LINKING WETLAND MANAGEMENT, AGRICULTURE PRODUCTION AND POVERTY ALLEVIATION IN RWANDA. CASE STUDY OF BAHIMBA WETLAND IN RULINDO DISTRICT

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Master of Science in Geo-information for Environment and Sustainable Development

2019

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By

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Thesis submitted to the University of Rwanda in partial fulfilment of the requirements for the degree of

Master of Science in Geo-information for Environment and Sustainable Development

College of Science and Technology

School of Architecture and Built Environment

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October 2019

Declaration

I, Odette NISHIMWE, student number 215042916, hereby declare that this research report is the result of my own original work. It is being submitted for the degree of Masters of Science in Geo-Information for Environmental and Sustainable Development. I also declare that it has neither been submitted nor being concurrently submitted in any other institution.

_____ _____

Odette NISHIMWE Date

(MSc. Candidate)

The above declaration confirmed

_____ _____

Dr. Gaspard RWANYIZIRI Date

(Supervisor)

Acknowledgement

Thanks and praises be to the Almighty God for his plentiful grace and protection during the whole course of my University study.

My heartfelt thanks and gratitude goes to my supervisor Dr. Gaspard RWANYIZIRI for his tireless support and commitment during the development of this research work. His useful critiques, suggestions and encouragement were invaluable. May God bless him abundantly!

My sincere gratitude is also expressed to Raphael MURASANDONYI, Agriculture Officer of Rulindo District; Olivier KALIBUHUNGU, Agriculture Officer of Mbogo Sector; Elie HABIMANA, head of farmers' cooperative (COVAMABA) and the local farmers from Bahimba wetland for their great cooperation and support that enabled me to successfully accomplish this project.

I am thankful to my brothers and sister for all their emotional and moral support.

Odette NISHIMWE

October 2019

Abstract

This research was carried out in Bahimba wetland located in Rulindo District. The main objective was to assess the linkage between wetland management, agriculture production and poverty alleviation in Rwanda with a case study of Bahimba wetland in Rulindo district. The methods and technics used for data collection include review of published and unpublished reports from government and academic institutions, field observation, household questionnaire survey applied on 97 local farmers and key informant interviews (KII) applied on 3 agriculture officers, one at district level and two at sector level. Data analysis was done using the Statistical Package for Social Sciences (SPSS) for windows. The information from questionnaires was coded in Ms Microsoft excel. During data interpretation process tables, charts, and diagrams were used to handle statistical data. In addition photos were used to explain realities on the ground.

Research findings showed that agricultural productivity in Bahimba wetland increased at a moderate rate between 2013 and 2017 and the use of fertilizers, improved seeds and following advices from extension officers by farmers has contributed to higher yields, especially for maize. Moreover, Household nutritional level of 84% of farmers has improved since they start farming in Bahimba wetland and the income they earn from wetland crop production is high compared to the upland. In addition, they are member of cooperative which make them to get more income due to the market availability as 80% of the wetland crop production is market oriented. The money they get from crop production is helping them in household basic needs like paying bills for medical care and school fees etc. However, evidence on the ground such as flooding, soil erosion and soil acidity constitute the great and present threats to the existence of the wetland and its resources. The study suggests strategies to bring order in utilization and management of the wetland. These include hillside protection through radical terracing, agro-forestry and equitable wetland resources use. Besides, strengthening institutional framework in wetland resources governance is the top solution to all challenges.

Key words: *Wetlands, Wetland agriculture, Bahimba wetland, Food security, Poverty, Wetland Management, Local farmers*

List of Abbreviations and Acronyms

AWIs	Agriculture Wetland Interactions
CICA	Centre d'Information et de Communication Agricole
COVAMABA	Coopérative de Vulgarisation du Marais Bahimba
EDPRS	Economic Development and Poverty Reduction Strategies
ETOA	Environmental Threats and Opportunities Assessment
FAO	Food and Agriculture Organization
GoR:	Government of Rwanda
HH	Household
IPAR	Institute of policy Analysis and Research – Rwanda
KII	Key Informant Interviews
MA	Millennium Assessment
MINALOC	Ministry of Local Government
MINAGRI	Ministry of Agriculture & Animal Resources
MINIRENA	Ministry of Natural Resources, Water Resources Management
MINITERE	Ministry of Lands, Environment, Forestry and Mines
NBI	Nile Basin Initiative
RDDP	Rulindo District Development Plan
REMA	Rwanda Environment Management Authority
RNRA	Rwanda Natural Resources Authority
RoR	Republic of Rwanda
SDGs	Sustainable Development Goals
SSA	Sub-Saharan Africa
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
USAID	United States Agency for International Development
WFP	World Food Program

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Chapter 1. Introduction

1.1. Background Information

Worldwide it is estimated that wetlands cover about 6% of the earth's land surface and are unevenly distributed across the globe and found across every climatic region (Martin, 2014). Wetlands are species-rich habitats performing valuable ecosystem services such as flood protection, water quality enhancement, and food chain support and carbon sequestration. Worldwide, wetlands have been drained to convert them into agricultural land or industrial and urban areas. A realistic estimate is that 50% of the world's wetlands have been lost (Verhoeven & Setter, 2010). According to the same source from the early beginning of agricultural activities, such riverine wetlands have been recognized as valuable land areas for food and fodder production, because they have fertile soils as a result of regular sediment deposition during flood events.

According to Wood & van Halsema (2008), people have had an intimate association with wetlands from prehistory to the present day. Wetlands such as swamps, marshes and estuaries have been among the most attractive areas in the landscape, satisfying a variety of needs for hunting and gathering, spirituality, water resources and agriculture. However, some wetlands have been sources of diseases and other hazards, and this has limited their use. There is evidence that wetland agriculture has made a significant contribution to the wellbeing of many societies around the globe over the centuries and even millennia.

In East Africa humans have lived with and within wetlands throughout history using seasonal swamps as grazing lands, harvesting swamp plants for variety purposes including materials for roofing; furniture and fish traps; and exploiting wetlands for fisheries and aquaculture (Chapman, Balirwa, Bugenyi, Chapman, & Crisman, 2001). Moreover, East African wetlands play both environmental and productive functions. They provide natural products that could be harvested and processed and provide good soils and abundant moisture which makes them suitable for agriculture (Dixon & Wood, 2003). Wetlands serve a variety of vital roles – they represent natural water purification and flood control systems, well-watered agricultural land, reserves of biodiversity, and a stock of natural grasses, clays and other resources used for handicrafts. Drainage of wetland areas for agricultural production especially in the hilly areas of

Rwanda weakens the role of wetlands as 'buffers' (storing water and hence lessening the effects of drought and flood) and 'filters' of water pollutants for downstream ecosystems (UNDP and UNEP, 2006).

Wetland agriculture is often a major economic pursuit among rural communities since they provide suitable cultivation conditions for a range of crops such as rice, maize and various vegetables. In many parts of Eastern and Central Africa where annual rainfall is high, drainage regimes, which balance water losses with water retention, are an integral part of the agricultural exploitation of wetlands. In some cases, up to three crops per year are grown under wetlands conditions. Wetland reclamation and consequent cultivation is often initiated in response to local food shortages, but has major implications for freshwater management (Nabahungu, 2012).
Wetlands contribute in diverse ways to the livelihoods of millions of people. They are often inextricably linked to agricultural production systems. In many places, growing population, in conjunction with efforts to increase food security, is escalating pressure to expand agriculture within wetlands (Matthew Mc. et al, 2010a). In addition, wetlands play an important role for the suggested Sustainable Development Goals (SDGs) on food security and poverty eradication, ecosystems and biodiversity, water and climate change adaptation. If disconnected, actions taken to achieve one goal can easily conflict with others.

