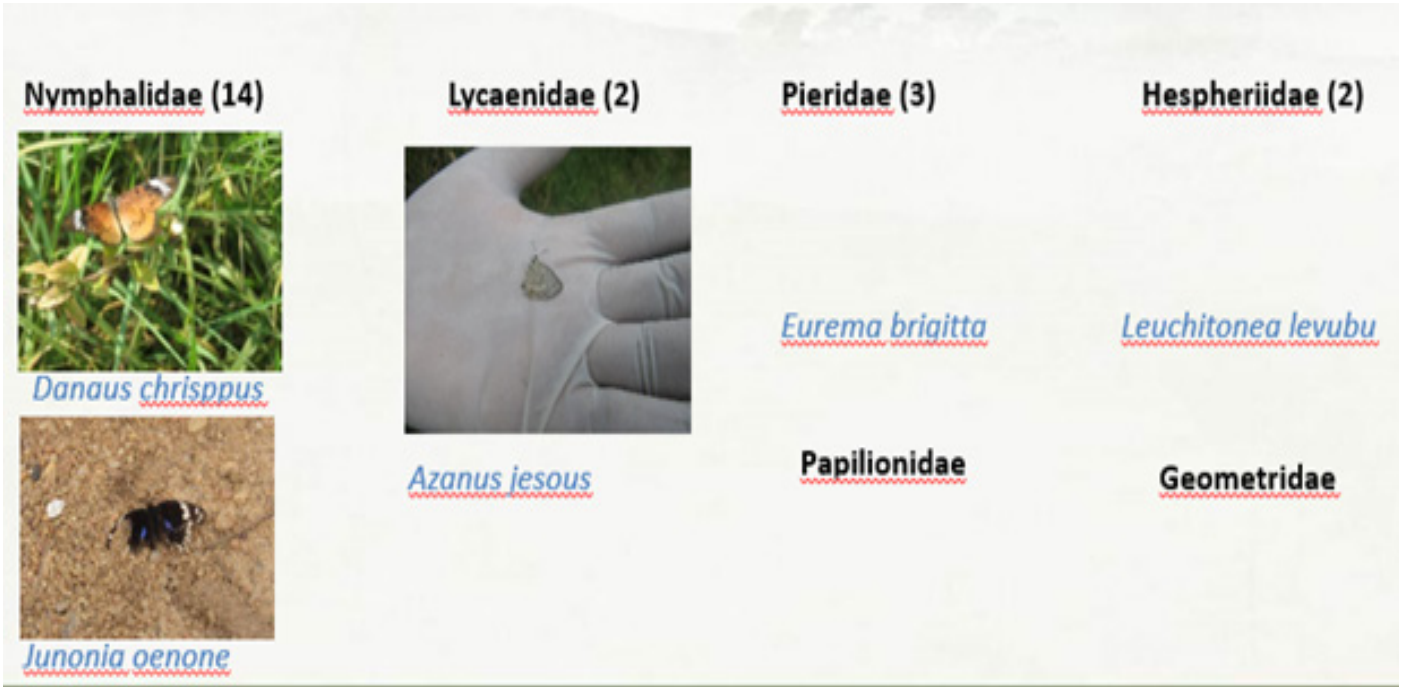
III.2.4.2 Sampling Approach for Butterflies and Odonatan

A predefined transect of 1km along the wetland side in each site, was visited for three day from 9:00 am and 16:00pm. Sampling were based on adult individuals and all dragonflies, damselflies observed within 1-3 m from the observer on every side of the river banks or wetland were directly identified using the handbook of odonatan for Eastern Africa by (Dijkstra et al 2013) and . We 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 (Cherry et al. 2015).

III.2.4.3 Distribution of Butterflies and Odonatan Species per Families

Around 164 georeferenced records of butterflies with 47 different species from 6 families and 141 georeferenced records of odonata with 44 different species from 6 families were recorded





Different Photos of species recorded during the assessment

III.2.4.4 Species Richness per Wetland Complex

The southern Kirehe wetland exhibited the highest butterfly species followed by city of Kigali wetlands. Akanyaru and Rweru Mugesera complex wetland has similar species richness. On the other hand, the city of Kigali was very species rich in odonatan followed by the Southern kirehe and esatren kirehe exhibited the lowest species richness in odonata.

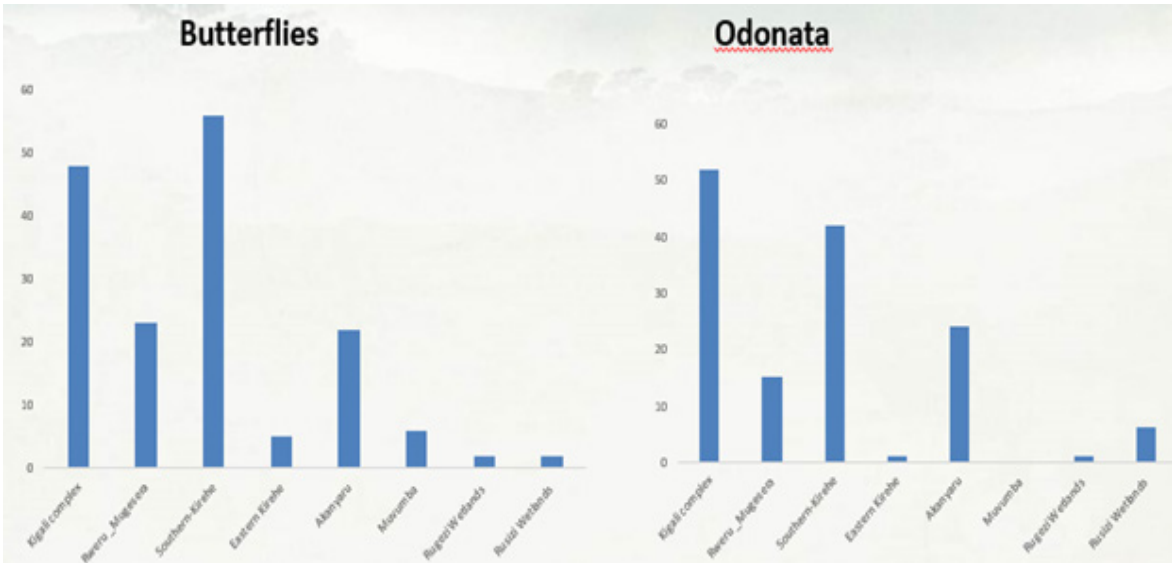


Figure 10: Species richness for odonata and butefly species from different assessed wetland complexes

