ECONOMIC VALUATION OF ECOSYSTEM SERVICES OF THE RWERU-MUGESERA WETLANDS COMPLEX IN RWANDA

FINAL REPORT

August18, 2021

Economic Valuation of Ecosystem Services of the Rweru-Mugesera Wetlands Complex in Rwanda

Final Report

Report Produced by:

IUCN Rwanda Office

For

ARCOS Network

This report was produced as part of the Rwanda Wetlands ecological integrity assessment project supported by JRS Biodiversity Foundation, implemented by ARCOS in collaboration with REMA, IUCN and other members of the National Project Advisory Committee. ARCOS is grateful for the technical contribution from the following persons: Philip Otieno, Dr Dawit W. Mulatu, Dr Sam Kanyamibwa, Charles Karangwa, Jean Paul Kubwimana, Ephrem Manirareba and Christian Mukama.

Suggested Citation:

ARCOS(2021): Economic Valuation of Ecosystem Services of the Rweru-Mugesera Wetlands Complex in Rwanda. Technical Report.

August 18, 2021

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

AGC	Above Ground Carbon
ALU	Area of Land of Use
ARCOS	Albertine Rift Conservation Society
BGC	Below Ground Carbon
CIP	Crop Intensification Programme
CO_2	Carbon dioxide
CS	Consumer Surplus
CSO	Civil Society Organisation
DAP	Di-Ammonium Phosphate
DDS	District Development Strategies
DP	Development Partners
ES	Ecosystem Service
ESP	Ecosystem Services Partnership
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GIS	Geographic Information System
GoR	Government of Rwanda
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union of Nature Conservation
KII	Key Informant Interview
LPG	Liquefied Petroleum Gas
MIFOTRA	Ministry of Public Service and Labour
MINAGRI	Ministry of Agriculture and Animal Resources
MINALOC	Ministry of Local Government
MINEACOM	Ministry of Trade, Industry, and East African Community Affairs
MINEDUC	Ministry of Education
MINICOFIN	Ministry of Finance and Economic Planning
MINIRENA	Ministry of Natural Resources and Forest
MINISANTE	Ministry of Health
MOE	Ministry of Environment
MYICT	Ministry of Youth and ICT
NB	Net Benefit
NGO	Non-Governmental Organisation
MININFRA	Ministry of Infrastructure
PS	Producer Surplus
PVC	Present Value Cost
RDB	Rwanda Development Board
REMA	Rwanda Environment Management Authority
RICA	Rwanda Institute for Conservation Agriculture
RNRA	Rwanda Natural Resources Authority
RwF	Rwandan Francs
SSP	Strategy Support Programme (e.g., the Rwanda SSP)
TEEB	The Economics of Ecosystem Services and Biodiversity
TLU	Tropical Livestock Unit
UR	University of Rwanda
WTP	Willingness To Pay

EXECUTIVE SUMMARY

Introduction and aims of the valuation study

Wetland ecosystem services can be defined into two broad categories. They can be categorized into those services related to water supply, and those services related to water demand. The wetland ecosystem services related to water supply include: (1) Maintenance of water flow and supplies, for example replenishment of water sources, water storage and regulation of flows; (2) Regulation of water quality, for example wastewater purification and control of sedimentation and siltation; (3) Minimization of water-related hazards and disasters, for example flood attenuation, and maintenance of water supplies in dry seasons and droughts. The wetland ecosystem services related to demand for and use of water include: maintenance of aquatic and terrestrial resource productivity and the associated products that these yields, for example fisheries, plants, pasture and forest products. It is these goods and services that have to be considered when talking of the linkages between ecosystems, water and the economy. The major challenges to sustainable management of wetlands is that quite often wetland users and decision-makers have insufficient understanding of the consequences of alternative management and policy regimes on wetland functioning, ecosystem services and human well-being. To reap the optimal benefit from the wetlands while ensuring their sustainability at the same time, better to conserve them earlier than trying to restore them after more damage has occurred to them. In this regard, conducting wetland ecosystem services valuation will enhance the preparation and implementation of wetland management plans not only to protect the wetlands but also creates new opportunities from the preservation of them. Thus, the need to recognize and value wetland ecosystem services is important for better decision makings to enhance wetlands ecosystem services. In this proposed study the main objective is to carry out a total economic valuation of ecosystem services of Rweru-Mugesera wetlands. The study will involve the development of a replicable methodology for ecosystem services assessment and total economic valuation and providing key and actionable recommendations for ecosystem mainstreaming in various sectors of development.

Approach and Methodology

We used a modified version of the Wilson Troy model of ecosystem valuation which entails; delineation of the wetland boundaries and this was based on three fundamental parameters that define a tropical freshwater wetland-presence of hydric soils, presence of hydrophytic vegetations (mainly the presence of phragmites), and levels of permanence or periodic inundation of the areas; delineation was then followed by typology development which was an exercise involving identification of the land use and land cover found within the wetland delineated boundaries, this was largely conducted through a thorough review of the literature in which five main land uses were identified and they included; water bodies, papyrus(phragmites), other vegetations, grassland, and crop lands. Fifteen ecosystem services were also prioritised for valuation in this exercise. Typology development was then followed by data collection using both probability sampling and purposive sampling, and use of secondary data. Probability sampling deployed cluster sampling of 199 households from a population of 52,173 households for a household survey exercise, while purposive sampling deployed key informant interviews, focus group discissions, and stakeholder workshop. Data collection stage was followed by mapping of land use change between 2010 and 2018 in order to obtain a trend of change to enable projection of future patterns if the implementation of the current institutional frameworks is sustained. Based on the trends obtained for land use change, a cost benefit analysis assessment was conducted for the baseline economic values for the next 30 years based on per unit hectarage available for each land use category and the related ecosystem services provision, a discount factor of 10% per annum was applied to establish present values of both benefits and costs over the 30-year period.

Results and Discussions

Fifteen ecosystem services were considered for valuation, and as indicated in the methodology section, this results section covers the findings from the data collection strategy section, i.e., estimation of the baseline economic values, and scenario analysis. Nine provisioning ecosystem services were considered for baseline economic valuation and they all yielded a total of over $US 52 million per year, these nine provisioning ecosystem services included; domestic water supply, water for livestock, crop farming, livestock grazing, grass harvesting, capture fisheries, papyrus products, fuelwood, and herbal medicine. Similarly, five regulating services were valued and these together were valued at approximately $US 499 million and they included; water purification, sediment control, flood control, carbon storage & sequestration, and habitat for biodiversity.

The total present values of the benefits of the wetland ecosystem services under the current institutional frameworks governing wetland management for the next 30 years is $US 4.2 billion while the present value of costs under the same time frame is $US 228 million, giving a net present benefit of $US 3.99 billion, and a benefit-cost ratio of 18.88.

Policy Implications

- More than 93% of the local community depend on the wetland for domestic water use, therefore conservation of wetland will enable them access water of reasonable quality. However, the amount of time spent in collecting water makes it time consuming and such precious time could be channelled elsewhere in the economy.
- Conservation of the Rweru-Mugesera wetlands complex would enable more than 5% of the local community to have access to water for livestock use. Even though the amount of time spent in watering livestock this way is not economically desirable if other sources of opportunities for casual labour were available.
- The Rweru-Mugesera wetlands complex currently offers more than 24 thousand households opportunity to income and nutrition through crop farming inside the wetland. However, such a carrier function is often in competition with other wetland uses which when all combined score more than crop farming and other related activities within the wetland.
- Conservation of the Rweru-Mugesera wetlands complex would enable more than 5% of the local community to have access to pasture for livestock use. Even though the amount time spent grazing livestock is not economically desirable if other sources of opportunities for casual labour were available.
- The Rweru-Mugesera wetlands complex currently offers more than 19 thousand households access to grass to feed their livestock.
- The Rweru-Mugesera wetlands complex offers fishery livelihoods and income to more than 7 thousand of the households, and earn them income worth more than $US 16 million per year.
- Conservation of the Rweru-Mugesera wetlands complex would enable more than 20 thousand households in the local community benefit from papyrus and other phragmites with opportunities for mulching, making handicrafts among others that are worth more than $ US 3 million.
- More than 19 thousand households in the local community access fuelwood from the Rweru-Mugesera wetlands complex hence conservation of the resource would provide a source for fuelwood to them. However, the amount of time spent harnessing fuelwood from the Rweru-Mugesera wetlands complex makes it economically undesirable.
- The Rweru-Mugesera wetlands complex has a carbon storage potential of over 10 million tons of carbon, and with a sequestration potential of 18 thousand tons annually. This can help the country meet her global obligations towards mitigation of climate change.
- Conserving the wetland eliminate pollutants that would cost about $US 29 million to clean from the lake reservoirs.
- The Rweru-Mugesera wetlands complex traps sediments amounting to 78.4 tons per ha annually. Conservation of the wetland would therefore saves the stakeholders a dredging cost of $US 2 million annually.
- Forty-five percent(45%) of the households are exposed to the possibility of annual flooding that can destroy their produce; protection of the wetland would therefore save them from annual damages worth $US 300 thousand.

Conclusions

The wetlands complex supplies a host of ecosystem services to more than 48 thousand households or about 194 thousand individuals at an estimated economic value of over $US 52 million. However, there are some ecosystem services whose utilities are not economically desirable if labour is considered as a remunerable factor of production at the prevailing rates; such ecosystem services include: drawing and carrying of water from the wetland for domestic use, livestock grazing, and watering in the wetlands, and fuelwood harvesting. If the current policy and management measures are sustained, then there will be a continuing enhancement in the value of the wetland ecosystem services, and the ecosystem services values in the wetlands complex will increase by more than $US 22million from the current value over the next 30 years; from a baseline (2020) value of slightly more than $US 455 million to slightly more than $US 478 million by 2050. Therefore, it is estimated that Rweru-Mugesera wetlands complex ecosystem services will accumulate ecosystem services worth over $US 13 billion by 2050, with a present value slightly more than $US 4 billion.

Recommendations

- For many of the ecosystem services, especially the regulatory services, there were no easily available, timely and consistent data that could have facilitated use of primary or original use of site-specific data and information, it is therefore recommended that stakeholders consider putting investments in creating the necessary infrastructure for regular data collection and ease of access by the scientific and research community to enable generation of evidence for policy and management guidance.
- To keep track of the flow of the ecosystem services provision, there is need for investments in regular data collection
- There is a need to promote other sources of access to water through investments that help shorten the distance or reduce the time that the local community currently takes in drawing water from the wetlands complex. This should also apply to access of water for livestock.
- Keeping and grazing the local breeds of cattle in the wetlands is not economically desirable, there is need to continue with investments that encourage improved breeds of cattle; and cutting and carrying grass from the wetland be encouraged.
- Investment measures to protect the wetland with the aim of preventing damage to farms due to flooding should be considered.
- There is need to explore the tapping of the economic potential of climate change mitigation role of the wetlands complex.
- While the quantity of the wetland ecosystem is on the ascendancy, the same cannot be said of the water quality, there is need for regular collection of data on water quality and measures to help improve water quality in the wetlands.
- Develop specific wetland management plans for Rweru-Mugesera and Akagera wetlands complexes and confirm Rweru-Mugesera wetlands complex as a Ramsar site.
- Overall, implementation, enforcement and ensuring compliance to the current policies, laws, regulations, and strategies aimed at conservation and protection of the wetland complex should be sustained.

INTRODUCTION

1.1. Background and Context

Wetland ecosystem services can be defined into two broad categories. They can be categorized into those services related to water supply, and those services related to water demand. The wetland ecosystem services related to water supply include: (1) Maintenance of water flow and supplies, for example replenishment of water sources, water storage and regulation of flows; (2) Regulation of water quality, for example wastewater purification and control of sedimentation and siltation; (3) Minimization of water-related hazards and disasters, for example flood attenuation, and maintenance of water supplies in dry seasons and droughts. The wetland ecosystem services related to demand for and use of water include: maintenance of aquatic and terrestrial resource productivity and the associated products that these yields, for example fisheries, plants, pasture and forest products. It is these goods and services that have to be considered when talking of the linkages between ecosystems, water and the economy

Wetlands have multidimensional contributions for the ecosystems. While covering only 6% of the Earth's surface, wetlands provide a significant number of ecosystem services and amongst the Earth's most productive ecosystems (Cherry 20011), providing diverse array of important ecological functions and services, ranging from flood control and flow control to ground water recharge and discharge, water quality maintenance, habitat and nursery for plant and animal species, biodiversity, carbon sequestration and other life support function (Birol *et al.* 2006). Wetlands provides provisioning, regulating, supporting and cultural ecosystem services, notably related to tourism, recreation, and research (Smakhtin 2012; Mitsch & Gosselink 2015). However, in contrast to their international importance, many wetlands have been treated as wasteland and drained or otherwise degraded (Barbier. E.B *et al.* 1997; Zedler & Kercher 2005). Note that the major challenges to manage wetlands sustainably is that Rweru-Mugesera wetlands complex users and decision-makers have insufficient understanding of the consequences of alternative management and policy regimes on wetland functioning, ecosystem services and human well-being (Jogo & Hassan 2010).

According to wetland international[1] report, currently about 131 million hectares of the African continent is covered by wetland areas. However, wetlands degradation is one of the major causes for ecosystem deprivation. The poor, who are relatively highly dependent on wetlands ecosystem services, were found to be disproportionately affected compared to the non-poor. Because wetlands provide multiple benefits of ecosystems that many of the locals in developing countries rely on for their livelihoods (Turyahabwe & Johnny 2013). Although interventions to restore wetlands ecosystem were not designed as poverty reduction mechanism but primarily as means of improving natural resource management, proponents argue that interventions to improve wetlands degradation can improve the welfare of the poor through the provision of in-cash or in-kind flow (by participating in conservation efforts and practices), and as a means of household income diversification and create incentive for continued benefits (Kakuru *et al.* 2013; Mulatu 2014).

To reap the optimal benefit from the wetlands while ensuring their sustainability at the same time, better to conserve them earlier than trying to restore them after more damage has occurred to them. In this regard, conducting wetland ecosystem services valuation will enhance the preparation and implementation of wetland management plans not only to protect the wetlands but also creates new opportunities from the preservation of them. Thus, the need to recognize and value wetland ecosystem services is important for better decision makings to enhance wetlands ecosystem services

To achieve these stated objectives in the Terms of Reference (ToR), the consultant proposed a standard economic valuation analysis using the Economics of Ecosystems and Biodiversity (TEEB) as a major methodological approach.

1.2. Need for valuation and purpose of the study

Generally, valuation of ecosystem services can take one of the approaches which include: (1) an impact analysis if the main desire for valuation or the problem at hand is a specific external impact e.g., effluent polluting a wetland; (2) partial analysis, if the issue is about making one choice between a host of wetland use options such as conversion of a wetland to a residential land or diversion of upstream water for irrigation; and (3) a total valuation if the issue is a bit general such as determination of the worth of a wetland as a protected

1 http//www.africa.archive.wetlands.org

Table 1: Some of the applications of valuation

Purpose	Possible assessment question	Example
Comparing alternative policies, programmes and projects	How do alternatives differ in terms of the gains and losses of ecosystem services (ESs) they are likely to produce or that are likely to arise from their implementation?	Assessing options for wetland protection for a range of grey and green infrastructures, including mixes of these
Identifying livelihood, development and investment opportunities	What new or improved economic opportunities can be developed based on the conservation and sustainable use of ESs?	Assessing the recreational value of wetland areas, to identify possible investment strategies to promote responsible tourism as a driver of local development
Designing environmental policy instruments, incentives, regulations and monitoring	What information on ESs will enable the design of effective, equitable and sustainable environmental policy instruments?	Assessing the value of carbon sequestration by wetland conservation project to access carbon markets and generate revenues that could support peatlands, and related co-benefits
Undertaking scoping and situation analyses	What is the state of ESs in a given context, and what values and stakeholders are associated with them?	Stakeholder consultation and ES assessment to identify the perceived importance of ESs among groups and to set priorities for wetland management (e.g., harvesting intensity and the frequency and size of set-asides)
Enhancing environmental awareness or advocating for a policy option	How can information on the provision and impacts of ESs be used to "make the case" for a given policy option?	Assessing the impact of a wetland restoration compared with those associated with other development to inform decisions making
Tackling environmental conflicts	How can a focus on ESs provide credible information on environmental change to help resolve conflicts?	Meetings with stakeholders and experts to manage human wildlife conflict
Assessing the impacts of policy changes, thus informing choices among competing uses	What are the impacts on competing resource uses of changes in existing policies?	Assessing the impacts of wetland policy changes in the conversion of wetland to agricultural land uses

In this proposed study the main objective is to carry out a total economic valuation of ecosystem services in the selected wetlands in Kigali City, and Rweru-Mugesera wetlands. The study will involve the development of a replicable methodology for ecosystem services assessment and total economic valuation and providing key and actionable recommendations for ecosystem mainstreaming in various sectors of development. It will involve collection, organization and the analysis of spatially explicit data to identify, assess and evaluate the key/priority ecosystem services in Kigali City and Rweru-Mugesera complexes. The results of this assessment will be the core input for a participatory process that aims to identify and prioritize management options and policy instruments to maintain and/or improve the flow of these key ecosystem services for the development processes in Rwanda. The expected outcome is an ecosystem-based decision-making guide for wetland management.

1.3. Scope of valuation

In the valuation study of ecosystem services, it is imperative that the ecosystem whose ecosystem services are to be valued is identified, in this case then it is wetland ecosystems which will include the Rweru-Mugesera complexes and two to three other wetlands within the Kigali city. Establishing the scope of a valuation study entails identifying the wetland area under consideration, the time scale of the analysis and the geographic and analytical boundaries of the system (Barbier et al., 1997). Once the system and analytical boundaries are defined, then the basic characteristics of the wetland should be determined for valuation, that is identification of ecosystem services. The scope of valuation can be considered to look at the kinds or categories of ecosystem services to be valued as is classified under the Millennium Assessment Report (MA,2003).