Agriculture–wetland interactions (AWIs) are becoming more important as rising demand for food production exacerbates pressures on wetlands. The Millennium Ecosystem Assessment (MA) identified agriculture as the major cause of wetland degradation and loss. However, while some ecosystem services, such as regulating and supporting services may be reduced, agricultural development has considerably increased the provisioning services of wetlands (Wood & van Halsema, 2008). In addition, farming activities are major economic pursuits in and around many wetlands, where crops such as rice, maize, and various vegetables and fruit are cultivated. Seasonally inundated floodplains are often particularly important farming resources because they frequently have very fertile soils, with high clay content (which facilitates water retention in the dry season).In 2005, the World Resources Institute produced the Millennium Ecosystem Assessment Report on Wetlands and Water. This document states clearly that wetlands are an important ecosystem resource in multiple dimensions. Complex wetland

ecosystems provide "…services vital for human well-being and poverty alleviation…" including essential freshwater and energy resources, regulation of hydrologic regimes and climatic processes and soil erosion control (Amler, 2015).

A significant proportion of people in developing countries depend upon the use of wetland resources in one way or another for their livelihoods. In particular, the conversion of wetlands to agricultural production area has increased rapidly over the last decades due to the acute scarcity of agricultural land (Nabahungu, 2012). Most countries in Sub-Saharan Africa depend on rain-fed agriculture for food security and employment to keep their economies growing and viable (MIDIMAR, 2015). In Rwanda, agriculture represents more than 43% of the Gross Domestic Product and crop production constitutes the major part of agricultural production for the majority of the Rwandese households (MIDIMAR, 2015). The Rwandan government currently considers wetlands as an important niche for increasing food security and income through the production of rice and other commodities (Nabahungu, 2012).

In Rwanda the total area of wetland is 278536 ha (REMA, 2009c). At present wetlands support the livelihoods of many poor people through agriculture providing both food and income. Most Rwandan farmers practice subsistence farming. Farmers living in the uplands make use of the neighboring wetlands and generally plant similar crops in both up- and lowlands, except for paddy farming which is cultivated only in wetlands (Mbabazi, 2010). In the wetlands of Rwanda, rain fed agriculture is performed in the dry areas, and groundwater dependent agriculture is practiced in the wet areas. Traditionally, farmed wetlands are simple, require low budget inputs, and cover small areas. Generally, yields in the wetlands are higher compared to yields in uplands. This is due to the continuous availability of water and the relatively higher fertility of wetlands (Nabahungu, 2012). According to the same source, the Rwandan government considers wetlands as an important resource for the intensification of agriculture, which is required to achieve the goals of food security and poverty reduction as targeted in the agricultural policy of May 2000.

1.1. Problem Statement

Many wetlands are fragile and transient ecosystems, easily prone to degradation from natural processes and exploitative human interventions. Depending on the hydrological characteristics of the wetland, their use for agriculture is often a major economic activity undertaken by rural communities to produce crops such as maize, rice and various vegetables (Nabahungu, 2012). In Great Lakes Region of Eastern and Central Africa, the wetlands are threatened by the increased population growth which increases the needs for water, food, energy and other livelihood needs; the wetlands are being reclaimed to meet this population needs (RAMSAR, 2014). Wetlands provide food and other agricultural products such as fuel and fiber directly through agricultural production activities that take place within wetlands, such as in rice paddies, coastal grazing marshes, recession agriculture and aquaculture in large floodplains, and cropping of small seasonal wetlands. Wetlands also support agriculture indirectly, for example by providing fertile soils and reliable supplies of good quality water (RAMSAR, 2014).

Wetland agriculture, which can be viewed as a provisioning ecosystem service, provides a development opportunity and a poverty reduction strategy for many poor people, but care is needed to ensure that other ecosystem services including other means of food security (e.g., fisheries), also vital for poor people, are not lost. Therefore, given their importance for water supply and food production, wetlands are a key element of achieving the goals of poverty alleviation worldwide. Many marshlands are threatened by silting and reduced water retention due to continued vegetation loss and erosion; the pressure of more people using unsustainable land use practices on nearby hillsides; and the downstream impacts of declining water quality (USAID, 2014).

Wetlands in Rwanda have been used in different ways and have a great role to play in the national economy. The main functions of wetlands in Rwanda include agriculture production, hydrological functions, biodiversity reservoirs, peat reserve, and mitigation of climate change, leisure, tourism, and cultural value. In Rwanda where many rural households face food insecurity, poverty and vulnerability, these goods and services make an important contribution to livelihood. In particular, the conversion of wetlands to agricultural production has increased rapidly over the last two decades due the acute scarcity of agricultural land (REMA, 2009a). To a

great degree, the Rwandan government supports the wetland development with the aim to boost agricultural production, revitalize the rural economy and reduce poverty. Despite their important role and the strict legal regime, Rwanda's wetlands continue to be lost to fallow fields, afforestation, pisciculture (fish-farming), human settlement and to agriculture (REMA, 2011). Furthermore, the wetlands are threatened by human activities such as agricultural production; already out of the total 165,000 hectares of wetlands, 92,000 hectares are used for agriculture. While most of the marshlands in the country are under traditional cropping, some have been developed through extensive drainage or irrigation. Others have been reclaimed for the production of rice and sugar cane. These human activities have contributed to the disappearance of permanent springs, lower volumes of water outflow from some wetlands, lower ground water yields and disruption of the ecological services provided by wetlands (REMA, 2010).

One of the main ways in which mankind has been using the valley bottom wetland or fresh water marsh is cultivation. The importance of such wetlands in this regard lies mainly in their remarkably higher productivity compared to most upslope areas. People living in settlements close to the wetlands and earning their living from their resources remain alienated from the conservation policies, ignorant of the implications of their practices and uninformed of the new messages or the long-term benefits they could achieve (Ironga, 2005).

The cultivation of wetlands, which as a rule calls for some degree of drainage, however, can lead to their rapid degradation and loss of perennial supply of water unless it is done wisely. One of the well-known consequences of the unwise cultivation of wetlands is not only the loss of the wetlands themselves but also the fast decline in the fertility of the soils. Wetland soils are formed under special chemical conditions of a waterlogged environment and tend to turn acidic under drained conditions. Although wetland agriculture can bring significant benefits in terms of food security, health and income, ill-considered development often results in wetland degradation, deleterious environmental impacts and harmful consequences to peoples' (UNEP, 2011).

Bahimba wetland supports a variety of livelihood activities, which are economically beneficial among the adjacent communities. As long as it is managed wisely, the wetland will continue to support the country's efforts in poverty alleviation and maintenance of human wellbeing. Studies in wetland farming and associated technologies have not received much attention to justify

management decisions on wise use. Bahimba wetland have existed for long time in Rulindo district. Few studies have established on socio-economic contribution of this wetland to the livelihood of the population that resides around them. Despite the growing awareness of the wetland values and functions and consequences of human intervention to these values and functions, the issue of Bahimba wetland degradation has received much less attention. The study established the extent to which this wetland contribute towards the social and economic wellbeing of the residents surrounding Bahimba wetland.

The use of Bahimba wetland calls for inventory and critical study of the socio-economic aspects of the wetland, development on plans for a wise, efficient, and beneficial utilization of its resources using participatory approaches.

1.1. Research Objectives

1.1.1. General Objective

The overall objective of this research is to link wetland management, agriculture production and poverty alleviation in Rwanda by focusing on Bahimba wetland in Rulindo district.

1.1.2. Specific Objectives

Specifically, this research aims:

1. To evaluate the current relationship between wetland management and agriculture production in Bahimba wetland;

2. To analyze the contribution of wetland crop production in increasing livelihood options and in reducing the problem of food insecurity among local farmers;

3. To identify major challenges related to wetland management and propose sustainable solutions towards the wise use of Bahimba wetland.

