



TOWARDS WISE USE OF WETLANDS OF SPECIAL IMPORTANCE IN RWANDA

Case Study: Rweru-Mugesera wetland

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TABLE OF CONTENTS

TABLE OF CONTENTS 1

LIST OF FIGURES 2

I. SUMMARY 3

1. General Background..... 3

2. Purpose of the Study..... 4

II. METHODOLOGY OF THE STUDY 5

1. Description of the site..... 5

III. DATA ANALYSIS 9

IV. PRESENTATION OF STUDY RESULTS..... 10

1. Biodiversity 10

i. Plant assesement.....10

ii. Macro-invertebrate survey14

iii. Bird survey.....16

2. Ecosystem services..... 18

V. DISCUSSION AND INTERPRETATION OF RESULTS..... 22

1. Biodiversity 22

2. Ecosyetm services 23

VI. CONSIDERATIONS FOR RAMSAR SITE DESIGNATION OF RWERU-MUGESERA WETLAND 24

A. Eligibility of Rweru-Mugesera wetland complex against Ramsar criteria..... 24

B. Recommendations for further research 28

VII. PERSPECTIVES FOR THE FUTURE OF RWERU-MUGESERA WETLAND 29

1. Monitoring the wetland biodiversity and ecosystem services 29

2. Community-based wetland management and monitoring 30

3. Zonation of the wetland..... 30

VIII. REFERENCES 31

I. LIST OF APPENDIXES34

A. Appendix 1 : Data sheet example for the ILAM protocol34

B. Appendix 2 : Ecosystem services questionnaire35

LIST OF FIGURES

Figure 1: Rweru-Mugesera Wetlands Complex	5
Figure 2: A battery of birds nests near Lake Rweru and a bird perched on a banana tree in Nyiragiseke Village	6
Figure 3: Location of Transect 1 and 2 in Rweru-Mugesera wetland complex	7
Figure 4: Extent of the biodiversity and ecosystem services survey	9
Figure 5: Distribution of plant species across transects	10
Figure 6: Plant species richness across the two transects	11
Figure 7: Rweru – Mugesera wetland complex , 2015 versus 2016 satellite images	12
Figure 8: Rweru – Mugesera wetland complex , 2015 versus 2016 normalized vegetation indexes	13
Figure 9: Odonate species distribution across the study site, alongside the lake's edge (1) and across the wetland (2).....	14
Figure 10: Benthic macroinvertebrates species distribution in the lake and the wetland at Lake Rweru	15
Figure 11: Bird species distribution alongside the lake (a,b) and within the wetland (c)	16
Figure 12: Bird species rarefaction curve across the study site	17
Figure 13: Important resources benefited from Rweru wetland.....	18
Figure 14: status of wetland water use	19
Figure 15: Benefits associated to living in proximity to Rweru – Mugesera wetland complex.....	20
Figure 16: Major threats to the wetlands as perceived by the local communities	21
Figure 17: Elliot's Chameleon in the Wetland. Credit: ARCOS	24
Figure 18: Annual average precipitation in Rwanda, Source : REMA 2011	26

I. SUMMARY

1. General Background

In its Vision 2020, Rwanda has a very explicit goal to achieve an economic growth that relies on the country's natural resources but in a sustainable way. Indeed, the Government of Rwanda (GoR) aspires that *“by 2020, it [GoR] will have built a nation in which, pressure on natural resources, particularly on land, water, biomass and biodiversity, has significantly been reduced and the process of environmental pollution and degradation has been reversed; a nation in which the management and protection of these resources and environment are more rational and well regulated in order to preserve and bequeath to future generations the basic wealth necessary for sustainable development (MINIRENA 2011)”*.

This is a very ambitious objective given the fact that 90% of the country's population relies on agriculture and the pressure on land translates in encroachment onto areas that are normally set aside for protection of biodiversity or for their important ecological processes which are at the origin of the vital services that the population and the economy rely on (e.g. water and food provision, soil fertility, pollination, flood regulation, biodiversity, etc.)

Wetlands form one category of key ecosystems in Rwanda. Apart from their exceptional biodiversity, they also provide a range of services that are crucial to other development sectors in the economy such as energy, agriculture, and tourism. Rwanda is endowed with many wetlands of different shapes and sizes. The national inventory of wetlands conducted by the Rwanda Management Authority (REMA) in 2008 through a project called *“Integrated Management of Critical Ecosystems-IMCEI* concluded that 10.5% of the country's surface is covered by wetlands, 20% of which are protected; 74% are under conditional use for agriculture; while the remaining 6% fall under the non-condition category (IMCE, MINIRENA 2008).

In many parts of the developing world, the importance of wetlands for the hydrological system and for local communities that derive their subsistence from wetlands has been ignored by policy (Silvius et al. 2000). As a result, the existence of natural wetlands has been threatened by unsustainable development initiatives. Those initiatives include the intensification of agriculture within wetlands, or the complete conversion of wetlands, via drainage, to commercial cropping or urban and/or industrial development (Thompson & Hollis 1995; Dungan 1990). Given this competitive uses of wetlands in a land-scarce environment such as Rwanda, the country has taken a pro-active step to classify its wetlands into different categories and allocate each class to a type of use that maximizes its benefit to the environment, economy, and communities. For the ‘protected wetland’ class, more measures were taken to further maximize their integrity through various restoration and protection interventions such as conducting required research, establishing buffer zones, conducting public awareness campaigns and, developing alternative livelihoods for adjacent communities.

At legal and institutional level, the government of Rwanda also established clear structures that support proper governance of these important ecosystems both at national, sub-national and local levels. Several national policy and legal documents were also developed and enacted and the country ratified a number of international agreements that are conducive to proper protection of wetlands.

One of these international instruments is the Ramsar Convention which is an international treaty whose stated mission is to promote the conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world.

Rwanda ratified the convention in April 2006 and so far the country has a single wetland gazetted as a Ramsar site (Rugezi wetland) and a number of several other wetlands of international importance that have been proposed to the convention to be gazetted as Ramsar sites.

The Rweru-Mugesera wetland complex is one of such proposed Ramsar sites and it is one of the 4 important wetlands systems in the country, and the only one which does not experience a high degree of protection as a part of a national park or an international site¹.

The gazettement of Rweru-Mugesera wetland as a Ramsar site is a non-trivial decision given the geographical, economic and social context in into which the wetland is found. In fact, the wetland located in one of the driest regions of the country where communities rely on agriculture. Therefore, the wetland constitutes the last resort for adjacent communities to raise food during the long dry season. All of these aspects mean that decision-makers have a lot of options to consider and they therefore require accurate and enough information to make sensible trade-offs.

In the case of Rweru-Mugesera complex, currently available information on the wetland is patchy and not updated. For instance, the last biodiversity inventory for the wetland was conducted more than 5 years ago and did not include socio-economical aspects among local communities that affect the wetland.

To respond to this challenge, ARCOS in collaboration with the University of Namur, UNAMUR, Belgium through a funding from the International Foundation for Science (IFS) have undertaken a project to update the information on the Rweru-Mugesera wetland to support the decision to gazette Rweru wetland as a Ramsar site. This pilot project was intended to demonstrate the importance of evidence-based decision-making in promoting sustainable management of natural resources through the use of modern biodiversity informatics technologies.

The data resulting from this study has been prepared according to international biodiversity data standards and published using GBIF's data publication tools to allow access and integration of the data with other datasets to allow more advanced analysis. The preliminary analysis that was conducted was done on the basis of the Ramsar Sites Criteria.

2. Purpose of the Study

The ARCOS' Integrated Landscape Assessment and Monitoring (ILAM) programme provides tangible information for the characterisation of key biodiversity areas and their corresponding conservation value.

The programme is therefore important vis-à-vis research that investigates the level of biodiversity and ecosystem services (such as the status of landscape, taxa, tracts, buffers to wetlands or other types of habitat important), to provide conservation enhancers and mitigate conservation barriers for the maintenance of biodiversity or ecological processes.

Rweru-Mugesera wetland complex satisfies most of the Ramsar Biodiversity significance criteria. The complex features several tracts or discrete areas of remnant vegetation composed of one or more remnant units dominated by *papyrus cyperus* surrounded by non-remnant vegetation and encroachment patches.

¹ Other wetlands are the Kamiranzovu which is inside Nyungwe National park, the Rugezi wetland which is already gazetted as a Ramsar site, and the Kagera wetland whose large part is inside the boundaries of Kagera National park.

The wetland is, in particular, home to threatened species of avifauna which enhances its eligibility as an area of biodiversity significance based on the presence of endangered, vulnerable and/or near threatened (EVNT) species as defined in the national, regional and international wetland protection conventions, laws and policy i.e. the Biodiversity Assessment and Mapping Methodology BAMB, (Environment and Heritage Protection 2014).

II. METHODOLOGY OF THE STUDY

1. Description of the site

The Rweru-Mugesera wetland complex is located in the South-East part of the Bugesera district. The complex counts 11 lakes in Rwanda and associated wetlands (the lakes of Rweru, Cyohoha south and north, gaharwa, Kilimbi, Mirayi, Rumira, Kidogo and Gashana in Bugesera and the lakes of Mugesera, Birira and Sake in the district of Gisaka. The complex is part of the Nile basin (and lake Victoria basin), in the Akagera catchment. The Kagera basin itself covers 67% of the country and drains 90% of the national waters. In Figure 1, we can situate on the south, the lake Rweru and between the districts of Rwamanaga and Ngoma, the lake Mugesera. The total area of the complex covers 13,845 ha (REMA 2003).

The two sites used for this study are located in the surroundings of lake Rweru near the village of Nyiragiseke and the wetland of Mugina. Lake Rweru covers a surface of 100km² overlapping Burundi (with 80km²) and Rwanda (with 20km²). The shoreline of the lake represents 76km and the average depth of the lake is 2.1m. The lake is surrounded by marshes. The Kagera river flows out of this lake and continues to the east along the border first between Rwanda and Burundi and then between Tanzania and Rwanda.

The fishing activities help the surrounding communities to support themselves and the total fish production in the Rwandan part is between 200 and 250 tonnes per year (Fortune of Africa 2016).

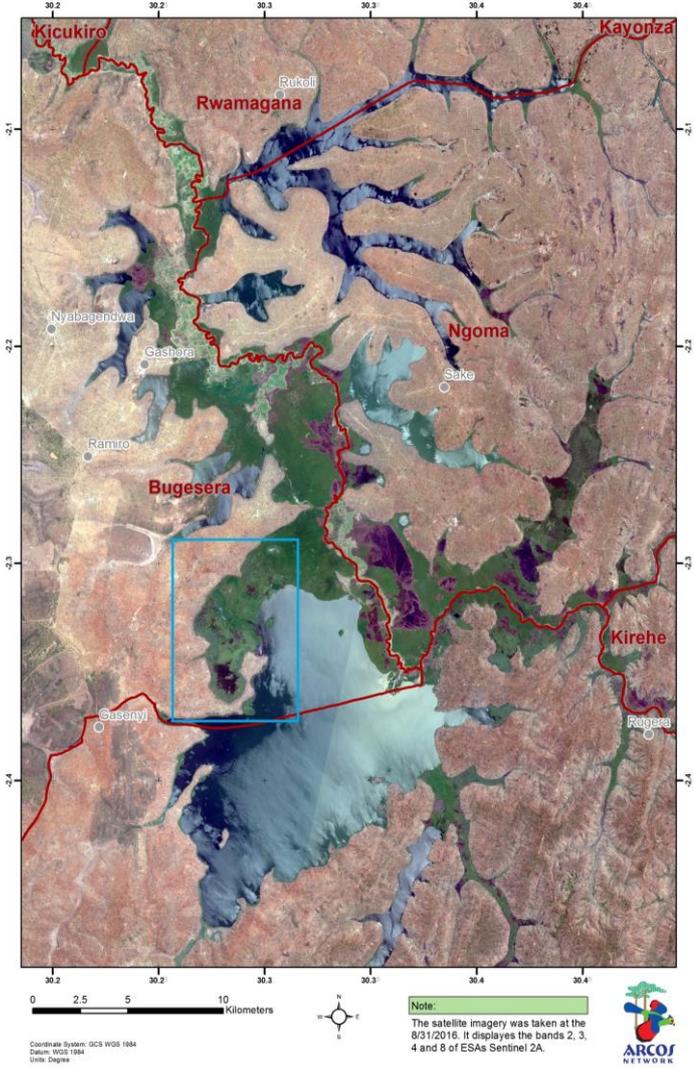


Figure 1: Rweru-Mugesera Wetlands Complex

Lake Rweru is surrounded by marshes that extend to lake Mugesera and beyond. The wetland constitutes an important water catchment in the region which is one of the driest in Rwanda with a mean annual rainfall of 832 up to 1000mm (Figure 18). The average elevation of the region is 1300m. The first rain season of the year begins on average around mid-February (from early February to 1st day of March) calculated with the following standard criteria: first window of 3 days that totals 20mm or more and with at least 1 wet day and that is not followed by a 7-day dry spell within the next 21 days (Rwanda Meteorology Agency 2017)

The village of Nyiragiseke is at the very lake's edge with the closest houses being as close as 15m from the lake's bank. The nearest borehole is at approximately 500m from the centre of the village. As we can see in **Error! Reference source not found.**, the village is surrounded by the wetland on its north part whereas the habitations extend further on the west part to the next village of Mugina and Gakindo. This wetland is dominated by indigenous papyrus (*Cyperus papyrus*). The agriculture is dominant in the landscape and even encroaches on the wetland and the lake's protected buffer zones. The complex has a great biodiversity. In fact, Lake the Rweru is a famous bird watching site and, in addition, the crocodiles, varans and snakes are well represented in the wetland. Rweru-Mugesera marshes constitute indeed the second most rich wetland habitat for mammals' species outside national parks (E.G Kironde & REMA 2012).