III.2.4.4.1 Butterfly and Odonatan Species Richness per Assessed Site

Inside each wetland complex, the team has assessed the species richness of butteflies and odonata per site visited. Within the city of Kigali complex wetland Nyarutarama pond exhibited the highest richness of odonatan followed by Nyandungu and Nyabugogo while Ruliba has the highest species richness of butterflies followed by Nyandungu and Nyarutarama. In Southern Kirehe wetland complex, Musaza is the richest site in both odonata and butterflies while Cyanya exhibited the lowest species richness of odonatan

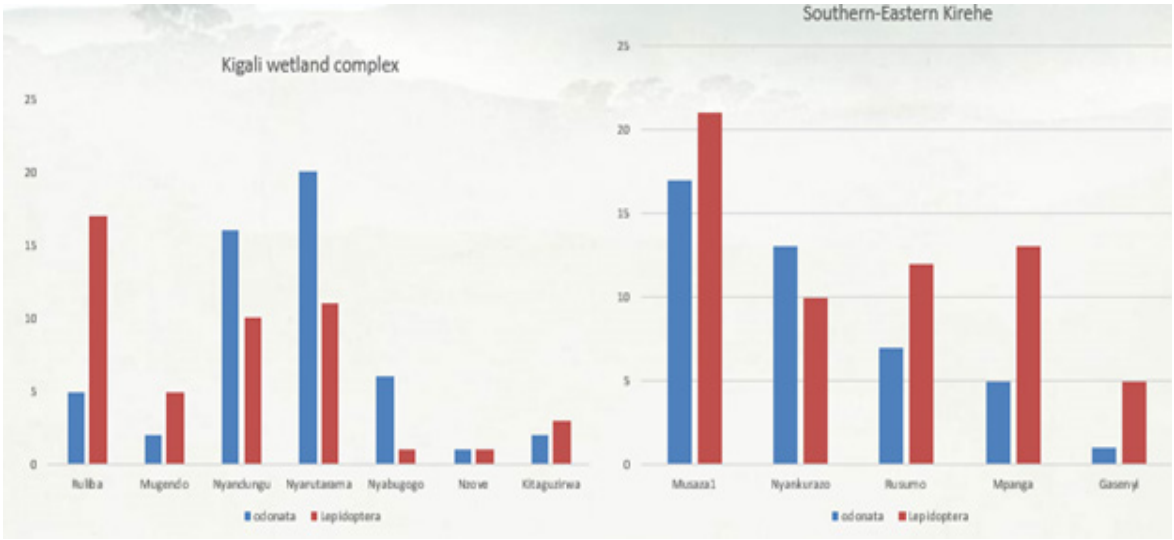
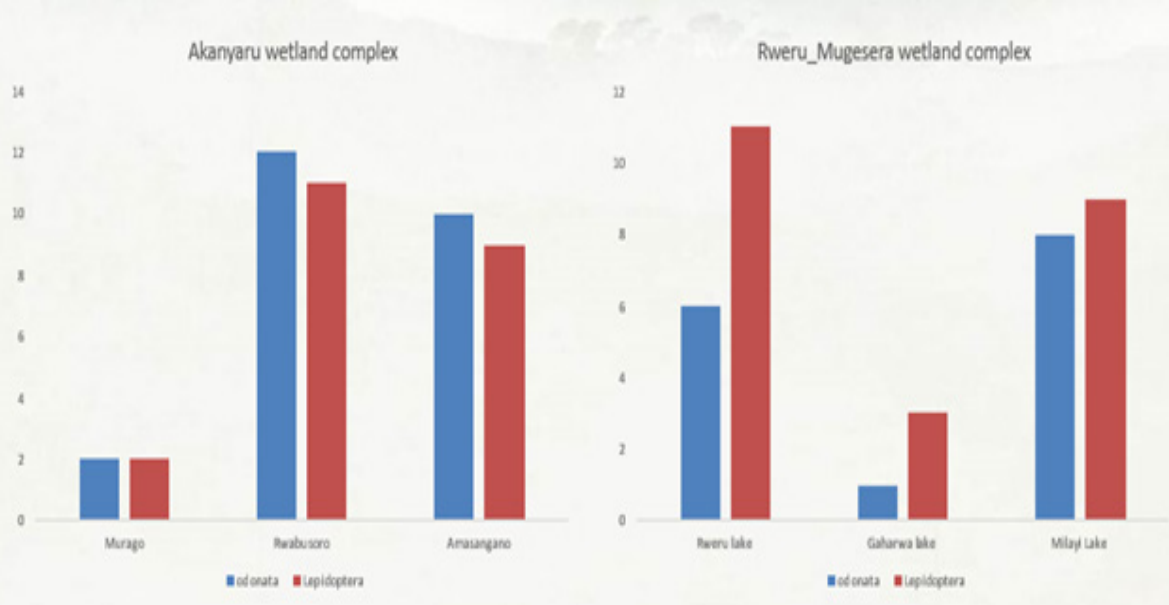
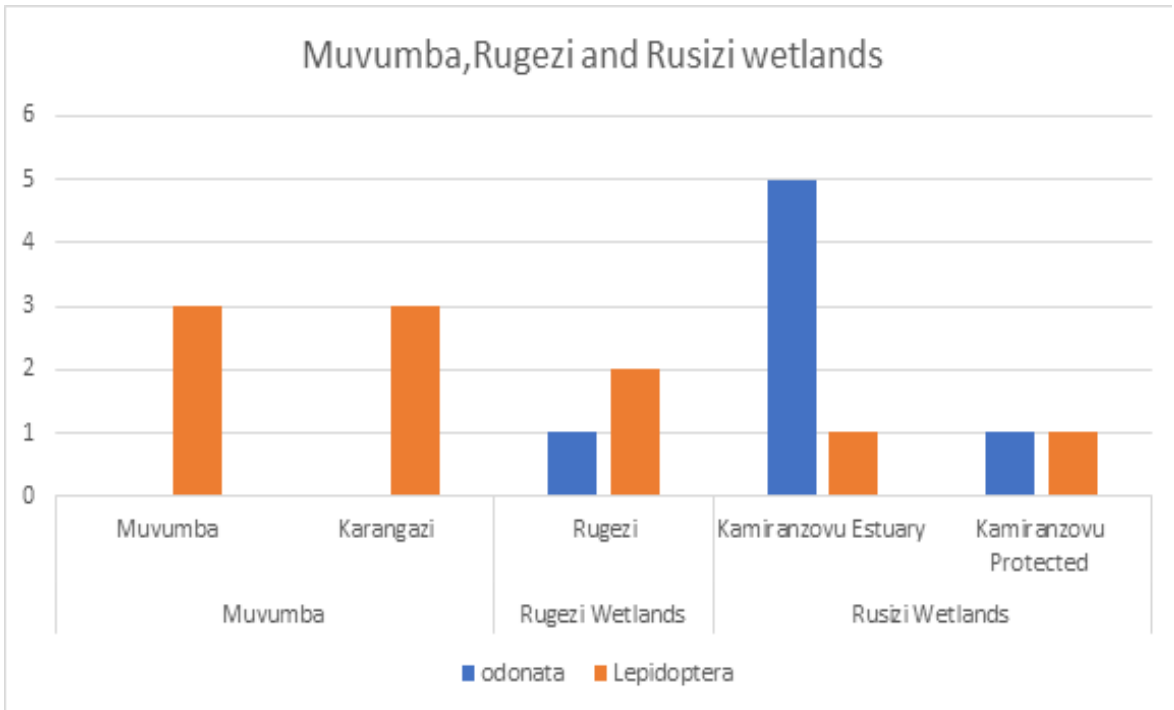