1.4. Review of wetland ecosystem services

Wetlands are able to provide high-value ecosystem services because of their position in the landscape (Zedler 2006) as recipients, conduits, sources, and sinks of biotic and abiotic resources. They occur at the land–water interface, usually in topographically low-lying positions that receive water, sediments, nutrients and propagules washed in from up slope and catchment. Within catchments, wetlands allow sediments and other materials to accumulate and settle, providing cleaner water for fish, wildlife and people. The combination of abundant nutrients and shallow water in receiving wetlands promotes vegetation growth, which in turn affords habitat and food for a wide range of fish, birds and invertebrates. Wetlands also accumulate floodwaters, retaining a portion, slowing flows, and reducing peak water levels, which cumulatively have significant roles in flood abatement. The near permanent wetness of wetland ecosystems is equally important. Saturated areas have very low levels of oxygen, particularly in the 'soil' where it is accessed by roots and microorganisms (Sorrell and Gerbeaux 2004). Such anoxic conditions promote changes in critical microbial processes resulting in anaerobic nutrient transformations that make nitrogen available for use by plants (nitrogen fixation) and convert nitrates into harmless gas, thereby improving water quality (denitrification). Having anoxic and aerobic conditions in close proximity is a natural property of shallow water and wetlands (Zedler 2006). The anoxic conditions also promote peat accumulation, locking up carbon, which in turn regulates atmospheric carbon levels and helps cool global climates (Frolking and Roulet 2007).

In summary, wetlands provide a wide range of ecosystem services vital for human well-being, and these have been categorized into four broad classifications namely; provisioning, regulating, cultural, and supporting ser-

1.5. Stakeholders of Wetlands and Wetland Ecosystem services

Wetlands attract a number of stakeholders. It is also important to identify stakeholders to help in determining the main policy and management objectives, to identify the main relevant services and assess their value and to discuss the trade-offs involved in the wetland use. A stakeholder is a person, organization or group with interests in an issue or particular natural resource. Stakeholders are people with power to control the use of resources, and those with no influence but whose livelihoods are affected by changing the use of the resource. Stakeholders are typically classified or organized in terms of influence and importance to the study so that the relative levels of influence and importance determine whether a stakeholder is a primary, secondary or external stakeholder.

Table 2: Stakeholder analysis

Stakeholder category	Stakeholder description	Examples
Primary	Those who have high importance to the resource use, though they may have low influence	Local community resource user groups such as mat makers, charcoal makers, fisher folks among others
Secondary	Those who can be both important and influential	Governmental agencies implementing various policies and programmes on protection and or harnessing of wetlands and wetlands resources
External	Those who can also be influential but tend to have low importance for particular	Civil society organisations, development partners, property developers

1.6. An Overview of Valuation and Wetland Valuation Techniques

1.6.1. Value and Value systems

Value refers to the contribution of an object or action to specific goals, objectives, or conditions (Costanza, 2004). Costanza further fronts that value of an object or action may be tightly coupled with an individual's value system because the latter determines the relative importance to the individual of an action or object relative to other actions or objects within the perceived world, where value systems refer to intrapsychic constellations of norms and precepts that guide human judgment and action (Farber et al., 2002). They refer to the normative and moral frameworks people use to assign importance and necessity to their beliefs and actions and are therefore internal to individuals but are the result of complex patterns of acculturation and may be externally manipulated through, e.g., awareness creation (Farber et al., 2002; Costanza, 2004) vices as presented in TEEB (2010).

People's perceptions are limited, they do not have perfect information, and they have limited capacity to process the information they do possess (Farber et al., 2002; Costanza, 2004). An object or activity may therefore contribute to meeting an individual's goals without the individual being fully (or even vaguely) aware of the connection (Farber et al., 2002; Costanza, 2004). The value of an object or action therefore needs to be assessed both from the subjective standpoint of individuals and their internal value systems and from the objective standpoint of what we may know from other sources about the connection (Farber et al., 2002; Costanza, 2004).

Reasoning on value of ecosystems runs between two approaches: (1) the anthropocentrism/utilitarian approach: Elements of Ecosystem Services are valuable insofar as they serve human beings; Valuable is what creates 'the greatest good for the greatest number'; and (2) eco- or biocentrism approach-rejects the 'dominant species' argument and replaces utility with intrinsic value: "value in and for itself, irrespective of its utility for someone else.

Some services of ecosystems, like fish or timber, are bought and sold in markets. Many ecosystem services, like wildlife viewing, are not traded in markets. Markets for most ecosystem services are missing but we still can measure their dollar values. We require a measure of how much one will give up to get the service of the ecosystem, or how much people would need to be paid in order to give it up. The value of an eco-system can be interpreted in many different ways e.g. (1) the value of the current flow of benefits provided by that ecosystem; (2) The value of future flows of benefits; (3) The value of conserving that ecosystem rather than converting it to some other use.

1.6.2. Valuation

This is the process of expressing a value for a particular action or object. Value is a measure of the maximum amount an individual is willing to pay (WTP) for goods and services, it entails financial value which is measured in prevailing market prices and economic value which is measured in economic or efficiency prices. The economic value prevails in a competitive market, free of any market imperfections (e.g., monopolies) or policy distortions (e.g., taxes or barriers to trade). It is a more accurate reflection of the contribution of a good or service to social welfare (Bishop, 1999).

In valuing ecosystem services we are interested in: (1) Value of the total flow of benefits from ecosystems: Contribution to economy by adjusting national account--We use total economic value; (2) Net benefits of interventions that alter ecosystem conditions: Arises in a project or policy context: We use marginal or net values; (3) Examining distribution of costs and benefits of ecosystems: This is to different stakeholder groups; (4) Identifying potential financing sources for conservation among others, see the purpose section above(Pagiola et al., 2004).

1.6.3. The concept of willingness to pay

In principle, economic valuation of ecosystem services is based on "people preference" and their choices. Therefore, it is quantified by the highest monetary value that a person is willing to pay in order to obtain the benefit of that particular service (Mehvar et al., 2018). The "willingness to pay" approach determines how much someone is willing to give up for a change in obtaining a certain ecosystem good or service (MEA, 2005). Thus, the key outcome of valuation studies is to illustrate the importance of a healthy ecosystem for socio-economic prosperity and to monetize the gains that one may achieve or lose due to a change in ecosystem services (Sukhdev et al., 2014).

1.6.4. Ways of measuring the value of ecosystem services

The value of ecosystem services can be measured in three different ways (Tinch and Mathieu, 2011): (1) Total economic value (TEV) that refers to the value of a particular ecosystem service over the entire area covered by an ecosystem during a defined time period; (2) average value of an ecosystem service per unit, which is often indicated for a unit of area or time; (3) marginal value which is the additional value gained or lost by an incremental change in a provision of a particular service.

Valuation starts from estimating a TEV of an ecosystem, which is in fact a sum of Consumer Surplus (CS) and Producer Surplus (PS). This is done by applying different valuation techniques. By definition, CS is the difference between the actual market price of the product and the maximum amount that people are willing to pay, while PS refers to the benefit that the producer earns when the market price is higher than the costs of production (also called net income). For example, in the case of tourism, PS is the direct or indirect benefit from the local ecosystems for the tourism sector by considering the revenue made from tourists minus the costs of providing these services to them (van Beukering et al., 2007). In addition, CS conveys the maximum amount that tourists are willing to pay for visiting the specific recreational area.

Value of nature depends on the perspective of various stakeholders such as local residents, visitors, policy makers, etc. The key factor of valuation studies is to show how a healthy ecosystem is important for socio-economic prosperity (Sukhdev et al., 2014).

1.6.5. Valuation techniques

Valuation methods can be separated into two broad categories: stated preference and revealed preference methods. Each of these broad categories of methods includes both indirect and direct techniques. Revealed preference methods are those that are based on actual observable choices that allow resource values to be directly inferred from those choices. Stated preference methods use survey techniques to elicit willingness to pay for a marginal improvement or for avoiding a marginal loss (Tietenberg & Lewis, 2016).

Table 3: Valuation techniques

Methods	Revealed Preference	Stated Preference
Direct	Market Price Simulated Market Production Function	Contingent Valuation
Indirect	Travel Cost Hedonic Property Values Hedonic Wage Values Avoidance Expenditures Replacement Costs	Choice Modelling ○ Choice experiment ○ Choice ranking ○ Choice rating
Source: Adopted and Modified from Tietenberg & Lewis (2016)		

1.7. Threats and Drivers of Wetland Degradation

Rwanda has a very rich wetland cover of approximately 280,000 ha and this accounts for about 11% of the total land of the country. These wetlands provide critical habitats for wildlife and biodiversity, they maintain important hydrologic processes which are essential in cleaning and protecting the surface and groundwater, and they support a variety of local livelihoods. Despite these benefits, these wetlands are experiencing a myriad of challenges as a result of land use conversions, over utilization of and competition for resources and climatic factors. Rwanda's wetlands are the fastest lost and degraded compared to any other ecosystems in the country. Currently more than half of the wetlands in Rwanda are being used for agricultural activities and energy production.

The main threats to the wetlands include reclamation, over exploitation of natural resources in which there is extensive use of wetlands for the purpose of generating hydropower and as mine for clay, sand, gravel and peat include the most direct threats which are faced by wetlands in Rwanda. The hydropower plants usually require a sufficient amount of water which are mostly connected to the wetland schemes. The hydroelectric power plants are usually more susceptible to sedimentation which as a result damages turbine and tubing due to the inadequate storage capacity of wetlands. The drop of water levels has serious economic losses. The other threat to wetland conservation includes invasive species such as water hyacinth, and Mimosa pigra. Water hyacinth grows rapidly to form thick mats on water surfaces, increases swamps areas, reduces water supply and undermines transport, hydroelectric power production, fisheries and fish breeding. It can also affect human health by harbouring mosquitoes (malaria), snails (bilharzias), and snakes (Chemonics International Inc. 2003). Water hyacinth has covered large sections of most of the lakes in the eastern province making them difficult to navigate. In some cases the weeds have contributed to the drying of shallow seasonal lakes. Alien and invasive species which continue to alter the biodiversity balance of the ecosystems that as a result decrease the services which they provide. Pollution is another threat to wetlands health, and this includes point and non-pollution from industries, settlements, and agricultural activities. The use of chemical fertilizers, fungicides and insecticides has modified the chemical composition of these hydrologically-connected water resources. These chemicals seep through the wetlands and join other water sources most of which form rural domestic water supply points such as wells and streams. Spillages from industrial processes also pollute water and wetlands, for instance, during the washing of coffee. The physical and hydrological modifications mainly relate to erosion due to inappropriate agricultural practices. Drains and channels constructed to divert or to increase water out-flow from wetlands lower the water table and can lead to loss of biodiversity through drying out of the wetlands.

Generally, and in summary, the major threats to wetlands are; agriculture expansion, pollution, peat mining, sand and clay mining, invasive/exotic species, bushfire, various infrastructure development and others. 53 per cent of Rwanda's wetlands has been converted into agriculture. The Rweru-Mugesera Swamps are highly affected by the following human activities: agriculture, cattle grazing, production of loam bricks and cutting of plants for animal feeding and construction purposes. Also, invasive plants, especially the water hyacinth (Eichhornia crassipes), are a major threat to the natural vegetation. The area is actually not protected.

The causes and or drivers of wetland degradation challenges in Rwanda include: population growth which pushes people to look for more space and land; Poverty/Unemployment which has forced a wide range of people to rely on wetland resources for survival; agricultural expansion and intensification in which wetlands such as Rweru-Mugesera complex, and the Kigali wetlands have been intensively cultivated for crops like flowers, rice, eucalyptus, sweet potatoes and sugarcane. Wetlands which are under the traditional utilization of water, fodder, livestock and small-scale agriculture have the ability to regulate water flow. When this water is drained and utilized for intensive agriculture, the water is rapidly conveyed downstream which reduces the ability of the wetland to buffer peak flows, hold water and retain sediment. Other uses include conversion of wetlands into livestock grazing areas. This has, however, been reduced due to the zero-grazing policy being enforced by the government. Approximately 30 per cent (90,000 ha) of the swamps area is already being used for agriculture. Of these, 5,000 ha are used all year round (MINIRENA 2008). Cultivation of swampland affects their chemical, physical and hydrological nature. Urbanization and industrial development are other causes of wetland degradation in which rural-urban migration has been brought about by the growth of towns in the country. Industrialization, especially industries which are located around the wetlands and infrastructure development such as industrial parks also lead to wetland encroachment and degradation. Other causes include Policy and regulatory shortcomings; Inadequate waste management, Lack of awareness on the values of wetland ecosystem goods and services

1.8. Policy, Legal, Regulatory and Frameworks

This analysis is focused on the goals of the policies, instruments, policy typologies, laws and regulations, plans and strategies. The agricultural policy of 2000, considers wetlands as an important resource for the intensification of agriculture, which is required to achieve the goals of food security and poverty reduction for Rwanda to achieve an overall GDP growth rate of 6.4%, agriculture should grow at 5.3%. According to the National Poverty Reduction Programme of the Ministry of Finance and Economic Planning. The policy further estimates that improved wetland management has the potential to contribute to this growth by 0.5%. Other policy frameworks under analysis include; environment policy, organic law, Land use policy 2004, Human settlement Policy 2004, Urban Housing Policy 2008, Land law 2013, Land use planning & Development law 2012, National Land use master plan (2010-2020), National Irrigation Master Plan, Crop Intensification Programme, One Family One Cow Programme among others.

1.8.1. National Environment and Climate Change Policy

Adopted in 2019, this policy is a successor to the environment policy that was adopted in 2003. The 2003 environment policy had the policy goal of

The national environment policy and climate change has the goal of Rwanda being a nation that has a clean and healthy environment, resilient to climate variability and change that supports a high quality of life for its society.

The policy stipulates the following targets or actions that are specifically relevant to wetlands:

Integrate Natural Capital Accounting and valuation of ecosystem services into national development planning frameworks

Regularly conduct an inventory of degraded ecosystem and prepare restoration development plans

- Develop a master plan and implementation strategies for wetland management in Rwanda
- Develop guidelines for the use of wetlands
- Identify all polluted wetlands and develop a decontamination plan including the use of environmentally-sound technologies (Phytoremediation) for pollution prevention, control and remediation

- Promote and intensify wetland protection, and restoration and rehabilitation of degraded wetlands
- Strengthen collaborative and participatory management of wetland resources
- Strengthen existing wetland research and encourage conservation and restoration of ecosystems critically threatened by climate change
- Ensure the protection of wetlands, riverbanks, hilltops and slopes from unsustainable practices to prevent soil erosion and environmental degradation.
- Ensure that developmental activities within wetlands or in the buffer of wetlands conform with EIA process and procedures. Promote the use of alternative forms to biomass fuel (e.g., gas and electricity) in urban and rural areas

The policy will be implemented through ministerial and DDS, SSPs, annual Imihigo targets and action plans. The policy will also be implemented through the action plans of development partners, CSOs and the private sector who will translate the policy into action. Develop master plan and implementation strategies and sector specific detailed guidelines for wetland management in Rwanda (MOE, MINAGRI, REMA) between 2018 and 2024.

Identify all polluted wetlands, develop and implement their decontamination plan (REMA, MoE, MINAGRI, UR, CSO, DP) between 2019 and 2024.

1.8.2. Agricultural policy of 2017

Adopted in 2017, the policy is a successor to the agriculture policy of 2004. This policy has the mission of ensuring food and nutrition security of Rwandans by using modern agribusiness technologies, professionalizing farmers in terms of production, commercialization of the outputs and then creating a competitive agriculture sector. The policy has identified four main strategic and enabling pillars upon which core policy guidance and actions have been based:

- Productivity and Commercialization for Food Security, Nutrition, and Incomes
- Resilience and Sustainable Intensification
- Inclusive Employment and Improved Agrofood Systems' Skills and Knowledge
- An Effective Enabling Environment and Responsive Institutions

MINAGRI is the key leading institution to deliver on the implementing of the policy. MINAGRI will closely collaborate in the policy implementation with a range of public institutions that influence the sector (MINALOC, MINICOFIN. RDB, MINEACOM, MINISANTE, MINIRENA, MIFOTRA, MINIFRA, MINEDUC, MYICT) through the creation of collaborative platforms.

More detailed policy guidance on a specific policy-area to be defined by subsidiary policies. Specific actions are and timelines are to be defined by subsidiary strategies.

1.8.3. Biodiversity Policy

Considers the rehabilitation of degraded ecosystems in Rwanda as an urgent and major task that requires the commitment of significant resources from both national budgets and other sources.

1.8.4. Energy Policy

recognizes the need to shift consumption from biomass-based energies to clean energies like electricity and Liquefied Petroleum Gas (LPG) to reduce pressure on forest resources. It also focuses on renewable energy infrastructure as one strategy to fight global warming through reductions in greenhouse gas emissions.

1.8.5. Prime Minister's Order N°006/03 of 30/01/2017

The minister's order drew up a list of swamps, their characteristics, and boundaries, and determined modalities of their use, development and management. The Rweru-Mugesera wetland complex is proposed to be considered as a Ramsar site and of international importance. Its use is to be considered under specific conditions.

1.8.6. National irrigation master plan

This plan was developed in the year 2010 with the aim of development and management of water resources to promote intensive and sustainable irrigated agriculture and to improve food security (GoR, 2010). The potential of the country for irrigation as captured in the plan is estimated at 600,000 hectares, from this, the potential for wetland use for irrigation is estimated at 219 793 hectares (GoR,2010).

The estimated total area of marshes in the country is 275 689 ha, of which 55 896 ha are fully protected, 204 198 ha are non-protected but with limitations while 15 595 ha are non-protected without limitations. It is these latter two categories that have been summed up to carry the irrigation potential for the marshlands (GoR, 2010).

By the end of 2006, almost 11 000 ha of swampland had been reclaimed and used for rice production, and it was projected that by the end of 2020, 40 000 ha of swampland should have been reclaimed, and a plan for irrigating 1000 ha in Bugesera was prepared and implemented (GoR,2010).

1.8.7. Crop intensification programme

The Crop Intensification Program (CIP) is a cornerstone program for staple food activities within MINAGRI and the GOR. Launched in 2007, the CIP is the main policy adopted by the Rwandan government to bring about agricultural modernisation. The CIP aims for the prioritisation of six food crops (maize, wheat, cassava, beans, Irish potatoes, and rice), and uniformity in farming practices across the country. The programme focuses on four axes: (1) land use consolidation; (2) the distribution of fertilisers (namely DAP – diammonium phosphate – and urea) and improved seeds; (3) the provision of proximity extension services; and (4) the improvement of post-harvesting handling and storage. Since its implementation, the CIP has led to encouraging results in terms of productivity. Production of maize, wheat and cassava tripled between 2007 and 2010, bean production doubled, and rice and Irish potato production increased by 30% over the same time span (MINAGRI 2011).