Figure 2: A battery of birds nests near Lake Rweru and a bird perched on a banana tree in Nyiragiseke Village



2. Data Collection Techniques and Protocols

To assess the biodiversity of the sites, several bio-indicators were used to achieve a "rapid ecological assessment of the biodiversity" (Secretariat of the Convention on Biological Diversity 2006). Bio-indicators allow to rapidly and efficiently assess the environmental status of a habitat (Ibid.) Amongst the indicators, **plants** were selected to reflect the characteristics of the soil, the **butterflies** as indicators of environmental changes due to their high sensitivity, the **odonates** to reflect the water quality and the environment degradation based on their terrestrial and aquatic lifecycle (The Xerces Society 2011), the **benthic macro-invertebrates** composition to indicate the degree of pollution and the water quality (Smith et al. 2007), and finally the **birds** being the very important inhabitants of wetland, their species richness and composition was used to reflect the health of the wetland (Hu et al. 2011).

A 2km long transect was defined to collect the plants, butterflies, odonates and birds data. This transect was designed in the way to pass through various habitats in order to better represent the complexity of the environment (Secretariat of the Convention on Biological Diversity 2006). Transect 1 was set alongside the lake bank while transect 2 was established through the wetland perpendicularly to the first one (Figure 3). The transects were visited twice at one day of interval. As far as possible, the surveys were conducted from 08H00 to 11H00 AM and from 15H00 to 18H00 in the afternoon, therefore covering the transects while the fauna is most active and when midday heat is most likely to have less influence to the observations.

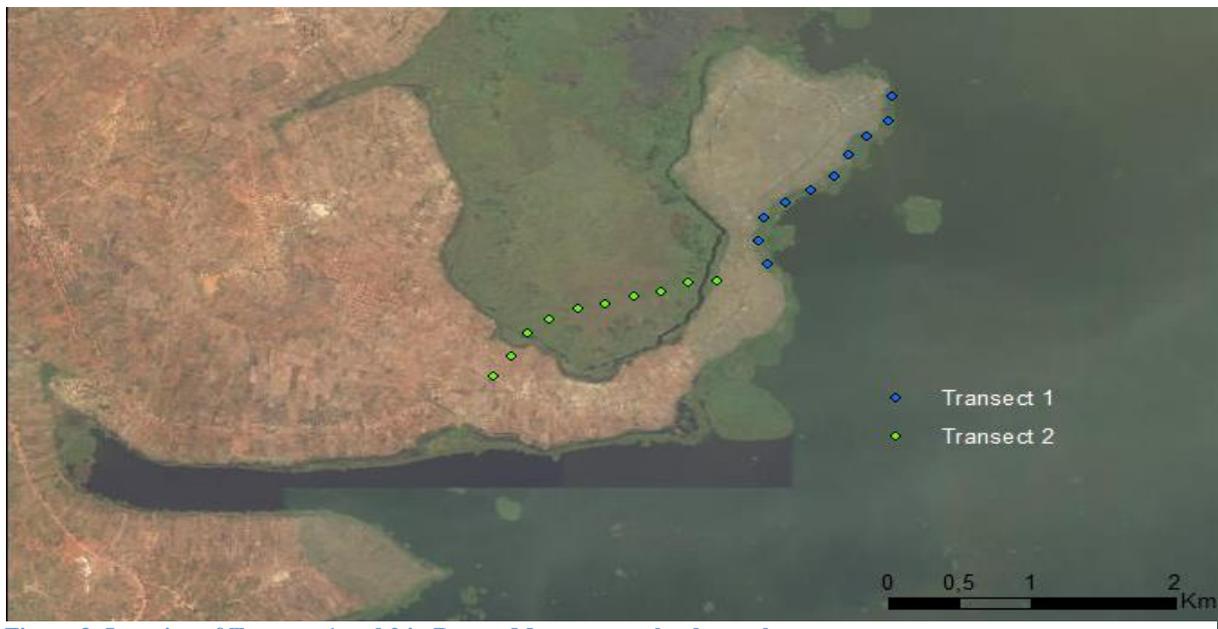


Figure 3: Location of Transect 1 and 2 in Rweru-Mugesera wetland complex

Transect 1 passes along the lake's bank

Transect 2 passes through the wetland and ends at the village of Mugina

Both transects comprised 10 observation points at 200m distance one another on average. GPS coordinates as well as the time and the altitude were registered at each count point.

Except for plants, for all other indicators the number of individuals were counted for every species to have, at the end, the species richness and an indicator of species abundance. The threats and pressure on the ecosystem and on bio-indicators were recorded and ranked at each count points. The threat level uses the following ranking : 1 = nil, 1 = little (0-25%), 2 = Medium (25- 50%), 3 = High (50-75%), 4 = Very high (75-100%). An example of data sheet is founded on the Annexe 1.

a) Plant cover

The identification and estimation of dominant plants as well as important plant species was completed over a surface of 2m² along the transect. The observation points were the same as those set for the fauna survey (every 200m) but these were only done just one time. The phenology state of the plant were noted (N : None, FW : Flowering, FR : Fruits). When the habitat was within an agriculture system, only the naturally occurring plants and trees were counted. The surface was then not strictly respected but estimated and satellite images were used to illustrate the extend of the encroachment of the region.

b) Macro-invertebrates

i. Odonates and butterflies

The identification and counting of individuals of each species was completed. The identification was done at each count point within a distance of 5m around the centre of the point and 10 minutes observation were respected at the count point.

The individuals were identified with binoculars and when needed captured with insects nets for closer observation and at the end the insects were freed. When the identification was not completed directly, pictures were taken to further complement the identification. In some cases, specimen were conserved into alcohol and small containers. The identification was completed using the book "The Dragonflies and Damselfies of Eastern Africa" (Dijkstra & Clausnitzer 2014).

ii. Benthic macroinvertebrates

A standard insect net with mesh of 3mm was used to capture the benthic fauna in the lake. Along the transect, a boat was used to facilitate navigation and sampling within the 5 sites in the lake. Individuals were conserved in 10% alcohol for a later identification. The identification was performed up to the family level.

c) Birds

A 25m radius zone was demarcated in order to count and identify encountered birds at each count points. Bird species were identified using direct observation with binoculars, sound recognition and field guides, the Birds of east Africa" book of Princeton Field Guides (Stevenson et al. 2005).

d) Ecosystem services

To assess the importance of the wetland for the surrounding communities, a questionnaire was filled by the heads of households in the adjacent villages of Nyiragiseke (North) and Mugina (South). This questionnaire discussed the topics of water use (domestic and agricultural) as well as the agricultural, fishing and handcraft practices. The questionnaire template is found in the annexe 2.

III. DATA ANALYSIS



Figure 4: Extend of the biodiversity and ecosystem services survey

To compare the diversity of the sites between each other but also between other adjacent environments, the number of species (S), the Shannon index (H'), A diversity index that takes into account both abundance and evenness of species present in the community and the Pielou's evenness index (J') which is the distribution of individuals across the species present, or relative abundance were computed. This latter was particularly used to allow comparison of the evenness of two areas normalised on the number of species, to specifically separate the evenness of the transects with its species richness, in order words to compare different fields.

The Shannon index was preferred over the Simpson index because it emphasizes the richness composition of the diversity rather than the evenness component (Nagendra 2002). The accumulation curves were used to compare the species richness of the sites considering the sampling efforts. The ecosystem services component was assessed using calculation of percentages, trends, means, majorities and medians.

IV. PRESENTATION OF STUDY RESULTS

1. Biodiversity

Sampling was completed twice within Transect 1 set alongside Rweru lake, on the 31st of March, 06H00 to 09H00 and on the 01st of April, 09H00 to 11H45, respectively. For the transect 2 set through the wetland, sample collection was completed on the 31st of March from 10H15 to 14H10 and due to heavy rain, only the 4 firsts points have been surveyed for birds on the 01st of April from 15H50 to 16H45.

i. Plant assesement

The plant species and their abundance were recorded (*graph a,b*). We note that all plants commonly harvested as crops were not taken into account.

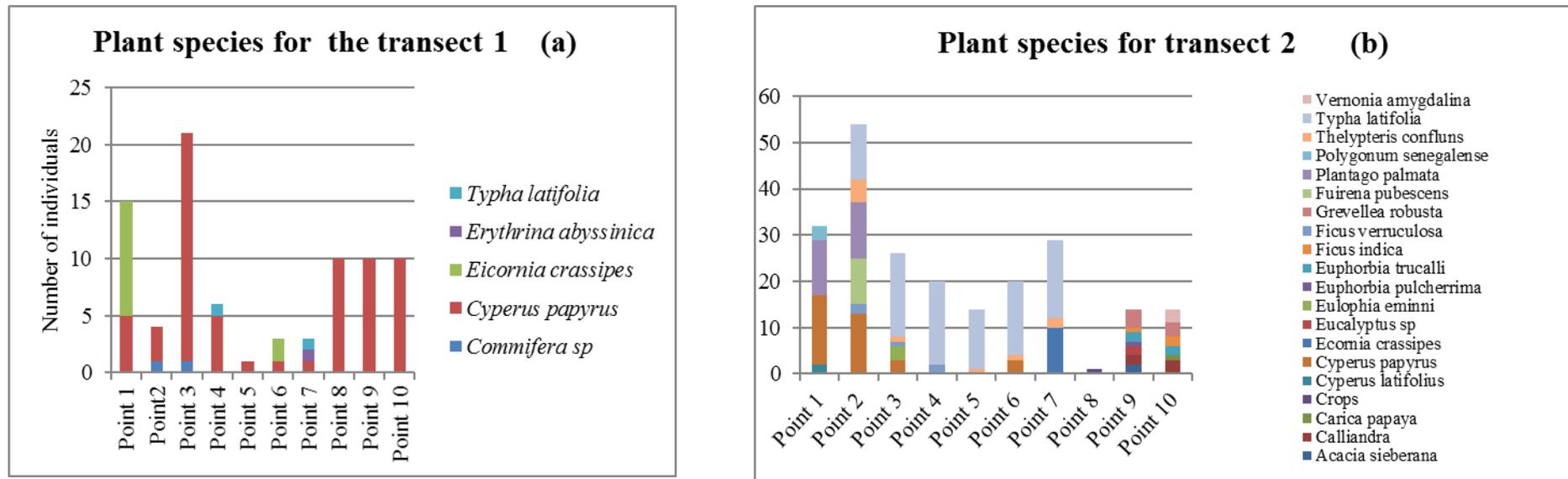


Figure 5: Distribution of plant species across transects

Dominant plant species have been recorded and plotted in the graphs for the transect along Rweru lake's banks (a) and through the wetland (b). The graph above (a) shows that papyrus plant is dominant in almost all parts along the transect. Field observations reveal that in the case papyrus is not dominant, the encroachment of agriculture reaches the edge of the lake and farmers (people) have actually then cleared the lake's bank.

In the wetland, papyrus (*Cyperus papyrus*) was also found to be the dominant species at the edge, but once the transect goes further, the common bulrush (*Typha latifolia*) was found to dominate the landscape. According to field observations, illegal agriculture practices occurs in the wetland from point 4 while within transect 1, severe encroachment was already observed from point 1.