Figure 11: Species richness of odonata and butterfly species per specific site visited

Within Akanyaru wetland complex the team fund the highest species richness for both butterflies and odonata in Rwabusoro site. Rweru lake was followed by Mirayi lake in butterfly species richness but inversely for the case of odonata.

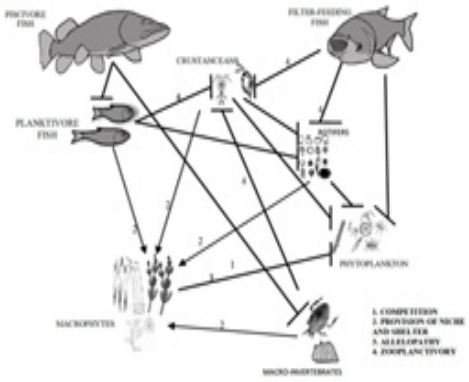


For Rusizi wetland complex Kamiranzovu estuary had a high species rich on odonata comparatively to Kamiranzovu inside Nyungwe National Park. More butterfly species than odonata species in Rugezi wetlands and few odonata species in Muvumba wetland complex.



III.2.5 Algae

III.2.5.1 Introduction



The protection of wetlands, specifically the freshwater biodiversity, is somehow the ultimate conservation challenge because it is influenced by the upstream drainage network, the surrounding land use and the riparian zone .Phytoplankton as primary producers in an aquatic ecosystem, providing organic carbon for the food web, are very sensitive to environmental alteration (Descy et al., 2012; Darchambeau et al., 2014); This makes them a reliable tool for investigating the quality and health of the aquatic ecosystem.

The structural complexity of a wetland mediates competitive and predatory interactions and sustains diverse communities.

III.2.5.2 Methodology

The random samling method was used whereby Phytoplankton samples were collected at each sampling point and directly pooled in the 125 mL bottles and fixed with Lugol's solution and Formalin. The samples were stored in the laboratory at room temperature. The phytoplantkon were identified mostly at genus level, using a light microscope and different freshwater taxonomic identification keys.

IV.2.5.3 General Representation of Relative Abundance of Identified Phytoplankton in all Wetland

The total of 55 phytoplankton species dominated mainly by Synedra ulna, Trachelomonas spp. , Microcystis aeruginosa, Cryptomonas spp. , Gomphonema spp., Navicula spp. , Monoraphidium spp. , Merismopedia spp.

Taxa	%
Synedra ulna	16.41
Trachelomonas spp.	13.02
Microcystis aeruginosa	10.62
Cryptomonas spp.	7.94
Gomphonema spp.	4.55
Navicula spp.	4.34%
Monoraphidium spp.	4.3
Merismopedia spp.	4.01

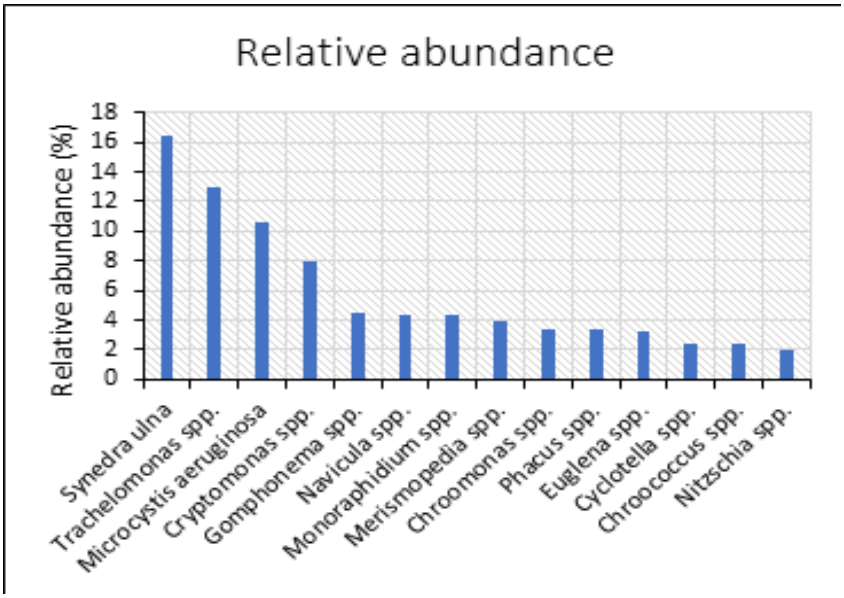


Figure 12: Relative abundance of species above 2% identified in all wetland

III.2.5.4 Relative Abundance of Species by Wetland Complex Assessed

Table 11: Relative abundance of phytoplankton species per wetland complex

	Kigali	Bugesera	Kagera mid-upstream	Kagera downstream	Akanyaru	Northern Wetlands	Kamiranzovu
Trachelomonas spp.	27.58	14.19	12.66	-	15.07	12.45	29.51
Microcystis aeruginosa	18.04	9.35	-	10.29	-	39.42	-
Synedra ulna	13.14	26.54	10.55	30.86	-	23.65	24.59
Cryptomonas spp.	12.63		11.39	-	13.7	-	16.39
Monoraphidium spp.	-	8.85	-	-	-	-	-
Gomphonema spp.	-	8.35	-	10.29	-	-	-
Chroococcus spp.		8.18	-	-	-	-	-
Cyclotella spp.	-	-	16.03	-	-	-	-
Navicula spp.	-	-	11.81	-	-	-	18.03
Euglena spp.	-	-	9.7	-	-	-	-
Nitzschia spp.	-	-	-	20.58	-	-	-
Merismopedia spp.	-	-	-	-	44.24	-	-