The Crop Intensification Programme covers all the three districts that have footprints in the wetland complex, with Rwamagana and Ngoma districts earmarked for maize and beans growing, while Bugesera district is allocated maize growing only under the programme. The Rweru-Mugesera wetlands complex, though considered as one of the four most important wetlands in Rwanda, is not a protected wetland and therefore qualifies for conditional use for crop farming.

1.8.8. The Girinka program

The one Cow per Poor Family is the cornerstone for the livestock programme. The Girinka program was approved as one of the implementation measures for national key leading policy, strategies and programs. It aims to enable every poor family to access a dairy cow for income, nutrition, and organic fertilizer. The policy will change the dynamics of pasture access in the wetland as more households embrace the programme. It will lead to a decline in the local breeds that are usually raised through free range and kept in large numbers to a mode of livestock keeping where households will mostly own one cow and access the wetland to cut and carry the grass as opposed to grazing in the wetland.

2. METHODOLOGY

2.1. An overview of the approach adopted for the study

We adapted and modified the methods described in Troy & Wilson (2006) to develop the research methods which entailed; delineation of study area, typology development, data collection strategy, mapping, and data analysis (estimation of current economic values, and scenario analysis i.e. projections of future ecosystem services values based on feasible alternative options for the management and governance of the wetland) as discussed in the next paragraphs.

2.2. Study area delineation

The economic values of ecosystem services are typically expressed as per household, per individual, or per hectare values (Barton et al., 2019; He et al. 2015; Bateman et al.,2010; Siikamaki et al., 2015). This is an important step to factor in and take care of since even small boundary adjustments can have significant impacts on the final ecosystem service value estimates. Spatial boundary needs to correspond to the bio-geophysical boundaries, such as being consistent with the characteristics of wetland ecosystem biophysical features such as presence of papyrus plant species, soil type, and areas of inundation (hydrographic boundary) as well.

2.2.1. The hydrology of the wetland complex

Rweru-Mugesera wetland complex is located at the Upper Akagera catchment. The Upper Akagera catchment covers a surface area of 3052 square kilometres. The catchment is transboundary with Burundi and Tanzania to its downstream. The catchment drains the area from the confluence of Nyabarongo and Akanyaru rivers down to the Rusuma Falls. The catchment has two sub catchments namely Mugesera /sake, and Rweru sub catchments (RNRA, 2015).

The wetlands complex whose main water supply is derived from Nyabarongo river comprises a mosaic of several lakes (Mugesera, Gashariga, Kidogo, Rumira /Gashora, Birara, Mirayi, Sake, Kilimbi, Gaharwa, and Rweru). River Nyabarango empties its waters in River Akagera and lake Rweru and it is also flanked by a phragmites dominated land cover on either of its sides (Fischer et al., 2011).

2.2.2. The ecology of the wetland complex

The Rweru-Mugesera wetlands complex is dominated by plant and animal communities of various phyla. Around fifty-three (53) vascular plant species can be found in the wetland. There exists a landscape dominated by phragmites plan species classified as Cypero papyri-Dryopteridetum gongylodis. Other reed communities are the Phragmitetum mauritiani with dominating Phragmites mauritianus, the Echinochloetum pyramidalis and the Cyperetum latifolii. Along the rivers, a community with Sesbania sesban and Phoenix reclinata is developed (Sesbanio-Phoenicetum reclinatae). The open water surfaces are colonized by communities of aquatic plants, e.g., the Nymphaeetum calliantho-mildbraedii with Nymphaea lotus and Nymphaea nouchalii, and the Ceratophylletum demersi. Free floating species are Azolla nilotica and the neophytic Eichhornia crassipes.

For the animal community, there are around thirteen (13) species of amphibians which have been recorded, 6 species of reptiles have also been recorded. Other animal groups include; over 40 bird species including two listed in IUCN (Papyrus Gonolek and the Papyrus Yellow Warbler) have been recorded, including Laniarius mufumbiri species. The wetland is also home to mammals (16 species) such as Hippopotamus, Bushbuck, Sitatunga and jackal have been observed.

2.2.3. The socio-economy of the wetlands complex

Rweru-Mugesera wetlands complex traverses three districts (including Ngoma, Bugesera, and Rwamagana) in the Eastern Province of Rwanda. Major settlements around the wetland are found in; ten (10) sectors in Ngoma district, four (4) sectors in Bugesera district, and four (4) sectors in Rwamagana districts. The total household population within three kilometres radius from the wetland in these sectors based on projected (to 2020) 2012 population census is 52,173.

Table 4: Local community household population

District	Sectors	2020 household population considered
Rwamagana	Nyakaliro, Karenge, Rubona	2491
Ngoma	Rurenge, Mugesera, Karembo, Rukumberi, Zaza Gashanda, Sake, Jarama, Mutenderi, Kazo	41,395
Bugesera	Gashora, Rilima, Jiru, Rweru	8287
Total		**52,173**

There are a host of educational centres and facilities in the local community surrounding the wetland complex; they include: approximately over 40 primary schools, and over 25 secondary schools (GoRa, 2014; GoRb, 2015). Other social services and facilities in the local community include the presence of health facilities in nearly at least every sector. Markets and trading centres also exist too in nearly every sector though in some cases such facilities are situated more than two kilometres away from some settlements. Markets and trading centres also exist in nearly every sector and just like with health facilities, these also in some cases are situated more than two kilometres away from some settlements (GoR, 2014).

Major sources of livelihoods include; crop farming, livestock, wages, trade, among others, while the mean poverty levels for the three districts or 17 sectors is around 48% which is above the national average of 39% (GoRa, 2014; GoRb, 2015).

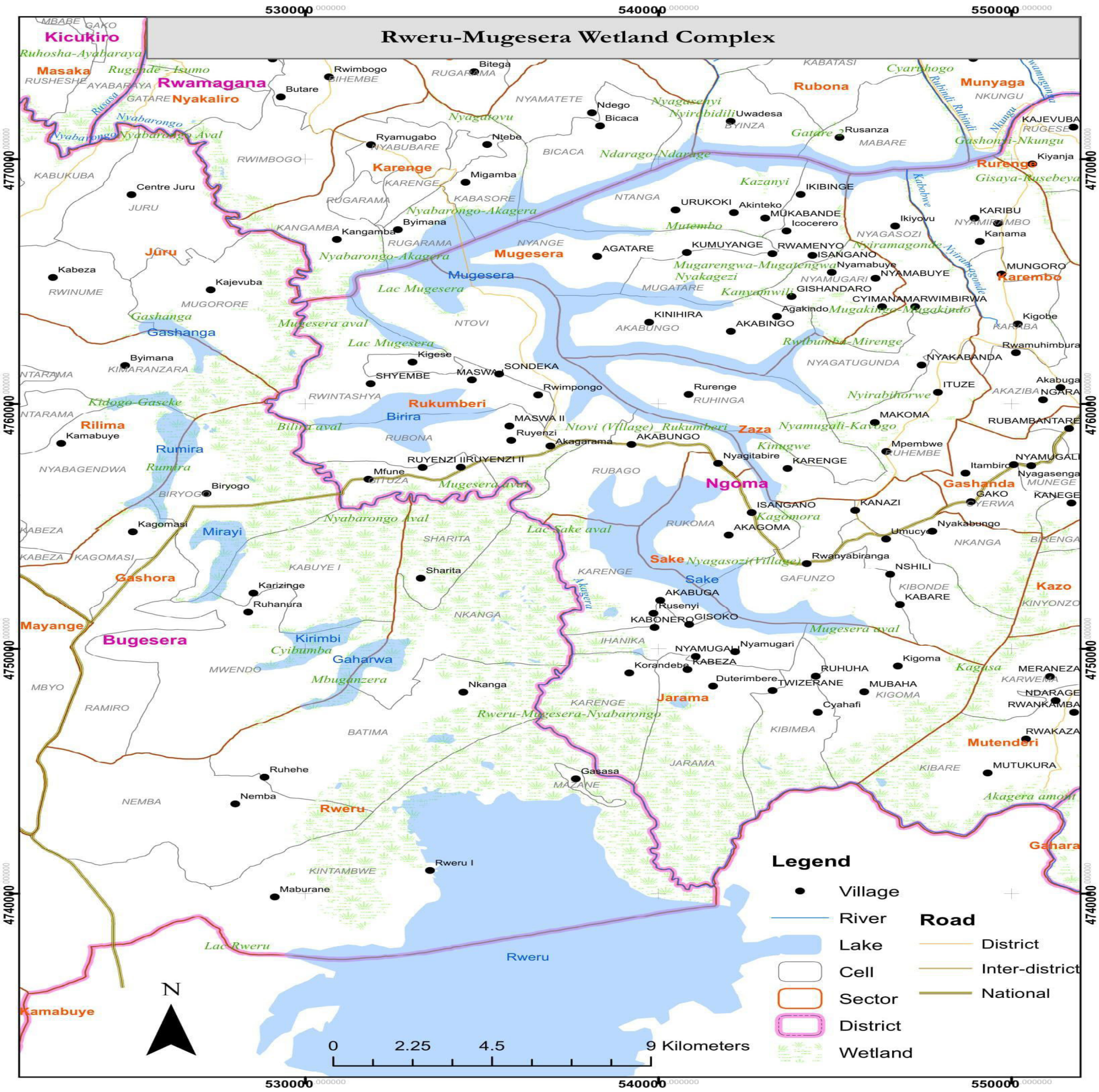

Figure 1: Map of Study Area showing villages of the affected population

From the above figure, we can situate on the south, lake Rweru and between the districts of Rwamagana and Ngoma, lake Mugesera, and the main river, Nyabarongo acting as the boundary for the three districts in most of its reaches. The total area of the lakes in the complex is approximately 13,660 ha, while the whole of the complex measures approximately 32,081 hectares.

2.3. Typology Development

Typology has to do with the determination of land use and land cover types that exist in the delineated area of study or ecosystem of study. In this stcudy, this was conducted through a review of existing materials on the Rweru-Mugesera wetland ecosystem or other wetlands of similar nature, and through GIS and remote sensing. The land use land cover determined are as shown in the table below. This was followed by a review of economic studies to determine whether ecosystem service value coefficients have been documented for these cover types in a similar context. For the lakes, lake Rweru covers an area of 3383 ha on the Rwandan side, Gashanga= 202ha, Kidogo=199ha, Rumira=247ha, Mirayi=265ha, Kirimbi=288ha, Gaharwa=469ha, Mugesera=5829 ha, Sake= 2123, Birira= 656 (UNEP et al., 2007).

Table 5: Land use, land cover types in Rweru-Mugesera wetlands complex

Land use, land cover type	Areal extent in 2020 (ha)
Water body (Lakes, river, streams etc)	13,660
Papyrus (Phragmites)	12206
Grassland	2297
Cropland (within the wetland delineated area & buffer zones)	1517
Other vegetation	2401
Total area	**32,081**

2.4. Data collection strategy

2.4.1. Data needs, types, and sources

The table below shows the various data needs that are necessary in order for the study objectives to be achieved. The information needed is presented for the potential ecosystem services that are likely to be valued in this study, the nature of the data, the potential sources of the data, and the preferred valuation method.

Table 6: Data Needs, and Sources

Potential Product/services	Valuation Method	Data needs	Potential Sources of data
Fuelwood	Market price	Potential Production Volume (M^3), estimated cost of production (variable and fixed cost)	State level reports, Rwanda Bureau of Statistics
Agricultural crops	Market prices	Production volume, local units and conversion, cost of production, and Market prices	Local market prices and quantity supplied, Rwanda Bureau of Statistics, District level responsible offices, literature and annual reports
Domestic water supply	Market price	Number of households whose water source is from the wetland Average water uses per household Water use price	Rwanda Bureau of Statistics, state and national level reports
Communal grazing	Market price	Number of cattle which graze from the wetland	Review of existing literature, national and state level reports
Livestock watering	Market price	Number of cattle which drink water from the wetland, average amount of water consumed per head per day	Local market price, national and state level reports
Fish	Market price	Amount of fish extracted per annum, cost of fish extraction, price of fish	Local market prices, literature, reports at federal & state levels, Rwanda Bureau of Statistics
Natural medicines	Market price	Number of people treated by natural medication Average estimated cost of medication	Existing literature, Rwanda Bureau of Statistics
Fodder	Surrogate, Market prices	Quantity in kg, sacks and other local measures to be converted to kg, estimated cost of production	Household surveys, Local market prices, literature, reports at federal & state levels, Rwanda Bureau of Statistics
Carbon sequestration	Market prices	Above ground Biomass (AGB), Below ground biomass) (BGB, Soil biomass), international voluntary carbon market, total area under vegetation, IPCC carbon default values.	Existing literature on estimated CO_2 sequestration at local or regional level, IPCC reports Reports on National and/or regional and/or local level carbon sequestration levels
Water attenuation	Market price and/or avoided cost	Number of Households around the wetland, estimated cost that would have been incurred for flood control	Available litterture,global and TEEB database
Water purfication	Market price and/or avoided cost	Total number of households that uses wetland as a major source of water, cost that would be incurred for water purification	Exciting literature, national and regional level report
Soil protection (prevented soil erosion)	Avoided cost	-cost of 1 ton of sediment removal -ratio of sediment entering rivers or reservoirs to total soil lost -Soil erosivity for restored and non-restored forest (tons/ha)	Literature, reports from Ministry of Water Resources & Irrigation, Rwanda National Lands Commission, and State Lands Commissions, National and/or regional and/or local level soil maps
Education & research	Averted cost Revealed price Value Transfer	Cost learning institutions would incur to visit other wetlands of similar nature	Annual reports from learning institutions/ market information, existing literature
		Funds spent by researchers	Records from research clearing institutions, and research institutions
Habitat for biodiversity	Revealed price and/or value transfer	Expenditures (budget allocated) for biodiversity conservation by national and international actors (agents)	National budget allocation, budget set by international actors and NGOs, annual reports and literature

2.4.2. Sampling Procedures and Strategy

Both purposive and probability sampling will be used in this study to collect data. Purposive sampling will be used for qualitative data collection methods such as key informant interviews, and focus group discussions. Data collection through purposive sampling become adequate and reliable once saturation is reached, i.e., a point in which any new respondent interviewed or more focus group discussion adds no new information, Guest et al., (2006) proposed that for Key Informant Interviews, saturation is reached at the 12th respondent for a homogenous group/population. In this proposed study, three kinds of target population have been proposed. They include government agents with interest and mandates on wetland resources, civil society groups with interest in wetland resources, and local community user groups. Therefore, to achieve the minimum requirements for saturation, a total of 36 respondents, 12 for each of the three stakeholder groups will be conducted. For focused group discussions, Guest et al., (2017) advice that a study objective can be sufficiently addressed by between three and six focus group discussions for homogenous groups. Therefore three (3) focus group discussions will be held for each study site, totalling to nine (9) focus group discussions.

For the probability sampling, the target populations were households in the local community who reside in the area where they can exact a direct influence on the wetland. Delineation of two kilometres radius from the wetland's buffer zone was used. Multistage cluster sampling was used in which the sectors/cells acted as clusters. A total of 17 sectors were mapped and out of these, 18 cells were randomly picked for sampling, from the randomly picked cells, 18 villages were also randomly picked and from each village picked, 11 households were randomly picked for survey. Household heads or their spouses were considered for interview; this was based on the assumption that household heads or their spouses are in a position to make financial decisions for the entire household.

An assumption of normal distribution of the ecosystem services under consideration among the cells and villages if made using the simple random sampling, then based on Yamane (1967) sample size calculation formula (equation 1), the right sample size determination can be made.

$$n = \frac{N}{1+N(e)^2} \qquad (1)$$

Where is the sample size, is the population size, and is the level of precision? Desiring a 95% confidence level and precision levels of 0.05.

2.4.3. Data collection

Both primary and secondary data will be collected and analysed. Wetland related policies in particular and environmental related policies, strategies, and plans in general are briefly reviewed and incorporated to understand the enabling policy and strategy environment to implement wetland conservation activities and to support integrated development decisions. Other relevant information from secondary sources will be consulted during KII and FGDs to complement this review.

Given the benefit transfer approach is the plausible option considering the circumstances of the study sites; much information will be extracted from available secondary sources and literatures. The existing TEEB database and reports1 and valuation studies and the global Ecosystem service valuation database for data and knowledge sharing at Ecosystem Service Partnership (ESP)2 will be good asset for this purpose. Population data of the wetland site and national level, activities performed in and around the wetlands, benefits obtained from the wetland areas, challenges of the wetlands and related information will be generated from secondary sources. Statistical bulletins, published and unpublished materials about these issues will be consulted in this regard. Primary data will be collected through Key Informant Interviews (KII) and Focus Group Discussions (FGDs). KIIs and FGDs provide us vital information that could help us in understanding the local contexts, and to develop possible scenarios for wetland conservation options and to value the wetlands ecosystem services.

1 The Nile Basin wetland TEEB data base was collected and can be shared at any need

2 https://www.es-partnership.org/services/data-knowledge-sharing/

a. Key Informant Interviews (KIIs)

KIIs planned to be carried out with selected experts at different levels of the administrative and institutional hierarchy to solicit information related to the wetlands using a checklist that is prepared as a guide for interviewing3 and the consultation process. In addition, information about the existing situation of the wetlands, stakeholders impacted by the wetlands, wetland conservation options given the local circumstances, viability of the different wetland conservation options, socioeconomics and biophysical characteristics of the wetland area, current estimates of costs and benefits from alternative wetland conservation options (if any), expert outlooks of the state of the wetlands and other information are outlined and obtained from the KIIs workout. The Key informant checklists and potential stakeholders is developed and annexed.

Figure 2: Discussion with fisheries stakeholders near lake Rweru

b. Focused Group Discussions (FGDs)5

Again, more qualitative information expected be solicited and explored through the focused group discussions. The FGDs participants will further communicated for avail information and consultations. The lists of guiding questions that will be used during focus group discussions with potential stakeholders is developed and annexed.

Household Survey

Household survey has been designed to among others:

Establish the level of consumption of provisioning ecosystem services in terms of the population that harness these ecosystem services, the amount that they extract, their socio-economic and demographic characteristics such as levels of income, gender, age, education among others;

Knowledge, attitude and practices towards wetland conservation and biodiversity

Establish the population that are at risk of various environmental hazards such as those that are related to wetland regulating services e.g., flood mitigation, water purification, groundwater recharge and discharge, among others.

