







Using Ecological Integrity Assessment and Information Management to Guide Wetland Management Decisions in Rwanda

Rwanda Wetlands Cover Change Mapping 2008-2018

FINAL REPORT

March 2021

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I. Introduction

I.1. Background

The aim of the project, Using Ecological Integrity Assessment and Information Management to Guide Wetland Management Decisions in Rwanda, led by ARCOS, is to avail information on Rwanda's wetland biodiversity, and ecological integrity, build the capacity of key players and provide adequate information management capacity to guide wise decision-making. The project will assess the status and threats of biodiversity, ecosystem services and social economic conditions of community within and around selected wetland landscapes in Rwanda. One of the key components of the project is to map out different ecosystem types (open water bodies and associated hydrology networks, natural vegetation, agriculture) referring to the National Wetlands Inventory of 2008 as baseline -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 should also refer 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%). That is from "Inventaire rapide des Marais", but during the systematic land registration process, the need for update was inevitable/eminent. Since then wetland delineation was an issue for peoples with land adjacent to wetland and former RNRA (RMLUA) have been piloting the team for resolving sporadic boundary conflicts. Consequently, wetland definition, boundary delineation and categorization should be the first activity.

The above mentioned statistics of Rwandan wetlands status description (cover types and their proportions) are provided as text and tabular information without an annexed map spatially illustrating those covers and uses within each wetland.

I.2. Aim of wetland mapping and RS

Ecological Integrity Assessment and Information Management to Guide Wetland Management Decisions in Rwanda need a spatially explicit approach. Detailed information on wetland boundary and characteristics need an appropriated spatial data collection and organisation allowing an efficient spatial query and analysis generating various outputs maps/graphs easy to understand and disseminate.

That objective was achieved in two main steps:

Rapid Assessment of all the wetland zones in Rwanda (location and main cover types); and

Detailed assessment focusing on 4 among 8 catchments namely Nyabugogo and Nyabarongo (8), Rweru-Mugesera Wetlands Complex wetlands (4), Akanyaru (2&3) wetlands (See Figure 1).

But a technical team meeting of July 27th 2020 reviewed the list of four wetlands to be focused on for detailed analysis, and decided the following: (1) Rweru-Mugesera Wetlands Complex; (2) Akanyaru downstream; (3) Akagera upper/amont and (4) Akagera downstream/aval.



Figure 1: Selected catchments as study zones for the Rwanda's Wetlands Ecological Integrity Assessment Project

II. Methodology

Currently, wetland boundary and detailed cover types is made easy from available and accessible techniques and tools of Geo-information and Earth observation. Readily available Remote Sensing imagery with medium and high-resolution can allow visual and digital interpretation of small scale wetland cover / wetland use types. With the support of the updated wetland shapefiles data from the Rwanda Land Use and Management Authority, the wetland cover delimitation was carried out by the use of high resolution aerial photographs for Rwanda from 2008/2009 (for the version of 2008 wetland cover types), and google earth images were used for the latest (2018) version.

With ortho-photographs of 2008/9, we produced maps from visual interpretation and digitalizing of high resolution, with limited field data collection and field truthing. Intensified field data visits, for collecting training and validation datasets were valuable source of proxy factors for mapping hardly visible information on image, such as vegetation community of invasive species with reluctant contrast on reflectance value compared to native plants or crops. That dataset comes from research teams field survey exercise.

Rwandan wetlands environment were found to be dynamic in space and time¹, our exercise was to try to make a spatial temporal assessment, taking reference to the year 2008 and 2018 as the latest period.

II.1. Review of existing data

The implementation of the project, started with an inventory of available spatial data, reports and publications on Rwandan wetlands, as presented in the Table 1 below.

S/N	Source	year	Size (ha)	Comments			
1	MINAGRI	1992	164, 947	Assisted by FAO & UNDP (PNUD/FAO/RWA/89/006), no digital map			
2	CGIS	2000	180,489	Digitalizing from topographic map of 1988, digital map is available (without metadata)			
3	REMA	2008	278,536	Inventaire rapide des marais, digital map and detailed report is available			
4	REMA &	2015	177,867	Joint exercise of wetland boundary correction, digital			
	RNRA		176,348	maps are available with slightly different sizes!			

Table 1. Available information on wetland at national level

Random location-specific of wetland mapping and characterisation are also available² and was useful for cross-validation for selected four wetlands.