III.2.5.5 Relative Abundance of RFGs above 3% Identified per Wetland Complex Assessed

Table 12: Relative abundance of RFGs above 3% identified per wetland complex

	Kigali	Bugesera	Kagera mid-upstream	Kagera downstream	Akanyaru	Northern Wetlands	Kamiranzovu
H1	13.62	-	-	-	-	-	36.68
W1	-	-	14.06	-	-	-	-
W2	20.82	11.82	9.58	-	11.54	29.51	-
MP	15.56	16.97	23	34.08	-	18.03	-
D	-	22.11	-	28.09	-	24.59	22.01
Y	-	-	-	-	10.49	-	-

III.2.5.6 Discussion

Table 13: Description of the main phytoplankton RFGs (with more than 3% contribution) in all wetlands

RFG	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	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

The taxonomic grouping of phytoplankton is said to have many drawbacks (Gebrehiwot et al., 2017). Functional classification was reported to be a good approach to understand, explain and predict the phytoplankton dynamics by grouping phytoplankton taxa regarding their identical ecological characteristic (Reynolds et al., 2002; Kruk et al., 2012). This, because the environment filters traits rather than species (Borics et al., 2016; Gebrehiwot et al., 2017).

Among the identified taxa Synedra ulna and Trachelomonas spp were almost everywhere. The dominance of Synedra ulna is associated with the nutrient-enriched and well-ventilated waters liable to be turbid (Reynolds et al., 2002) ; while the dominance of Trachelomonas spp. might be associated with the area rich in organic matter (Gebrehiwot et al., 2017). The Cyanobacteria, especially Microcystis is reported to became abundant because of anthropogenic eutrophication, where it expresses a preference for high-phosphorus conditions (Reynolds, C.S., 2006).

IV.2.5.7 Conclusion & Recommendations

The results show the anthropogenically induced pressure in the wetlands that is the main cause of pollution. The main anthropogenic activities were: agriculture, cattle ranching and the runoff resulting from human activities as well. We therefore recommend the waste management system of point source and non-point source pollution. We also recommend the inclusion of aquatic macrophytes (e.g.: Phragmites, papyrus…) in the restoration schemes of wetlands to improve the water quality and generate ecologically healthy food web in the littoral zone of lake. To ensure the conservation of Rwanda's wetlands, the long-time monitoring of wetland and its catchment areas is needed to increase the awareness on the seasonal effect of anthropogenically induced changes and their effects on wetland's ecological integrity.

The study could be conducted during both the wet season and the dry season to increase the understanding of the phytoplankton behavior regarding seasonal variation. For instance, the nutrient input and the biological processes are expected to be different in the wet season versus the dry season.

III.3 Wetlands Condition and Status

III.3.1 Introduction

Rwanda is a contracting party to the Ramsar Convention and is expected to manage the sites either designated or proposed as Ramsar sites in a way to maintain their ecological character and remain informed of any changes and be able to notify the Ramsar Secretariat at early opportunity (Ramsar Convention 1987, Article 3.2 and further clarified by the Parties in Resolution VIII.8, 2002; Ramsar Convention 2005, Resolution IX.1 Annex B). Ecological character is the combination of the ecosystem components, processes, benefits and services that characterize the wetland at a given point in time (Ramsar Convention 2005a, Resolution IX.1 Annex A). The purpose of describing the characters of the assessed wetlands in Rwanda, is provide updated information on the current status of wetland conditions in Rwanda and provide recommendations that should guide and inform decision makers and other stakeholder for setting out strategies to sustainably manage wetland resources.

The description of Rwanda wetland ecological characters followed the pressure state and response model and different indicators were measured. For each indicator, the status was ranked from very low (0-20%), low (20-40%), medium (40-60%), high (60-80%) and very high (80-100%) (Faber-Langendoen et al, 2016). Measured indicators include: 1) State: The overall conservation status of wetlands evaluated at three levels (i) status and trends in wetland ecosystem extent (ii) Trends in extent of selected biomes, ecosystems and habitat connectivity/fragmentation, and (iii) Overall population status and trends of wetland taxa. 2) Pressure: The status of threats affecting the wetland in terms of (i) The intensity of threats, (ii) The frequency of threats, (iii) Overall status and trends of threats on wetland taxa. 3) Response: Wetland sites with implemented conservation or wise use. We evaluated if the wetland and its catchment are under some measures of protection or conservation and wise use.

III.3.2 The Current State of Assessed Wetland Complexes

The status of ecosystem extent in terms of ecosystem extent was evaluated at 50% of its potential. Out of 8 assessed wetland complexes, 4 were ranked high (60-80%). they include Eastern and Southern Kirehe, Rugezi wetland complexes and part of Rusizi wetlands (Kamiranzovu inside Nyungwe Park), 1 was ranked Medium (40-60%) namely Rweru-Mugesera wetland complex, while AKanyaru and city of Kigali were ranked low (20-40%) and finally Muvumba wetland complex was ranked very low (0-20%). The size of the major ecological zones in Eastern and Southern Kirehe wetland complexes was not much reduced over the last 2 decades, the same for Kamiranzovu and Rugezi. However, the size of Rweru-Mugesera complex wetland was reduced transforming the natural vegetation into agriculture land especially on the side of Gashora for rice cultivation and cattle grazing. Akanyaru wetland complex ecosystem was very much reduced in size mainly caused by transformation of natural habitat into sugar cane plantation, and invation by water hyacinth especially in open water of Cyohoha lake

Table 14: Detailed description of wetland ecological character on the ecosystem extent

DESCRIPTION OF WETLAND ECOLOGICAL CHARACTER			Wetland complexes	Very Low (0-20%)	Low (20-40%)	Medium (40-60%)	High (60-80%)	Very High (80-100%	Comments	Overall status
State	Indicator 1: The overall conservation status of wetlands:	Status and trends in wetland ecosystem extent	Kirehe S&E				x		Kirehe wetlands still have big area of open water and connected natural vegetation	50% of assessed wetland complexes in Rwanda are in good state in terms of ecosystem extent.
			City of Kigali		x				natural vegetation has been altered. Except in few sites	
			Akanyaru		x				Conversion of Natural vegetation into sugar can plantation, Pit mining, sand and clay extraction	
			Rweru-Mugesera			x			The wetland remains with natural vegetation, open water bodies	
			Muvumba	x					agriculture intensification with monoculture vegetation	
			Rusizi				x		Protected inside NNP	
			Rugezi				x		Ramsar site. Few threats	