3 https://www.es-partnership.org/services/data-knowledge-sharing/

4 Leading or guiding KII questions and checklist are annexed

c. Mapping

Map creation involves GIS overlay analysis and geoprocessing to combine input layers from diverse sources to derive the land use/ cover map. In this study, the land use cover in Rweru-Mugesera was analysed and it revealed that the existing land uses include; water body, phragmites, crop land (within the wetland & buffer zones) grassland, these maps are facilitators for the analysis and modelling of the stocks and flows of wetland ecosystem services using various valuation techniques including value transfers as shown in table 7 shows the acreage extent for each land use, and land cover.

Table 7: Trends in Land use, land cover in Rweru-Mugesera wetlands complex

Land use, land cover type	**2010** extent **(ha)**	**2020** extent **(ha)**	change
Water body	13660	13660	<=0
Papyrus(phragmites)	10661	12206	+1545
Grassland	2297	2297	<=0
Cropland (within the wetland & buffer zones)	3062	1517	-1545
Other vegetation	2401	2401	>=0

2.6. Baseline Economic Values Calculation

Once each mapping unit is assigned a cover type, it can then be assigned a value multiplier from the economic literature , allowing ecosystem service values to be summed and cross-tabulated by service and land cover type.

The total ecosystem service value flow of a given land use/cover type is then calculated by adding up type and

$$AEV(ES_i) = \sum_{k=1}^{n} A(LU_i) * AEV(ES_{ki}) \quad (2)$$

Where:

$AEV(ES_i)$ = Annual economic value per unit area for ecosystem service type k generated by land use or cover type i,

$A(LU_i)$= area of land use or cover type i

Where:

annual economic value per unit area for ecosystem service type generated by land use or cover type ,

= area of land use or cover type

The economic value of individual ecosystem services are initially estimated using various techniques and models as indicated in the table 8 below

5 Leading or guiding key FGD questions are annexed

Table 8: Models for estimation of the baseline economic values of ecosystem services

Ecosystem service	Valuation technique	Model	Model Explanation
Domestic Water supply	Market price	Vn=l*m*n*365 day	l= Households dependent on wetlands for water supply m=Average use of water per household n= Market price per m^3 (US $) V_W= Gross annual value of water for domestic consumption (US $)
Water for Irrigation	Production function	Agronomic model $lnY_{ic} = \ln a + blnLD + clnW + dlnLA + elnS + fln\,CH + glnI + hlnCA$	Y= Yield in tons; i= location; c= crop type; LD= Land size; W= Irrigation water; LA= labour; S= seed CH= chemicals; I= implements; CA= capital; a= is the specific total factor productivity which explains effects in total output (CV) not caused by inputs; b to g = are the output elasticities of the input variable
		Economic model $MP_W = \frac{\partial lnY}{\partial lnw} \cdot \frac{Y}{w}$ $P_{shadow} = P_{output} \cdot MP_W$	MP_W = Marginal product of irrigation water P_{shadow} = Shadow price of irrigation water P_{output}= Output price of irrigation water
Water for Livestock	Market price	Vlw=p*q*r*365 Adopted from (Kakuru et al., 2013)	Vlw= value of livestock grazing p= Number of cattle obtaining water from wetlands q= Amount of water consumed per day per head of cattle r= Cost of water per 20 liters (US$)
Crop farming in the wetland	Market prices	$T_v = (Q_i * P_i) - C_i)$	T_v is the economic value of the product/output, Q_i is the quantity of good/product; P_i is farm gate price of the product, C_i is the cost of production. The value of costs and benefits will be calculated per hectare to develop the enterprise budget
Livestock grazing in the wetland	Market price	Vg=o*p*365 Adopted from (Kakuru et al., 2013)	Vg= value of grazing o= Number of cattle raised in wetlands p= Average value of pasture consumed per day per animal (US$)
Grass harvesting	Surrogate, Market prices	$T_v = (Q_i * P_i) - C_i)$	Where, T_v is the economic value of the product/output, Q_i is the quantity of good/product; P_i is farm gate price of the product, C_i is the cost of production,
Capture fisheries	Market price	Vf= (Qf*Pf) - Cf	Vf= Value of fish Qf= Quantity of fish harvested Pf= Price of fish, say, per tonne Cf = cost of extracting fish, say, per tonne
Products from Papyrus & other related grasses	Market price	$T_v = (Q_i * P_i) - C_i)$	Where, T_v is the economic value of the product/output, Q_i is the quantity of

			good/product; P_i is farm gate price of the product, C_i is the cost of production,
Fuelwood	Market price	$T_v = (Q_i * P_i) - C_i)$	Where, T_v is the economic value of the product/output, Q_i is the quantity of good/product; P_i is farm gate price of the product, C_i is the cost of production,
Natural medicine	Market price	$T_m = (Q_m * Pm))$	T_m- the economic value of medication Q_m – number of people treated by natural medication P_m- estimated price of medication
Pottery	Market price	$T_v = (Q_i * P_i) - C_i)$	Where, T_v is the economic value of the product/output, Q_i is the quantity of good/product; P_i is farm gate price of the product, C_i is the cost of production,
Carbon sequestration & storage	Market prices	- $V_R = (Q_r * P_c * S_r) - (Q_d * P_c * S_d)$ This is adapted from InVEST model	V_R=the carbon sequestration value of conservation transition; Q_r=carbon sequestration (CO_2) in restored area; P_c=the international carbon sequestration price; S_r = the area restored (ha); Q_d is the carbon sequestration (CO_2) in degraded area; S_d is the area degraded (ha)
*Water purification	Market price and/or avoided cost	Vp=A*B Adapted from (Verma and Negandhi, 2011)	V_p is the economic value of water purification A= total purification cost per household in the absence of the wetland B= total number of households who uses the wetland as a source of water
Sediment control	Avoided cost	$V_k = K * G \sum_{i=1}^{n} S_i * (d_i - d_0)$	Where V_K is the economic value of soil-erosion regulation; -K is the cost of a ton of sediment removal; -S_i is the area of forest-vegetation types in hectares; -G is the ratio of sediment entering rivers or reservoirs to total soil lost; -d_i is the erosivity of non-restored land (tons/ha); and d_0 is the erosivity of restored land (tons/ha).
Flood control	Market price and/or avoided cost	V_W= A*B Adapted from (Merriaman, 2016)	V_W- value of water attenuation Total household likely damaged by disaster without wetland ecosystem Estimated cost per household for flood control or storm surge protection or wave attenuation
Education & research	Averted cost of travel	V_e = A*B	V_e =Value of wetland for education A= Total trips made likely to be made by schools for wetland educational tours in a year B= Estimated cost per trip to the nearest wetland of similar nature
	Research expenditures	$\sum_{i=1}^{n} RE_i$	RE= research expenditures

Habitat for biodiversity	Conservation budget expenditures	$\sum_{i=1}^{n} CE_i$	CE= Conservation expenditure
Nearly all Ecosystem Services	Value transfer	$In(y) = a + X_s b_s + X_p b_p + X_e b_e + u$	Where a is the usual constant term, u a vector of residuals (assuming well behaved underlying errors), and the vectors b. contain the estimated coefficients on the respective explanatory variables.

Economic valuation of market price methods entails assessment of both financial and economic analyses for each of the provisioning ecosystem services. Data for provisioning ecosystem services was obtained through household survey and complimented with key informant interviews, focus group discussions, and other objectively available data such as fisheries data.

The general methods/ formulas for conducting financial analysis and economic analysis are presented in table 5 below.

2.7. Assessment of the economic consequences of the current institutional frameworks

Finally, scenario or historic change analysis can be conducted by changing the inputs at the data collection and mapping stages. For future scenario analysis this involves changing the land use, land cover input to reflect an existing and or proposed management alternative. In this study, models of how the use of the wetland and wetland resources, and the area and quality of the ecosystem could change in the next 30 years (between 2020 and 2050) are applied. A baseline for the physical coverage of the Rweru-Mugesera wetlands complex in 2020 is considered, and then followed by an analysis of scenarios for the changes in that coverage and the implications this will have on the value of ecosystem services that the wetland currently delivers by the year 2050. Key drivers of change identified based on literature review include; population growth, changes in agriculture, poverty, overfishing, policy interventions (law enforcement)

The Rweru-Mugesera wetlands complex is currently not protected, and its management and use is governed by the extent of enforcement and compliance with the current policies, laws and the implementation of existing strategies.

Rapid population growth will be maintained because of cultural values, and immigration to the region due to currently planned projects including the creation of RICA will see a steady increase in population as projected in demographic studies and censuses. The trajectory of poverty is that the overall GDP of the country will improve. However, it has been observed that while the country may continue to have an upward trajectory towards wealth, life will continue to be difficult to the vast majority given that inflation in the country grows at a faster rate than poverty eradication.

There are a host of policies that govern the management of wetlands in Rwanda, they for instance entail, crop intensification programme, water resource management strategy, national irrigation master plan among others, all of which have implications on the land use practices on Rweru-Mugesera wetlands complex.

The implications of the trajectory of drivers of change under this business-as-usual scenario means that there will be continued gain of the Rweru-Mugesera wetlands complex at the current rate of 6.7 %, but with a decline in water quality. The spatial dimension of degradation will however, be influenced by some other internal factors based on the drivers of degradations.

2.7.1. Assumptions and patterns of change for the ecosystem services under the current institutional frameworks

The scenarios will be used to make projections on the future availability of the biophysical quantities of the ecosystem services based on the per unit change of the spatial land uses, and the corresponding economic values coefficients at constant prices as shown in equation 2.

$$K = \frac{A_{final} - A_{initial}}{A_{initial}} \; X \; \frac{1}{T} \; X \; 100\% \qquad (3)$$

where K refers to the land-use dynamic index for a single land-use category, A_{final} and $A_{initial}$ are the areas of a certain land use at the final and initial years of a period, respectively, and T is the study period. If T is one year, K refers to the annual change rate (Lin et al., 2018).

The land-use dynamic degree of the study period (T) is defined as

$$S = \left(\sum_{i,j}^{n} \left(\frac{\Delta A_{i-j}}{A_i}\right)\right) \; X \; \frac{1}{T} \; X \; 100\%, \qquad (4)$$

Where A_i is the area of land-use category i at the initial year of the period, $\Delta A_{i \to j}$ is the total area of land-use category i converted into land-use category j, and n represents the types of land use (marshland, cropland, grass land, lakes, settlements, and bare land) (Lin et al., 2018).

2.7.2. Cost Benefit Analysis of the current institutional frameworks

The assessment of Cost Benefit Analysis of the various ecosystem services under the prevailing institutional frameworks governing the management of the wetland complex is premised on a number of parameters and assumptions. However, some ecosystem services have case specific drivers, i.e., demand rates, supply rate, and regeneration potential. Overall, cost and benefit analysis are conducted under Net Present Value approach and Benefit Cost Ratio analysis approaches. To estimate the future (up to 30 years' time horizon) gross values for the various ecosystem services were used. The general formula for determining the annual economic values of the ecosystem services is given by the diminishing balance method to predict how the future of ecosystem services will evolve amid competing land use practices as shown in 3 and 4 above.

The net benefits (NB) of a management action are simply the difference between management benefits and management costs (NB= benefits- costs). The difference between present value benefits and present value costs is referred to as the net present value (NPV):

$$NPV = PVB - PVC \qquad (5)$$

and

$$PVB = \sum_{t=0}^{n-1} \frac{B_t}{(1+r)^t} \qquad \text{While } PVC = \sum_{t=0}^{n-1} \frac{C_t}{(1+r)^t} \qquad (6)$$

Hence

$$NPV = \sum_{t=0}^{n-1} \frac{B_t}{(1+r)^t} - \sum_{t=0}^{n-1} \frac{C_t}{(1+r)^t} \qquad (7)$$

Net present value can be estimated in a number of ways: (1) based on a simple projection of present net benefits; (2) Based on a stream of present net benefits in which future values are altered from the current values along the lines of feasible or expected growth or declines in value; (3) Using dynamic ecological economic models to predict the change in the resource base and hence the change in the benefit streams yielded by different resources. This takes ecological linkages between different resources into account (Turpie et al., 1999).

3. RESULTS AND DISCUSSIONS

3.1. The socio-economic characteristics of the local community living around the wetland

Based on the household survey conducted in the delineated study area, the mean age for household heads was 44 years, while average household size in the local community was five (5) members. In terms of education, 48% of those sampled reported that the highest level of education they had was secondary school level (48%). The dominant ecosystem service in terms of the number of the household population harnessing them is access to water for domestic use, followed by crop farming within the wetland. Figure 2 shows the proportion of the population who benefit from the various ecosystem services found in the Rweru-Mugesera wetland complex.

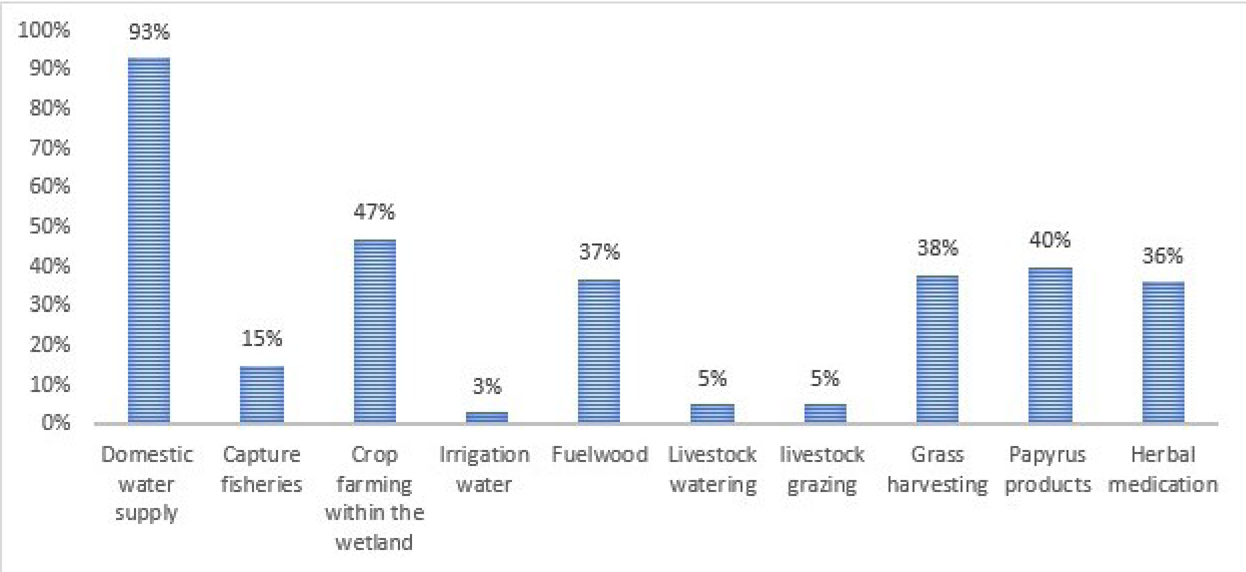

Figure 3: The population who benefit from wetland ecosystem services

3.2. The ecosystem-economic linkages and stakeholders identified

More than 17 sectors are either wholly or partly situated with a three (3) km radius of the wetlands complex, and as such the wetland forms a reasonable catchment in which they can harness the various ecosystem services found in the wetlansd. The total population living within the limits of these sectors is close 240 thousand forming a household population of 52,173. Table 9 shows the description of the economic linkages that ecosystem services bring to humanity, and the proportion of the local population who directly acknowledge that the wetland is beneficial to them.

Table 9: The ecosystem-economic linkages and the stakeholders

Ecosystem services	Economic linkages	Key stakeholders
Water supply	*Sustainable of life for the need for drinking, cooking, and washing*	A total of 48,426 households equivalent to a population of 203,389 individuals
Capture fisheries	*Local and national nutrition, income, foreign exchange & employment*	A total of 7826 households equivalent to a population of 32,869 individuals
Crop farming within the wetland	*Local and national nutrition, income, foreign exchange & employment*	A total of 24,521 households equivalent to a population of 127,510 individuals
Irrigation water	*Local and national nutrition, income, foreign exchange & employment*	A total of 1565 households equivalent to a population of 6574 individuals
Fuel wood	Saved expenditures on purchase of fuel, nutritional value addition	A total of 19,304 households equivalent to a population of 81,077 individuals
Livestock watering	Saved expenditures for purchase of water, livestock are a source of livelihood, and income	A total of 2609 households equivalent to a population of 10,956 individuals
livestock grazing	Saved expenditures for purchase of feedstock, livestock are a source of livelihood, and income	A total of 2609 households equivalent to a population of 10,956 individuals
Grass harvesting	Saved expenditures for purchase of feedstock, livestock are a source of livelihood, and income	A total of 19,826 households equivalent to a population of 83,269 individuals
Papyrus products	*Local and national nutrition, income, foreign exchange & employment*	A total of 20,869 households equivalent to a population of 87,650 individuals
Herbal medication	Improved health, saved expenditures from other potential medical expenses	A total of 18,782 households equivalent to a population of 78,996 individuals
Carbon storage and sequestration	Local income; local, national and global expenditures & damage costs avoided	Tropical wetlands also sequester and store carbon that helps in mitigation of climate change
Water purification	Protection of fragile ecosystem services such as fisheries, reduced expenses on water purification	Tropical marshlands are known to absorb and trap nutrients that become toxic to aquatic plants

Water purification	Protection of fragile ecosystem services such as fisheries, reduced expenses on water purification	Tropical marshlands are known to absorb and trap nutrients that become toxic to aquatic plants and animals when are present in higher than recommended loads
Sediment /erosion control	Reduced loss of fertile soil hence increased agricultural productivity,	Tropical marshlands are known to trap sediments thereby helping lowering the negative impacts of sediment transport into lakes such as in the cases of Lakes Rweru, and Victoria that are linked to the Rweru-Mugesera wetland complex
Flood Regulation	*Averted cost of compensation for damages and losses,*	45% of the households have been affected by floods that damage crops and property in the last 15 years
Habitat for biodiversity	*Employment for conservation, revenues to the government, preservation of cultural heritage* *Maintenance of primary production, maintenance of ecological balance hence averted costs related to such imbalance such pollination losses, pest and diseases control costs*	Tropical wetlands are normally rich in biodiversity species abundance and richness

3.3. The baseline (current) economic values of the wetlands ecosystem service

3.3.1. Domestic Water Supply

There are over 52,173 households living around the Rweru-Mugesera wetlands complex in Rwanda. Out of this population, around 93% of them reported to access water from the wetlands for domestic use. The domestic use of water mainly entails uses of the wetlands's water for drinking, laundry, cooking, bathing and washing of utensils. The average daily amount of water abstracted from the wetlands for domestic use by the local community is 35 litres per household. And the average duration it takes to access water from the wetlands by the local community members is 28 minutes, the common container used are 20 litres Jerry Cans which costs an average of USD 1.78 and may last for two years hence having an annual value of USD 0.89. Majority (96%) access water on foot, while some 15% use bicycles though not always. Absolute bicycle users are some 4% of the local community. The pricing of water (RWF 228/ or $0.23/) as stipulated by the Rwanda Utilities Regulatory Authority has been adopted as a price for water obtained from the wetlands. The gross economic value of domestic use of wetlands water resource by the local community is USD 142,677

Figure 4: WASAC water intake facility near Gashora wetlands

3.3.2. Livestock watering

During the household survey, it is estimated that 5% of the local community take their animals to graze in the wetlands. The wetlands serves as a source of drinking water and pasture for the livestock that graze there. The average number of livestock owned by a household is around 3 cows). Livestock watering in the wetlands which is taken to proceed concomitantly with livestock grazing in the wetlands typically takes place during the dry and or low rain seasons which include; the months of January, February, and May to September. The total gross economic value of water for livestock use is USD 13,300. We estimate this value by taking the product of annual average water consumption per TLU (i.e., 0.05 by 0.70), price of livestock watering ($/), and the number of livestock that used wetlands's water for livestock. Table 11 shows the computed economic value of water for livestock watering.