1.4. Research Questions

1. What is the relationship between wetland management and agriculture production in Bahimba wetland?

2. What is the contribution of wetland agriculture production to household income and food security among local farmers?

3. What are the main challenges to Bahimba wetland and what can be sustainable solutions to those challenges?

1.5. Conceptual Framework for the Study

Conceptual framework is the system of concepts, assumptions, expectations, beliefs and theories which support and inform a given research, the key part of research design. It is either a visual or a written product and it explains either graphically or in a narrative form the main things to be studied, the main concepts, factors or variables – and the presumed relationship between them (Okech, 2016).

The conceptual framework for this study is given in Fig. 2. The study assumes that firstly, farming in Bahimba wetland play a key role in increasing household income and food security to local communities especially those farming in wetland. Secondary, wetland management strategies can be applied particularly in protecting wetlands resources as they contribute to the factors influencing wetland agriculture. In this study framework, the agricultural products from Bahimba wetland have a significant contribution to economic benefits of the people to household income and food security. This framework relates to the study objectives.

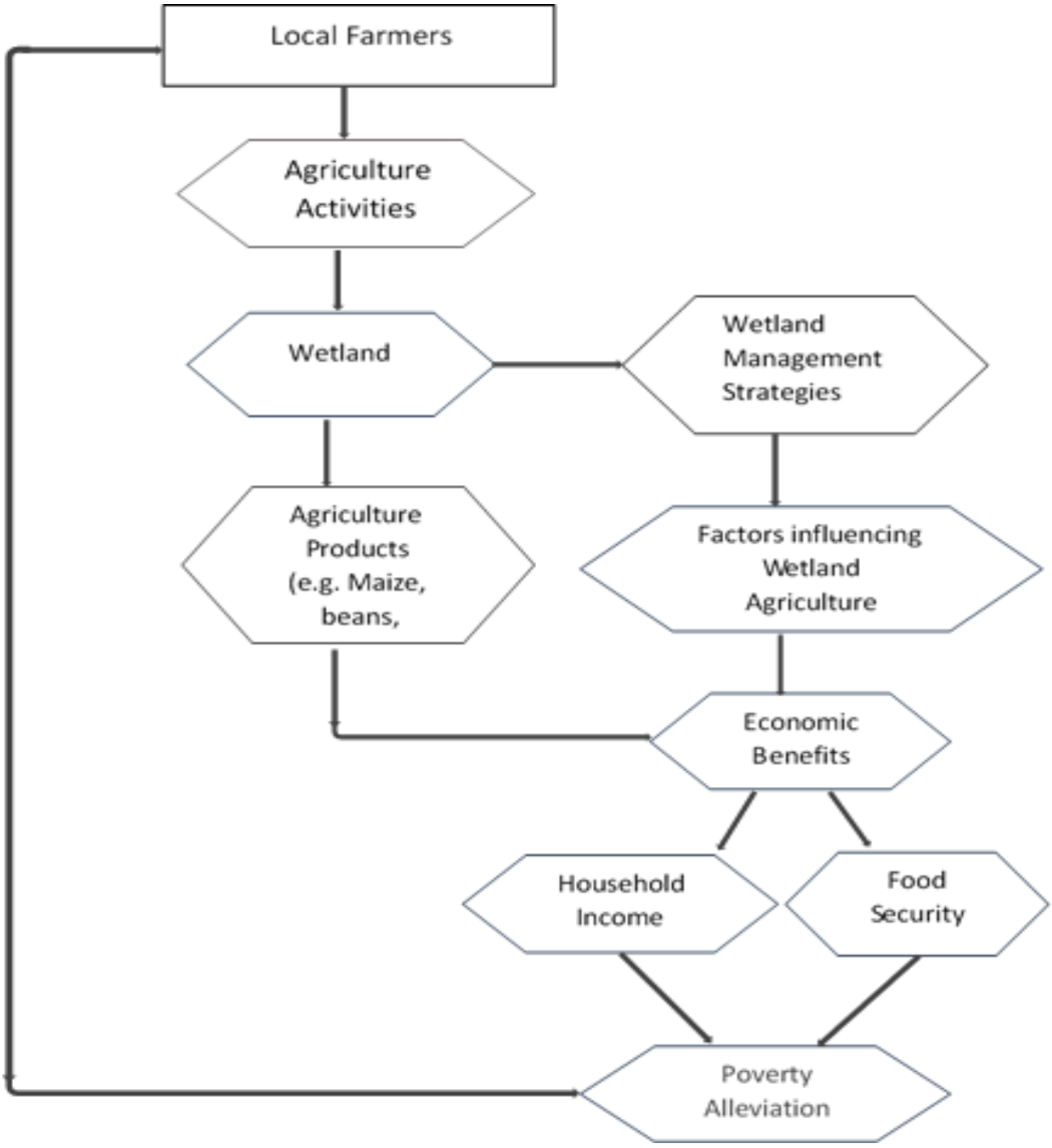

Figure 1: Conceptual Framework of the study (Author, 2018)

1.5. Limitations of the Study

The study encountered several limitations during data collection. However, necessary measures were taken to overcome them to ensure success.

i. The major problem was concern with absence of head of household in their home place at a time of conducting interview and this problem occurred because most of them went to their farmland. A researcher handled this problem by visiting them to their farmland and able to acquire information.

ii. High cost of data collection was also one of the limitations because the district is very large with 5 the sectors neighboring Bahimba wetland among 17 sectors of Rulindo Ditsrict. This means that the researcher would spend a lot of money and time to cover the entire study area.

iii. Apart from collecting data from local farmers and local leaders related to agricultural activities and environmental management, only sampled participants were from Tumba and Mbogo sectors. This makes the findings and conclusions specifically more relevant to these two sectors, and may not necessarily be readily generalizable to the whole country.

Chapter 2. Literature Review

Wetlands are among the world's most diverse and productive ecosystems (Ongoro, 2017). Throughout history wetlands they have played an important role in human development and many great civilizations (Matthew Mc. et al, 2010a). They have been confirmed to deliver a wide range of critical and important services vital for human well-being. Therefore, it is clear that sound wetland management is now expected to not only consider conserving the ecological integrity of the ecosystem but also to pay specific attention to the well-being of local people, thereby contributing to poverty alleviation.(Atapattu, Silva, & Sellamuttu, 2010).

2.1. Definition of Key Concepts

2.1.1. Wetlands

Wetlands can be considered as sinks into which surface water or groundwater flows from a surrounding catchment. Within landscapes they are "natural harvesters" of rainwater and, by definition, sites where water occurs at or close to the ground surface (Matthew Mc. et al, 2010a). The most broadly known definition of wetlands is one given by the Convention on Wetlands of International Importance also known as the Ramsar Convention which is formulated as "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters" (Ramsar Convention Bureau, 1997). In the Rwandan context, 'wetland' is defined as all lowlands and comprises the entire valley bottom, both the well-drained and wet areas (REMA, 2010).

2.1.2. Food Security

Food security is a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAO, 2006). World Food Summit (2000) defines household food security as availability of food that is sufficient, safe and nutritious that maintains healthy, active life and acceptable to all household members".

Commonly, the concept of food security is defined as including both physical and economic access to food that meets people's dietary needs as well as their food preference. Food security is built on four pillars which are: i. Food availability that means sufficient quantities of food available on a consistent basis, ii. Food access that means having sufficient resources to obtain

appropriate foods for a nutritious diet, iii. Food use that means appropriate use based on knowledge of basic nutrition and care, as well as adequate water and sanitation and iv. Food stability (Yusuph, 2016). Conferring to the same source, at the household level, food security refers to the ability of the household to acquire adequate, safe and quality food, through production/or purchase, transfer or exchange, to fulfil the nutritional needs of all members of the household (FAO, 1995 & FAO, 1998).