The level of wetland complexes habitat connectivity/fragmentation was evaluated at 52.5% of assessed wetland complexes. Mostly, large patches of Southern Kirehe and Eastern Kirehe as well as Rugezi wetand complexes in addition to Kamiranzovu wetland inside Nyungwe National Park are less fragmented. This is because of the legal protection status of the last two wetlands, as well as large water bodies within Kirehe wetlands, which does not allow intensive agriculture. Akanyaru habitat has been very much fragmented whereby the natural vegetation was converted into sugar cane plantation, peat mining areas, and encroachment for subsistence farming by local community. Muvumba wetland complex still has less than 15% of its natural vegetation covered by a remnant forest of acacia trees. The habitat in the city of Kigali was highly fragmented by industrial setting and illegal settlement with some zones for rice and maize cultivation.

Table 15: Detailed description of wetland ecological character on ecosystem connectivity

DESCRIPTION OF WETLAND ECOLOGICAL CHARACTER			Wetland complexes	Very Low (0-20%)	Low (20-40%)	Medium (40-60%)	High (60-80%)	Very High (80-100%)	Comments	Overall status
State	Indicator 1: The overall conservation status of wetlands:	Trends in extent of selected biomes, ecosystems and habitats Connectivity/ fragmentation of ecosystems	Kirehe S&E				x		still have intact natural habitat (Unfragmented) the ecosystem	52.5% of assessed wetland complexes have a very high connectivity except City of Kigali and Muvumba
			City of Kigali	x					Habitat connectivity is very low.	
			Akanyaru			x			Fragmentation is high but some patches are still connected	
			Rweru-Mugesera				x		Water body in different lakes and Akagera river	
			Muvumba	x					Totally converted to rice pad	
			Rusizi				x		Inside the NNP but before the Shower lines of Kivu there is fragmentation	
			Rugezi				x		Natural mat of pit and water body	

In addition, the overall population status and trends of wetland taxa is very good with the presence of species of special conservation concern for both fish, mammals, birds and amphibians.

Table 16: Detailed description of wetland ecological character on status of wetland taxa

DESCRIPTION OF WETLAND ECOLOGICAL CHARACTER			Wetland complexes	Very Low (0-20%)	Low (20-40%)	Medium (40-60%)	High (60-80%)	Very High (80-100%)	Comments	Overall status
State	Indicator 1: The overall conservation status of wetlands:	Overall population status and trends of wetland taxa	KireheS&E					x	18 fish species over 26 recorded in all wetlands (70%)	Overall population status is good in assessed wetlands. 72.5%
			CoK			x			There is a high bird and fish species diversity in Kigali	
			Akanyaru				x		High species diversity for fish and water bird	
			Rweru-Mugesera					x	High diversity of fish and water bird species,	
			Muvumba		x				Gallery forest along the river	
			Rusizi				x		Home to endemics, endangered, vulnerable, rare species	
			Rugezi					x	About 82 bird species. Grey crowned cranes), Grauer's swamp warbler	

III.2.3 Pressure on Assessed Wetland Complexes

The level of intensity and frequency of threats is very high (65%) in all wetlands except in Rugezi and Kamiranzovu inside Nyungwe National Park. The main threats include Agriculture encroachment, sand and peat mining, habitat fragmentation for sugar cane plantation, climate change and invasive species mainly the water hyacinth.

Table 17: detailed description of wetland character on the intensity and frequency of threats

DESCRIPTION OF WETLAND ECOLOGICAL CHARACTER			Wetland complexes	Very Low (0-20%)	Low (20-40%)	Medium (40-60%)	High (60-80%)	Very High (80-100%	Comments	Overall status
Pressure	Indicator 2: The status threats affecting the Wetland	The intensity and frequency of threats	Southern and Eastern Kirehe wetland complexes			x			Agriculture, Sand Mining, Enrooting Papyrus for manure production, burning wetlands to limit crop raiding by Blue monkey and Baboons,	The intensity and frequency of threats is high at 65% in all wetlands except in Rugezi and Kamitanzovu inside NNP Consequently, the Overall status and trends of threats on wetland taxa is high on most of wetlands and many species can go extinct if nothing is done (e.g we can learn from the case of extirpation of Statunga in Rugezi)
			City of Kigali					x	These included agriculture wastes dumping, urbanization, free access to wetland resources and exploitation.	
			Akanyaru					x	Fragmentation, farming (mainly sugar cane), and mining (mainly pit) activities	
			Rweru-Mugesera					x	Overexploited for agriculture that extend also in buffer zones. overfishing, papyrus cutting, Inversive species (water hyacinth), and siltation of Rweru lake	
			Muvumba					x	Permanent claiming of wetland for rice and soja cultivation	
			Rusizi			x			Low level of threats inside NNP but peat mining in Gishoma	
			Rugezi	x					Only collection of papyrus for domestic use but it is done illegally	

III.3.4 Responses / Interventions to Address the Challenges

Less than 35% of wetland complexes assessed have benefited from different initiatives for sustainable use. Few solutions intervene at catchment level mainly because of limited funds. Only Rugezi and Kamiranzovu benefited from measures put in place by the Government of Rwanda like the Gazettement of Rugezi wetland for full protection as a Ramsar site, and Kamiranzovu being inside a National Park fully protected.

Table 18: detailed description of wetland ecological character on conservation or wise use management actions in place

DESCRIPTION OF WETLAND ECOLOGICAL CHARACTER			Wetland complexes	Very Low (0-20%)	Low (20-40%)	Medium (40-60%)	High (60-80%)	Very High (80-100%)	Comments
Response	Indicator 3: Wetland sites with implemented conservation or wise use management actions or plans	Wetland and its catchment are under some measures of protection or conservation and wise use Any measures to maintain or restore populations of species of selected taxonomic groups	Southern and Eastern Kirehe		x				Agroforestry and water management by some institutions (REMA, ARCOS in Southern Kirehe) MINAGRI/KWAMP and Kirehe District
			City of Kigali		x				**Effort of the Government of Rwanda** • Relocation of settlements, • Development of Wetland master plan and CoK Master plan, • Initiatives extending to smart transport, burning plastic bags…
			Akanyaru		x				Some buffer zone protection but using bamboo
			Rweru-Mugesera		x				buffer zone empowering agroforestry system in some zones (REMA, ICRAF, …)
			Muvumba		x				• Preservation of gallery forest along the river, • Erosion control measures in place
			Rusizi		X				Some initiatives in place
			Rugezi				X		Gazette as a Ramsar site. Different interventions of REMA, RWCA, Burera District and Communities to restore the catchment