In addition to wetland information, others data used for spatial Analysis, such as assessment of the status (statepressure-responses) using soil, hydrology and Land use/Land or vegetation cover maps and their change, etc. The status of existing data collection is summarized in table of annex 1.

In addition to the initially gathered data, the data collected by Water for Growth Project under the Water Resources Management Department of the Rwanda Water and Forestry Authority (RWFA) was very useful for this assignment. The latter, called Catchment Restoration Opportunity Mapping Spatial Decision Support (CROM DSS) tool, contributed to availing datasets and information on the spatial extent and the status of the irrigation schemes and existing pressures in the wetlands.

¹ Nyandwi, E., Veldkamp, T. & Amer, S., 2016; Regional climate sensitivity of wetland environments in Rwanda: the need for a location-specific approach. Reg Environ Change (2016) 16: 1635

² Ndayisaba et. Al, 2017. Mapping and Monitoring the Akagera Wetland in Rwanda. Sustainability 2017, 9, 174

II.2. Rapid appraisal of wetland covers types for 2008 and 2018

Using ortho-photographs (from the latest aerial mission in Rwanda) as background and layer of wetland in 2008 we started by making some cleaning, topological check-up of wetland boundary and re-establishing their characteristics according to four main cover type which were discriminated visually: Water body, natural vegetation, cropland and fallows.

For 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.

II.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 in Table 4 of wetland LCLU between 2008 and 2018. With red colour indicating the loss in the initial (2008) size of the land cover type, and the green indicating the gain of more size (2018) compared to the initial size of the land cover type.

III. Wetland Cover maps in 2008 and 2018

III.1. Wetland land cover/use maps of 2008

III.1.1.Introduction

The exercise needed special attention as you can see from the illustration in Figure 2 bellow, and from the need to respect current 'official boundary'. Where needed, with mistake, a lot of time was spent to decide for adjusting the boundary. That was achieved while coupled with wetland polygons cutting according to different cover types, as exemplified in the snapshots in the following Figure 2.

Figure 2. Snapshot showing inaccurate wetland boundary (in red) at one location in central plateau



III.1.2. Classification outputs

As stated above, using different digitalisation tools (create polygon, cut polygon, reshape....) Wetland cover map of 2008 was created. The four classes are distributed as summarized in Table 2 bellow and detailed per district in Table of annex 2.

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	100.00	

 Table 2. Summary of statistics of Rwandan Wetland cover in 2008

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. Those are likely to be bare soil, mining/quarry areas (for sand and/or clay extraction).

The layer of wetlands, in GIS format, with new attribute of cover types is also submitted separately.

III.2. Wetland land cover/use map of 2018

As explained under section the maps come from classified Landsat -8 images with similar cover types as in 2008 to easy to comparison. Wetland cover types for the year of 2018, are summarized with Table 3 bellow.

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

Table 3. Summary of statistics of Rwandan Wetland cover in 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.

III.3. Wetland cover/use changes between 2008 and 2018

As summarized in table 4 bellow in some Districts wetland cover types either have increased (green colour) or decreased (red colour). The final layer maps were submitted separately, but location specific maps can be generated as illustrated in Figure 3 and 4 of sampled wetlands for specific sites analysis.



Figure 3. Kamusenyi wetland change detection during last decade

Figure 4. Rwabashamana wetland change detection during last decade



As illustrated in Figure 5, Wetlands of Kigali city have known important vegetation cover changes during last decade.



Figure 5. Land cover/use and changes in Kigali City wetland during last decade

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Table 4. Changes in Wetlands cover between 2008 and 2018*

Land Cover Type Province and District	Сгор	land	Natural	Vegetation	Water	r 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				
				North	ern 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				
				West	ern 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				
				Easte	ern 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					

*Note: RED COLOUR indicates the loss (decrease) in area coverage of a land cover type, while GREEN COLOUR indicates the gain (increase) in area coverage of a land cover type. The table aims to clarify different types of land cover types which lost their parts at the expense of the increase of others.

IV. Detailed assessment of wetland status and pressures

For a detailed assessment, using the preliminary results from all teams involved in this project four wetlands were eligible for the analysis. That consisted to the discrimination of more wetland cover types. Thus, from three classes and one of non-identified (others) we made seven cover type categories as summarized in the Table 5 below.