2.1.2.1. Pillars of Food Security

a) Availability

Food availability relates to the supply of food through production, distribution, and exchange. Food production is determined by a variety of factors including land ownership and use; soil management; crop selection, breeding, and management; livestock breeding and management; and harvesting (Yusuph, 2016).

b) Access

Food access refers to the affordability and allocation of food, as well as the preferences of individuals and households. The UN Committee on Economic, Social, and Cultural Rights noted that the causes of hunger and malnutrition are often not a scarcity of food but an inability to access available food, usually due to poverty. Poverty can limit access to food, and can also increase how vulnerable an individual or household is to food price spikes. Ecker and Breisinger (2012) observed that access depends on whether the household has enough income to purchase food at prevailing prices or has sufficient land and other resources to grow its own food (Yusuph, 2016).

c) Utilization

The World Food Summit's definition of utilization (the third element of food security) is "safe and nutritious food which meets their dietary needs". The availability of and access to food on their own are not enough, people have to be assured of "safe and nutritious food". The food consumed has to provide sufficient energy to enable the consumer to carry out routine physical activities. Utilization also covers factors such as safe drinking water and adequate sanitary facilities to avoid the spread of disease as well as awareness of food preparation and storage procedures. Utilization therefore covers a range of aspects that hinge on the consumer's

understanding of what foods to select and how to prepare and store them (Napoli, Muro, & Mazziotta, 2011).

d) Stability

The World Food Summit says that stability must be present "at all times" in terms of availability, access and utilization for food security to exist. The literature distinguishes between chronic food insecurity where food needs cannot be met over a protracted period of time and transitory food insecurity, where the time period is more temporary (Maxwell and Frankenberger 1992, cited in (Napoli et al., 2011).

2.1.3. Poverty

Poverty is a complex phenomenon, which always involves a value judgement on what constitutes a minimum acceptable living condition and the spheres of life that should be taken into account. Its definition and measurement affects the way estimates should be interpreted and used (NISR, 2012). Poverty is recognized as a multi-dimensional, value-laden, context specific, and dynamic phenomenon. This is consistent with current thinking on the concept and measurement of poverty, which over the past four decades has evolved from an emphasis on access to physical commodities to an approach which includes capabilities, or the ability to achieve human well-being (RAMSAR, 2012).

Some of the dimensions used to describe poverty include "inability to satisfy basic needs, lack of control over resources, lack of education and skills, poor health, malnutrition, lack of shelter, poor access to water and sanitation, vulnerability to shocks, violence and crime, lack of political freedom and voice". Poverty has also been expressed as "pronounced deprivation of well-being". The Millennium Ecosystem Assessment identified poverty and well-being as two extremes of a multi-dimensional continuum. Poverty is also considered to be a dynamic phenomenon, with some people remaining in a state of chronic poverty over time whilst others experience a more transient state and may move in and out of poverty (RAMSAR, 2012).

2.1.3.1. Symptoms or Signs of Poverty

According to (Donkor, 2011) the symptoms of poverty include:

a. Low levels of income: Here the income levels of the people are very low and unreliable.

a. Low levels of economic wealth: Economic wealth derives from assets that can generate income, capital gains or liquidity. Assets such as cattle and farm lands play an insurance role in the event of adverse shocks such as drought or the loss of a wage worker or pensioner, helping to smooth consumption in areas where households do not have access to efficient insurance and credit markets (Little, 2002).

b. Low levels of health: High levels of morbidity and infant mortality are often the result of poor nutrition and inadequate health care.

c. Poor standards of housing: Inadequate housing in urban townships and rural settlements. However, it is not only the type of dwelling that is important, but also the density of occupation, what the dwelling is constructed of, and whether or not sanitation is hygienic and water is safe to drink (Shinns, 2003).

2.1.4. Livelihoods

Livelihoods are the means that enable people to earn a living. This includes the capabilities, assets, income and activities people require in order to ensure that their basic needs are covered. A livelihood is sustainable when it allows people to cope with, and recover from, setbacks and stress (such as natural disasters and economic or social upheavals), and improve their welfare and that of future generations without degrading the environment or natural resources base (CITES, 2015).

Household assets and capabilities are the basic components of livelihood. It broadly includes natural, physical, human, financial, public and social capital as well as household variables. Based on access to a particular set of assets and capabilities different activities are employed by the household. These are like inputs which lead to the different strategies of livelihood. Within a household these components interact with each other and give self-defined goals, termed as livelihood outcome. Sustainability of the livelihood is based on this livelihood outcome. Food security, gender security, better health condition, increase in income, better living condition, reduced vulnerability are some of the requisite as livelihood outcome for sustainable livelihood.

Livelihoods are similar for groups of people doing similar things. We call a “livelihood group” a group of people who access similar resources, share similar social and cultural values and have a comparable economic status. Moreover, people of the same livelihood group share the same risks and kinds of vulnerability. It is common to see more than one livelihood group in a geographical area (FAO, 2007).

2.2. Wetland Management

Many wetland areas experience a rapidly growing population with poor people moving into the areas in search of livelihood opportunities leading to a strong economic pressure for conversion of wetlands to other functions and only limited considerations are given to the sustainability of the changes (Yusuph, 2016). All over the World, wetlands management is applied to degrading wetlands in order to conserve successfully wetlands and their biodiversity and develop them for the present and future generations. Conservation of wetland ecosystems is essential not only for sustainable fresh water supply but also for preserving biodiversity and ensuring other services necessary to the health and well-being of people around the world (FAO, 2008). The priority when making choices about wetlands management decisions is to ensure that the ecosystem services of the wetland are maintained, and where appropriate, restored (Ramsar, 2007). Management of wetlands and water resources is most successfully addressed through integrated management at the river (or lake or aquifer) basin scale that is linked to coastal zone management for coastal and near-shore wetlands and that takes into account water allocations for the ecosystems (Ramsar, 2007). Maintaining the natural functioning of wetlands through an appropriate management will enable them to continue to deliver appropriate services (IMCE, 2008).

Wetland management is the only practice that can mitigate wetland degradation in developed and developing countries. However, this does not preclude wetlands from being utilized; on the contrary, wetland management promotes the partial conversion of wetlands in order to meet economic needs of societies. A balance has to be struck between the environmental functioning of wetlands and their use for livelihood purposes thus promoting sustainable wetland management. Many communities and international organizations have found a way of encouraging wetlands management. For example the Ramsar Convention promotes the sustainable utilization of wetlands. Ramsar Convention describes the wise use of wetlands as the sustainable utilization of wetlands for the benefit of human kind in a way that is compatible with the maintenance of the natural properties of the ecosystem. Sustainable utilization is defined by the Convention as the human use of a wetland so that it may yield the greatest continuous benefit

to present generations while maintaining its potential to meet the needs and aspirations of future generations (Mbabazi, 2010).

2.3. Wetland and Agriculture Production

For many millennia, humans have been cultivating land for food production. In the course of history, wetlands have been reclaimed for agriculture in many parts of the world with ever more effective drainage and land amelioration measures (Verhoeven & Setter, 2010). Agriculture is a commonly associated feature of wetlands throughout the world, with millions of hectares of wetland of various types supporting a wide range of activities (Matthew Mc. et al, 2010a). As the human population increases and further influences the management of water and other natural resources, the value of wetlands to society increases, but so also do the pressures on them. Wetland agriculture is important for poverty reduction and food security in many developing countries. In recent decades, agricultural use of wetlands has increased significantly in many developing countries, particularly in Africa, where they are perceived by some as the "new frontier" for agriculture (Wood & van Halsema, 2008).

Wetland is a foundation of wetland agriculture which develops based on large-scale exploitation of wetland. The formation of wetland agriculture depends on the following conditions a) a region with more precipitation/rainfall, monsoon climate; b) low-lying and flat terrain, prone to form natural wetland, and 3) formation of large-scale agriculture due to wetland to be reclaimed for long time (Zhu, Yu, & He, 2013). The conversion of wetlands towards agricultural production areas has increased rapidly over the last three decades due to the acute scarcity of agricultural land. In this situation it is of the utmost importance that wetland reclamation occurs in a sustainable way, to ensure that agriculture does not compromise capacity of the wetland to provide the array of ecosystem services that also support the livelihood of local people (Nabahungu, 2012). Wetlands cover an area of approx. 18 Mio ha in the East African countries of Kenya, Rwanda, Uganda and Tanzania, with still a relative small share being used for food production. Current upland agricultural use intensification in these countries due to demographic growth, climate change and globalization effects are leading to an over-exploitation of the

resource base, followed by an intensification of agricultural wetland use. (Leemhuis, Amler, Diekkrüger, Gabiri, & Näschen, 2016).