III.4 Key Important Wetland Areas in Rwanda

III.4.1 Introduction

As part of the assessment, the team has gathered and discussed on data from different wetland complexes to allow the categorization of wetlands in terms of their level of importance at both local, National, and international levels following the criteria Ramsar criteria for identifying wetlands of international importance5 summarized into 5 to bring them to the context of Rwanda as listed in the table below:

Table 19: different criteria for ranking wetland importance adapted for wetlands of Rwanda

Locally (District)	Nationally	Internationally
1. The wetland is a good example of a wetland type occurring within a biogeographic region locally	1. The wetland is a good example of a wetland type occurring within a biogeographic region in Rwanda	1. The wetland is a good example of a wetland type occurring within a biogeographic region in the Region
2. It is a wetland which plays an important ecological or hydrological role in the natural functioning of a major wetland system/complex.	2. It is a wetland which plays an important ecological or hydrological role in the natural functioning of a National major wetland system/complex.	2. It is a wetland which plays an important ecological or hydrological role in the natural functioning of a regional major wetland system/complex.
3. It is a wetland which is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail	3. It is a wetland which is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail in the entire country	3. It is a wetland which is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail in the region
4. The wetland supports native plant or animal taxa or communities which are considered endangered or vulnerable at the national level.	4. The wetland supports native plant or animal taxa or communities which are considered endangered or vulnerable at the national level.	4. The wetland supports native plant or animal taxa or communities which are considered endangered or vulnerable at the Regional level.
5. At District Level, the wetland is of outstanding historical or cultural significance.	5. At national level, the wetland is of outstanding historical or cultural/esthetic significance.	5. At national level, the wetland is of outstanding historical or cultural/esthetic significance.

a) Description based on biogeography of the assessed wetland complex

After the exercise on wetland complex characterization, the team has evaluated both Southern and Eastern Kirehe wetland complexes as very important for local community and Kirehe District, as well as for the National and International levels as they are low altitude wetlands in the Eastern savannah habitat in which drought conditions prevail all along the year. They are adjacent to the kagera region of Tanzania which is also a savannah system hence enhancing the habitat connectivity.

[5]Ramsar Convention (2005b).

Rweru-Mugesera and Akanyaru wetland complexes are important at both local, National and International levels. They are situated in the Mayaga, Bugesera agroecological zone of Rwanda, one of the biggest semi dry areas and peat lands of the country, fed by Akanyaru, Nyabarongo and Akagera rivers and connected to Rweru lake which are transboundary waters between Rwanda and Burundi. These wetlands constitute a big part of the Nile Basin and contain so many lakes important in the great lake's region.

Muvumba wetland complex is important at local and National level. This is because it is like an oasis in the desert. Located in the Eastern savannah agroecological zone. We considered Rugezi and Kamiranzovu wetlands as control zones as they are both already benefiting from full protection status. The City of Kigali is important at both Local and National levels. Located in the central plateau agroecological zone and specifically in the capital city of the country.

b) Description based on ecological and/or hydrological role of assessed wetland complex in the natural functioning of a major wetland system/complex.

The City of Kigali, Akanyaru, Rweru-Mugesera, and Southern and Eastern Kirehe wetland complexes are important as water reservoir which serves for both agricultural production and both domestic and wildlife. They host a wide range of biodiversity and provide refuge for some species of mammals, birds, amphibians during the severe droughts. regulate naturally the water pollution from the upstream and maintains water quantity needed for irrigation and other purposes They enhance connectivity and suitability of the habitat for animals from the Akagera National Park. Their importance was evaluated to be at both Local, National, and International levels

c) Description based on suitability of the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail

Akanyaru, Rweru-Mugesera, and Southern and Eastern Kirehe wetland complexes are specifically very high productive because of various lakes and rivers connectivity and host various species of fish including Synodontis rwandae and Haplochromis erythromaculatus which are (EN), bird species like the Grey crowned crane (EN), Papyrus gonolek, Laniarius mufumbiri (NT) and endemic to the East Africa, Mammal species like Hippopotamus amphibious (VU), Aonyx congicus and Hydrictis maculicollis (NT). Their importance was evaluated to be at both Local, National, and International levels

d) Description based on presence of native plant or animal taxa considered endangered or vulnerable either at national, regional or international levels.

Akanyaru, Rweru-Mugesera, and Southern and Eastern Kirehe wetland complexes are specifically very important as they host a species of fish (Haplochromis erythromaculatus) which is native of north Rwandan wetlands. This species was recorded in different wetland ecosystems including mpanga lake in Kirehe district and its status is enderngered at IUCN red list.

e) Description based on the outstanding historical or cultural significance of wetland at District or national Level

No information recorded about this

IV. Wetlands and Policy Framework.

Wetlands have been considered as biological supermarkets and kidneys of the landscape (IUCN 1999). Policy Frameworks are in guiding wetlands wise use, maintain values and functionality, for the present and future wellbeing of the people (Rwanda Biodiversity Policy 2011). The government of Rwanda recognized this by incorporating wetlands in various policies, laws, regulations and strategies. They include the Rwanda biodiversity policy (2011), the Practical tools on soil and water conservation measure (REMA 2010), The National Environment and climate change policy (2019), the Organic Law Determining the modalities of protection, conservation and promotion of environment in Rwanda (2005). Apart from these good policies and lows, Rwanda has joined other countries by signing and ratifying conventions/treaties/protocols on wetlands and water like The United Nations Framework Convention on Climate Change (1998), Ramsar Convention 1971 and Protocol 1972 (2002) (ratified), Convention on International Trade in endangered Species of wild Fauna and Flora (CITES) (1981).

VI. Discussion and Conclusions

Some previous studies have focused on key wetlands like Kamiranzovu, Rugezi , Rweru Mugesera and Akagera and highlighted the importance of the wetlands in terms of habitat for biodiversity(Fischer, E. et al 2011). They found a total of 457 vascular plants, among them 57 Albertine Rift endemics, were recorded in the four study sites. Altogether 33 species of amphibians have been found comprising 9 Albertine Rift endemics. 26 species of reptiles were observed including 5 Albertine Rift endemics. 115 birds with 4 Albertine Rift endemics were observed. 33 mammals (6 Albertine Rift endemics) are known from the four swamps in Rwanda. They discussed and proposed measures for protecting other Rugezi, Rweru-Mugesera and Akagera wetlands as they found them very important to the extent of Kamiranzovu which was fully protected (Fischer, E. et al 2011).