Diverse therats were observed starting with the invasion of hyacinth (*Eicornia crassipes*) in the lake. The encroachment with illegal agriculture on the 10m buffer zone² is critically severe along the lake, alongside the wetland and even in the wetland. Encroachment practices were observed from point 1 and point 4 in transect 1 and transect 2 respectively. The encroachment was however critical from point 6 within transect 2 where, a larger area was being systematically cleared with farmers creating small mounds to dry the soil and grow crops in this very fertile soil.

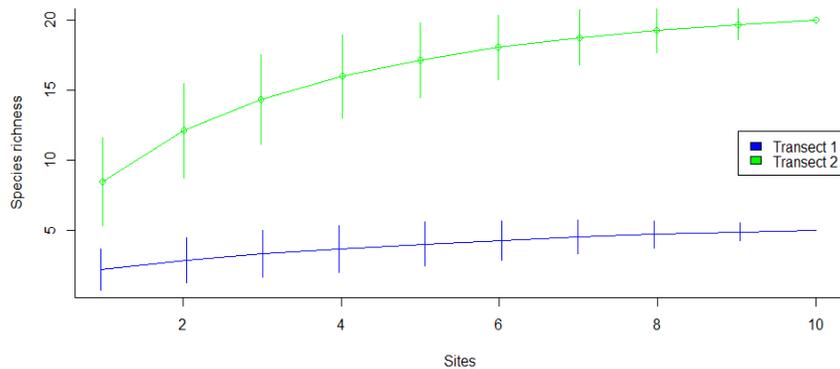
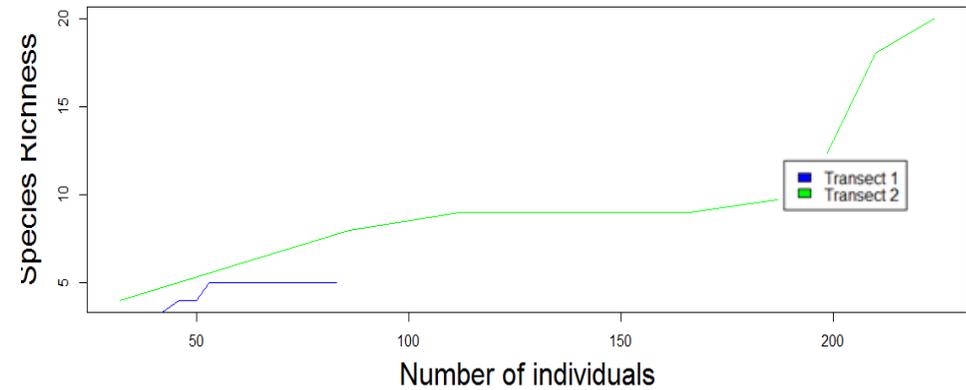


Figure 6: Plant species richness across the two transects



The accumulation curve (a) contrasting the species richness and sampled sites show that the transect set through the wetland (Transect 2), counted more species. From field observations, a severe encroachment started occurring from point 1 of the transect 1 while in the transect 2, it occurred only from point 4. In fact, the wetland transect (transect 2) passes through a region that is less degraded and counts more natural vegetation, most likelt to be undisturbed compared to the transect 1 alongside the wetland and lake’s edge. We note that the harvested vegetation was not considered for sampling in this survey.

From the rarefaction curve (b) contrasting the species richness versus the number of individuals shows a few number of sampled individuals in transect 1 compared to transect 2. Even if the swamps covered by papyrus are known to be species-poor plant communities (Fischer 2011), the encroachment in transect 1 was critically severe.

² The buffer zone is a 10m large zone which has been protected by law.

The following satellite images illustrate the encroachment of agriculture in the wetland for August 2015 and September 2016. The normalised vegetation index has been used.

Comparison of satellite imagery of the Rweru wetland in 2015 and 2016

16th September 2015



31st August 2016



5/19/2017

Note:
The satellite imageries display a true colour imagery taken from the bands 2, 3, 4 and 8 of ESAs Sentinel 2A. For a better visual comparison the imagery of 9/16/2015 was artificially brightened by +30 %.



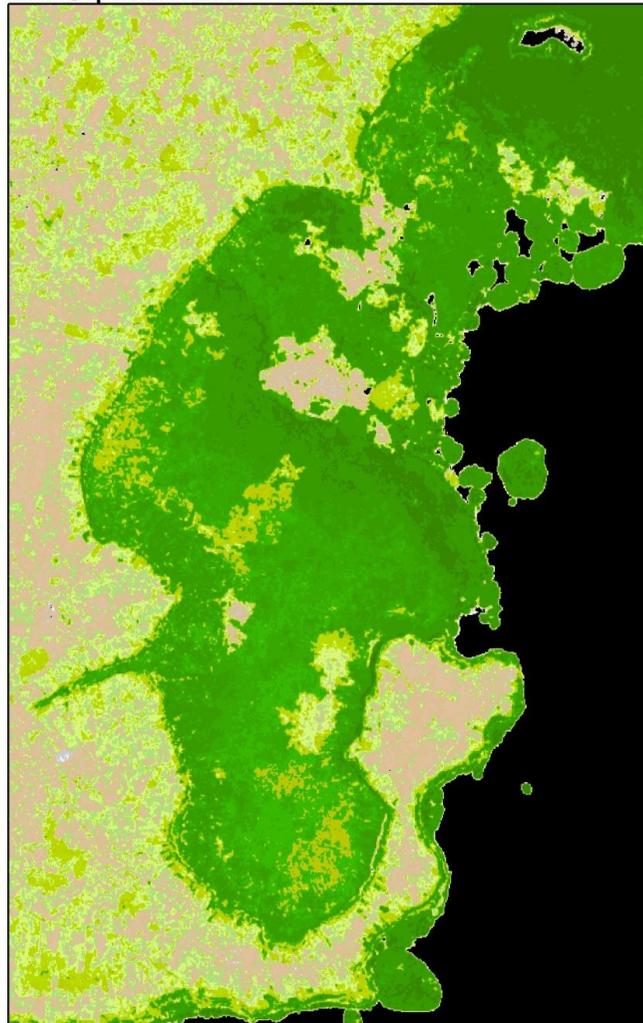
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Coordinate System: GCS WGS 1984
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Figure 7: Rweru – Mugesera wetland complex , 2015 V versus 2016 satellite images

Comparison of the Normalized Difference Vegetation Index of the Rweru wetland in 2015 and 2016

16th September 2015

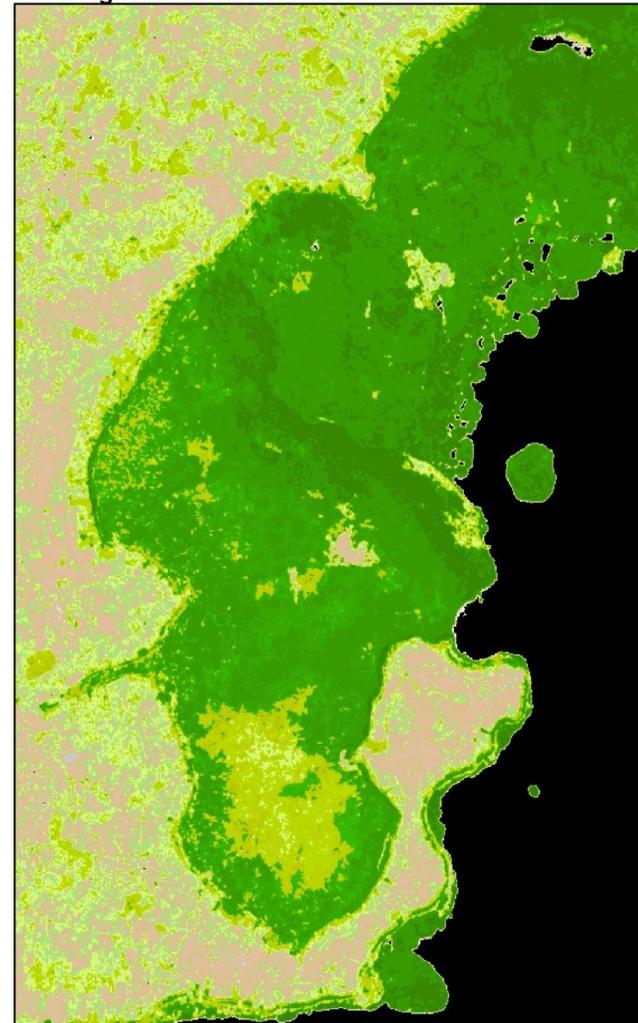


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31st August 2016



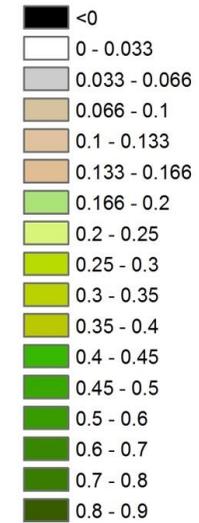
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5/19/2017

NDVI - Value



Note:

The satellite imageries display the NDVI taken from the bands 4 and 8 of ESAs Sentinel 2A.



Figure 8: Rweru – Mugesera wetland complex , 2015 versus 2016 normalized vegetation indexes

These satellite images show a rise of the wetland encroachment from one year to the another. Compelling reasons might not have been the same and some more comprehensive research should be conducted, for instance those accounting for seasonality and precipitations. Despite this uncertainty as to the cause of this encroachment, these images illustrate the growing risk for the wetland following the harvesting in the marsh itself.

ii. Macro-invertebrate survey

1) Odonates

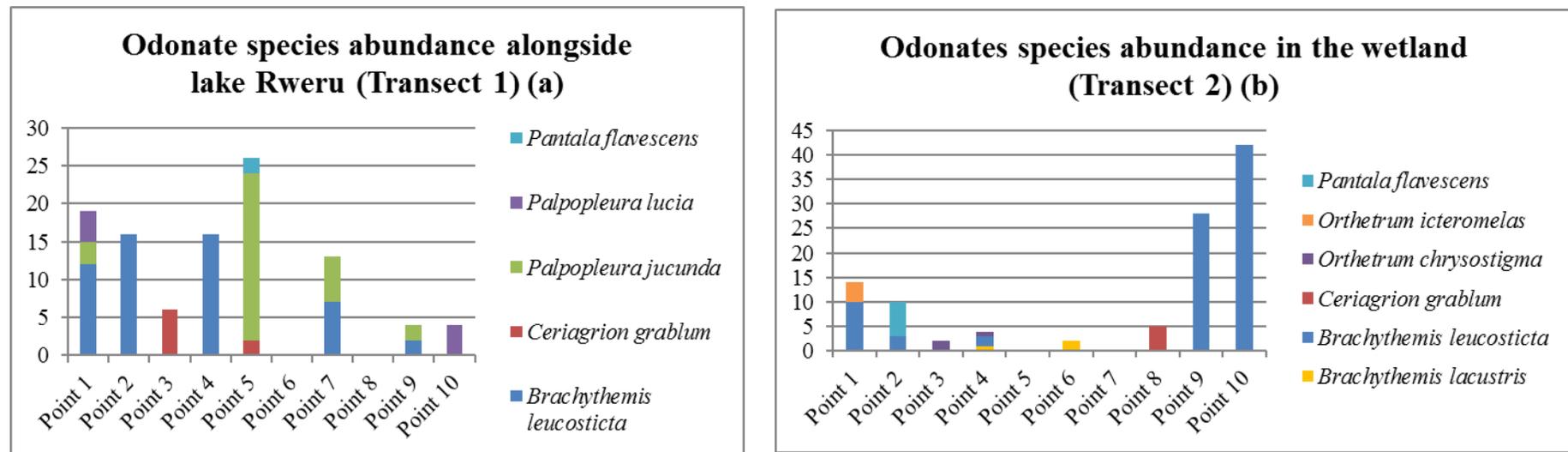


Figure 9: Odonate species distribution across the study site, alongside the lake’s edge (1) and across the wetland (2)

In order to enable comparison of the two transects, points that were surveyed in the morning were selected for both two graphs. The indexes were computed using combination of the points covered in the morning and those in the afternoon which were merged together to form the *transect 1 Total*. Only 5 and 6 species have been counted for transect 1 and 2 with 104 and 107 individuals and Transect 1 was found to have higher diversity and relative abundance indexes than transect 2, H' and J' respectively. (Table 1).