3.3.3. Livestock grazing within the wetlands

During the survey, 5% of the respondents reported grazing livestock in the wetlands, especially during the dry season and majorly it is cattle that is typically grazed. The average number of livestock kept in the local community was three (3), this translates into a total of average cattle population grazing in the wetlands as 7800 heads of cattle. The average total number of days of grazing in the wetlands is around 212 days. The total gross economic value of livestock grazing in the wetlands is estimated at around US$ 13 thousand, while the net economic value is on the negative of US$ 53 thousand if grazing time, normally supplied for free by a household member, is considered as labour. We estimated the value of grazing by considering the number of animals grazing in the wetlands, duration of grazing in the wetlands, daily forage uptake per cow, and price of hay as the proxy value of grass. A study conducted in 2020 (NBI Technical Reports- WRM 2020-08) estimated the economic value of livestock (cattle in particular) to be $US 10.6 thousand, the study was based on the number of cattle (64,400) in the study and the average value per cattle which was $US 167.

3.3.4. Fuelwood access from the wetlands

From the survey, 37% of the respondents reported that they access fuelwood from the wetlands on a monthly basis. The mean bundle of fuelwood harnessed from the wetlands by a household was around 9 bundles in a month or 108 bundles per year. The average hours spent by a household to collect fuelwood from the wetlands was 3 hours. Other costs associated with collected fuelwood from the wetlands were deemed negligible and therefore not accounted for. The total net economic value of fuelwood from the wetlands is USD **-158,654**. Table YY shows the computation of the economic value of fuelwood from the wetlands.

3.3.5. Herbal medicine

When asked if they used any plants from the wetlands to make herbal medicine, 36% responded in affirma*tive*. Some of the plants used as herbal medicine include; *Amasununu, nyirabahogoma, icyumya, Bagorebeza, Imifumbegeti, iminyonza, Imikorokombe, iminyonza,imivumwe,imifu, Imiravumba, Imisara, Imyicanzoka,umucyuro,Irecye,Imisabiro,Isonga,Itoma,gutwikumwe, Umubembanfura,imibirizi,imiravumba, Umubimbafuro n'umunkamba, Umubirizi, Umwenya, igicumucumu.*

Common ailments treated using plants obtained from the wetlands include: A*mabere cg ifumbi, Amaso, y'inkubisi, Greep, Icyomunda, Ifumbi, inzoka, Imifumbegeti (icyo mumabere n'ifumbi). Imikorokombe (ifumbi), iminyonza, Imyicanzoka(inzoka zomunda), umucyuro, Irecye(inzoka abana), Imisabiro (inzoka), Umubembanfura (inzoka), imiravumba, Umwenya (inkorora)*, Worms.

Information about frequency of treatment, earnings from herbal medicine, and costs incurred from treating patients could not be obtained from the respondents during the survey, therefore such parameters have been borrowed from other studies conducted elsewhere; based on those other studies it is taken that on average the average price charged per patient is USD 5: while the costs incurred include travel to access herbal medicine and harness them or see a patient estimated as eight (8) hours; other costs include use of fuelwood for boiling the herbal medicine estimated as USD 0.97. The economic value of herbal medicine is estimated at a gross value USD 563, 460 and net value of USD 311, 969.

The economic value of herbal medicine was estimated by considering the number of households who use herbal plants, average household frequency of used herbal medicine in a year, average cost of payment for seeking herbal medication, also considered were costs incurred which include time spent in searching and preparation of the herbal medicine, and fuelwood used in the preparation of boiled concoctions. See annex 1 for the parameter values for the estimations.

3.3.6. Crops growing within the wetlands

A number of households living around the wetlands practice farming in the wetlands. During the survey, around 47% of the respondents reported to be conducting crop farming in the wetlands. Among the crops grown include; pineapple, maize, sweet potatoes, vegetables, bananas, rice, chewing canes, beans among others. The mean size of a wetlands farm was 0.8 acres. The gross economic value of crops farming in the wetlands complex is $US 20 million. It is calculated using the area of land covered by the crops, the average per hectare production (kg/ha), average price of the various crops grown and the average per hectare production cost. Similarly, the overall net economic value of crop farming in the wetlands is $US 15 million. It was calculated by subtracting production costs from the gross economic value. A study conducted in 2020 (NBI Technical Reports- WRM 2020-08) estimated the economic value of crop farming in the wetlands to be $US 69 million, the study was based on average per ha value of the crops of $US 500 and an arable area of 138,808.152 hectares

3.3.7. Grass harvesting for zero grazing

Thirty eight percent (38%) of the respondents reported to be harvesting grass from the wetlands. The average number of cows placed under zero grazing by households in the wetlands area is approximately 2 cows per household (estimated amount is 1.7). The average cost of a sack of grass is RwF. 820 or USD 0.82. While the average amount of bundles of grass harvested by a household in a month was 52 or equivalent to 624 bundles in a year. The average time by a household to harvest a bundle of grass is 2.5 hours. The economic value of grass harvesting from the wetlands is a gross economic value of USD 10,144,568, while the net economic value is USD 2, 133,382.

We estimated the value of grass harvesting by considering the quantity harvested, rate of harvesting, price per quantity, price of substitute products, area of wetlands used for harnessing the products, cost for harnessing these services. Annex 1 shows the computed parameters and values used in the estimation of the economic values of grass harvesting.

Figure 5: Cut and carry grass harvester near Gashora

3.3.8. Capture fisheries

There are over ten lakes and other water bodies in the wetlands complex and marshlands, and these form habitats for fish. The main fish found in the wetlands complex include; Ibihonda, Imamba (Catfish), Inkube, Isangara, Tilapia, Amafuro, Imiraba, Kamango (Mudfish), and Sardine. During the survey, 15% of the respondents reported to engage in fishing from the wetlands complex. Around 60% of the fisherfolks reported to belong to fishing cooperative. Major fishing grounds are the Rweru and Mugesera lakes. Peak season for fishing is typically between June and August where fish catches are around three times compared to other months i.e., January to May, and September to December. Closed seasons where fishing is prohibited to enable breeding of fish to flourish is normally in the month of April to June. Typical fishing equipment is the canoes normally operated by a single individual. Fishing effort is averagely 10 hours and catches are between 8 and 10 kg. The average selling price of a kg of fish is Rwf = 1800 per kg of Tilapia or Rwf=1000 per kg for other types of fish. The main fishing gears in use include, net of size 4 for catching Tilapia and net of size 6 for catching Kamongo. One pack (12 pieces of the size 6 type of net costs around Rwf= 8000 and lasts for about six (6) months, while for size 4 type of net, a pack costs Rwf= 17,600 and a piece is used for 4 months. The equipment canoes are either constructed or curved, the constructed one's costs around Rwf= 50,000 and lasts for a year, while the curved ones last for 4 years and typically cost around Rwf= 70,000. Other costs include fees payable to cooperatives which is Rwf= 100 per kg of fish caught by each fisherman, life jacket which costs Rwf= 12,000 and usually lasts for a year. The average frequency of fishing in a month is around 15 times. Closed seasons are typically in the months of April to June. The average total fishing days in a year by a household is 150 days. The total gross economic value of fishing in the wetlands is estimated at $ 16.4 million while the net economic value is $ 13.6million. Annex 1 shows the parameters used to estimate the economic value of fishing to the local community. We estimated the economic value of fishing by considering the annual total fish catch in weight, price of fish by weight, area of wetlands inhabited by fish and costs of fishing including effort. The study conducted in 2020 (NBI Technical Reports- WRM 2020-08) on the other hand estimated the economic value of capture fisheries to be $US 528 thousand, the study was based on an estimated total harvest of 550 tons of fish and a selling price of $US 0.96 per kg of fish.

3.3.9. Papyrus and other grasses products

Rweru-Mugesera wetlands complex has a papyrus and related phragmites plant population covering an area of around 12,206 hectares. Papyrus plants and other related phragmites provided multiple benefits to the local population. For instance, they are harnessed to make mats (ikirago), baskets (Ibitebo), brooms (Umweyo), mulching, roofing (papyrus) among others. During the survey, 40% of the respondents reported harnessing papyrus plants from the wetlands for various purposes such as mat making, basket making, brooms making, thatching, mulching. The annual estimated gross economic value of papyrus harvested from the Rweru-Mugesra wetlands complex is about $ 3.8 million per year, while the net economic value is $ 3.2 million per year. In estimating the economic value for each of the products made or obtained from papyrus harvested from the wetlands complex, we obtained information about the number of households who harvest papyrus and the kinds of products they make, the average number of papyrus products a household makes in a year, the market price of selling a papyrus product, cost of making a papyrus product (hours spent harvesting and making the products as labour, other costs such as depreciation of tools used in the making of the products etc). Annex 1 shows the parameters used for the computation of the economic values of the various products obtained from papyrus and papyrus related phragmites.

3.3.10. Flood Control

Wetlands play an appreciable role in minimising flood peaks and reducing flow velocity, because they store water and even out its release over time. At the onset of a rainy season, or in times of peak river flow, their large surface area to depth and volume ratios mean that they are able to absorb and spread-out water over a large area (Emerton & Bos.,2004).

During the survey, respondents were asked if they had flood experience resulting in damage of property or crop land as a result of flooding in the area associated with the river Nyabarango and the associated wetlands of Rweru-Mugesera complex. The proportion of farmers who have experienced flood destruction of their farms in the area in the last fifteen years is 45% of the sampled population and the mean frequency of flooding in the last fifteen years is 3.8 times, while the mean size of farms destroyed per household is 1.26 acres.

There are various techniques that could be used in valuing flood regulation ecosystem services of a wetlands, such techniques may include effects on production, damage cost avoided, mitigating & avertive expenditures among others.

In this study, the damage cost avoided approach is preferred. The economic value of flood control was obtained as a product of the total area under threat, and the value of net production using rice budget and the probability of flood occurrence yearly. Flood occurrence yearly was obtained as a fraction of frequency of total number of seasons with rainfall within a full climate cycle (35 years) and this was 70 as shown in table 10 below. The economic value of flood control is $USD is 322 thousand. The study conducted in 2020 (NBI Technical Reports- WRM 2020-08) on the other hand estimated the economic value of flood control to be $US 25 million, the study was based on an estimated area of 25,488,048 ha and a per ha value of $US 639, it is however, not clear how the value of around $US25 thousand was arrived at. Similarly, a study by BIOFIN for REMA (2019) for the Akagera wetlands complex was

Table 10: Computation of economic value of flood control

	Parameter	Amount
A	Acreage of farms under threat(acres)	29,583
B	The crop (rice) budget per acre (USD)	202
C	Probability of flood occurring annually (3.8/70)	0.054
D	Value for flood control (A*B*C) USD	**322,691**

3.3.11. Waste assimilation and water purification

Many types of wetlands absorb, filter, process and dilute nutrients, pollutants and wastes. They tend to have a high nutrient retention capacity, and are effective in removing bacteria and microbes. Wetlands plants physically, chemically and biologically eliminate pollutants and trap sediments; suspended solids, pollutants and pathogenic organisms accumulate and decompose in wetlands bottom sediments; and wetlands help to dilute pollutants. In this study, water purification is a concern from the perspective of Lake Rweru fertilization by the nutrients from agricultural and industrial wastes which in turn may fertilize the lake, and also contribute to the fertilization of the Lake Victoria given that Akagera river also originates from Lake Rweru. Preferred techniques to facilitate this study included replacement method or Avertive method; This needed to be estimated through cost of replacing an ecosystem services with artificial or man-made products, infrastructure or technologies, in terms of expenditures saved (Emerton, 2009). When applying infrastructure or technologies, the method assesses the cost of replacing wetlands's role in water purification and waste assimilation services with artificial waste treatment plants or water supply systems. Data needed include: bill of quantities for the construction, operation and maintenance, and decommissioning of a sewage treatment facility; or bill of quantity for cost of construction, operation, maintenance, and decommissioning of a water supply system, level of pollution of water at the start of the wetlands ecosystem, level of water pollution at the lower reaches of the wetlands. Useful parameters include; Nutrients such as nitrates, phosphates and others, turbidity among others. Table 11 shows the level of pollution following a study by REMA in Rweru-Mugesera wetlands complex in 2014.

Table 11: Inorganic Fertilizer pollution data in Rweru-Mugesera Wetlands Complex

Wetlands orientation	Land cover	TSS (mg/L)	TN (mg/L)	T P (mg/L)	POT (mg/L)	C O D (mg/ L)	BOD (mg/L)	D O (mg/L)
Upper reaches of the wetlands	Marshland	165	4.1	2.01	25.719	181	110.7	0.68
Upper reaches of the wetlands	River Nyabarongo just before lake Mugesera	162	4.6	2.29	15.153	169	100.6	0.84
Middle reaches of the wetlands	Lake Sake	28	3.6	1.67	16.008	80.6	50.7	2.22
Lower reaches of the wetlands	Lake Rweru	13	1.9	0.69	23.54	-	-	-
Standard for surface water			<3	<5	12	50	30	30

Sources: adopted from REMA,2014

From the results in table 11 above, there is a clear difference between nitrogen and phosphorus levels concentration between the upper reaches of the wetlands compared to the lower reaches (Lake Rweru) with concentration of levels difference of 2.7 mg/L we can therefore argue that the marshy areas of the wetlands cleaned up to 2.7 mg/L (59%) of nitrogen pollutants. Nyabarongo river has mean annual discharge of 162.5 (GoR, 2009) giving an annual river discharge of around 5.1 billion of water, it implies an annual purification of 1,898,000 kg of nitrogen. A study conducted in the US by Industrial Economics Inc (2011) in 2010 revealed that it requires an average cost of $US 188 to remove a kilogramme of nitrogen in Delaware, this represents the cost removing nitrogen by connecting an onsite wastewater treatment and disposal system to the sewer, applying this approach would require adjusting the dollar values to reflect differences in GDP per capita parity, and inflation occasioned differences in years of study. However, one challenge we have with this estimation is that there are also horizontal sources of pollutants which in this case we have not factored in. We therefore go by the value transfer of using existing per unit (area of wetlands) values already worked out by the ecosystem services partnership (ESP) and in which other confounding factors like inflation and income disparities have been taken care of; therefore, based on its estimations, the unit value of water purification service is US$ 2,043, and with a water purification functional (marshland) area of 12,206, the total economic value of water purification is taken as the product of the unit value per hectare and total phragmites and grassland area giving a value of US$ 24,936,858.

3.3.12. Sediment Control

Sediments are double edged swords, on one hand they have the advantage of increasing soil agricultural productivity, but on the other hand they pose a plethora of negative impacts for instances: sediments are known to be responsible for water turbidity, thereby making water use for domestic and industrial supply purification to remove turbidity costly; high water quality due to low turbidity levels may lead to increased opportunities downstream, e.g., for recreation and commercial fisheries, and may have biological impacts on survival of habitats and species; reduced sediment loads helps mitigate damages to water conveyance facilities where such damages can occur through deposition of sediment in rivers, drainage ditches and irrigation canals, which can lead to adverse effects on navigation and water storage capacity, and can increase flooding (Turner et al., 2004)

The Rweru lake which is fed by the Nyabarongo river that straddles the Rweru-Mugesera wetlands complex has an average depth of five (5) deep. Sedimentation of the lake largely by sediment loads from Nyabarongo river is posing a threat to the lake, in addition, the already established rice and maize schemes within the formerly phragmites dominated areas of the wetlands complex are also at risk from sedimentation which can cover and destroy germinating crops, and also block irrigation channels. Commonly used methods for valuation of sediment control include replacement cost method, avertive or mitigative costs, damage cost avoided, residual imputation, value transfer method among others. In this study, a value transfer approach has been adopted.

A study by Olson et al., (2010) estimated that a total of 35 to 100 tons of soil is exported per hectare per year to water bodies. The Upper Akagera catchment in which the wetlands is located has an area of 305,200 hectares (MINIRENA-RNRA, 2015). It therefore implies that wetlands complex receives more than 30,520,000 tons of soil a year, given that the river Nyabarongo that studdles the wetlands also collects sediments along the way from its feeder catchments across its close to 300km length (Meierhenrich, 2009). Similarly, a study by Philipps (2015) revealed that Phragmites vegetations (papyrus) have the potential to retain up to 93% of sediments they receive. A study on economic valuation of the Akagera wetlands complex adopted a figure of 78.4 tons per hectare as the amount of sediments that a wetlands retains in a year (REMA,2019).

To avoid double counting, the focus on sediment retention here is not aimed at domestic water supply, but rather on blocking irrigation channels, and sedimentation of the receiving water bodies such as lake Rweru. Hence the approach adopted is the avoided cost of the prospects of mechanical dredging the equivalent amount of sediments retained by the wetlands annually. The average of three value transfer studies and adjusted for inflation and income disparities were used. They included a value of: $ US 0.66 for a study conducted in India by Verma et al., (2015); $US 4.011 for a study conducted in Nigeria by Adeogun et al., (2018); and $US 1.98 for a study conducted in Kenya by Langat (2015). The adjusted (to 2020) average value for these studies is RwF 1623 or $US 1.72. Therefore, the total economic value of sediment control by the wetlands complex is **$US 1,955,700.** The estimate was arrived at by considering the product of the wetlands's marsh and grass area of 14,503ha, and the average retained sediments by a wetlands (78.4 ton) per hectare, and the average cost of $US 1.72 of mechanical removal of a ton of soil.