Among 8 assessed wetland complexes, Kamiranzovu and Rugezi are high altitude wetlands, while City of Kigali, is in mid altitude of the central plateau and Akanyaru and Rweru-Mugesera are in low altitude hence serving for Water reserve, water source, filter and well as hotspot for biodiversity (Fischer, E. et al 2011).

Table 20: Wetland species of special conservation concern identified from different sites

Biodiversity	Species	IUCN Status	City of Kigali				Rweru-Mugesera			Akanyaru	Southern and Eastern Kirehe			Muvumba	Rugezi	Kmiranzovu
Common name	Scientific name		Kitaguzirwa	Nyange	Gahanga	Rwezangoro	Rweru	Cyohoha	Gashora	Murago	Mpanga	Rusumo	Mpanga Lake	Kahi		
Birds																
Grauer's Swamp Warbler	Bradypterus graueri	EN / Endemic													X	X
Grey Crowned Crane	Balearica regulorum	EN	X	X		X	X				X			X		
Malagasy Pond Heron	Ardeola idea	EN									X					
Martial Eagle	Polemaetus bellicosus	VU								X						
Papyrus Gonolek	Laniarius mufumbiri	NT		X							x					
Mammals																
Hyppopotamus	Hippopotamus amphibius		X	X	X	X	X	X			X	X	x			
Congo clawless otter	Aonyx congicus	NT		X	X						X		X			
Spotted-necked otter	Hydrictis maculicollis	NT	X	X	X		X				X		X			
Amphibians																
Hyppopotamus	Hyppopotamus amphibius															
	Hyperolius rwandae	Endemic							X							
Fish																
	Synodontis rwandae	EN									X					
	Haplochromis erythromaculatus	EN									X					
	Total		3	5	3	2	3	1	1	1	8	1	3	1	1	2

VII. Recommendations

Wetlands of Rwanda are very much valuable in terms of supporting life in water, but also economically very important. However, they are very vulnerable due to different threats.

We highly recommend the following:

- Gazette the Southern and Eastern Kirehe as well as Rweru-Mugesera wetlands complexes as Ramsar sites (They are already proposed as Ramsar site)
- Have a wetland management plan for Southern and Eastern Kirehe, Rweru-Mugesera and Akanyaru Wetlands.
- Enhance the protection of Muvumba wetland complex as it is very important for the country as well as the local community of Nyagatare and neighboring districts
- Few of the wetland complexes assessed benefited from presence of buffer zones but others are still suffering from lack of buffer. Enhance buffer zones protection in all wetlands but find a way to use and adopt native species adapted to wetlands conditions
- There is a big gap in both taxonomic and skills in the country. Research and monitoring of biodiversity and Ecological integrity of wetlands should be a priority and be done regularly. The academia should enhance the training of young researchers in different neglected taxon
- Biodiversity data availability is the only tool that can help the government of Rwanda to take adequate decisions for sustainable use and management of wetland. Biodiversity data sharing should be enhanced and supported by different Government Institutions

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VIII. Annexes

Annex 1: Wetlands Cover Types Status per District in 2008

Land Cover	Cropland (Ha)	Cropland (%)	Natural Vegetation (Ha)	Natural Vegetation (%)	Water Body (Ha)	Water Body (%)	Others (Ha)	Others (%)	Total 1 (Ha)	Total 1 (%)
Kigali City	4,934.3	63.1	2,176.2	27.8	298.0	3.8	414.7	5.3	7,823.2	100.0
Nyarugenge District	1,256.6	59.5	616.8	29.2	182.6	8.7	54.9	2.6	2,110.90	100.0
Kicukiro District	1,089.0	37.9	1,464.1	51.0	84.9	3.0	235.5	8.2	2,873.54	100.0
Gasabo District	2,588.7	91.2	95.3	3.4	30.5	1.1	124.3	4.4	2,838.73	100.0
Northern Province	10,259.5	57.6	6,701.4	37.6	383.7	2.2	482.5	2.7	17,827.0	100.0
Burera District	1,600.0	21.5	5,781.6	77.8	30.6	0.4	21.5	0.3	7,433.7	100.0
Gakenke District	1,537.1	81.3	43.6	2.3	256.0	13.5	54.294643	2.9	1,890.9	100.0
Gicumbi District	3,274.2	78.9	630.3	15.2	33.3	0.8	212.5	5.1	4,150.4	100.0
Musanze District	727.6	88.5	44.4	5.4	4.7	0.6	45.4	5.5	822.0	100.0
Rulindo District	3,120.6	88.4	201.5	5.7	59.1	1.7	148.8	4.2	3,530.0	100.0
Western Province	8,475.9	80.7	1,469.7	14.0	318.0	3.0	236.9	2.3	10,500.5	100.0

Karongi District	968.6	91.9	15.4	1.5	43.4	4.1	26.3	2.5	1,053.7	100.0
Ngororero District	769.7	73.2	60.9	5.8	185.3	17.6	35.9	3.4	1,051.7	100.0
Nyabihu District	599.9	54.8	335.9	30.7	77.9	7.1	80.2	7.3	1,093.9	100.0
Nyamasheke District	1,873.1	68.5	833.8	30.5	3.2	0.1	23.8	0.9	2,733.8	100.0
Rubavu District	469.7	99.0	0.4	0.1	4.5	1.0	-	-	474.6	100.0
Rusizi District	3,133.6	93.5	182.6	5.4	1.3	0.0	35.4	1.1	3,352.9	100.0
Rutsiro	661.2	89.4	40.7	5.5	2.4	0.3	35.5	4.8	739.8	100.0
Eastern Province	16,951.0	16.5	76,700.4	74.8	2,372.1	2.3	6,489.4	6.3	102,513.0	100.0
Bugesera	3,281.8	15.4	15,916.9	74.5	2,027.9	9.5	140.4	0.7	21,367.1	100.0
Gatsibo	3,390.7	19.5	13,015.4	74.7	55.3	0.3	957.4	5.5	17,418.8	100.0
Kayonza	2,505.2	11.3	19,190.0	86.9	80.5	0.4	319.7	1.4	22,095.3	100.0
Kirehe	1,009.9	8.1	11,340.1	90.8	144.9	1.2		-	12,494.9	100.0
Ngoma	1,602.8	16.1	8,295.3	83.4	41.4	0.4	7.1	0.1	9,946.7	100.0
Nyagatare	2,662.0	16.7	8,228.6	51.6	-	-	5,064.8	31.7	15,955.4	100.0
Rwamagana	2,498.6	77.2	714.1	22.1	22.1	0.7	-	-	3,234.8	100.0