#	Main cover type	Detailed cover types	#
		Intensified agriculture	1
1	Agriculture	Traditional agriculture	2
2	Water body	Clear water	3
	water body	Water covered by aquatic flora (water hyacinth)	4
		Dense papyrus	5
2	Natural Vacatation	Non dense natural vegetation	6
3	Natural vegetation	Not typical for wetland vegetation	7

In the selected wetlands, there is high pressure of human activities and need for conversation to irrigation scheme. The detailed maps on the status and pressures are submitted separately, but Figure 6,7 and 8 are providing an illustration.

Figure 6. Detailed land cover/use map of Akagera Amont





Figure 7. Human induced pressure on Akagera amont wetland surrounding landscape

Figure 8. The irrigation status within Akagera Amont wetland



V. Conclusion

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. The land cover/use is very dynamic in time and most threatening pressures may include Coffee Washing Sations (CWS) and Agriculture. But well planned irrigation schemes may be promising as sustainable use of wetlands.

Although the approach provides a general trend which reflect the reality, the results should be considered with caution since we hardly use same type of imagery.

Therefore, with the possibility of getting real time imagery in an ongoing arrangement between government organisation and the worldview imagery, a proven possibility, in this pilot exercise, of an integrated ecological assessment and information management to guide wetland management decisions will be enabled.

Annex 1

Useful data/information for Assessment and Information Management to Guide Wetland Management Decisions in Rwanda

	Dataset	Variables	Description	Format	Status
I. Bi	o-physical		•		
			DEM 30X30 m from Shuttle Radar Topography Mission (SRTM) - high quality	grid	very high quality for spatial modeling , acquired
		Digital Elevation model (DEM)	DEM 30X30 m from Aster images	grid	generating some problems during analysis, acquired
1			DEM 10X10 m from Rwanda aerial mission 2008/9	grid	missing extreme party of the country, acquired
		Topographic map	Topographic map of 1980, produced using Aerial mission of 1978	raster	scanned and georeferenced in 16 sheet and still valuable for physical features,
		Slope and others terrain derivatives	Slope %ge, TSI, Aspect,	shapefile	calculated from DEM,
			Lakes	shapefile	acquired
2	Hydrology	Surface water	Rivers : main river to streams and thalweg	shapefile	acquired
			Others water bodies (Dams - water development project)	shapefile	not acquired, to check with MINAGRI
		Groundwater	Groundwater estimate	shapefile	not acquired, to check with MoE, Water department- Water for Growth
2	Goology		Geological units digitalized from geological map at 1/250 000	shapefile	acquired
3	Geology		Geological map at 1/50 000 in 43 sheets mosaicked in one image	raster	acquired
		Soil physical property	texture and structure according to FAO and USA Taxonomy of 2003	shapefile	from MINAGRI, acquired
			Soil depth estimated from soil	attribute	from MINAGRI,
4	Soil	soil chemical property	attributes tables, but out of dates-2003	attribute table	from MINAGRI, acquired
		Soil degradation	soil degradation and Landslide	shapefile	Acquired: Minagri(2004), MIDIMAR (2015)
		Soil water recharge		grid of 1km	acquired
	<u> </u>	(?)	water recharge value	<u>-tiff</u> Version 1990.	• •
			Land cover maps at regional scale by RCMRD	2000, 2010, 2015	acquired
5	Vegetation	Land cover	Land cover maps at continental scale by AfriCover- FAO	version 2000	acquired
			Land cover national mapping - high resolution	version 2016	MoE-Water, acquired
П.С	limatic				