3.3.13. Carbon storage and sequestration

Freshwater water tropical wetlands largely comprising marshlands and reclaimed wetlands also provide climate regulation ecosystem services (Wong et al.,2017). These wetlands play an important role in carbon sequestration and storage. Freshwater marshlands like the one found in Rweru-Mugesera complex, are known to sequester and store carbon thereby contributing to climate change mitigation (MEA, 2005).

$$GHG\ Benefit\ Flux_{it} = CS_{it} + AvCO2_{it} - M_{it} \qquad (8)$$

where i is the habitat type, and t is time expressed in years; CS is the annual carbon sequestration rate, taken as 1.29 metric tons of carbon per hectare per year (Mitsch., 2021), which continues as the habitat is retained; $AvCO2$ is the $CO2$ emissions avoided from the habitat's conversion; and M represents the annual methane emissions that continue to be emitted as the habitat remains intact (Murray et al.2011). Similarly, in computing and adjusting the carbon biophysical values to the reference year relative to the years in which site studies were conducted, one main assumption that was made is that methane gas emissions from the naturally occurring wetland is subtracted from creditable avoided emissions, and is assumed to be 1.85 tons of carbon dioxide equivalents per hectare (Murray et al.2011). Table 11 shows carbon storage and sequestration across various wetland land uses and the carbon pools.

Table 12: Computation of carbon storage in various wetland land uses based on 2020

Land use	land -use area (ha)	AGC/ ha	BGC /ha	SC/ha	DM /ha	Total C stored	Annual C sequestration
Marshland	12,206	23	43.5	683	5.7	9,217,971	15,746
Grass land	2,297	1.5	26	108.4	0.3	312,851	-
Cropland	1,517	1.9	0.9	118.8	0.1	184,619	-
Other vegetation	2,401	60.2	26.8	107.1	7.2	483,321	3,097
Water bodies	13,660	-	-	-	-	-	-
Total	**32,081**	431,606	656,395	9,023,059	87,702	**10,198,763**	**18,843**
Where AGC= Aboveground Carbon; BGC= Belowground Carbon; SC= Soil Carbon, DM=Dead matter carbon; C=carbon							

Source: adopted from BIOFIN et al., 2019

In a natural carbon sink like a wetlands, it is not that there are never emissions, typical emissions include natural decay from disturbed wetlands, and natural emission of methane gas due to the anaerobic conditions as already discussed in above paragraphs. Table 13 shows the computed carbon dioxide equivalent emissions from decay and methane gas on a per hectare basis.

Table 13: Computation of carbon losses from various wetlands land uses

Land use	Land use area (ha)	Emissions from methane (t CO2e/ha)	Total (tCO2e)
Papyrus (Phragmites	12,206	1.85	22581.1
Grassland	2,297	1.85	4249.45
Cropland	1,517	1.85	2806.45
Other vegetation	2,401	>=0	0
Water bodies	13,660	>=0	0
Total	32,081		29,637

From the two evaluations above, it can be deduced that for the baseline year of 2020, the Rweru-Mugesera wetlands carbon storage was **10,198,763** tons, and that annual carbon sequestration was **18,843** tons, while the natural emissions were **29,637** tons of carbon dioxide equivalence. Therefore, the total carbon mitigation potential of the wetlands would be the difference between emissions, and storage and sequestration combined. In order to estimate the economic value of the carbon, the tons of carbon need to be converted to its carbon dioxide gas equivalence by multiplying it with the conversion factor of 3.67 (Murray et al.,2011), and this gives a total of **37,508,991** tCO2e as the climate change mitigation potential of the wetlands. The value of a ton of carbon dioxide equivalence was taken as worth $US 10 per ton of carbon dioxide equivalent of greenhouse gas, therefore, the total economic value of carbon is **worth $US 370,508,991.**

Figure 6: Phragmites dominated land cover near Lake Rweru

3.3.14. Habitat for biodiversity

Wetlands are some of the ecosystems known to be home for diverse and usually abundant flora and fauna biological diversity. Wetlands occupy an important niche in the food chain. They provide a rich source of nutrients for all forms of life, including fish, and are favored breeding grounds and nurseries for some marine and freshwater animal species.

Based on the analytical model presented in table 10 and valuation techniques presented in table 9, the prioritized primary economic valuation technique for the valuation of the wetlands as a habitat for biodiversity was revealed as a price method, followed by value transfer in the absence of or due to inadequate data. The revealed price favored is based on the funds allocated by national government agencies, local governments, and non-governmental organizations and spent for the conservation of the Rweru-Mugesera wetlands complex in the year 2020. However, there was inadequate information on such expenditures, therefore value transfer approach was used, this was done by taking the average studies reviewed and corrected for inflation, income disparity, and purchasing power as documented and archived in the ecosystem services partnership (ESP) data base, which reveals that the economic value of the habitat for biodiversity conservation role of tropical wetlands is **$US 3427** per ha per year, and with the current functional area of the Rweru-Mugesera wetlands complex area of 28,143 ha (excluding crop land), the total economic value of biodiversity value is **$US 96,446,061**

3.3.15. Summary of the baseline (2020) gross economic values of wetlands ecosystem services

Table 14 shows the computed total economic value of the Rweru-Mugesera wetlands complex which is an annual (2020) of $US 531 million. Economic valuation conducted for three other wetlands of priority importance in the country included; economic valuation of Nyungwe National Park in 2014 which had a total economic value of $US 4.8 billion; total monetary value of Rugezi wetlands was $US 374.32 million in 2014; while the total economic value of the Akagera Wetlands Complex includes a stock value (carbon storage) of 1.1 billion USD, and an annual flow value of 11.9 million USD[1].

Table 14: Summary of current economic values of the wetlands ecosystem services

Ecosystem service	Wetlands area yielding the service (ha)	Unit Value per Area (USD/ ha)	Total Economic Value (USD)	Percentage economic contribution
Domestic water supply	12,206	11.69	142,677	0.027%
Water for livestock	25,866	0.5	13,300	0.003%
Crop farming	7093	2841	20,153,465	3.795%
Livestock grazing	2297	5.79	13,300	0.003%
Grass harvesting	2297	4416	10,144,568	1.910%
Capture fisheries	28,143	574	16,144,568	3.040%
Papyrus products	12,206	318	3,884,790	0.732%
Fuel wood	14607	93	1,456,511	0.274%
Herbal medicine	16,904	33.33	563,460	0.106%
Waste a & pollution control	14,503	2043	29,629,629	5.579%
Sediment control	14,503	134.85	1,955,700	0.368%
Flood control	12,206	26	322,691	0.061%
Carbon storage & sequestration	18,421	20,113	370,508,991	69.766%
Habitat for biodiversity	28,143	3427	96,446,061	18.161%
Total Value			**531,070,269**	**100%**

While table 14 shows the gross economic values of the ecosystem services in the wetlands, figure 7 shows the net economic values of the ecosystem services. Net values are derived by obtaining the difference between total revenues/values and production costs which comprises several parts such as input costs, capital costs, labour costs, and subsidies such as fertilizers.

6 https://www.worldagroforestry.org/file-download/download/public/23133

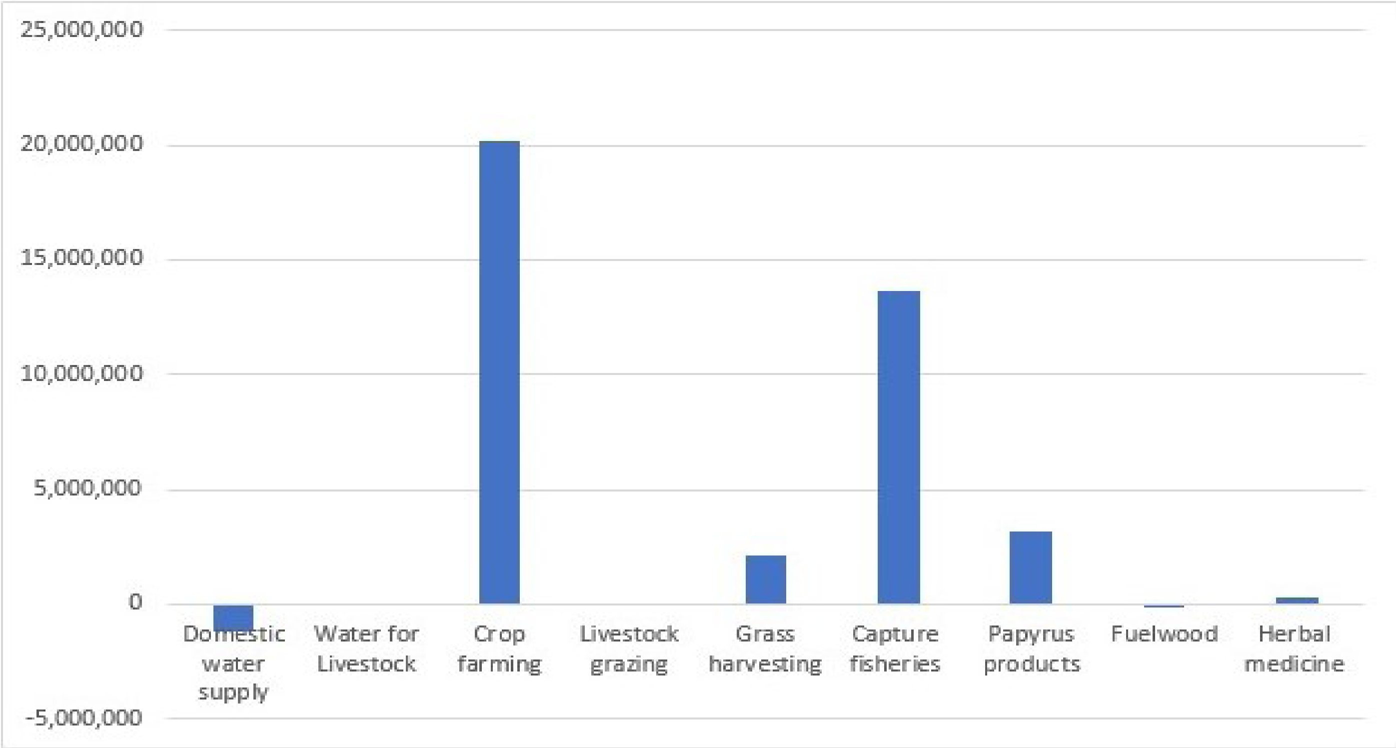

Figure 7: Net Economic Values of Provisioning Ecosystem Services

From the figure 3 above, while all the ecosystem services improve the livelihoods and boost income earnings of the local community members that harness them, if considered within the national context, a number of ecosystem services being harnessed in the current context are not economically desirable. Such services have negative net economic values, especially if we consider labour which is normally supplied by household members for without assigning/attaching remuneration to them, this is however, understandable since levels of employment are high and not many options are available to members of the local community.

3.4. Cost Benefit Analysis of the current institutional frameworks governing wetland management

This section focuses on the benefits and costs associated with baseline economic values of the ecosystem services under the current existing institutional frameworks governing the management of the wetland complex for the next 30 years with 2020 as the baseline at constant prices and at 10% discount rate.

3.4.1. Benefits of the wetland ecosystem services under the existing institutional frameworks

Under the current institutional frameworks, the wetland' s land use will change with the key driver being the cessation of crop farming in the wetland as the government seek to promote conservation of the fourth most important wetland in the country. The overall change will see an annual curvilinear decline in harnessing of the wetland for agricultural purposes as shown in in table 15.

Table 15: Projected land use, land cover change under existing institutional frameworks up to 2050

Land use, land cover	2020 size (ha)	2050 size (ha)	Change in size (ha)
Water body	13,660	13,660	>=0
Papyrus (Phragmites)	12,206	15,815	3609
Other vegetation	2401	2401	>=0
Grassland	2297	2297	>=0
Crop land	1517	185	-2332
Total	32,081	32,081	>=0

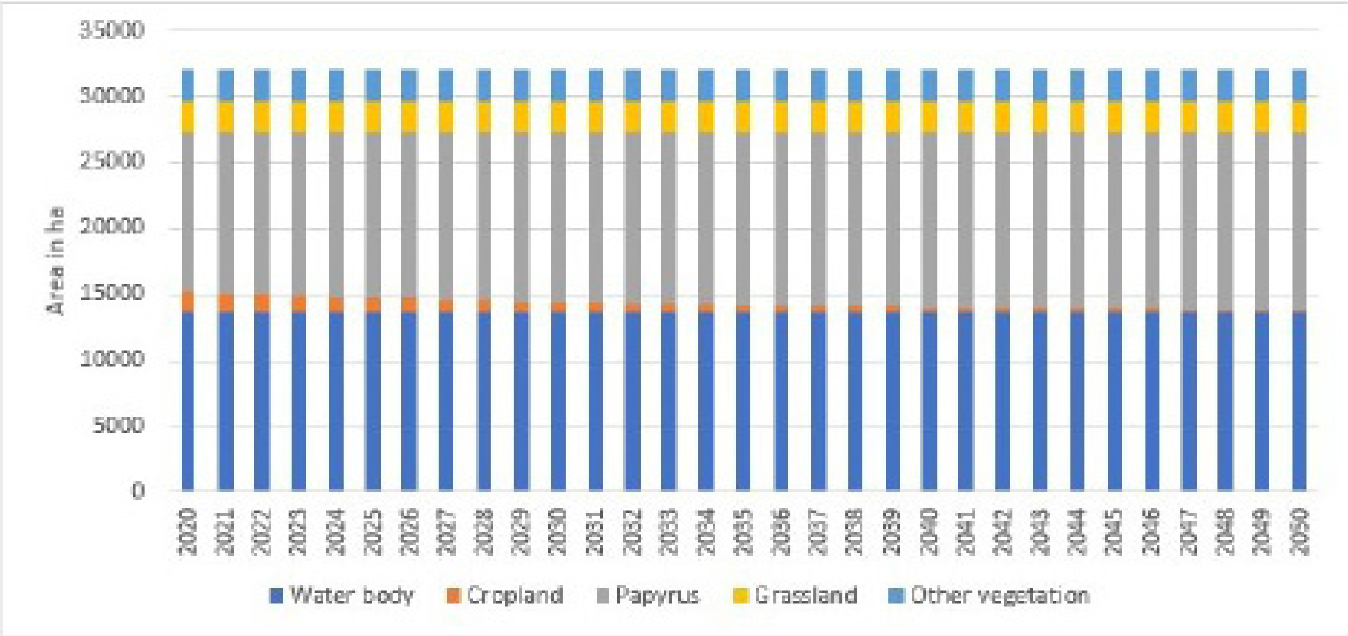

Figure 8: Projected Land use change between 2020 and 2050 in Rweru-Mugesera wetland complex

Table 16 also shows the computed economic values of the ecosystem system services based on the spatial and temporal dimensions of the wetland under the current institutional frameworks indicating the economic value of the ecosystem services for 2050, the aggregate values and the present value of the benefits.

Table 16: Present values of the benefits of wetland ecosystem services

Ecosystem services	Baseline ecosystem value ($US)	2050 economic value ($US)	Total economic value by 2050	Present Value of total benefits
Domestic water supply	142,677	158,259	4,598,437	1,403,797
Water for livestock	13,300	13,985	412,987	128,430
Crop farming	20,153,465	2,457,725	243,447,625	110,851,587
Livestock grazing	13,300	13,300	398,989	124,467
Grass harvesting	10,144,568	10,143,552	304,306,560	95,622,397
Capture fisheries	16,144,568	16,918,650	500,226,650	154,540,780
Papyrus products	3,884,790	4,305,084	125,090,070	38,187,116
Fuelwood	1,456,511	1,482,327	43,281,735	13,257,661
Herbal medicine	563,460	1,694,088	49,634,565	15,353,733
Waste a & pollution control	29,629,629	32,350,905	944,427,825	289,252,423
Sediment control	1,955,700	2,135,350	62,337,784	19,092,359
Flood control	322,691	351,988	10,227,490	3,122,217
Carbon storage & sequestration	370,508,991	405,721,092	11,115,047,190	3,467,411,606
Habitat for biodiversity	1,013,148	1,061,820	31,394,700	9,771,123
Total Value	455,946,798	478,808,125	13,434,832,607	4,218,119,696

3.4.2. Costs associated with current institutional frameworks

Costs associated with status quo considered in this study include: **opportunity costs** which are the economic value of the forgone alternative use of the wetland resource, and this taken as agricultural production based on the current productivity rate, that is instead of instead of wetland cropland being lost at the current rate of 6.7% per year, it gains by the percentage every year. The other cost considered is the **production cost**, mainly for the provisioning ecosystem services. Due to paucity of information and data, **management and implementation cost** of the BAU have not been considered. It also assumed that the quantities withdrawn per hectare under the BAU are optimal and sustainable hence there are no **degradation costs** in the current use of the resources, also not considered are the **externalities** e.g., the effect of fertilizer use on climate regulation.

Table 17: Present value of costs under the current institutional frameworks

Items	Baseline value of costs	2050 value of costs	Total economic value of costs by 2050	Present value of total costs
Production costs				
Capture fisheries	333,578	349,364	10,329,497	3,214,878
Crop farming	4,721,802	575,830	57,038,248	26,054,715
Domestic water supply	1,283,642	1,423,656	41,366,263	12,723,813
Livestock grazing	66,706	70,141	2,071,290	644,125
Grass harvesting	8,011,186	8,011,186	240,335,580	75,520,765
Herbal medicine	251,491	271,331	7,949,657	2,459,111
Firewood	1,615,165	1,762,451	51,460,924	15,881,718
Papyrus products	695, 706	771, 628	22,420,704	6,896,365
Livestock watering	66,706	66,706	2,001,180	568,190
Sub total	16,350,276	12,530,665	434,973,343	143,963,680
Opportunity costs				
Agricultural production	20,153,465	30,834,172	417,797,059	84,293,922
Total Value	**36,503,741**	**43,364,837**	**852,770,402**	**228,257,602**

The Net Present Values of the current institutional frameworks

Net present value is the difference between present value of benefits, and present value of costs over the entire project period. A positive present value shows economic efficiency of the management option or policy option. Table 18 shows the net present value of the business-as-usual scenario.