Southern Province	32,447.5	88.0	1,799.9	4.9	457.3	1.2	2,163.3	5.9	36,868.0	100.0
Gisagara	9,089.9	98.3	84.5	0.9	74.6	0.8	2.1	0.0	9,251.1	100.0
Huye	4,301.3	91.6	-	-	129.3	2.8	264.3	5.6	4,694.9	100.0
Kamonyi	2,633.7	52.8	1,405.8	28.2	-	-	944.1	18.9	4,983.5	100.0
Muhanga	1,916.8	74.4	-	-	19.4	0.8	641.7	24.9	2,577.9	100.0
Nyamagabe	1,688.9	90.4	45.4	2.4	127.9	6.8	6.8	0.4	1,869.0	100.0
Nyanza	5,461.5	95.1	164.0	2.9	34.5	0.6	81.2	1.4	5,741.2	100.0
Nyaruguru	3,920.5	95.2	98.8	2.4	39.5	1.0	59.2	1.4	4,118.0	100.0
Ruhango	3,435.0	94.6	1.5	0.0	32.1	0.9	163.9	4.5	3,632.4	100.0
Total 2	73,068.2	41.6	88,847.6	50.6	3,829.1	2.2	9,786.8	5.6	175,531.7	100

Annex 2: Wetlands Cover Types Status per District in 2018

Land Cover Type / Province and District	Cropland		Natural Vegetation		Water Body		Other			
	Coverage (ha)	Coverage (%)	Coverage (ha)	Coverage (%)	Coverage (ha)	Coverage (%)	Coverage (ha)	Coverage (%)	Total (Ha)	Total Per District (%)
Kigali City										
Nyarugenge District	540.9	25.6	960.8	45.4	151.9	7.2	461.3	21.8	2,114.85	100
Kicukiro District	424.7	14.8	1,716.0	59.6	99.6	3.5	637.6	22.2	2,877.76	100
Gasabo District	1,842.8	64.8	86.6	3.0	56.7	2.0	859.5	30.2	2,845.61	100
Sub-Total Kigali	2,808.3	35.8	2,763.4	35.3	308.1	3.9	1,958.4	25.0	7,838.2	100
Northern Province										
Burera District	867.8	11.7	5,679.9	76.3	27.8	0.4	871.5	11.7	7,447.1	100
Gakenke District	1,060.1	55.9	21.8	1.1	226.3	11.9	587.831676	31.0	1,896.0	100
Gicumbi District	2,989.7	71.9	524.4	12.6	50.9	1.2	591.9	14.2	4,156.9	100
Musanze District	418.4	50.8	19.8	2.4	58.1	7.1	326.9	39.7	823.2	100
Rulindo District	2,826.8	79.9	17.2	0.5	59.1	1.7	633.2	17.9	3,536.3	100
Sub-Total North	8,162.7	45.7	6,263.1	35.1	422.2	2.4	3,011.4	16.9	17,859.4	100
Western Province										
Karongi District	600.0	56.9	40.5	3.8	142.6	13.5	270.8	25.7	1,053.9	100
Ngororero District	500.4	47.6	-	-	270.7	25.7	280.4	26.7	1,051.5	100
Nyabihu District	443.8	40.6	316.3	28.9	202.8	18.5	130.9	12.0	1,093.7	100
Nyamasheke District	938.4	34.4	655.2	24.0	107.7	3.9	1,029.3	37.7	2,730.6	100
Rubavu District	330.6	69.7	-	-	-	-	143.7	30.3	474.3	100
Rusizi District	1,717.6	51.2	494.8	14.7	50.3	1.5	1,091.8	32.5	3,354.4	100
Karongi District	600.0	56.9	40.5	3.8	142.6	13.5	270.8	25.7	1,053.9	100
Sub-Total West	4,890.1	46.6	1,506.8	14.4	821.8	7.8	3,278.6	31.2	10,497.3	100

Eastern Province										
Bugesera	1,219.0	5.7	13,671.1	63.8	3,184.4	14.9	3,343.2	15.6	21,417.6	100
Gatsibo	4,061.9	23.2	10,722.1	61.4	662.9	3.8	2,025.0	11.6	17,471.9	100
Kayonza	1,893.3	8.5	15,562.0	70.0	1,386.7	6.2	3,400.5	15.3	22,242.4	100
Kirehe	740.7	5.7	10,357.4	80.3	561.6	4.4	1,239.5	9.6	12,899.3	100
Ngoma	975.1	9.7	6,715.0	66.8	359.6	3.6	1,996.4	19.9	10,046.1	100
Nyagatare	6,184.7	38.1	7,028.9	43.3	521.0	3.2	2,494.6	15.4	16,229.2	100
Bugesera	1,219.0	5.7	13,671.1	63.8	3,184.4	14.9	3,343.2	15.6	21,417.6	100
Sub-Total East	16,601.1	15.9	64,726.0	62.0	7,724.6	7.4	15,380.1	14.7	104,431.8	100
Southern Province										
Gisagara	4,295.0	46.7	1,085.2	11.8	120.1	1.3	3,687.6	40.1	9,187.9	100
Huye	3,149.8	67.0	-	-	85.6	1.8	1,467.6	31.2	4,703.0	100
Kamonyi	2,209.5	44.3	1,900.6	38.1	202.3	4.1	680.4	13.6	4,992.8	100
Muhanga	1,547.6	59.8	-	-	234.0	9.0	805.3	31.1	2,586.9	100
Nyamagabe	1,350.2	72.3	-	-	29.0	1.6	489.2	26.2	1,868.4	100
Nyanza	3,578.2	62.2	564.8	9.8	664.9	11.6	942.2	16.4	5,750.1	100
Nyaruguru	2,872.5	69.7	-	-	62.4	1.5	1,186.4	28.8	4,121.3	100
Ruhango	2,575.9	70.8	159.1	4.4	126.8	3.5	777.9	21.4	3,639.7	100
Sub-Total South	21,578.7	58.6	3,709.6	10.1	1,525.2	4.1	10,036.6	27.2	36,850.1	100
Overall Total	54,040.9	30.4	78,969.0	44.5	10,801.9	6.1	33,665.1	19.0	177,476.9	100

Rwanda Wetlands Ecological Integrity Rapid Assessment Report

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