A variety of food crops, which include paddy, maize, beans, sweet potatoes, sugarcane, onions and vegetables, are grown in the wetlands. In Rwanda, Approximately, 92,000 of the total 165,000 hectares are used for agriculture. This is mainly because 90 per cent of the country's population is still engaged in agricultural activities (MINAGRI 2008). Most of the Rwanda marshlands are under traditional cropping. However, some have been developed through extensive drainage or irrigation. Some of these wetlands have been reclaimed increasingly for rice production and sugar cane growing. Wetland grasslands provide critical areas for livestock grazing, especially during the dry season (Nabahungu and Visser, 2013). However, the wetlands are threatened by human activities such as agricultural production; already out of the total 165,000 hectares of wetlands, 92,000 hectares are used for agriculture. While most of the marshlands in the country are under traditional cropping, some have been developed through extensive drainage or irrigation. Others have been reclaimed for the production of rice and sugar cane. These human activities have contributed to the disappearance of permanent springs, lower volumes of water outflow from some wetlands, lower ground water yields and disruption of the ecological services provided by wetlands (REMA 2009).

2.4. Wetlands and Poverty Interlinkages

The issue of poverty is associated with a decline in resource flows to the rural households which applies more to agriculture than it does to other sectors. Rural households depend on agricultural projects in order to cope with poverty. The poor, who for the most part live close to the land, are directly dependent on their immediate environments. Poor households in particular rely heavily on expenditure-saving, labour-intensive activities for their subsistence and survival, such as growing food, collecting water and fuel wood or grazing animals (REMA, 2011).

Wetland ecosystem services (the benefits people derive from wetlands) form an integral part of the livelihood strategy of wetland-dependent communities. Their livelihood systems often involve adapting to the overall ecological character of the wetland so as to optimize livelihood outcomes. The ways in which ecosystem services integrate with other livelihood capitals,

particularly the social, economic and political contexts under which ecosystem services accrue to the livelihoods of dependent communities, become important variables in influencing the sustainability of livelihood strategies as well as poverty within wetland communities (RAMSAR, 2012).

Conversely, livelihood strategies of communities living in and around wetlands may also influence a wetland's ecological character. Failure to follow wise use principles can exacerbate the problem by pushing people into poverty (transforming the non-poor into the poor), by maintaining the status quo for those who are already in poverty, and by pushing already poor people further into poverty (RAMSAR, 2012). For poor rural households that are short of food, wetlands can provide a life-saving safety net. Some rural households increasingly use wetlands to supply local markets with irrigated vegetables and other products which generate income. For these households, wetlands represent a development opportunity which can lead them out of poverty (Matthew Mc. et al, 2010a). The government of Rwanda supports wetland development with the aim to boost agriculture, revitalize the rural economy and reduce poverty (Mbabazi, 2010).

2.5. Major Wetlands in Rwanda and Challenges related to their Management

In Rwanda, the wetlands and marshlands, which occupy about 10 percent of the country, are comprised of three large swamps and small wetlands scattered among the country's many hills. The main swamps are Akanyaru (12,546 ha) on the border with Burundi, Kagera along the Tanzania border to the east (12,227 ha), and the Nyabarongo (24,698 ha) and Rugezi wetlands (6294 ha) to the north (Mbabazi, 2010). Major wetlands, their location and spatial extent are summarized in the table below.

Table 1: List of Major Wetlands in Rwanda

Wetland	Area (Ha)	Location	Economic and Ecological Features
Nyabarongo complex	24,698	Central plateau to southern plains	Agricultural activities along its vast watershed; Medium size HEP sites
Rugezi	6,294	Northern parts, draining into Lakes Burera and Ruhondo	Recharges Burera and Ruhondo lakes downstream, which are points of HEP generation; Large agric. Watershed with well-moderated micro-climate; Threatened habitant for rate fauna and flora species
Akanyaru	12,546	Southern border areas with Burundi	Support agriculture, artisanal fishing and have potential for transport;
Akagera	12,227	Southern plains along the border with Tanzania in the east	Hydropower; agriculture; navigation; tourism

Source: REMA (2010)

The principal threats to wetlands of Rwanda are linked to the agricultural (mainly rice) and livestock activities, mining activities, human settlements, exploitation of clay and sand quarries. Agricultural pressure is particularly important since most of the population depend on agriculture. There is pollution from sources such as domestic effluents, waste leachates, industries, agro-chemicals and storm water. The 2008 national wetland inventory showed that 41 percent of the inventoried marshlands still maintained natural vegetation, 53 percent had been converted to agriculture, and about six percent had been cleared but were then fallowed and not being actively cropped (USAID, 2014).

Sustainable use of wetlands is defined by the Ramsar Convention (Ramsar, 2000) as "human use of a wetland so that it may yield the greatest continuous benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations". This definition

is based on the concept that human use of wetlands is possible without endangering the long-term integrity of the wetland ecosystem (Nabahungu, 2012). The 'wise use' of wetlands, at the centre of the Ramsar philosophy, is defined as "the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development" (Ramsar Convention Secretariat, 2007). Wise use therefore has at its heart the conservation and sustainable use of wetlands and their resources for the benefit of humankind (McInnes, 2010).

Currently sustainable wetland use is threatened by agricultural intensification, exploitation of natural resources, urbanization, inadequate wetland policy and lacking technical capacity of stakeholders (GEF/WB, 2005; Nabahungu, 2012). According to (Collins, 2005), the impact of the intensification is evident in many wetlands. When drained and used for intensive agriculture, the water is conveyed rapidly downstream reducing the wetlands ability to buffer peak flows, retain sediment and hold water. The capacity of the wetlands to deliver services to the community is greatly affected by the degradation (REMA, 2009b). Wetland loss and degradation are different in that the latter can be managed and controlled using suitable wetland management techniques while wetland loss needs restoration and mitigation measures, which are expensive and complicated in terms of capital and engineering expertise, an issue that can be a greater challenge for developing countries (Mbabazi, 2010).

2.6. Laws, Policies, and Strategies in Wetland Management in Rwanda

2.6.1. Laws

The country's wetlands are protected by Law n°48/2018 of 13/08/2018 on Environment. The Organic Law prohibits a range of activities in the country's wetlands including to pile soil and any other materials in wetlands; to compact or change the nature of the wetland; to build in the swamp and in the buffer zone in a distance of twenty metres (20 m) away from the swamp boundaries; to drain the swamps without prior authorization of the competent authority; to carry out any activity, except that related to research and science in reserved swamps; to introduce plants or animal species whether alien or indigenous into wetlands without prior authorization of the competent authority (GoR, 2018b).

Since 2006, wetlands of Rwanda were protected under the Organic Law N° 04/2005 determining the modalities of protection, conservation and promotion of the environment. Its stipulations are

consistent with those of the Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention). Rwanda ratified the Ramsar Convention in 2003 and it came into force in the country in April 2006. The Organic Law prohibits a range of activities in the country's wetlands including construction of buildings, sewage plants, dumping of untreated waste water and hazardous waste and creates a 20 meters construction-free buffer zone around all swamps. It also stipulates that the use of wetlands shall be preceded by environmental impact assessments (EIAs) (REMA, 2011).