		Annual rainfall	Average of Rainfall for last 30 years at 183 stations nationwide	shapefile- point and grid	from RMA, acquired
6	Rainfall	Annual fannan	annual records - historical data	grid map	to be requested
		Duration (of strong rainfall)	?	?	worldClim data
		Intensity (of extreme rainfall)	?	?	worldClim data
		Annual average temperature	Average temperature for last 30 years at 183 stations nationwide distributed	shapefile- point and grid	from RMA, acquired
		Min and Max Temp.	annual records - historical data	grid map	
7		Heat waves	?	?	
		Daily thermal oscillation	?	?	
			?	?	
		Relative humidity	long time average relative humidity nationwide	Points maps from 183 meteor stations and grid maps	acquired
8	Climate derivative	Evapotranspiration (ETP)	long time average ETP nationwide	Points maps from 183 meteor stations and grid maps	acquired
		GHG (Green Houses Gasses)	<u>https://www.wri.org/</u> <u>resources/data -sets/</u> <u>cait-country-greenhouse-</u> <u>gasemissions-data</u>	?	
<i>III.</i> S	Socio-econoi	ny at a state		[]	
		01 Country, 04	Administrative boundary		
		City 20 Districts	MINALOC in 2006 and the	shapofilo	From NSIP
9		416 Sectors, 2148 Cells and 14815	shapefile was created in 2006 and updated by the 2012	2012	Acquired
		Villages	Census mapping. Public and private domain of at	shapefile	From RI MUA
10	Forest	Forest cover	least 0.25 ha	2015	acquired
	Forest		From LC map of 1990, 2000,	shapefile	
		Livelihood	2010 and 2015		acquired
11		conditions according to most grown crops (seasonal/perennial crops)	Livelihoods zones generated in 2011	Shapefile- polygon	acquired
12	Ecological zones	Agro-Ecological Zones (AEZ)	10 Zones defined by combining physical factors and crop suitability	Shapefile	acquired
			National Road Paved	Shapefile	
			National Road Unpaved	Shapefile	
40	Transmission	Deadarative	District Road Class 1	Shapefile -line	Acquired from
13	iransport	KOAO NETWORK	End/Start point	Shapefile -points	RTDA
			Land mark	Shapefile -points	
				chanofilo	

IV. C	IV. Cross- cutting											
14	Policies, Laws and Strategies	Grouped in seven thematic	Agriculture, Climate Change, Ecosystem and Environmental Management, Food security, General development strategies, Human wellbeing and Water Resources Management	documents	gathered from different source							

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
Nvabihu 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

Annex 2: Wetlands cover types status per district in 2008

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
Ниуе	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 3: Wetlands cover types status per district in 2018

Land Cover	Crop	oland	Natur	al	Wate	er Body	(Other		
Туре			Vegetat	ion						
Province and District										
	Coverage	Coverage	Coverage		Coverage (ha)	Coverage (%)	Coverage (ha)	Coverage (%)	Total (Ha)	Total Per District
	(ha)	(%)	(ha)							(%)
						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
		<u> </u>	<u> </u>			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
		<u> </u>	I						I	
						Western Province				
Karongi District	600.0	56.9	40.5		3.8 142	2.6	.3.5 2	270.8 2	5.7 1,05	3.9 100
Ngororero District	500.4	47.6	-		- 27	0.7 2	25.7 2	280.4 2	6.7 1,05	1.5 100
Nyabihu District	443.8	40.6	316.3	2	28.9 202	2.8 1	.8.5 1	.30.9 1	2.0 1,09	3.7 100
Nyamasheke	938.4	34.4	655.2	2	24.0 10	7.7	3.9 1,0	029.3 3	7.7 2,73	0.6 100
Rubavu District	330.6	69.7	-		-	-	- 1	43.7 3	0.3 47	4.3 100
Rusizi District	1,717.6	51.2	494.8	1	4.7 5	0.3	1.5 1,0	091.8 3	2.5 3,35	4.4 100
Karongi District	600.0	56.9	40.5		3.8 142	2.6	.3.5 2	270.8 2	5.7 1,05	3.9 100
Sub-Total West	4,890.1	46.6	1,506.8	1	4.4 82	1.8	7.8 3,2		1.2 10,49	7.3 100

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

29.0

664.9

62.4

126.8

1,525.2

10,801.9

-

-

9.8

4.4

10.1

44.5

-

-

564.8

159.1

3,709.6

78,969.0

489.2

942.2

1,186.4

777.9

10,036.6

33,665.1

1.6

11.6

1.5

3.5

4.1

6.1

26.2

16.4

28.8

21.4

27.2

19.0

1,868.4

5,750.1

4,121.3

3,639.7

36,850.1

177,476.9

100

100

100

100

100

100

The Rwanda Wetlands Mapping and Remote Sensing

1,350.2

3,578.2

2,872.5

2,575.9

21,578.7

54,040.9

Nyamagabe

Nyanza

Nyaruguru

Ruhango

Sub-Total South

Overall Total

72.3

62.2

69.7

70.8

58.6

30.4

End