Table 1 Odonates species richness, diversity and evenness

	Number of Species	Number of individuals	H'	J'
Transect 1 Total	5	169	1,69480481	0,7299127
Transect 1	5	104	1,70000904	0,73215404
Transect 2	6	107	1,19409194	0,46193782

2) Butterflies

Only two species of butterflies were identified within each transect. Transect 1 was surveyed twice where 24 individuals of the species *Colotis danae* (6 versus 18 in the morning and afternoon respectively) and 8 individuals of the species *Amarius ochlea* were found (4 in the morning, 4 in the afternoon). In transect 2, 2 individuals of the species *Amarius nivius* and 13 of the species *Bicyclus anynana* were identified. No endemic species were found (Davenport 2003)

3) Benthic Macroinvertebrates

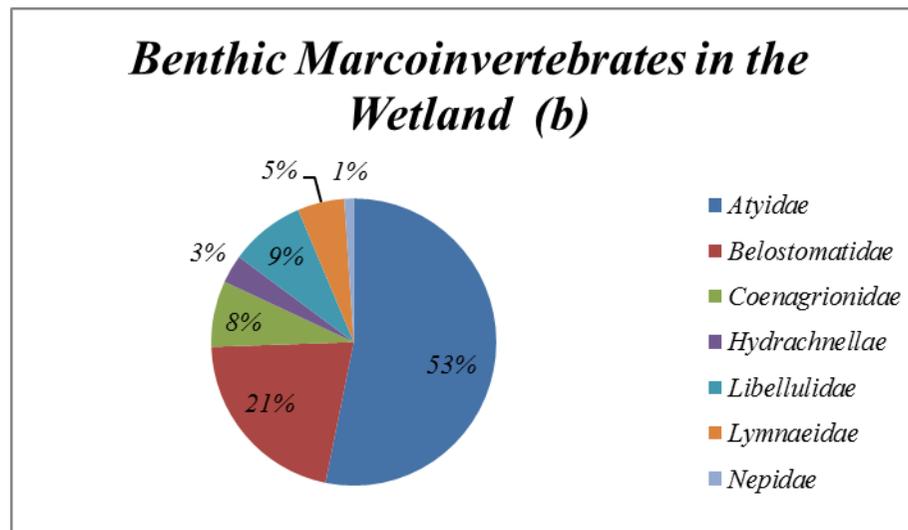
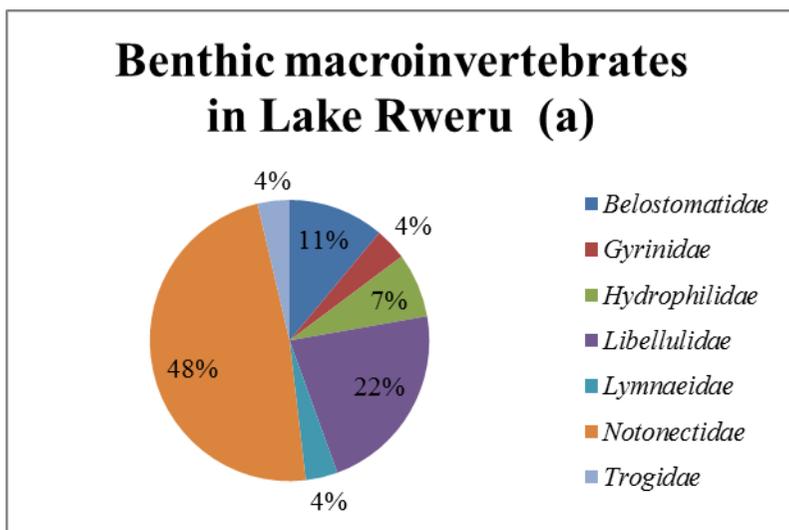


Figure 10: Benthic macroinvertebrates species distribution in the lake and the wetland at Lake Rweru

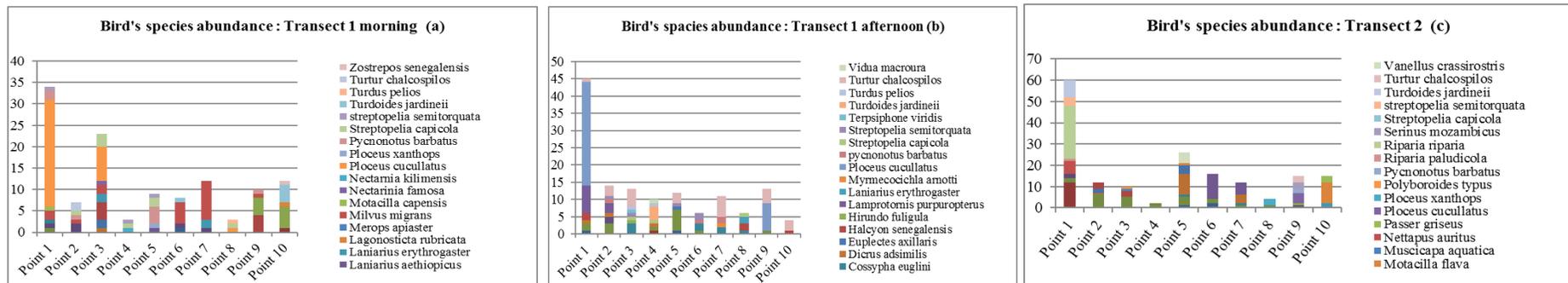
These families are all highly tolerant to pollution except the Atyidae and Hydrachinellae found in the wetland, moderately tolerant to pollution. Seven (7) different species were recorded in each transect and the lake was found to have higher diversity and relative abundance indexes than the wetland, H' and J' respectively. (Table 2).

Table 2. Benthic macroinvertebrates species diversity

Benthic macroinvertebrates species diversity				
Site	Number of Species	Species richness	H'	J'
Lake	7	1,82047845	2,14857717	0,76533863
Wetland	7	1,32062749	1,9945103	0,7104589

iii. Bird survey

A total of 46 species have been recorded during the survey comprising 33 species observed alongside the lake and 27 in the wetland. All birds recorded are native with three species of non-breeding migrants and out of 47 different species recorded in the study sites, 12 are waterbirds and 3 are migrants species. The endangered black crowned crane listed Vulnerable by IUCN (International Union for Conservation of Nature and Natural Resources, 2000a) has been observed in the wetland during the survey and its population is still decreasing (BirdLife International



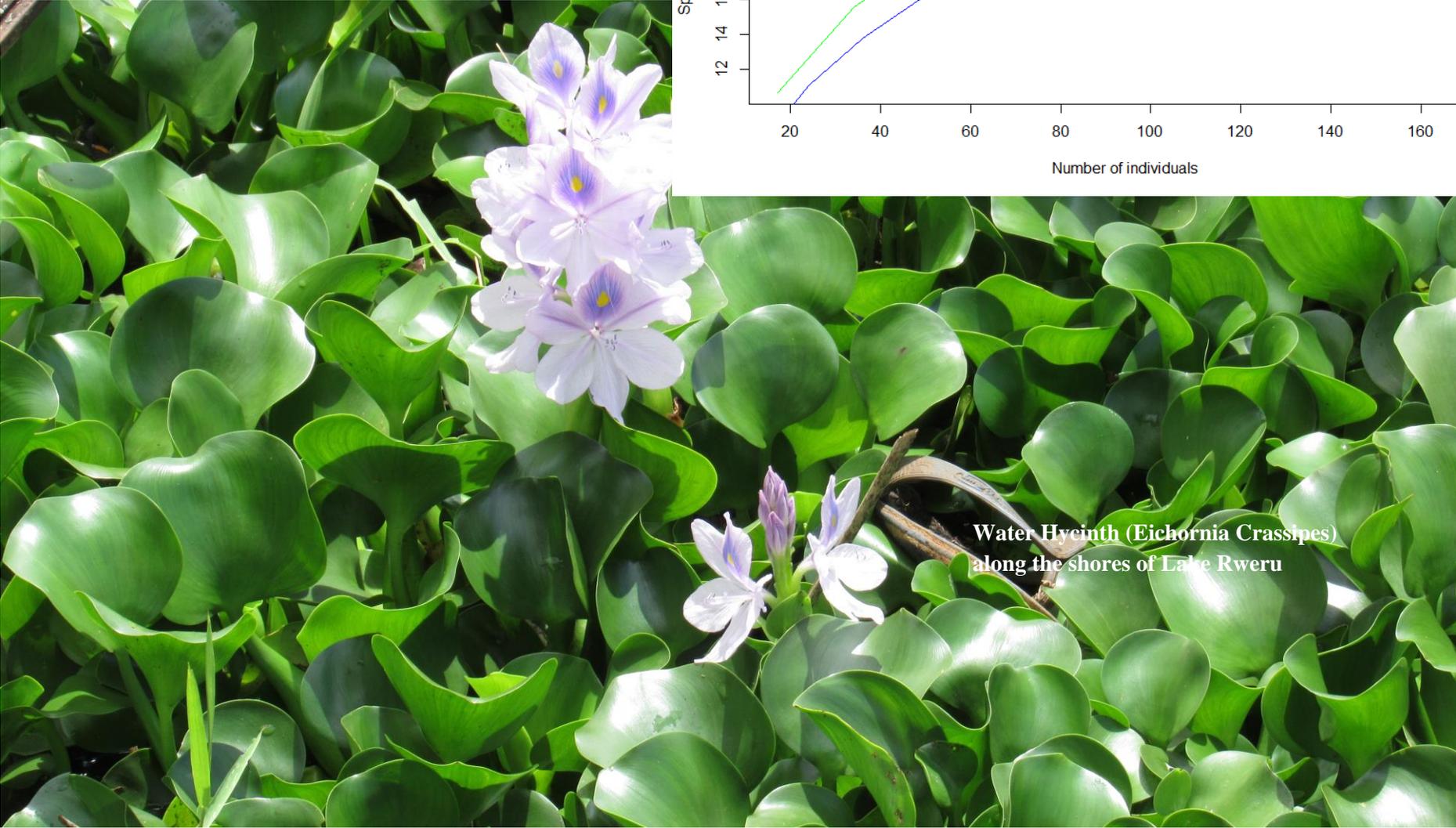
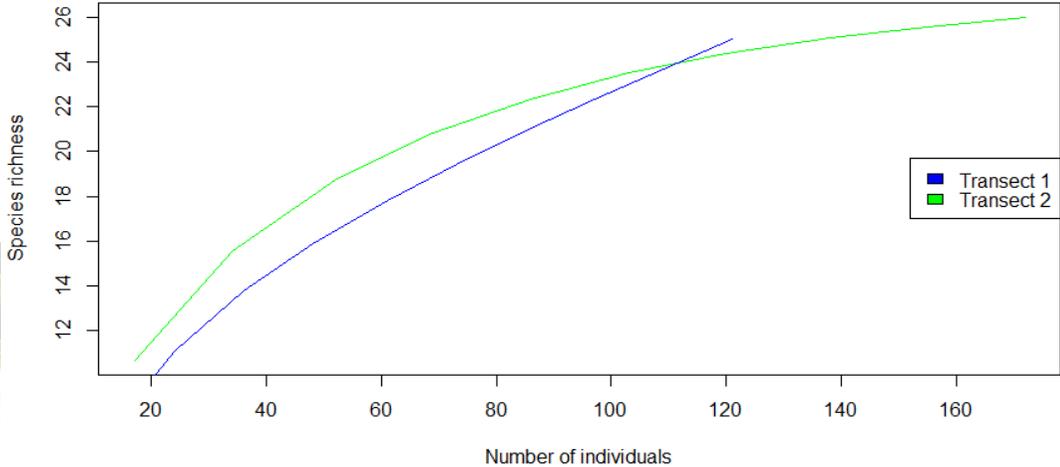
2017a).

Figure 11: Bird species distribution alongside the lake (a,b) and within the wetland (c)

From field data, the morning surveys in both transects, accumulated to 25 and 27 species alongside the lake (Transect 1) and within the wetland (Transect 2), respectively and the transect set through the wetland had higher diversity and relative abundance values than the transect alongside the lake, H' and J' respectively (Table 3). The rarefied richness, relatively higher in the wetland than alongside the wetland, was computed to allow comparison of the transects while assuming constant sample size (Figure 10)

Table 3. Bird species diversity

Bird species diversity			
Site	Number of Species	H'	J'
Transect 1 Total	33	3.9	0.77
Transect 1	25	3.6	0.77
Transect 2	27	4.11	0.86



2. Ecosystem services

A. Overview

A total of 39 households in the study area were questioned about the ecosystem services associated to Rweru-Mugesera wetland. This sample comprised of 20 males and 19 females and 87% of them were married.

Nearly the half (46%) of the interviewed heads of households had no level of education at all and 18% hold only a primary school level whereas another 18% confirmed having dropped primary school education between the 2nd and 6th year. Only one person (a teacher) had a high degree of studies.