2.6.2. Policies

Rwanda is a developing country with little human capacity especially in terms of wetlands management. However, with the help of international environmental agencies, GoR has realized the potential of wetlands, which has led to the development of a wetlands draft policy. The draft policy is known as "National policy for wetlands conservation and management" (Government of Rwanda, 2003). This is the first wetland policy in the history of Rwanda after the 1994 genocide. The general objective of the policy is to "promote conservation and sustainable management of Rwandan wetlands in order to maintain their ecological functions and uses for the welfare of the present and future generations" (REMA, 2011).

According to the same source, the following are the ministries and institutions responsible for wetlands management implementation as mentioned in the draft policy. The Ministry of Land, Environment, Forestry, Water and Mines (MINITERE), Ministry of Agriculture and Animal Forestry (MINAGRI), Ministry of Infrastructure (MINIFRA), Ministry of Local Administration, Information and Social Affairs (MINALOC), Ministry of Education, Science, Technology and Scientific Research (MINEDUC), Ministry of Commerce, Industry, Investment promotions and Cooperatives (MINICOM), Decentralized Administrative structures for example the districts of Kigali City (MVK) that is Gasabo, Nyarugege and Kicukiro districts and the Rwanda Environment Management Authority (REMA).

2.6.3. Strategies

In 2002, the Ministry of Agriculture (MINAGRI) developed a master plan for wetland development, soil conservation and watershed protection funded by the African Development Bank (ADB) (MINAGRI, 2002). This scheme led to wetland classification in accordance with

their hydrological aspects, their level of degradation and recommended the conservation of highland wetlands as integral part in water resources management. In May 2003, MINITERRE recommended a study on the assessment of biological diversity of wetlands. This study came up with a classification of wetlands of international importance classified as Ramsar sites. It recommended that those sites should be under conservation by implementation of an ecosystem approach (Nabahungu and Visser, 2013).

Though not a policy as such, the wetland convention implementation office in Rwanda has formulated a "National Wetland Conservation Program for 2002, 2030" jointly working with the National Commission for Development and Reform, MINICOFIN, MINEDUC, MINITERE and MINAGRI. The program aims at engaging the various government ministries in wetland conservation and ensure a holistic approach to wetland management (REMA, 2011). All authorities concerned will have proper coordination of activities concerning wetland management, a factor that leads to efficiency implementation of policies. To avoid further exploitation of the resources, Rwandan Government has established rules governing wetlands in the country. This is done by subjecting any acts concerned with water and its resources like watering plants, the use of swamps to prior environmental impact assessment, which is submitted for approved to REMA or any person given a written authorization by REMA (Tsinda, 2011).

After the law determining the use and management of marshlands in Rwanda, wetlands are publically owned, whereas the uplands are privately owned (REMA, 2009c). To cultivate wetlands, farmers have to obtain authorization from the district authorities. If they do not follow the cultivation protocol from the local government, they may forfeit their rights to cultivation. However, the farming system and the level of organization of the farmers cultivating the wetlands differ, depending on the degree of reclamation and the size of wetland. Wetlands reclaimed by the public services or as part of agricultural projects have higher reclamation costs, partly because of the construction of required water storage, distribution, irrigation and drainage facilities (MINAGRI, 2002). Farmers can cultivate in reclaimed wetlands under the condition that they implement the agriculture policy that consists of regionalization and intensification of crop production (GoR, 2005). The crops and the cropping systems are selected by the district or by the management committee. The small and unofficial reclaimed and traditional farmed

wetlands are managed either by individuals or by families, and each farmer chooses which crops to plant. In cultivation and sowing periods, when high labour demand is observed, informal groups are formed in which farmers help each other in agriculture-related activities. Official reclaimed wetlands are intensively used for single crop production, following government policy (Nabahungu and Visser, 2013).

Chapter 3. Research Methodology

The methodology shows how the study is conducted in a particular field. Methodology is also a set of practices. This term may be used to refer to practices which are widely used across a scientific discipline, the techniques used in a particular research study, or the techniques used to accomplish a particular project (Mabaso, 2014). According to Saunders, Lewis and Thornhill (2003) research methodology refers to the method by which data is gathered for a research project. Cooper and Schindler (2006) emphasize that it is of great importance that a scientific method be followed in carrying out a research study.

1.5. Study Area Description

This study focused on Bahimba Wetland located in Rulindo District in highlands of Rwanda. Rulindo District is one of the five Districts that make up the Northern Province. The district is strategically located as the link to Rwanda's most touristic destinations of virunga in Musanze, Nyabihu, Ruhondo Beach in Burera and the Lake Kivu in Rubavu district as well as close to the country's capital city, Kigali. The District has 17 administrative Sectors, 71 Cells and 494 Villages (imidugudu) with an estimated total population of 288,452 of which 136,058 are males while 152,394 are females according to the provisional population census results of 2012. The surface area is estimated at 567 km2 and as per the 2012. This implies a population density of 509 per km2 with the average annual growth rate within the last ten years (2002-2012) being 1.4% (RDDP, 2013).

Rulindo District is mostly characterized by hills including Tare, Tumba and the Cyungo hills with their altitude rising to 2,438 m. These hills are interspersed by valleys and swamps that also border rivers such as Nyabarongo, Muyanza and Nyabugogo. The valleys and swamps such as Rugezi feeds lake Burera and in turn supplies the fall of Ntaruka in Burera district which is a source of hydro energy for the country. This interweaving of hills and valleys with rivers provides a beautiful and eye catching scenery to both citizens and visitors (RDDP, 2013)

According to the same source, Rulindo District has significant water reservoirs from local sources including rivers that have a steady flow into valleys that enables the district to have water even during the dry seasons. The main rivers that flow into the district are Base, Bahimba, Mulindi Cyonyonyo, Cyohoha, and Rukeri Muyanza. Rulindo District has a tropical climate, characterized by a succession of rainy seasons and droughts. The dry season usually extends from June to August and January to February while the rainy season normally stretches from September to December and March to May. The average annual temperature is 19 ° C. High temperatures are observed in August where they reach 28 ° C in the middle of the day. During the rainy seasons, the district encounters concentrations of mists in the valleys in the morning and on the hilltops in the late morning. Rainfall normally reaches 1,243.3 mm per year on average (RDDP, 2013). Bahimba marshland consists of 327.5 hectares and is used for maize, Irish potatoes and vegetable farming (Kathiresan, 2011). The wetland borders Bahimba River and lies between Tumba and Mbogo sectors as illustrated in the figure 1 below and these two sectors were the priority during the study.