Table 18: Net Present values of wetlands ecosystem services under the current institutional frameworks

Ecosystem services	Present Value of total benefits
Domestic water supply	1,403,797
Water for livestock	128,430
Crop farming	110,851,587
Livestock grazing	124,467
Grass harvesting	95,622,397
Capture fisheries	154,540,780
Papyrus products	38,187,116
Fuelwood	13,257,661
Herbal medicine	15,353,733
Waste a & pollution control	289,252,423
Sediment control	19,092,359
Flood control	3,122,217
Carbon storage & sequestration	3,467,411,606
Habitat for biodiversity	9,771,123

Present value of benefits	***4,218,119,696***
Production costs	
Capture fisheries	3,214,878
Crop farming	26,054,715
Domestic water supply	12,723,813
Livestock grazing	644,125
Grass harvesting	75,520,765
Herbal medicine	2,459,111
Firewood	15,881,718
Papyrus products	6,896,365
Water for livestock	568,190
Opportunity costs	
Agricultural production	84,293,922
Present value of costs	***228,257,602***
Net Benefit Net Present Value) ***(Present Value Benefits- Present Value Costs)***	**3,989,862,094**
Benefit –cost ratio ***(Present Value Benefits/ Present Value Costs)***	**18.48**

4. POLICY IMPLICATIONS, CONCLUSION, AND RECOMMENDATIONS

4.1. Policy and management implications of the study outcomes

A number of policy and management issues can be framed for each ecosystem services and the findings of this study can help in clarification of the potential policy and management issues of the ecosystem services, as highlighted in table 19 below.

Table 19: Policy and management implications of the study outcome

Ecosystem service	Policy or management issue	Policy and or management outcome
Domestic Water supply	Is the wetlands conservation of importance to the local communities in water provision	More than 93% of the local community depend on the wetlands for domestic water use, therefore conservation of wetlands to will enable them to access water of reasonable quality. However, the amount of time spent in collecting water makes it time consuming and such precious time could be channelled elsewhere in the economy
Water for Livestock	Is the wetlands of importance to the local communities in water provision for livestock	Conservation of the wetlands would enable more than 5% of the local community have access to water for livestock use. Even though the amount time spent in watering livestock this way is not economically desirable if other sources of opportunities for casual labour were available.
Crop farming in the wetlands	Is more reclamation of the wetlands for crop farming the best way to stimulate rural development	The wetlands currently offers more than 24 thousand households opportunity to income and nutrition though crop farming inside the wetlands. However, such a carrier function is often in competition with other wetlands uses which when all combined, score than crop farming and other related activities within the wetlands
Livestock grazing in the wetlands	Is the wetlands of importance to the local communities in water provision for livestock	Conservation of the wetlands would enable more than 5% of the local community have access to pasture for livestock use. Even though the amount time spent in grazing livestock is not economically desirable if other sources of opportunities for casual labour were available.

Grass harvesting	Is the wetlands of importance to the local communities in water provision for livestock	The wetlands currently offers more than 19 thousand households access to grass to feed their livestock
Capture fisheries	Is the wetlands of importance to the local communities in fish for nutrition and income	The wetlands offers fishery livelihoods and income to more than 7 thousand of the households, and earn them income worth more than $US 16 million per year.
Products from Papyrus & other related grasses	Is the wetlands of importance to the local communities in provision of fibres, and raw materials for mat making among others	Conservation of the wetlands enable more than 20 thousand households in the local community benefit from papyrus and other phragmites with opportunities for mulching, making handicrafts among others that are worth more than $ US 3 million
Fuel wood	Would protection of the wetlands make significant contribution towards energy mix of the rural communities	More than 19 thousand households in the local community access fuelwood from the wetlands hence conservation of the resource would provide a source for fuelwood to them. However, the amount time spent in harnessing fuelwood from the wetlands makes it economically undesirable.
Carbon sequestration & storage	Does the wetland contribute towards greening the country?	The wetland has a carbon storage potential of over 10 million tons of carbon, and with a sequestration potential of 18 thousand tons annually. This can help the country meet her global obligations towards mitigation of climate change
*Water purification	Would conservation of the wetlands protect the downstream water bodies from fertilization	Conserving the wetlands eliminate a waste and pollutants that would cost about $US 29 million to clean from the lake reservoirs
Sediment control	Would conservation of the wetlands protect the water bodies downstream from?	The wetlands traps sediments amounting to 78.4 tons per ha annually. Conservation of the wetlands therefore saves the stakeholders a dredging cost of $US 2 million
Flood control	Should this wetlands be protected to prevent flooding of the settlements in the surrounding areas	Forty-five (45%) households are exposed to the possibility annual flooding that can destroy their produce; protection of the wetlands would therefore save them from annual damages worth $US 300 thousand

4.2. Conclusion

Rweru-Mugesera wetlands complex as an ecosystem provide dozens of ecosystem services to the local community, the republic of Rwanda, regional and the global community. The wetlands supplies a host of ecosystem services to more than 48 thousand households or about 194 thousand individuals at an estimated economic value of over $US 52 million i.e., the wetlands generates ecosystem services worth an average of $US 271 a year per person of the dependent local community; value that is equivalent to around a third of the $USD 780.8[1] of Rwanda's GDP per capita. From a society perspective, there are some ecosystem services whose utilities are not economically desirable if labour is considered as a remunerable factor of production at the prevailing rates; such ecosystem services include: drawing and carrying of water from the wetlands for domestic use, livestock grazing, and watering in the wetlands, and fuel wood harvesting. The wetlands also generates regulating services that have national, regional and international significance, these include climate change mitigation, habitat for biodiversity, sediment control, and water quality improvement at a value slightly worth more than $US of 403 million. If the current policy and management measures are sustained, then there will be a continuing enhancement in the value of the wetlands ecosystem services, and the ecosystem services values in the wetlands complex will increase by more than $US 22million from the current value over the next 30 years; from a baseline (2020) value of slightly more than $US 455 million to slightly more than $US 478 million by 2050. Therefore, it is estimated that Rweru-Mugesera wetlands complex ecosystem services will accumulate ecosystem services worth over $US13 billion by 2050, with a present value slightly more than $US 4 billion.

7 https://pubdocs.worldbank.org/en/366631492188168425/mpo-rwa.pdf

4.3. Recommendations

4.3.1. Research as a tool for evidence-based Policy and Management Guide

For many of the ecosystem services, especially the regulatory services, there were no easily available, timely and consistent data that could have facilitated use of primary or original use of site-specific data and information, it is therefore recommended that stakeholders consider putting investments in creating the necessary infrastructure for regular data collection and ease of access by the scientific and research community to enable generation of evidence for policy and management guidance.

4.3.2. Policy and Management Recommendation

- From the findings of this study, several recommendations have been proposed for potential consideration by the relevant stakeholders.
- To keep track of the flow of the ecosystem services provision, there is need for investments in regular data collection.
- There is need to promote other sources of access of water through investments that help shorten the distance or reduce the time that the local community currently take in drawing water from the wetlands complex. This should also apply to access of water for livestock.
- Keeping and grazing the local breeds of cattle in the wetlands is not economically desirable, there is need to continue with investments that encourage improved breeds of cattle; and cut and carry grass from the wetlands be encouraged.
- Investment measures to protect the wetlands with aim of preventing damage to farms due to flooding should be considered.
- There is need to explore the tapping of the economic potential of climate change mitigation role of the wetlands complex.
- While the quantity of the wetlands ecosystem is on the ascendancy, the same cannot be said of the water quality, there is need for regular collection of data on water quality and measures to help improve water quality in the wetlands.
- Overall, implementation, enforcement and ensuring compliance to the current policies, laws, regulations, and strategies aimed at conservation and protection of the wetlands complex should be sustained.

References

Adeogun, A. G., Sule, B. F., & Salami, A. W. (2018). Cost effectiveness of sediment management strategies for mitigation of sedimentation at Jebba Hydropower reservoir, Nigeria. *Journal of King Saud University-Engineering Sciences*, *30*(2), 141-149.

Barton D.N., Caparrós A., Conner N., Edens B., Piaggio M., Turpie J. (2019). Discussion paper 5.1: Defining exchange and welfare values, articulating institutional arrangements and establishing the valuation context for ecosystem accounting. Paper drafted as input into the revision of the System on Environmental-Economic Acscounting 2012–Experimental Ecosystem Accounting. Version of 25 July 2019.

Bateman, I. J., Brouwer, R., Cranford, M., Hime, S., Ozdemiroglu, E., Phang, Z., & Provins, A. (2010). Valuing environmental impacts: Practical guidelines for the use of value transfer in policy and project appraisal. *Main Report to the Department for Environment, Food and Rural Affairs, Economics for the Environment Consultancy (eftec), London*.

Emerton, L., & Bos, E. (2004). *Value: Counting ecosystems as water infrastructure*. Iucn.

FAO and IGAD. 2019. East Africa Animal Feed Action Plan. Rome.

Government of Rwanda [GoR] (2009). The study on sustainable rural and agricultural development in Bugesera district, Eastern Province in the republic of Rwanda

He, J., Moffette, F., Fournier, R., Revéret, J. P., Théau, J., Dupras, J., ... & Varin, M. (2015). Meta-analysis for the transfer of economic benefits of ecosystem services provided by wetlands within two watersheds in Quebec, Canada. *Wetlands ecology and management*, *23*(4), 707-725.

Industrial Economics Inc (2011) Economic Valuation of Wetland Ecosystem Services in Delaware.

Karame, P., Avalos, T., & Gashakamba, F. (2017). *Towards wise use of wetlands of special importance in Rwanda–Case Study: Rweru-Mugesera wetland* (p. 37). Technical report of the ArcosNetwork.

Lin, X., Xu, M., Cao, C., P Singh, R., Chen, W., & Ju, H. (2018). Land-use/land-cover changes and their influence on the ecosystem in Chengdu City, China during the period of 1992–2018. *Sustainability*, *10*(10), 3580.

Meierhenrich, J. (2009). The transformation of lieux de mémoire: The Nyabarongo River in Rwanda, 1992–2009. *Anthropology Today*, *25*(5), 13-19

Millennium Ecosystem Assessment [MEA], 2005. ECOSYSTEMS AND HUMAN WELL-BEING: WETLANDS AND WATER Synthesis. World Resources Institute, Washington, DC.

MINIRENA-RNRA (2015). Rwanda National Water Resources Master Plan

Murray, B. C., Pendleton, L., Jenkins, W. A., & Sifleet, S. (2011). Green payments for blue carbon: economic incentives for protecting threatened coastal habitats. *Green payments for blue carbon: economic incentives for protecting threatened coastal habitats.*

Nile Basin Initiative [NBI] (2020) Economic Assessment of Wetland Biodiversity and Ecosystem Services as an Input for Development of Wetland Investment Plans: A Case Study of the Sio-Siteko

NBI Technical Reports- WRM 2020-08. Rweru-Bugesera Transboundary Wetlands Complex (Rwanda-Burundi)

Rijal, S., Saleh, M. B., Jaya, I. N. S., & Tiryana, T. (2016). Deforestation profile of regency level in Sumatera. *International Journal of Sciences: Basic and Applied Research*, *25*, 385-402.

Rwanda Environment Management Authority [REMA]. (2019). Economic Assessment of Akagera Wetland Complex: Identifying Finance Solutions for Improved Management

Rwanda Natural Resource Authority [RNRA] (2015). Rwanda National Water Resources Master Plan

Siikamäki, J., Santiago-Ávila, F. J., & Vail, P. (2015). Global Assessment of Non-Wood Forest Ecosystem Services. *Spatially Explicit Meta-Analysis and Benefit Transfer to Improve the World Bank's Forest Weatlh Database*, 1-97.

Troy, A., & Wilson, M. A. (2006). Mapping ecosystem services: practical challenges and opportunities in linking GIS and value transfer. *Ecological economics*, *60*(2), 435-449.

Turner, R. K., Georgiou, S., Clark, R., Brouwer, R., & Burke, J. J. (2004). *Economic valuation of water resources in agriculture: From the sectoral to a functional perspective of natural resource management* (Vol. 27). Food & Agriculture Org.

UNEP, U., & Poverty, G. O. R. Environment Initiative Project (PEI). 2007. Pilot Integrated Ecosystem Assessment of Bugesera. Kigali: UNPEI.

Vorstius, A. C., & Spray, C. J. (2015). *A comparison of ecosystem services mapping tools for their potential to support planning and decision-making on a local scale. Ecosystem Services, 15, 75–83.* doi:10.1016/j.ecoser.2015.07.007

Wong, C. P., Jiang, B., Bohn, T. J., Lee, K. N., Lettenmaier, D. P., Ma, D., & Ouyang, Z. (2017). Lake and wetland ecosystem services measuring water storage and local climate regulation. *Water Resources Research*, *53*(4), 3197-3223.

Annexures

Annex 1: Parameters for the computation of the baseline (current) economic values of the wetland provisioning ecosystem services

Domestic Water Supply

Table 20: Computation of economic value of water supply for domestic use

Parameter and its corresponding metrics	Parameter symbol	Amount/ Quantity
Number of households accessing water monthly (households)	A	48,426
Average annual amount of water collected by a household () (0.035*365)	B	12.81
Market price of water per (Rwfr=228 or USD 0.23)	C	0.23
Gross economic value of water supply *(A*B*C) (USD)*	**D**	**142,677**
Average total community man hours spent collecting water in a year in days [(0.467hrs/8) *A*212]	E	599,296
Casual labour wage rate per day (USD)	F	2.071
*Total labour cost (E*F) (USD)*	*G*	*1,240,543*
Capital costs (containers for holding water) (0.89*A)	*H*	*43,099*
Net economic value of fuelwood [D- (G+H)]	**G**	**-1,140,965**

Livestock watering

Table 21: Computation of economic values for livestock watering ecosystem services

Parameter and its corresponding metrics	Parameter symbol adopted	Amount/ Quantity
Annual water consumed by a cow based on grazing months in the wetland given the daily intake (0.035*212) ( )	A	7.42
Average price of water per	B	0.23
Average livestock population grazing in the wetland [5/100*52072) *3]	C	7800
Gross economic value (A*B*C)	**D**	**13,300**
Mean total time taken taking the livestock for watering in days for all households in a year [(0.467hrs/8) *2604*212]	E	32,225
Value of time used in taking livestock to the wetlands (E*2.07)	F	66,706
Net economic value (D-F)	**G**	**-53,406**

8 Based on information obtained from a wage evaluating website(https://www.minimum-wage.org/international/rwanda#) it is assumed that the standard national minimum wage for casual work is USD 2.07

Livestock grazing within the wetland

Table 22: Computation of the economic value of livestock grazing within the wetland

Parameter and its corresponding metrics	Parameter symbol adopted	Amount/ Quantity
Annual pasture consumed by a cow based on grazing months in the wetland given the daily intake (0.035*212) ( )	A	7.42
Average price of water per	B	0.23
Average livestock population grazing in the wetland [5/100*52072) *3]	C	7800
Gross economic value (A*B*C)	**D**	**13,300**
Mean total time taken grazing the livestock for all households in a year [(0.467hrs/8) *2604*212]	E	32,225
Value of time used in grazing livestock to the wetlands (E*2.07)	F	66,706
Net economic value (D-F)	**G**	**-53,406**

Grass harvesting for Zero Grazing

Table 23: Computation of economic value of grass harvesting for livestock feeding

Parameters and their metrics	Symbol adopted	Amount/ quantity
Total number of households harvesting grass	A	19,826
Average amount of grass harvested in a year by a household	B	624
Market price of a bundle of grass	C	0.82
Gross economic values of grass harvesting (A*B*C)	**D**	**10,144,568**
Total man hours spent in harvesting grass in days [(624 *2.5) / 8 * A]	E	3,866,070
Mean wage rate per day for casual work	F	2.07
Total value of labour (E*F)	G	8,002,761
Annual capital cost (sickles or machetes)2 (0.425*A)	H	8,425
Net economic value of grass harvesting [D-(G+H)]	**I**	**2, 133,382**

9 The average price of a machete is USD 5.09, and it takes an average of 6 years in lifespan, taking annualized value gives a value 0.85, it also assumed that there are duties carried out by household using a machete, therefore the portion allotted grass harvesting is 50% of the value giving an annual cost of USD 0.425

Table 24: Computation of economic value of capture fisheries

Parameters and their metrics	Symbol	Amount/ Quantity
Number of fishing households who reported to be members of cooperative	A	7810
Average fishing days in a year by a household	B	150
Average catch per household per fishing effort (kg)	C	10
Average price per kg in dollars	D	1.40
Gross economic value for cooperative members (A*B*C*D)	**E**	**16,401,000**
Total fishing effort in a year (A*B)	F	1,171,500
Total value of fishing effort (F*2.07)	G	2,425,005
Cost of life Jackets (USD 20*500)3	H	10,000
Cost of nets ($10.20 *3905)4	I	39,831
Costs of canoes ($33.75*3905)5	J	131,794
Fees payable to cooperatives (500*150*10*0.1)6	K	150,000
Cost of hooks and lines (3905 * 0.5)7	L	1953
Total net economic value for cooperative members [E-(G toK)]	**M**	**13,642,417**

Papyrus and other grasses products

Table 24 shows the parameters used for the computation of the economic values of the various products obtained from papyrus and papyrus related phragmites.