The majority of the population in these villages are farmers (77%); those practicing both farming and fishing account for 10% and only 5% rely exclusively on fishing for their livelihoods. The three remaining people were a teacher, a constructor and a businessman. The interviewed householders have been living in the region at least 22 years in average with 44% confirming having lived in the region since more than 30 years.

The mean distance of the houses to the wetland is 7.18km but more than 50% of the households interviewed live in a radius of 500km to the wetland's edge.

B. Resources benefited from the wetland

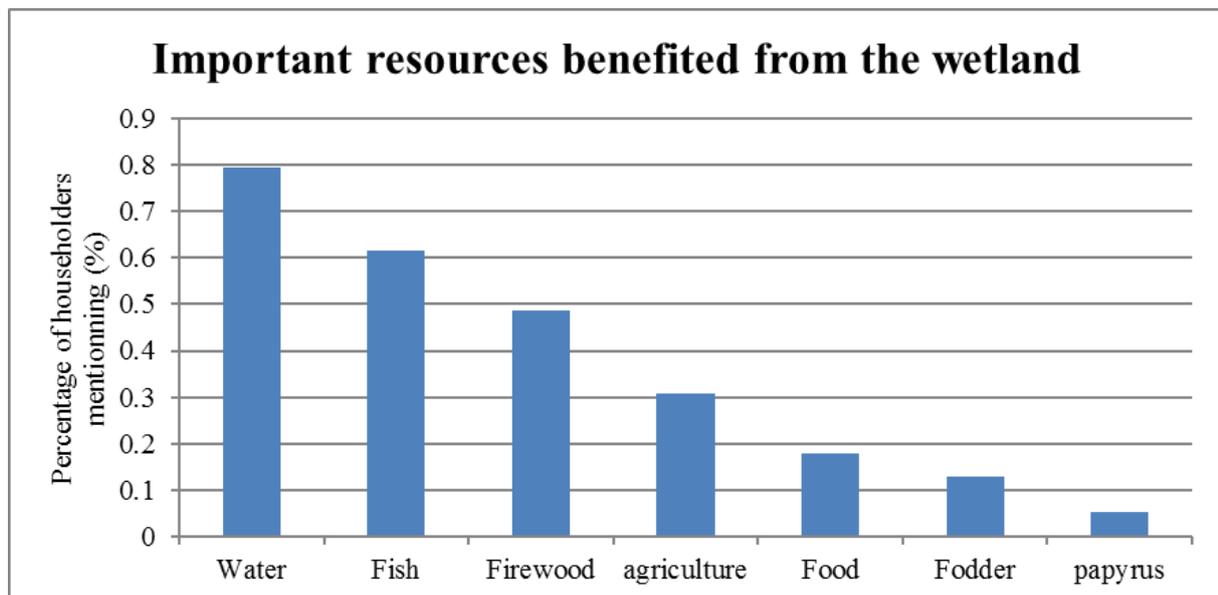


Figure 13: Important resources benefited from Rweru wetland

From the study of households' perceptions, water, fish and food were reported as being the most exploited resources from the wetland by 79%, 61% and 18% interviewed households respectively. 49% of the households ranked the provision of firewood as the second most important wetland resource (Figure 13).

The water, fish and firewood are the three principal resources mentioned by the interviewed local communities. Fish, water and agriculture have been defined as the first most important resource by respectively 33, 28 and 15% of the interviewed householders.

1) Water use

The water of the wetland is principally fetched for domestic use.

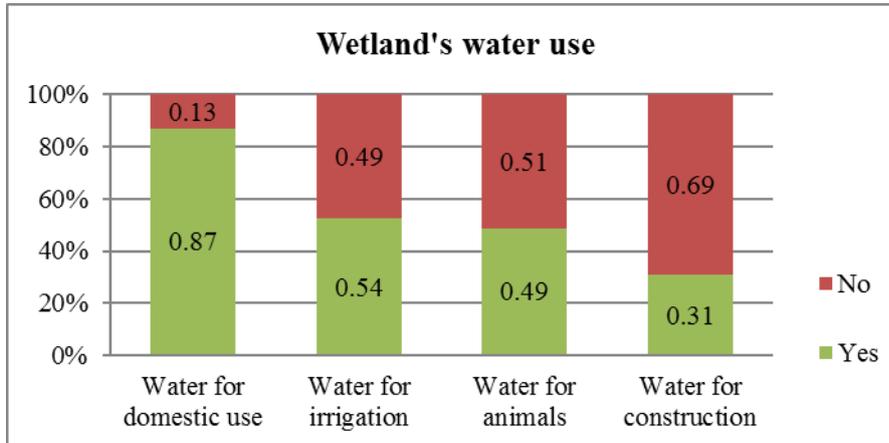


Figure 14: status of wetland water use

The wetland water harvesting is principally for domestic use by more than half of the households (54%); the use for irrigation and livestock accounts for 49% while its use for construction was reported to make up to 31% by the interviewed households.

In average, the extent of water use reaches 3.3 jerrycans per day equivalent to 66.6L daily. As far as drinking water is concerned, only 2 households out of the 39 use the water of the lake. The majority (71%) use water from a borehole and 23% use tap water.

Although the habit of washing in the lake is not generalised, a quarter of the interviewed householders confirmed carrying their washing directly in the lake.

2) Resources use

The majority of the households (97%) depend on the wetland solely for its fish resources while 23% of the community rely on the wetland as the principal source of daily livelihoods. Approximately 67% of the community fetch the wetland's grass for various uses including livestock fodder (69%), soil mulching (23%) and firewood (7%). More than 16 medicinal plants from the wetland are used by the local population (Table 4) to for diverse applications such as the ficus (*vallis-chaudae*) used to treat childrens belly button and *Chenopodium opulifolium* used for skin diseases.

A critical threat to the wetland is the excessive harvesting of resources inside the wetland which is practiced by around 64% of the households. The majority (72%) depend on the wetland as the sole source of their daily livelihoods while 28% engage in fetching and selling their harvest. This contrasts the trends for fishing as 100% of people fishing in the lake sell their fish in addition to consuming it.

Out of 35 interviewed farmers, 14 use fertilizer or pesticides while only 3 use organic fertilizers. Most farmers grow their crops in less than 500m from the wetland, and around 50% are within less than 100m from the wetland. The mean distance to the wetland is 400m with more than 50% of the farmers having their crops at less than 280m.

Table 4. summary of medicinal plants commonly fetched from Rweru wetland

Kinyarwanda name	Scientific name	Habitat
Umuzibanziba	<i>Mitragyna rubrostipulata</i>	Wetland forest
umurehe	<i>Ficus vallis-choudae</i>	Woodland along streams
umuberanya	<i>Typha latifolia</i>	Wetland
imikeri	<i>Rubus sp.</i>	Mix
umbwungo	<i>Polyscias fulva</i>	Forest
umuravumba	<i>Tetradenia riparia</i>	River bank
umusagara	<i>Rhus vulgaris</i>	River bank
umwisheke	<i>Chenopodium ambrosioides</i>	Montane grassland
umusharita	<i>Cissus rubiginosa</i>	Mix
bamburwa	<i>Coryza sumatrensis</i>	Cultivated land
umugombe	<i>Chenopodium opulifolium</i>	Open habitat
cyomya	<i>Salvia nilotica</i>	Mix
umuharata	<i>Toddalia asiatica</i>	Riverbank forest

3) *Benefits associated to living in the proximity of the wetland*

The most important benefits associated to the wetland (Figure 15) include water accessibility and abundance, cheap fish and possibility to grow crops during the dry season.

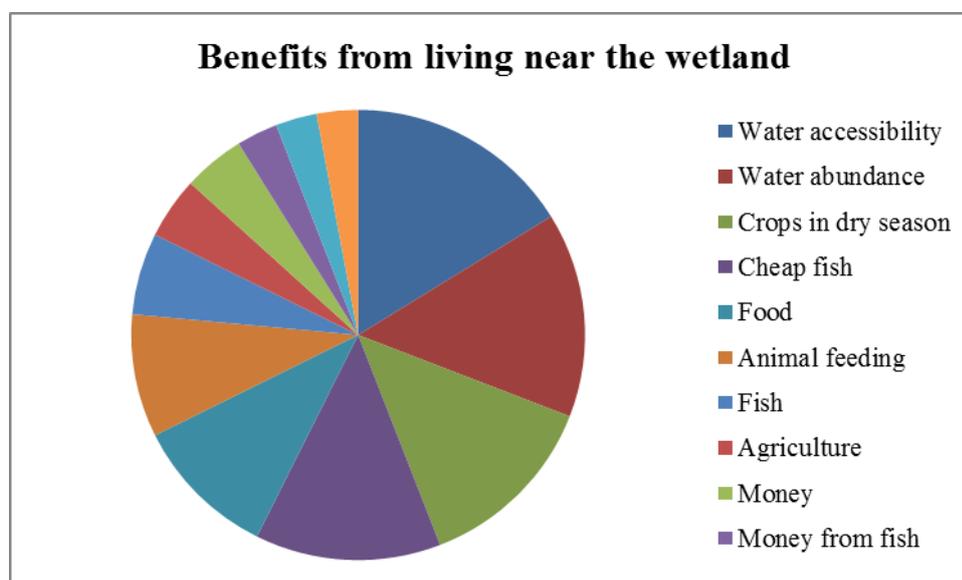


Figure 15: Benefits associated to living in proximity to Rweru – Mugesera wetland complex

C. Perception of the wetland

Several programs are implemented around the wetland with the overall goal to achieve its sustainable protection. Although the intrinsic value of the wetland is principally perceived by households as the basis of their livelihoods, roughly 30% of the households in the surroundings do not have comprehensive understanding of such protection projects which affect the implementation and sustainability of some of them.

Thus, only 30% of households understand the importance of the buffer zone and only 17% know the reasons for prohibition of crop growing in this zone. A few people are informed about the sustainable fish practices using adequate nets to avoid catching too small fishes. A low proportion of households acknowledged having heard about some educational programs on the importance of implementing anti-erosion practices on the hillside as well as stopping washing in the river or lake.

The majority of the householders (82%) consider that the condition of the wetland has decreased since 10 years and the same proportion consider the condition of fishing decreased as well. Several activities that constitute the common threats to the wetland (Figure 16) have been identified and include agriculture and water hyacinth accounting over 33% of all causes of wetland degradation, each. Another critical threat relates to the illegal and malpractice in fishing by Burundian fishermen who come across the Rwandan part of the lake and do not use sustainable nets. Illegal hunting and sedimentation have also been reported as problems while soil erosion was perceived at 5% as a problem in the region.

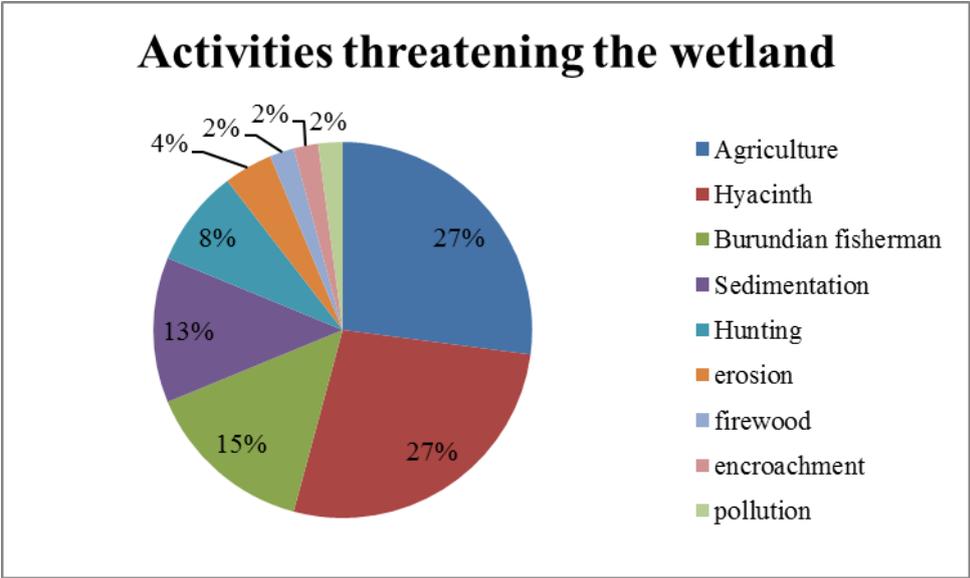


Figure 16: Major threats to the wetlands as perceived by the local communities

Vis-à-vis the existence of protective measures to safeguard the wetland, findings reveal that 66% of the households are aware of the buffer zone in place consisting of tree plantations alongside the lake where no agriculture practices are allowed and the sustainable fishing practices as well as the removal of the water hyacinth.