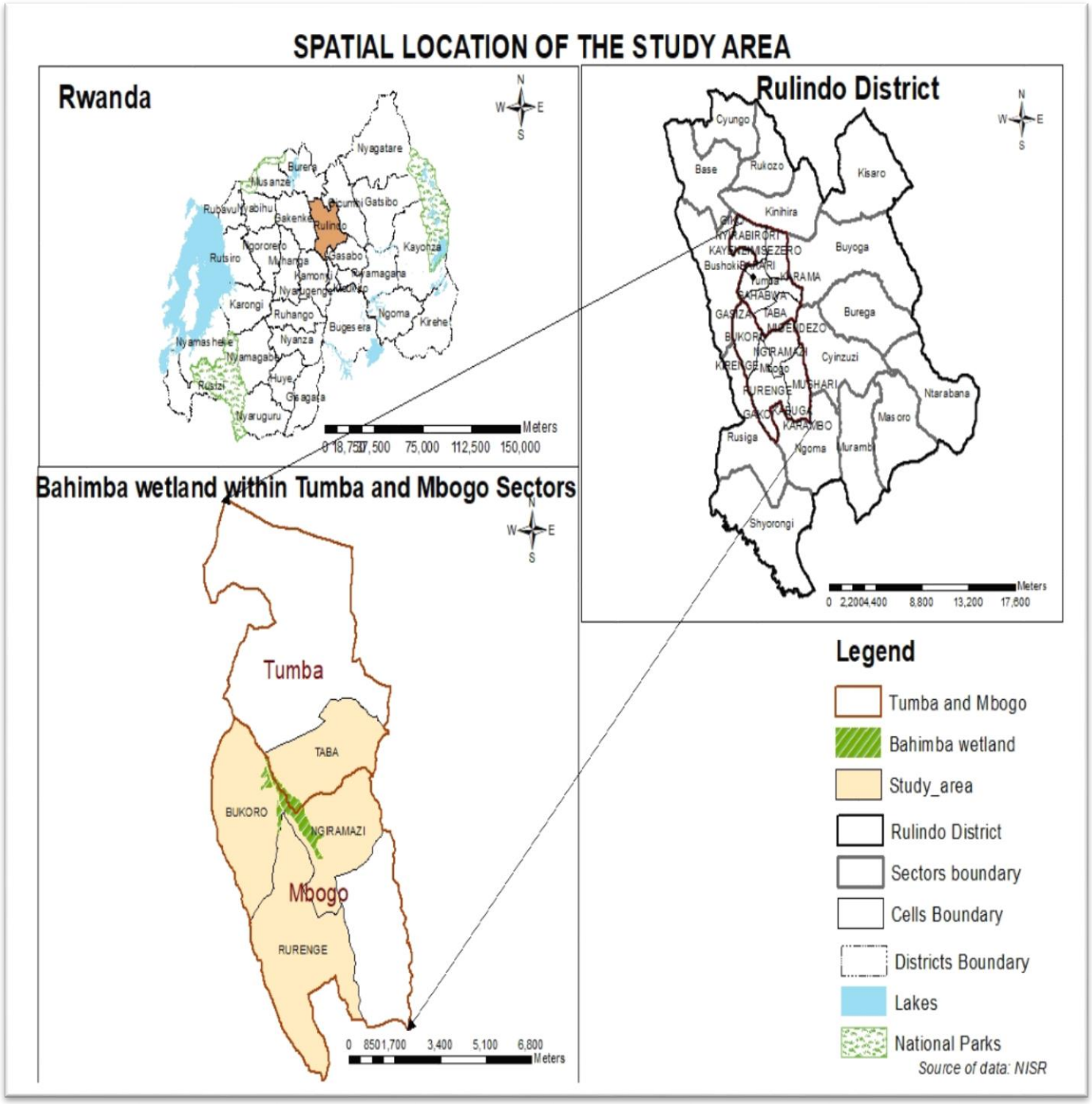

Figure 2: Map of the Study Area (Author, 2018)

1.5. Data Collection Methods

In order to achieve the research objectives, different data were used. Those data have been collected using different methods such as secondary and primary methods of data acquisition.

1.5.1. Secondary Data

Aaker, Kumar and Day (2006) define secondary data as data that is readily available, because it was collected for some other purpose other than the problem at hand. This study made use of books and internet sources (Mabaso, 2014). For this study, secondary data were collected through conducting literature review of various published books, reports and scientific papers from libraries and internet. Those data were collected in order to understand the linkage between wetland management, wetland agriculture and poverty alleviation.

a. Existing Literature

The literature review is an integral part of the entire research process and makes a valuable contribution to almost every operational step. All published and unpublished documents from Government and academic institutions such as books, papers, academic products (Dissertations, MSc and PhD theses) and reports have been consulted during this research.

b. Existing Spatial Data

Spatial data were collected from the National Institute of Statistics of Rwanda (NISR). These data are administrative entities (District, Sectors) boundaries, hydrological data such as rivers, Lakes, Parks and wetlands data that were used to produce the map of the study area.

1.5.2. Primary Data

According to Dawson (2008), primary data are data which are collected for the first time. For this study, those data were collected through field observation, key informants' interviews and questionnaires (household surveys). Primary data were collected from farmers practicing farming in Bahimba wetland. The collected information is based on socio - economic characteristics of the respondents, the evolution of agriculture production, main crops grown in Bahimba wetland (crops grown in dry and wet seasons), and economic importance of Bahimba wetland agriculture production to the household income and food security and the factors that influence wetland

agriculture in Bahimba. The questionnaire was administered on individual household basis. Farmer interviews took place in the farmers own homesteads to facilitate observation by the researcher and build rapport with the farmers. However, some interviews took place in farmers' fields where they were cultivating. The head of the household either the husband or the wife participated in responding to the questions. Food availability for consumption as an indicator of food security was used to assess food security at the household level. The following indicators were used to assess the level of poverty at household level, and these are type of income, household size and total monthly income as these have an influence on agriculture.

a. Field Observation

According to (Bailey 1987), observation is "a primary technique for collecting data and usually involves sight or visual data collection, touch, smell and hearing". Field observations by the researcher are very important because they help the researcher to compare the information given by respondents and the actual situation in field. In this research, direct observation on wetland use patterns with field notes and pictures were used to complement the questionnaire.

b. Household Questionnaire Survey

According to (Mabaso, 2014) a questionnaire is a document consisting of a set questions and scales to gather primary data. Household questionnaire was mainly used to get the opinions of local farmers practicing farming in Bahimba wetland about its role in terms of agriculture production using the list of questions where the researcher asked questions to the local farmers and wrote down the answers. This study used questionnaires as the research instrument for data collection.

i. Population of the Study

Population is "a set of elements that the research focuses upon which the results obtained by testing the sample should be generalized". A study population can also be defined as "the group that a researcher has in mind from whom he or she can obtain information". Thus, a population can be said to be the group from which information can be obtained and to which the results of the study are intended to apply (Kothari, 2004). The target population for this research included the total of 3200 local farmers in Rulindo district practicising agriculture in Bahimba wetland,

while the study population comprised all the local farmers in Bahimba wetland from the two sectors Tumba and Mbogo taking into account the cells adjoining the wetland.

i. Sample Size

Sampling is the process of selecting units (e.g., people, organizations) from a population of interest so that by studying the sample we may fairly generalize our results back to the population from which they were chosen (Trochim, 2006). For this research, a multi-stage sampling procedure was used. The population of interest comprised all farmers in Bahimba wetland within Rulindo district. In the first stage, 2 sectors were purposively selected from the 17 according to their geographical location. In the second stage, to avoid taking a sample from cells that are very far away from the wetland, only riparian cells from these 2 sectors were considered and these are 4 cells. Then from those cells, the probability proportionate to size sampling was used to select a sample of 100. Javeau (2018) has established the following formula to help in sampling size calculations and using this formula the sample will be chosen in Mbogo and Tumba sectors. According to NISR (2012), the total number of population from Tumba and Mbogo sectors is 36,077 that was used as the study population.

Where n is the sample size; N is the universe or total study population within the study area and no is the constant calculated from the probability of two complementary events p and q, where

p=q=0.5 p+q=1 $n = \frac{N \times no}{N + no}$

Cochran (1963) has developed the equation which gives the value of **no** as follows:

Where **z** is the threshold of confidence which is estimated to be equal to 2 and **e** is the stroke of errors that is estimated to 10% or 0.10

$$no = \frac{z^2_x \, p \, x \, q}{0.10^2} \qquad n_o = \frac{2^2 \times 0.5 \times 0.5}{0.10^2}$$

Then according to the formula above;

$$n_o = 100$$

Hence, $n = \frac{N \times 100}{N + 100}$

$n = \frac{36079 \times 100}{36079 + 100} = 97 \approx 100$

ii. Questionnaire Administration

The questionnaire was completed by the researcher herself. This reflects the face-to-face completion model of questionnaire administration where, the researcher asks questions and subsequently records answer him/herself. The first section of the questionnaire was designed for local farmers from Taba Cell of Tumba sector, Bukoro, Ngiramazi and Rurenge cells of Mbogo sector.

a. Interviews

The interview guide was designed to lead the interviews with key informants who are knowledgeable on wetland and upland agricultural activity mainly local leaders and authorities in charge of agriculture and environmental management at Sector and District levels. The questionnaire was composed of semi-closed and open-ended questions. Interviews were to complement data collected from the questionnaire survey. Three people in charge of Agriculture were interviewed namely one person at district level, Rulindo district and two persons at sector level; one from Mbogo sector and the second from Tumba sector.