10 It is assumed that life jackets are only used by members of cooperatives and these are also assumed to be 500 in number

11 It is assumed that up to half of all fishermen in the wetland use nets

12 It is assumed that up to half of all fishermen in the wetland use canoes and that the mean annualized value of canoe is $33-75

13 Fees payable to cooperatives is $ 0.1 per a kg of fish caught and it is assumed that upto 500 fishermen are members of cooperatives

14 It is assumed that upto half of all fishermen use hooks and lines and that annual cost of these are $0.5

Table 25: Computation of economic value of papyrus and other grasses products

Product	Parameter & its metrics	Symbol for computation	Amount/ Quantity
Mats	Number of households involved	A	18,600
	Average annual mats made by A household	B	9
	Price of mat ($)	C	2.5
	Gross economic value of mat making	**D**	**418,500**
	Total value of man hours spent in making mats in days (8hrs per mat) (8/8 * A*B* 2.07)	E	346,518
	Total value of other costs incurred in mat making (Negligible)	F	-
	Net economic value of mat making	**G**	**71,982**
Baskets	Number of households involved	A	1572
	Average annual baskets made by household	B	31
	Price of a basket	C	1.4
	Gross economic value of mat making	**D**	68,200
	Total value of man hours in days spent in making mats (8 hrs for a single basket) [8/8*2.07 *31*1572]	E	100,875
	Total value of other costs incurred in basket making (negligible)	F	-
	Net economic value of mat making	**G**	**-32,675**
Brooms	Number of households involved	A	262
	Average annual brooms made by a household	B	4
	Price of a broom	C	0.49
	Gross economic value of mat making	**D**	588
	Total value of man hours spent in brooms in days (5 hrs) [5/8 *300*4* 2.07]	E	1550
	Capital cost of broom (negligible)	F	-
	Net economic value of mat making	**G**	**-962**

Mulching	Number of households involved	A	2096
	Average annual bundles harvested by household	B	226
	Price of a bundle of papyrus ($0.82)	C	0.82
	Gross economic value of mat making	**D**	388,430
	Total value of man hours spent in days in mulching (2 hrs for a bundle of mulch) (2/8*A*B*2.07	E	245,138
	Other costs (negligible)	F	-
	Net economic value of mat making	**G**	**143,292**
Roofing / thatching	Number of households involved	A	262
	Average annual bundles of papyrus	B	20
	Price of a bundle of papyrus (0.82)	C	0.82
	Gross economic value of mat making	**D**	4290
	Total value of man hours in days spent in thatching (3days * A*B)	E	1627
	Total value of other costs incurred in thatching (Negligible)	F	-
	Net economic value of mat making	**G**	2663
Total Gross Economic Value of Papyrus Ecosystem Service			**3,884,790**
Total Net Economic Value of Papyrus Ecosystem services			**3,189,072**

Fuelwood access from the wetland

Table 26: Computation of economic value of fuelwood access from the wetland

Parameter and its corresponding metrics	**Parameter symbol**	**Amount/ Quantity**
Number of households accessing fuelwood monthly (households)	A	19,266
Average annual number of bundles collected by a household (bundles)	B	108
Market price of fuelwood per bundle (Rwfr=700 or USD 0.70)	C	0.70
Gross economic value of fuelwood *(A*B*C) (USD)*	**D**	**1,456,511**
Average total man hours spent collecting bundles of fuel wood in a year8 (A*324) in days	E	780,2739
Casual labour wage rate per day (USD)	F	2.0710
*Total labour cost (E*F) (USD)*	G	*1,615,165*
Net economic value of fuelwood (D-G)	**G**	**-158,654**

15 The mean annual hours spent by a household collecting fuelwood from the wetland is 324 hrs (108*3), therefore the total annual man hours spent by the local community on fuelwood collection from the wetland is obtained by multiplying 324 by total number of fuelwood collecting households which is 19,266 households.

16 Multiplying total households by total hours gives 6,243,184 hours. However, this has been converted into days assuming that a day is equivalent to 8 hrs of working, thus giving rise to the figure of 780,273 in row E in the table above

17 Based on information obtained from a wage evaluating website(https://www.minimum-wage.org/international/rwanda#) it is assumed that the standard national minimum wage for casual work is USD 2.07

Herbal medicine

Table 27: Computation of the economic value of herbal medicine ecosystem service

	Parameters and their metrics	Amount/ quantity
A	Number of households using herbal medicine	18,782
B	The average cost of treating a patient with herbal medicine in USD	5
C	Average annual household frequency of seeking herbal medication	6
D	Gross economic value of herbal medicine (A*B*C)	563,460
E	Total annual man hours in days spent harnessing herbal medicine [8/8*C*A]	112,692
F	Total annual cost of man hours spent in harnessing herbal medicine (E * 2.07)	233,272
G	Total cost of input (bundles of fuel wood) used by all households (USD 0.97 *18,782)	18,219
H	Net economic value of herbal medicine [D- (F+G)]	311,969

Annex 2: Data Collection Instrument

ECONOMIC VALUATION OF WETLANDS ECOSYSTEM SERVICES

Distance from the wetland

How far do live from the wetland? (in kilometres)…………………………..

Benefits obtained from the Wetland

Do you get the following services from the wetland?

Benefit	Yes	No
1. Water Supply (Domestic use)		
2. Capture Fisheries		
3. Herbal Medicine		
4. Papyrus and other grasses		
5. Cutting grass as fodder		
6. Firewood from papyrus and reeds		
7. Crop Farming		
8. Livestock Grazing		
9. Aqua Culture		
10. Sand Harvesting		
11. Brick Making		
12. Bee keeping		
13. Making pots		

WATER SUPPLY

Do you obtain any water from the wetland?

☐Yes ☐No

If Yes, What is the purpose of the water?

☐Domestic ☐Selling

If Domestic, Ho many litres do you fetch in a day ……………………

If selling how many litres do sell in a month……………………

If selling, how much do you pay (in a month) those who you hire help you in the business of selling water……

If selling, how much do you incur a month as other costs…………………..

How many minutes does it take you to bring water home per trip …………..

Which of the following modes of transport do you use to fetch water…………

Mode of transport	Yes	No
On foot		
Use donkey		
Bicycle		
Motorbike		
Wheelbarrow		
Cart(mkokoteni)		

If you don't fetch water from the wetland for your domestic use, which of the following are your main sources of domestic water.

Source of water	Yes	No
Piped water		
Water kiosk		
borehole		
Shallow well		
Water vendors		

CAPTURE FISHERIES

Do you catch fish from the lake/ wetlands?

Yes No

If Yes, which type of fish do you catch?

………
………
…………………………

If yes which of the following fishing gears and equipment do you use

Equipment/gear	Yes	No
1. Canoe		
2. Nets		
3. Hooks		

If you catch fish from the lake/wetland, are you a member of the cooperative association of fishermen?

Yes

No

If you are not a member of the cooperative association, could you share with us the reason as to why you are not a member

………
………

If you are not a member of the cooperative association of fishermen, how many days do you go fishing in a month.

PRODUCTS FROM PAPYRUS AND OTHER GRASSES

Do you use any papyrus reeds from the wetland for Mat making or other products?

Yes……………

No………………

If No, why don't you use papyrus to make mats and other products…………..

If Yes, how many mats do you make in a year?............................

How much do you sell one mat for………………..

Do you hire people to help you in mat making Yes …….. No……

If Yes, How much do you pay them per month ……………or in a year ………………..

What is the cost for transporting the mats to the market …………..

How much do you pay the county government / municipal council as tax in the market per month………..

Why don't you make mats in some months ……………………………………………………

HERBAL MEDICINE

Do you use any plants from the wetlands to make herbal medicine?

Yes No

If Yes, what are the plants that you use ………………………………………

What are they types of diseases that you treat people for …………………………..

How much do you charge per patient ………………………………………………

How many patients did you treat last year ………………………………………..

Do you spend any money when treating a patient

Yes No

If yes, which costs do you incur when treating a patient ……………………….

How much ……………………………………………

In your opinion, what is the trend of availability of the plants you use from the wetlands to treat patients

Abundant Increasing in Population Stable Population Decline in Population

AQUACULTURE

Do you have any fish ponds within the wetlands?

Yes No

If Yes, which fish species do you farm

Tilapia Catfish others

If Others, Please Specify ………………………………………

How many Kgs of fish do you harvest in 1 year ………………………

What is the price of 1kg of fish ………………………..

What is the size of 1 pond in square metres ……………………………

How many ponds do you have ……………………………………………………..

How much do you pay people who work for you in the fish ponds per month …………………..

How much do you spend on feeds per month ……………………………..

How much do you spend on stocking fingerlings per year ………………………….

How many years does a fish pond last before it is abandoned ……………………………

How much do you spend in a year to maintain the fish ponds ……………………………..

How much do you spend on permits per year ………………………..

How much do you spend on tax ………………………………

How much do you spend on transporting the fish to the market ……………………

Which tools do you use in the whole of your aquaculture enterprise…………………

GRASS HARVESTING

Do you harvest any grass from the wetland?

Yes No

If yes,

What do you use the grass for?

Domestic Selling

If Domestic,

What do you use the grass domestically for?

Thatching houses Livestock feeding Direct Selling

If Thatching,

How many bundles do you use ………..

How long does the roof last …………………………..

When was the roof last done ………………

How much did you spend on labor ………………………

If livestock feeding

How many cows do you feed from the homestead …………….

How many bundles of grass do you feed them in a week ………………

If selling, what do you use the grass for?

Broom making   Basket weaving

If Broom making,

How many brooms do you make in one month ………………..

How much do you sell one broom for ………………………….

How much do you pay the people who help you in making the brooms per month ………….

How much do you spend on tax per month …………………..

If basket Weaving,

How many baskets do you make in one month ………………

How much do you sell one basket for …………………….

How much do you spend on labor per month………………………

How much do you spend on transport to the market per month …………………

How much do you spend on tax per month …………………..

If Direct Selling the Grass,

How many bundles do you sell in one month …………………

How much do you sell one bundle for …………………………..

How much do you spend on labor per month ………………

How much do you spend on transport to the market per month …………………..

How much do you spend on tax per month …………………..

LIVESTOCK GRAZING

Do you take your livestock to graze in the wetland?

Yes   No

If Yes,

How many cows do you graze in the wetland ……………………………

How many times do you take your cows to graze in a week during the dry season ……………….

How many times do you take your cows to graze in a week during the wet season ……………….

How much do you pay a herds boy per month …………………………..

How much do you spend on treatment of cows for grazing in the wetland in one month ………..

HUNTING

Do you conduct any hunting activities in the wetland?

Yes No

If Yes,

Which animal do you hunt …………………

How many times do you hunt in a month during the dry season …………………

How many times do you hunt in a month during the wet season …………………..

Why do you hunt?

For food For Fun Controlling wildlife

SAND HARVESTING

Do you harvest any sand from wetland?

Yes No

If Yes,

How many trips of sand do you produce in one month during the dry season ………………

How many trips of sand do you produce in one month during the wet season ………………..

How much do you sell one trip of sand for …………

How much do you pay people who help you in harvesting the sand per trip …………………..

How much do you pay for loaders per trip ……………………

Where do you harvest the sand?

Riverbed River Bank Farms within the swamp

In which village do you harvest the sand ……………………………………………

BRICK MAKING

Do you conduct any brick making activities in the wetland?

Yes No

If Yes,

How much do you earn from brick making in one year ……………

Which village do you carry your brick making business in ……………….

How many times in a year do you make the bricks ……………………………

CROP FARMING

Do you conduct any farming activities in the wetland?

Yes No

Which Types of crops do you farm?

Vegetables Maize Yams Rice Sugarcane Beans

If Vegetables,

How many sacs did you harvest last year …………..

What was the maximum price of one sac …………………..

What is the size of the farm you use (In acres) …………………..

How much did you spend on hired labor last year ……………………..

How much did you spend on fertilizers last year ……………………

How much did you spend on pesticides last year ………………………

How much did you spend on seeds last year …………………

How much did you spend on transportation to the market last year …………………

How much did you pay for licenses and permits last year ……………

How much did you spend on tax at the market last year ……………

If Maize

How many sacs did you harvest last year …………..

What was the maximum price of one sac …………………..

What is the size of the farm you use (In acres) …………………..

How much did you spend on hired labor last year ……………………..

How much did you spend on fertilizers last year ……………………

How much did you spend on pesticides last year ………………………

How much did you spend on seeds last year …………………

How much did you spend on transportation to the market last year …………………

How much did you pay for licenses and permits last year ……………

How much did you spend on tax at the market last year ……………

If Yams

How many sacs did you harvest last year …………..

What was the maximum price of one sac …………………..

What is the size of the farm you use (In acres) …………………..

How much did you spend on hired labor last year ……………………..

How much did you spend on fertilizers last year ……………………

How much did you spend on pesticides last year ………………………

How much did you spend on seeds last year …………………

How much did you spend on transportation to the market last year …………………

How much did you pay for licenses and permits last year ……………

How much did you spend on tax at the market last year ……………

If Rice,

How many sacs did you harvest last year …………..

What was the maximum price of one sac …………………..

What is the size of the farm you use (In acres) …………………..

How much did you spend on hired labor last year ……………………..

How much did you spend on fertilizers last year ……………………

How much did you spend on pesticides last year ………………………

How much did you spend on seeds last year …………………

How much did you spend on transportation to the market last year …………………

How much did you pay for licenses and permits last year ……………

How much did you spend on tax at the market last year ……………

If Sugarcane,

How many sacs did you harvest last year …………..

What was the maximum price of one sac …………………..

What is the size of the farm you use (In acres) …………………..

How much did you spend on hired labor last year ……………………..

How much did you spend on fertilizers last year ……………………

How much did you spend on pesticides last year ………………………

How much did you spend on seeds last year …………………

How much did you spend on transportation to the market last year …………………

How much did you pay for licenses and permits last year ……………

How much did you spend on tax at the market last year ……………

If Beans,

How many sacs did you harvest last year …………..

What was the maximum price of one sac …………………..

What is the size of the farm you use (In mugende) …………………..

How much did you spend on hired labor last year ……………………..

How much did you spend on fertilizers last year ……………………

How much did you spend on pesticides last year ………………………

How much did you spend on seeds last year …………………

How much did you spend on transportation to the market last year …………………

Which equipment do you use for farming?

Sprayers Jembe Tractor Ox plough Bull Irrigation kits Panga Wheelbarrow

If Sprayers,

How many people did you employ for your farming activities last year ……..

IRRIGATION

Do you use any water from the wetland to irrigate crops grown outside the wetland?

Yes No

If Yes, which crops …………………………..

What is the size of the farm that you irrigate (immugende) …………………..

Which equipment do you use for irrigation ………………………?

How much do you buy the equipment for …………………………..

How much do you incur as costs in a year out of your irrigation farming……………..

How many days do you spend working on the irrigation farm in a year………………

FIREWOOD

How many bundles of firewood do you get from the wetland in a year ……………

How many bundles do you sell per month during season? ……………

How many bundles do you sell during wet season? ……………

How much do you sell a bundle of firewood per month during dry season? ……………

How much do you sell a bundle of firewood per month during wet season? ……………

How long does a trip to collect fuelwood from the wetland take you or a member of your ……………….?

How much do you pay (per bundle) people who collect for you firewood during dry season ……………

How much do you pay (per bundle) people who collect for you firewood during wet season ……………

FLOODS

Have you ever experienced flood destructions in your home or farm?

Yes No

If Yes, what size of your farm was destroyed (in acres) ……………….

Which is the latest year that you experienced the floods …………………….

BIODIVERSITY MAINTENANCE

Think about the status of the wetland. Which box do you think best describes the condition of the wetland in terms of degradation? (Please tick one box)

01. Heavily degraded
02. Somewhat degraded
03. Good State
04. Excellent state

In a scale of 1 to 5, do you agree that diversity of plants and animals in the wetland provide the following services to the people?

The wetland acts a nursery and breeding ground for fish and other wildlife

Fully disagree

Disagree

Somewhat agree

Agree

Fully agree

No idea

The wetland helps in recharge and discharge underground water

Fully disagree

Disagree

Somewhat agree

Agree

Fully agree

No idea

The wetlands plants abundance helps control flooding

Fully disagree

Disagree

Somewhat agree

Agree

Fully agree

No idea

The wetlands plants abundance helps in purification of the river

Fully disagree

Disagree

Somewhat agree

Agree

Fully agree

No idea

The wetland is home to some of the globally threatened plants and animals

Fully disagree

Disagree

Somewhat agree

Agree

Fully agree

No idea

The wetland attracts tourists and people seeking recreation

Fully disagree

Disagree

Somewhat agree

Agree

Fully agree

No idea

The wetland offers education and research opportunities for researchers and

Fully disagree

Disagree

Somewhat agree

Agree

Fully agree

No idea

Each member of the plants and or animal species plays an important role in that ecosystem

Fully disagree

Disagree

Somewhat agree

Agree

Fully agree

No idea

Do you think conservation of the wetland is important?

Yes No

The wetland consists of papyrus, reeds, open water channels, grasslands and trees, and wild animals, does it matter to you whether these plants and wild animal communities in the wetland exist in their natural state.

Yes No

How much of these plant and animal communities should be conserved in a natural state?

- All of them
- Most of them
- Half of them
- Little of them

· None of them

In your opinion, which management strategy for the wetland do you prefer?

1. Full conservation of the entire wetland
2. Conservation of a considerable section of the wetland
3. Conservation of only a small section of the wetland
4. Full reclamation of the wetland for agriculture
5. Full reclamation of the wetland for fish farming
6. Full reclamation of the wetland for settlements
7. Full reclamation of the wetland for industrial packs

The wetland is one of the places in Rwanda which is considered to be an environmentally significant place since they play a host of rich diversity of plants and animals; it is also a habitat for rare and threatened birds and animals, the abundance of reeds and papyrus helps in flood control, and many other benefits. Suppose you are asked to make some contribution to promote the conservation of the wetland so that the richness and abundance of the various plants and animals are enhanced would you be will to make such a contribution.

Yes……………………………….

No………………………………

If yes, which type of contribution would you be willing to make? (Tick one only)

Volunteer time for conservation of the wetland…………………………

Contribution of commodities as such maize………………………………

Cash contribution…………………………………………..

Hint: please consider your household financial needs and your monthly earnings and only propose that amount which you are willing to contribute out of this your monthly earnings

How much of your contribution would you be will to make? (Use only one method of contribution)

Contribution	Monthly	Twice a year	Once a year
Volunteer labour in hours			
Maize in tins or sacks			
Amount of Cash			

If you are not willing to make any contribution towards the conservation of the wetland's biodiversity, please kindly share with us some of the reasons that has informed your choice

……………………………………………………………………………………………..

HOUSEHOLD CHARACTERISTICS

What is your age in years? ……………………………………….

What is your gender?

01. Male

02. Female

How many people live in your household, including yourself? (Please count separately the number of adults and children)

01. Adults

02. Children (below 18 years)

What is the highest level of education you have obtained (until now)?

01. Never went to school , Years….0

02. Primary, Years…….

03. Secondary, Years…….

04. Certificate, Years ………

05. Diploma, Years……….

06. University degree, Years………..

07. Post-graduate degree, Years ………..

Do you belong to any environmental or social group?

Cooperative Association	Yes	No
Water users (for farming)		
Fishing cooperative		
Environmental protection		
Others		

What is your main source of income? (Tick one only)

01. Fishing

02. Crop farming

03. Animal keeping

04. Business

05. Salary

06. Wages

07. Remittance

08. Other (specify) ………………..

What is the distance in km from your place of residence to the nearest market? …………………

Do you have access to loan?

01. Yes

02. No

03. Do you belong to any environmental or social group?

Annual household income – Please indicate the approximate total **annual income** (before taxes) by all members of your household.