However, those measures are not considered as fair according to more than 50% of the households. The principal argument is the loss of land and hunger as a consequence of the implementation of the buffer zone. The remaining ones who consider the measures as fair, understand that such measures will allow a sustainable development of the landscape driving, at long term, to cheap food price.

Negative aspects of living near the wetland have been mentioned by only 35% of the householders. The main disadvantage is the presence of hippopotamuses which often destroy the crops at the edge of the lake. The unsustainable fishing practices by Burundian fishermen as well as the strict use of the buffer zone have been mentioned as well. In addition, there is a problem of mosquitoes which pose a risk for malaria outbreaks in the region.

Even if agriculture is considered as one of the main threats to the wetland and 64% of the householders harvest their crop in the wetland; 87% of the households consider agriculture not to have any negative impact to the wetland. They argue that since the wetland forms the basis of their livelihood and it has remained so for a longtime, then it's not harmful to continue using the wetland as their ancestors have. A few people acknowledged that sometimes the agriculture may have a negative impact typically with the over-draft of water during the dry season. As evidence for this confirmation of negative impact of agriculture to the wetland, the interviewed households cited the rare presence or sight of the once commonly abundant in the wetland. They are concerned that this wetland antelopes called siatitunga will disappear.

V. DISCUSSION AND INTERPRETATION OF RESULTS

1. Biodiversity

During this research, the study protocol was slightly deviated from (e.g. interrupted or delayed data collection) due to a couple of reasons including weather conditions, a short data collection period, limited resources, remoteness and so forth. In regard to this, transect 1 alongside the lake edges was surveyed twice (morning and afternoon) while transect 2 set through the wetland was visited only once (morning) which led to not having no replicates for the two transect comparison.

Given the very different sample sizes in the two transects of the study site, it was imperative to use rarefied richness as the species richness was therefore a function of total individuals collected since we assume not having completed to sample every species existing in both transects. Thus, even if a higher number of species was found in one transect than in the other (which could depend on sampling efforts in one transect), it does not legitimately mean that transect necessarily has higher species richness than the other. Only then, from rarefied richness, transect were compared assuming sample size held constant. Despite such deviations, the whole baseline survey data analysis is interesting and the findings most likely to provide the baseline information on the status of biodiversity, ecosystem services and conservation trends of the wetland in general.

Rweru-Mugesera wetland complex is dominated by *Cyperus papyrus* and *Thypha latifolia*. Such wetlands are known to have very little flora diversity (Global Invasive Species Database 2017). The transect alongside the lake counts very little number of species and individuals in comparison to the wetland, which is complemented by computed rarefied richness, higher in transect 2 (*rarefaction curve, Figure*). Compelling reasons include the fact that not only their transect has been undergoing a severe encroachment, but that even harvested plants were not taken into account as illustrated by satellites images (*Figure 6.a,b*). Further comprehensive research should be conducted on land cover and use to estimate the agriculture coverage and the extent of the encroachment. Enhanced satellite imagery would help to assess the zones or patches of the wetland which are still or remain intact in every season and those which are needed and most likely to be used by the farmers during dry season.

The macro-invertebrate survey revealed very few species of odonates and butterflies. The transect alongside the lake was found to be representative of a more diverse and equally distributed community of odonates compared to transect 2 set through the wetland (Shannon index slightly different, $H'_{transect1} = 1.69$ versus $H'_{transect2} = 1.19$) as complemented by high value of Pielou's evenness index implying that species frequencies or abundance are more similar or more even in transect1 than in transect 2 ($J'_{transect1} = 0.72$ versus $J'_{transect2} = 0.46$). In terms benthic macro-invertebrates species, the lake was found to shelter more species, with higher values of species richness (S) ($S_{Lake} = 1.82$ versus $S_{Wetland} = 1.32$), with a more diverse and equally distributed community of benthic macro-invertebrates than the wetland ($H'_{Lake} = 2.14$ versus $H'_{Wetland} = 1.99$; $J'_{Lake} = 0.76$ versus $J'_{Wetland} = 0.71$). This could be explained by bad weather conditions during the surveying period.

In fact, it was frequently raining and butterflies sense changes in pressure and relative humidity before the rain comes. Also, the cloudy weather has an influence on the butterflies' flight (Emmel & Emmel 1967). Thus, not only the rainy weather could have an influence over the presence of odonates and butterflies but even the season of flights which has not been determined in Rwanda is also an important factor.

From the birds survey, with the opportunistic observations along the transects, 47 species of birds were recorded including 12 waterbirds and 3 migrants. The wetland was found to be more diverse ($H'_{transect2} = 4.11$ versus $H'_{transect1} = 3.9$) and have quite even species in terms of abundance, higher J' ($J'_{transect2} = 0.89$ versus $J'_{transect1} = 0.77$) than the area alongside the lake and this is complemented by rarefied richness higher in transect 2 than in transect 1 (rarefaction curve, Figure 10). Some important species such as the endangered grey-crowned crane (*Balearica regulorum*) have been observed in the wetland which may suggest the wetland to be an important breeding site during the dry season.

In addition, the presence of waterbirds may indicate that the wetland is sufficiently healthy though the magnitude should be determined.

2. Ecosystem services

Overall, the households at the study area acknowledge that the wetland represents an important aspect of their life. Most of them use water from the lake/wetland once a day at least for domestic or agricultural use and eat fish from the lake. The wetland water is mostly used for domestic use and irrigation, and in the dry season, the wetland becomes a crucial farming land. A total of 72% households practice agriculture for subsistence and while Bugesera is one of the driest districts in Rwanda, 64% of the households practice agriculture directly in the wetland. It is therefore hard to prohibit completely the access to the wetland. However some sustainable practices can be implemented and recommended such as the use of biopesticides or biological control but also the use of natural fertilizer collected from the livestock in place of the chemical fertilizers which enriches the water of N and P and which can potentially lead to eutrophication.

It is particularly important to note that for the community, the wetland is perceived as an important asset for their livelihood, however they hardly understand its protection and several measures taken (Buffer zone, excluding crops from the limits of the wetland,...) are not respected due to the crucial need of fertile lands and hunger in the region.

VI. CONSIDERATIONS FOR RAMSAR SITE DESIGNATION OF RWERU-MUGESERA WETLAND

The Ramsar Convention on wetlands identified nine criteria to define wetlands of international importance. After the rapid assessment and with some complementary information from the administrative and local authorities in Bugesera district, the importance of the Rweru-Mugesera wetland complex has been highlighted through some of those nine criteria. This section has grouped the 9 criteria into two categories, the category of criteria on which enough data and information has been gathered to adequately assess the wetland's eligibility against them, and a category of other criteria whose proper assessment would require more data collection.

A. Eligibility of Rweru-Mugesera wetland complex against Ramsar criteria

- 1) *Criterion 2 stating that "A wetland should be considered internationally important if it supports vulnerable, endangered or critically endangered species or threatened ecological communities";*

Findings from the biodiversity survey at the Rweru-Mugesera wetland complex reveal its importance vis-à-vis this criterion. During the rapid biodiversity assessment, several individuals of the endangered species of grey crowned-crane (*Balearica regulorum*) have been observed in the transect 2 (located in the wetland). This endangered crane has a large home range but in East-African region, it breeds during the dry season. Wetlands and lakes in the driest regions like Bugesera can be very important for birds particularly for grey crowned cranes which inhabit diverse wetlands, marshes, riverbanks and so forth and breed within or near wetlands (BirdLife International 2017b). They construct a nest in or along the margins of wetlands, and for that, the undisturbed areas are crucial for this species and not only in the wetland but also within the buffer zone around.



Figure 17: Elliot's Chameleon in the Wetland. Credit: ARCOS

In line with this criterion, a second important species to mention is the sitatunga, an amphibious antelope (*Tragelaphus spekii*) which is listed as Least Concerned worldwide according to the IUCN red list (International Union for Conservation of Nature and Natural Resources. 2000b), species which are however disappearing and their population are decreasing due to hunting but also fragmentation of their habitat, swamps. For this species, swamps represent a very good refuge and their loss most likely make them vulnerable to predators and hunting.

According to several inhabitants of the region, Sitatungas were commonly seen 10 years ago, but their local population is now decreasing and individuals become rare to see. Marshes and dense wetland vegetation are vital for the lifecycle of Sitatungas and their fragmentation and destruction severely threaten the survival of sitatunga populations (Coash 2000).

In previous surveys (Kasavubu 2005; Fischer 2011), some remarkable species of birds have been found as the papyrus golonek (*Laniarius mufumbiri*) which is restricted to dense papyrus swamps. This is an endemic bird in the East African region and is listed as near threatened by IUCN because of the destruction of its habitat (International Union for Conservation of Nature and Natural Resources. 2000c).

The papyrus yellow warbler (*Calamonastides gracilirotris*) has also been seen in this wetland (Fischer 2011). Its habitat is primarily papyrus swamps and it is listed as Vulnerable by IUCN also because of the loss of its habitat (BirdLife International 2017c). In addition, around 70 waterbirds species have been spotted and 19 migratory birds (Kasavubu 2005). In this survey, the Elliot's chameleon (*Trioceros ellioti*) has been recorded during the transect in the wetland. This chameleon is endemic in the great lakes region.

The African Clawless Otter (*Aonyx capensis*) and the spotted-necked otter (*Hydrictis maculicollis*) have also been observed in the previous survey (Kasavubu 2005), these species are not vulnerable yet, but are listed as near threatened by IUCN and the population is still decreasing because of their specialised habitat and habitat loss.

2) Criterion 4: "A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse condition";

The geographical position, demographic characteristics and land use trends indicates the importance of Rweru-Mugesera wetland complex considering criterion 4. Bugesera is one of the driest district in Rwanda, with an average of annual precipitations from less than 700mm to 800mm (Figure 18).

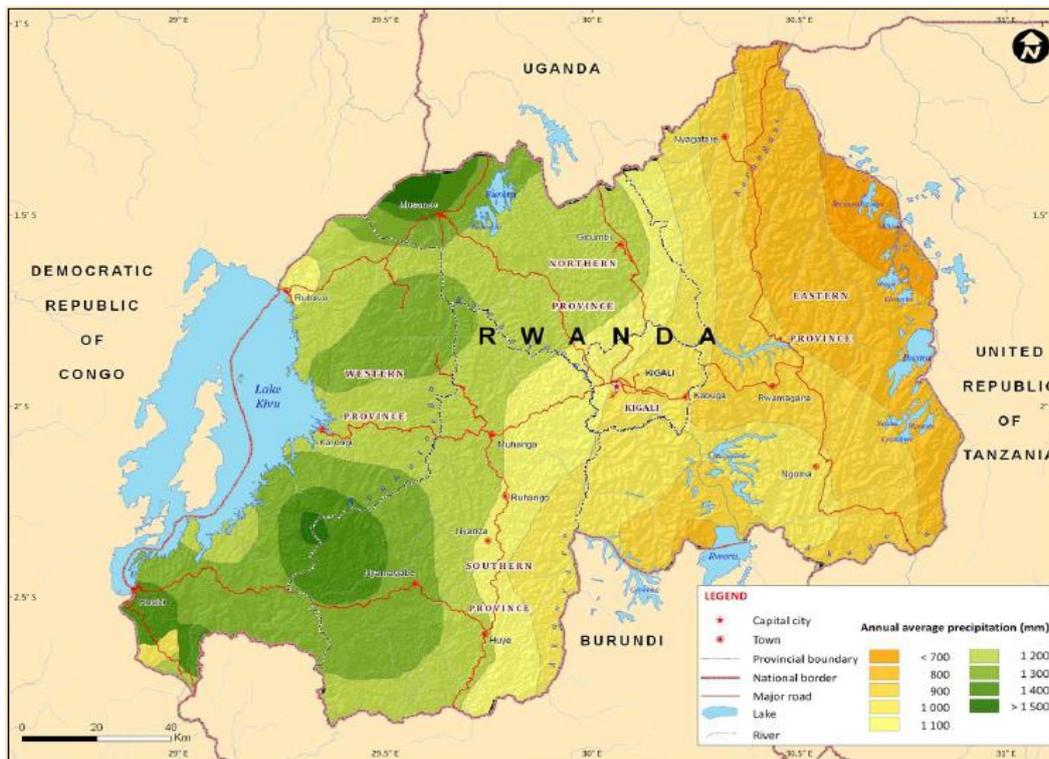


Figure 18: Annual average precipitation in Rwanda, Source : REMA 2011

Rwanda has two annual rain seasons, the first from March to May and the second from October to November. The months of dry season often count less than 100mm and wetlands and lakes are important refuges during that period of the year for biodiversity in general (REMA 2011). However, given the progressive encroachment of agriculture, the wetland becomes more drained and fragmented and the refuge area available for the wildlife decreases in return. Wetlands are known to be water filters and storage sources which are very important for the whole ecosystem surrounding and downstream. The wetlands avoid floods during the wet season which, with increasing soil exploitation and erosion, have been in dramatic increase in Rwanda (REMA 2009). The storing capacity of wetlands becomes more vital during the dry season where the wetlands represent a main source of food and water for the surrounding populations. This habitat represents then an important refuge and crucial environment for species like waterbirds which represent a forth of the birds surveyed in the rapid assessment but also situngas, amphibians, and other biodiversity.

3) *Criterion 7: "A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stage, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global diversity"; and*

And Criterion 8 : " A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks either within the wetland or elsewhere, depend";

Approximately 98% of the households in the study area consume fish. The average annual production is thought to be between 200 and 250 tonnes only for the lake Rweru.

More research should be conducted to survey and profile the distribution and diversity of fish species in Rweru-Mugesera wetland complex and the associated lakes. Local inhabitants have revealed that during the rainy season, the wetland and the lake are fully connected and at that moment, fish migrate from one site to another. In the case of this year (year 2017), fishermen said that the rainy season was late and as consequence the two ecosystems did not get connected which in turn led to less fish in their nets. Given these observations, it is a reasonable conclusion that wetlands are important habitat for fish in the lake and constitute a potential spawning nursery habitat for the fishes as also previously suggested (Ministry of Natural Resources 2011). One study realised in 2005 conjointly with FAO and MINAGRI (Kasavubu 2005) revealed that the ichthyofauna of the complex counts various vulnerable and endemic species. The greenhead Tilapia (*Oreochromis macrochir*) for example is present in the lake (Kasavubu 2005) and is considered as Vulnerable (International Union for Conservation of Nature and Natural Resources. 2000d). The *Haplochromis burtoni* is a fish that is only present in four countries (Burundi, Tanzania, Rwanda and Zambia) (and which is commonly found in this wetland (Ntakimazi 2010; Kasavubu 2005). The FAO and MINAGRI survey revealed the occurrence of the dwarf Victoria Mouthbrooder (*Pseudocrenilabrus multicolor ssp. Victoriae*) which is a fish typical from the swamps and wetlands, a species endemic in lake Victoria and Kanyaboli Bassin (Hanssens 2015). This wetland potentially contributes thereby to the global diversity.

The Dark Stonebasher (*Pollimyrus nigricans*) is an endemic fish of the Lake Victoria, Akagera, Lake Tanganyika, Rusizi and Malagarasi basins including the Rweru-Mugesera complex. This is rare and typical of the papyrus vossia vegetation wetlands, it is also migrant. This species is not considered as endangered but its major threats include, among others, the loss of papyrus swamps and water turbidity (FishBase team RMCA & Geelhand 2016c). The conservation strategies for this species imply taking into account an integrated conservation of the ecosystem and home range because of its migratory characteristic.

The Ningu (*Labeo victorianus*) is an endemic fish from the lake Victoria basin which is currently critically endangered. This fish is fully migrant (may be even present in Rweru–Mugesera wetland complex) and is threatened by the intensive fishing, the eggs collection and the regression of swamps and wetland (FishBase team RMCA & Geelhand 2016a).

The *Barbus acuticeps* and *Synodontis ruandae* are endemic fishes to the Akagera River system and are respectively near threatened with a decreasing population and vulnerable species. The main threats are the regression of swamps and wetlands due to agriculture, sedimentation and erosion. It is found in the main channels of rivers but also in swamps and ditches. Not a lot is known about these species but the protection of the species via the protection of swamps is necessary, for now, no conservation action is done to protect this species (FishBase team RMCA & Geelhand 2016b).

Findings from the ecosystem services survey reveal that the most fished species in the lake is the marbled lungfish (*Protopterus aethiopicus*) which inhabits swamps, riverbeds, floodplains and river deltas.

The juveniles are restricted to the papyrus roots which makes them vulnerable in case of swamps regression and banks encroachment (International Union for Conservation of Nature and Natural Resources. 2000e).

Though a more comprehensive assessment is needed for detailed explanations vis-à-vis the above-mentioned examples, it is clearly shown that the wetlands are crucial for the survival of fish species and that some species are highly internationally important due to their endemism and vulnerability.

- 4) Criterion 9: "A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species".**

More research should be conducted to provide sufficient information in order to position the importance of Rweru–Bugesera wetlands complex with regard to this criterion; notwithstanding, some species could be potential candidates for this criterion. Some fish for instance are dependent on the wetland (*see paragraph below about marble lungfish*), in addition to situngas and crocodiles (Kasavubu 2005). Research should be conducted to estimate the population of targeted species and then a long-term monitoring plan could be developed.

B. Recommendations for further research

- 1) In the light of Criterion 1 stipulating that: "A wetland should be considered internationally important if it contains a representative, rare or unique example of natural or near-natural wetland type found within the appropriate biogeographic region";**

The Rweru-Mugesera complex is dominated by papyrus (*Cyperus papyrus*) and common bulrush (*Typha latifolia*) and is qualified as Cypero papyri-Dryopteridetum (Fischer 2011). This type of wetland is commonly known to have small vegetation diversity but to host large fauna diversity. It is then absolutely important to mobilize all possible data and generate a comprehensive profile of biodiversity and ecosystem at Rweru-Mugesera wetland complex.

- 2) Criterion 3 : "A wetland should be considered internationally important if it supports populations of a plant/or animal species important for maintaining the biological diversity of a particular biogeographic region";**

In relation with the statement above, wetlands with dominance of *Cyperus papyrus* and *Typha sp.* are very important in East Africa and are known to host a large biodiversity especially the avifauna (Donaldson et al. 2016). They are also important for water quality and quantity which in this case, has an impact on the whole Nile basin.

Given the complexity of hydrological network, migration trends and increasing threats most likely to affect specific biodiversity of a given bioregion, in this case the East Africa, it is capital to keep safe any wetland or complex whose geographical demarcation provides great

chances to becoming a refuge, corridor or remnant patch within a number of different complex ecosystems, thus increasing the chance to constituting a biogeographic refuge.

3) Criterion 5 : "A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds" and;

Criterion 6: "A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird";

Waterbirds have undoubtedly been observed along the years in this wetland. 12 species over 47 have been recorded in this rapid assessment and more than 70 species were recorded during the study conducted by FAO and MINARGI (Kasavubu 2005). More studies should be undertaken to define the exact extent of the inhabitants waterbirds. For this, further assessment and long term monitoring should be implemented in the wetland.

VII. PERSPECTIVES FOR THE FUTURE OF RWERU-MUGESERA WETLAND

There is no doubt that Rweru-Mugesera wetland complex is important for the biodiversity of the region and for maintaining the associated ecosystem services such as water filtration, ground water recharge, water storage, and so forth, but also for the communities around which rely on wetlands for their survival.

Bugesera being one of the driest districts in Rwanda, the wetland is an important land for agriculture during the dry season. However, agriculture has become a serious threat to the wetland through a severe encroachment and critical conversion and clearing of the wetland for crop growing. Given the situation of households in the area, a definite restricted access to the wetland might threaten the survival of the local communities, principally those depending on its resources and associated ecosystem services. Fortunately, there are several solutions which can be implemented to maintain the integrity of the wetland while keeping the benefits the local population get from it. These include the implementation of a wetland community-based management and monitoring programme, development of a zonation and clear management plan for the wetland, and support of sustainable watershed management practices around the wetland.

1. Monitoring the wetland biodiversity and ecosystem services

In order to have a comprehensive understanding of the biodiversity and ecosystem services of the Rweru-Mugesera wetlands complex, further assessment should be conducted. One of the suggestions concerns for instance the monitoring of waterbirds species which are important for the description of a Ramsar site. The habitat of some endangered species hosted by the wetland such as sitatunga, grey-crowned crane, papyrus golonek should also be clearly determined. It is therefore paramount that this crucial information should be considered in order to have a sound protection plan of these wetlands in Rweru-Mugesera complex. In order to have a whole picture of the status and trends in the biodiversity and ecosystem services of the wetland, we recommend the use of a landscape monitoring model such as the ARCOS-initiated Integrated Landscape Assessment and Monitoring (ILAM) framework.

ILAM is a wholistic monitoring framework which integrates aspects of biodiversity, ecosystem services and the socio-economic conditions in the landscape that have an incidence on this biodiversity and ecosystem services. ILAM follows the Driver-Pressure-State-Impact-Response framework when defining the monitoring indicators to use for the landscape. The development of a long-term monitoring programme for the Rweru-Mugesera wetland using ILAM would thus provide a basis for an integrated, participatory and cost-effective system to collect data on the critical aspects of the wetland to underpin an informed decision-making in its management.

To further enhance the participatory aspect of the proposed wetland monitoring programme, we propose the design of such programme to integrate citizen science. Citizen science has been defined as a research technique that enlists the help of members of the public to gather scientific data (Bonney et al., 2009b). Environmental sciences hold a long tradition of using volunteers to collect monitoring data such as bird monitoring projects that work with amateur bird enthusiasts. With today's advent of new ICT tools and widespread use of powerful smart phones, this tradition has gained even more momentum and evolved into a fully fledged research technique. Volunteers are now called "citizen scientists" and the technique is famous for greatly reducing the costs of research and data collection. In that regard, we recommend the design of the Rweru-Mugesera wetland monitoring programme to leverage the opportunities offered by the raising of citizen science.

2. Community-based wetland management and monitoring

Raising public awareness on the importance of a wetland is crucial for its sustainable management. Indeed, if the laws or natural resources governance tools and structures are implemented impromptu while the community stands with inadequate understanding, there is a high risk of either leaving the community needs behind or getting lower community consideration and ownership and thus leading to implementation failure. If the communities do not understand and acknowledge some of their practices threatening the wetland, thus threatening, at long term, their own survival; there is a risk they could not make an effort to change these practices. On the other hand, if the planning and management decisions are established when involving communities in the process, the outcome is most likely to be positive in terms of fair resolutions, community ownership and effective implementation. In that regard, we recommend the support and strenghtning of the community strucutres that have been established for the participatory management of Rweru Mugesera wetland, namely the wetland community management committees that were established under the LVEMP project.

3. Zonation of the wetland

A strict protection and restriction of access to the wetland may threaten the survival of communities in the landscape who depend on the resources from the wetland. For Rweru-Mugesera wetland, the fact that the local population totally depend on wetland agriculture during the dry season makes total protection of this wetland unviable and could even spark hostility among local population. One of the possible solutions to that problem could be the zonation of the wetland. An assessment of the pristine parts of the wetland is needed as well as an evaluation of the lands needed for the subsistence of the surrounding communities. Protecting some strategic areas could benefit both the biodiversity and the benefits to the local population with an integrated management plan taking into account the connectivity needed for biodiversity to maintain a great diversity in the wetland.

Such a zonation would look at the critical areas of the wetland for the protection of its key biodiversity and ecological functions and allocate those areas for total protection and research. The remaining area would thus be prescribed for managed use by communities through a conservation agreement signed between communities and local authorities and facilitated by the wetland committees.

VIII. REFERENCES

- Bonney, R., Cooper, C.B., Dickinson, J., Kelling, S., Phillips, T., Rosenberg, K.V. and Shirk, J. (2009b). Citizen science: a developing tool for expanding science knowledge and scientific literacy. *BioScience* 59(11): 977–984, DOI: <https://doi.org/10.1525/bio.2009.59.11.9>
- BirdLife International, 2017a. *Black Crowned-crane (Balearica pavonina) - BirdLife species factsheet*, Available at: <http://datazone.birdlife.org/species/factsheet/Black-Crowned-Crane> [Accessed July 8, 2017].
- BirdLife International, 2017b. Grey Crowned-crane (*Balearica regulorum*) - BirdLife species factsheet. *BirdLife International (2017) IUCN Red List for birds*. Available at: <http://datazone.birdlife.org/species/factsheet/grey-crowned-crane-balearica-regulorum> [Accessed July 8, 2017].
- BirdLife International, 2017c. Papyrus Yellow Warbler (*Calamonastides gracilirostris*) - BirdLife species factsheet. *BirdLife International (2017) IUCN Red List for birds*. Available at: <http://datazone.birdlife.org/species/factsheet/Papyrus-Yellow-Warbler> [Accessed July 8, 2017].
- Coash, M., 2000. ADW: *Tragelaphus spekii*: INFORMATION. *Animal Diversity Web*. Available at: http://animaldiversity.org/accounts/Tragelaphus_spekii/ [Accessed July 8, 2017].
- Davenport, T.R.B., 2003. Endemic butterflies of the Albertine Rift - an annotated checklist. , 2002.
- Dijkstra, K.D.B. & Clausnitzer, V., 2014. *The Dragonflies and Damselflies of Eastern Africa: Handbook for All Odonata from Sudan to Zimbabwe*, Royal Museum for Central Africa. Available at: <https://books.google.rw/books?id=s55yrgEACAAJ>.
- Donaldson, L. et al., 2016. Subsistence use of papyrus is compatible with wetland bird conservation. *Biological Conservation*, 201(September), pp.414–422. Available at: <http://dx.doi.org/10.1016/j.biocon.2016.07.036>.
- Dungan, P.J., 1990. *Wetland conservation : a review of current issues and required action*, IUCN. Available at: https://books.google.rw/books/about/Wetland_Conservation.html?id=RaraYlXy_SsC&redir_esc=y [Accessed July 8, 2017].
- E.G Kironde & REMA, 2012. Rwanda State of the Environment Report. , p.177. Available at: <http://www.rema.gov.rw/soe/>.
- Emmel, T.C. & Emmel, J.F., 1967. THE BIOLOGY OF PAPHIA INDRA KAIBABENSIS IN THE GRAND CANYON. *Journal of the Lepidopterists' Society*, Vol. 21(1). Available at: [http://images.peabody.yale.edu/lepsoc/jls/1960s/1967/1967-21\(1\)41-Emmel.pdf](http://images.peabody.yale.edu/lepsoc/jls/1960s/1967/1967-21(1)41-Emmel.pdf) [Accessed July 8, 2017].
- Environment and Heritage Protection, 2014. Biodiversity Assessment and Mapping Methodology.
- Fischer, E., 2011. Biodiversity Inventory for Key Wetlands in Rwanda Final Report.
- FishBase team RMCA & Geelhand, D., 2016a. *Labeo victorianus*, Ningu : fisheries. *fishbase*.

- Available at: <http://www.fishbase.org/summary/11588> [Accessed July 8, 2017].
- FishBase team RMCA & Geelhand, D., 2016b. *Labeobarbus acuticeps* : fisheries. *fishbase*. Available at: <http://www.fishbase.org/summary/11274> [Accessed July 8, 2017].
- FishBase team RMCA & Geelhand, D., 2016c. *Pollimyrus nigricans*, Dark stonebasher : fisheries. *fishbase*. Available at: <http://www.fishbase.org/summary/11028> [Accessed July 8, 2017].
- Fortune of Africa, 2016. Lake Rweru, Rwanda. , pp.4–6.
- Global Invasive Species Database, 2017. *Thypha latifolia*. Available at: <http://www.iucngisd.org/gisd/species.php?sc=895> [Accessed July 8, 2017].
- Hanssens, M., 2015. The IUCN Red List of Threatened Species, *Pseudocrenilabrus multicolor* ssp. *victoriae*, *victoriae*, Dwarf Victoria Mouthbrooder. *The IUCN Red List of Threatened Species*, 8235.
- Hu, J. et al., 2011. Bird diversity and the conservation value of a new Ramsar site : Guangdong Haifeng Wetlands , China. , pp.266–278.
- IMCE, MINIRENA, R., 2008. « Etablissement d ’ un inventaire national rapide des marais et élaboration de 5 avant-projets d ’ arrêtés ministériels relatifs aux marais » Liste des annexes. , (ISSN 2307-8235 (online)).
- International Union for Conservation of Nature and Natural Resources., 2000a. *The IUCN red list of threatened species*, IUCN Global Species Programme Red List Unit. Available at: <http://www.iucnredlist.org/details/22692039/0> [Accessed July 8, 2017].
- International Union for Conservation of Nature and Natural Resources., 2000b. *The IUCN red list of threatened species*, IUCN Global Species Programme Red List Unit. Available at: <http://www.iucnredlist.org/details/22050/0> [Accessed July 8, 2017].
- International Union for Conservation of Nature and Natural Resources., 2000c. *The IUCN red list of threatened species*, IUCN Global Species Programme Red List Unit. Available at: <http://www.iucnredlist.org/details/22707593/0> [Accessed July 8, 2017].
- International Union for Conservation of Nature and Natural Resources., 2000d. *The IUCN red list of threatened species*, IUCN Global Species Programme Red List Unit. Available at: <http://www.iucnredlist.org/details/63336/0> [Accessed July 8, 2017].
- International Union for Conservation of Nature and Natural Resources., 2000e. *The IUCN red list of threatened species*, IUCN Global Species Programme Red List Unit. Available at: <http://www.iucnredlist.org/details/183073/0> [Accessed July 8, 2017].
- Kasavubu, M.G., 2005. Rwanda water and biodeiversity_ Kagera Transboundary Agro- Ecosystems Management Programme, TAMP- RWANDA.
- MINIRENA, R., 2011. *Rwanda Biodiversity Policy*, Available at: http://rema.gov.rw/rema_doc/pab/RWANDA_BIODIVERSITY_POLICY.pdf [Accessed July 8, 2017].
- Ministry of Natural Resources, 2011. Water Resources Management Sub-Sector Strategic Plan (2011 – 2015). , p.96. Available at: http://minirena.gov.rw/fileadmin/Media_Center/Documents/Strategic_Plans/WRM_Strategy-December_2011.pdf.

- Nagendra, H., 2002. Opposite trends in response for the Shannon and Simpson indices of landscape diversity. , 22, pp.175–186.
- Ntakimazi, G., 2010. *Astatotilapia burtoni*, The IUCN Red List of Threatened Species. *The IUCN Red List of Threatened Species*, 8235(ISSN 2307-8235 (online)), pp.2015–2017.
- REMA, 2011. Atlas of Rwanda’s Changing Environment, Implications for climate change resilience.
- REMA, 2009. Rwanda State of Environment and outlook. Available at: <http://www.rema.gov.rw/soe/summary.pdf> [Accessed July 8, 2017].
- REMA, 2003. Rwanda Water and Wetland Resources,. Available at: <http://www.rema.gov.rw/soe/chap7.pdf> [Accessed July 8, 2017].
- Rwanda Meteorology Agency, 2017. Historical Onset and Cessation Date, Observations for [30.15E-30.1875E, 2.25S-2.2125S] located in or near Bugesera,East/Iburasirazuba, Rwanda. *Rwanda Meteorology Agency, maproom, agriculture-historical onset date*. Available at: <http://maproom.meteorwanda.gov.rw/maproom/Agriculture/Historical/Onset.html?region=bb%3A30.15%3A-2.25%3A30.1875%3A-2.2125%3Abb> [Accessed July 8, 2017].
- Secretariat of the Convention on Biological Diversity, 2006. Guidelines for the Rapid Ecological Assessment of Biodiversity in inland water, coastal and marine areas. *CBD TECHNICAL SERIES NO. 22 / RAMSAR TECHNICAL REPORT NO. 1*, (22).
- Silvius, M.J., Oneka, M. & Verhagen, A., 2000. Wetlands: Lifeline for people at the edge. *Physics and Chemistry of the Earth, Part B: Hydrology, Oceans and Atmosphere*, 25(7–8), pp.645–652. Available at: <http://linkinghub.elsevier.com/retrieve/pii/S1464190900000794> [Accessed July 8, 2017].
- Smith, J., Samways, M.J. & Taylor, S., 2007. Assessing Riparian Quality Using Two Complementary Sets of Bioindicators. *Biodiversity and Conservation*, 16(9), pp.2695–2713. Available at: <http://link.springer.com/10.1007/s10531-006-9081-2> [Accessed July 8, 2017].
- Stevenson, T., Fanshawe, J. & Stevenson, T., 2005. *Birds of East Africa : Kenya, Tanzania, Uganda, Rwanda, and Burundi*, Princeton University Press. Available at: <http://press.princeton.edu/titles/7448.html> [Accessed July 8, 2017].
- The Xerces Society, 2011. The Xerces Society » Ecology and Conservation of Dragonflies and Damselflies. *The Xerces Society*. Available at: <https://xerces.org/ecology-and-conservation-of-dragonflies-and-damselflies/> [Accessed July 8, 2017].
- Thompson, J.R. & Hollis, G.E., 1995. Hydrological modelling and the sustainable development of the Hadejia-Nguru Wetlands, Nigeria. *Hydrological Sciences -Journal-des Sciences Hydrologiques*, 40(1). Available at: <https://pdfs.semanticscholar.org/687b/e7892327f34630cf6a93083d3a83fbadb29f.pdf> [Accessed July 8, 2017].

I. LIST OF APPENDIXES

A. Appendix 1 : Data sheet example for the ILAM protocol

		ARCOS - Integrated Landscape Assessment and Monitoring (ILAM)						Biodiversity Survey - Data Sheet		Data sheet		
Surveyors :						Transect :				District/ Sector :		
Site :						Season/ Weather:						
Date :												
POINT	TIME	LATITUDE	LONGITUDE	EPE	ALTI (M)	SPECIES	Nbr	HABITAT/PLANTS	PHENO	THREATS	THR. LEVEL	OBSERVATION
General Observations - State						General Observations Pressure(Threats)				General Observations Response (Interventions)		
Notes: OBSERVATION (Record dominant ,more utilized plant ,threat level)						Threat Level 0=Nil, 1=Little (0-25%), 1= Medium (25-50%); 2= High (50-75%); 4=Very High (75-100%)						
PHENOLOGY (N=None, FW=Flowering; FR=Fruits)												

B. Appendix 2 : Ecosystem services questionnaire
Modified ILAM in Rweru-Mugesera Wetland System

Ecosystem services survey Questionnaire

GPS Code: ----- GPS Label: -----

Interviewer: -----

Date: -----/-----/-----

Start time: ----- end time: -----

Identification

Names: ----- Age: ----- Gender: ----- Marital status: -----

----- Profession: ----- Level of education: -----

How long have you been living in this area? -----years

How close is the home to the wetland? -----km

What is the extent of your land? -----ha

How many people are living in your house?

Adults above 14 years old: -----

Children below 14 years old: -----

Ecosystem Services

1. What resources do you use from the wetland?

- 1 2 3
 4 5 6

2. Water

a. What do you use water from the wetland for?

Irrigation: Watering animals: Construction: Domestic
 use: Other use: Specify: -----

b. How much water from the wetland do you use? -----Jerrycans (20L)

c. Do you wash your clothes/dishes directly in the lake? Yes: No:

d. Is water, sanitation, firewood, a problem in this area? Yes: No:

e. Where do you get your drinking water from?

Rainwater: Bore hole: Tap water: Open water: Other:
 Specify: -----

3. Fishing

a. Do you fish from the lake? Yes: No:

If yes, which **species**? -----

How **often**? -----

For what **purpose**? -----

If not, do you consume fish from the lake? Yes: No:

Which **species**? -----

How **often**? -----

5. Agriculture

a. Do you collect grass from the wetland? Yes: No:

If yes, how often? ----- for what purpose? -----

b. Do you grow crops from the wetland? Yes: No:

If yes which crops? ----- For what purpose? -----

c. Do you use fertilizers and pesticides? Yes: No:

If yes, how often? ----- How far is your land from the wetland? -----km

d. How do you estimate the fertility of the soil on your land?

Very fertile: Moderate: Infertile:

6. What is the difference in terms of benefits of living close to the wetland?

7. What has been done to sustain these ecosystem uses?

Open questions

1. What is your perception of the intrinsic value of the wetland?

2. Is there a species with medicinal or cultural values?

1 ----- 2 ----- 3 -----

Explain

Are there any stories or beliefs associated with the wetland?

What condition is the wetland in compared to the last 10 years?

Water: Increased No change: Decreased

Fish: Increased No change: Decreased

Colour of water

Any other change?

3. What activities threaten the wetland?

1 ----- 2 ----- 3 -----

4 ----- 5 ----- 6 -----

4. What measures are being taken to protect the wetland?

Are these measures fair according to you? Yes: No:

Explain

Are these measures adequate according to you? Yes: No:

If no, what else should be done?

5. Are there any negative aspects associated to the wetland?

6. What is your role in protecting the wetland?

7. Do you feel you have a negative impact on the wetland? Yes: No:

Explain

8. What is your role in protecting the wetland?

Do you feel you have a negative impact on the wetland? Yes: No:

Explain