3.3. Data Analysis and Interpretation

The information collected was organized through compilation and editing in order to be analyzed and compared among them depending on their quality and relevance to the study's objectives. The objective of this section is to indicate how the collected data was analyzed by the researcher. According to Tustin et al (2005) the first step in analyzing data from completed questionnaire is known as data preparation and involves three operations: editing, coding and data capturing. Once data has been captured and coded, the data analysis process can start (Mabaso, 2014). Data analysis usually involves the reduction of accumulated data to a manageable size, developing summaries, looking for patterns and applying statistical techniques. According to Cooper & Schindler (2003), data analysis also includes the interpretation of research findings in the light of research questions, and determines whether the results are consistent with the research hypotheses and theories. The purpose of data analysis is to interpret and draw conclusions from the mass of collected data. Data analysis was done using the Statistical Package for Social Sciences (SPSS) for windows. All the information from questionnaires was coded in Ms Microsoft excel.

For quantitative data, the study used of graphs, tables and descriptive statistics to analyze them. Descriptive statistics was used in the analysis of personal and household information while graphs and tables were used to analyze other relevant information. Descriptive statistical analysis techniques including frequency and percentages were used to assess the agriculture production of Bahimba wetland (crops grown in the dry and wet seasons), agricultural utilization of wetlands in Bahimba wetland and to compare and correlate stakeholder views regarding the impacts of wetland agriculture on the local people's livelihoods. During data interpretation process photos were used to explain field evidence, tables, charts, and diagrams were used to handle statistical data. These tools have offered a useful means of presenting large amounts of detailed information

Chapter 4: Results and Discussion

As mentioned in the methodology, the household questionnaires, interviews and direct observations were used by the researcher in order to gather the information from key informants and local population around Bahimba wetland. In the current chapter, the researcher gives a detailed account of the main findings and their discussions. As far as the analysis of the data is concerned, the findings are presented and analyzed according to the order in which the questions were asked. In fact, this chapter deals with the presentation, analysis and interpretation of the responses from respondents. The tables and figures showing the frequencies of responses of particular questions were constructed; percentages of responses to particular questions were calculated. The displayed data in form of figures and tables are originated from field survey done in August 2018 by the researcher.

4.1. Socio-economic Characteristics of the Study Area

This section will discuss about the main socio-economic characteristics that were taken into consideration during the study. Firstly, it will discuss about gender, secondary will talk about household size. In addition, it will discuss about the main economic activities and finally will talk about land ownership (size of land and mode of land acquisition).

4.1.1. Gender Distribution

Gender relations are a major factor in respect to household activities with a connotation on household production and income. According to NISR (2018), in Rwanda women constitute 66 per cent of the agricultural work force. The gender distribution of the interviewed farmers in Bahimba wetland showed that females account for about 61% while male account for 39%. In addition, women are the more involved in the agriculture than men because the later are involved in the other income generating activities to support the agriculture in their households like mason, petty trade etc. It was observed that both male and female contribute to the family income and assuring food security through wetland agricultural activities.

4.1.2. Household Size

Family size is an important feature for determining the extent to which labour power is needed in food production and income and it reflects household's access to sufficient food, income and other basic needs. In Rwanda, more than half of all households (53 percent) contain three to five people (NISR, 2016). This was also revealed during the study that the majority (49.2%) of

households had about 4-5 persons per household followed by 2-3 persons (26.7%), 6-7 persons (21.7) and above 7 (2.5%). Yanda et al. (2005) reported that available labour influence wetland productivity. This imply that household with large family sizes are likely to have more labour force enough to utilize effectively wetland resources than small family sizes (Yusuph, 2016). This is again highlighted by MINAGRI, (2016) that in Rwanda, food secure households generally have a higher number of household members of working age (above 18 years) and households with a higher number of household members over the age of 18 years are generally wealthier than those with fewer adult household members.

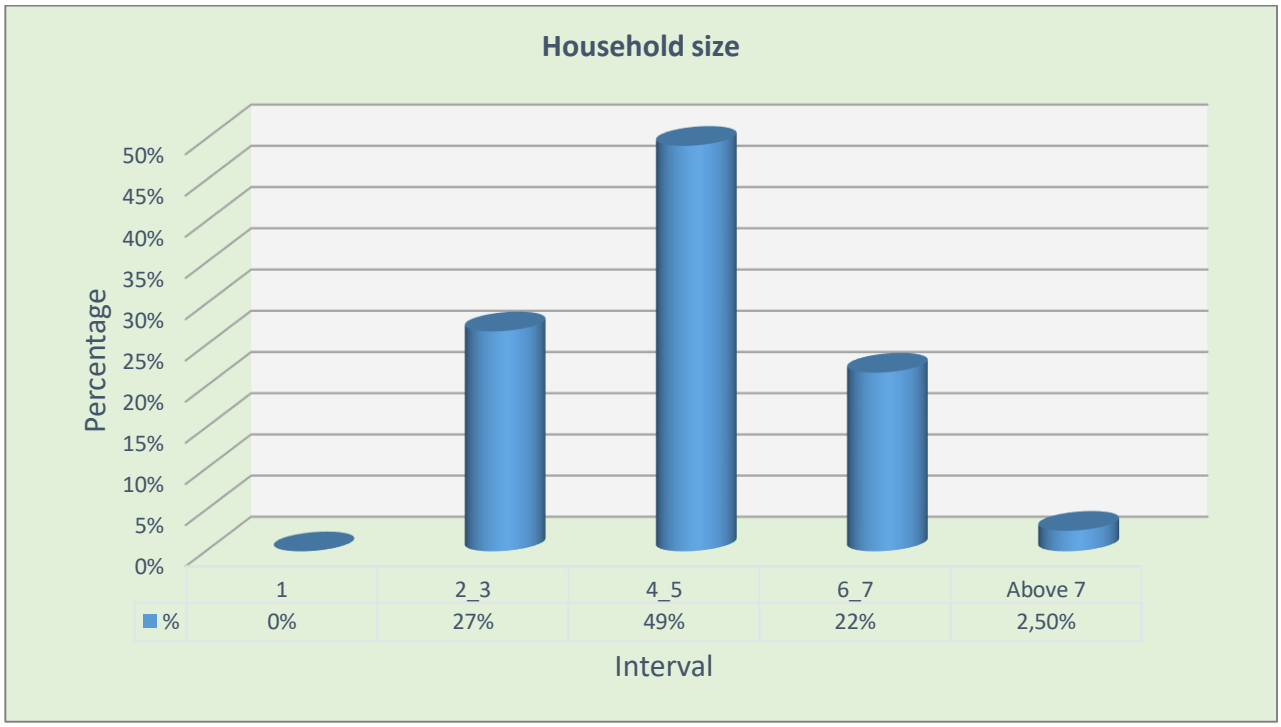

Figure 3: Household size of the respondents (Field Survey, August 2018)

4.1.3. Source of Income

Household income of household head is another factor that may affect farmer decisions to participate in agricultural activities. This is because the nature of employment a household head is engaged in is a source of income which could be channeled towards agricultural activities. Currently, the agricultural sector constitutes just over a third of the economy. It accounts for just under half of goods exports and provides employment for over two thirds of the working population. Hence, it remains the backbone for sustained economic growth, providing

livelihoods, and high standards of living for the population (GoR, 2018a). The interviewed households were asked about their main source of household income and the results are as shown in figure 4. Agriculture production is the main economic activity that takes place among the community practicing agriculture in Bahimba wetland (74.5%). Besides the agriculture activity, some people are implicated in other small activities in order to increase what they gain from agriculture such as mason assistance (13.2%), mason (7.3%), petty trade (3%) and casual work (2%) which supplement income from agriculture production. The diagram below illustrates the distribution of households according to main sources of income.

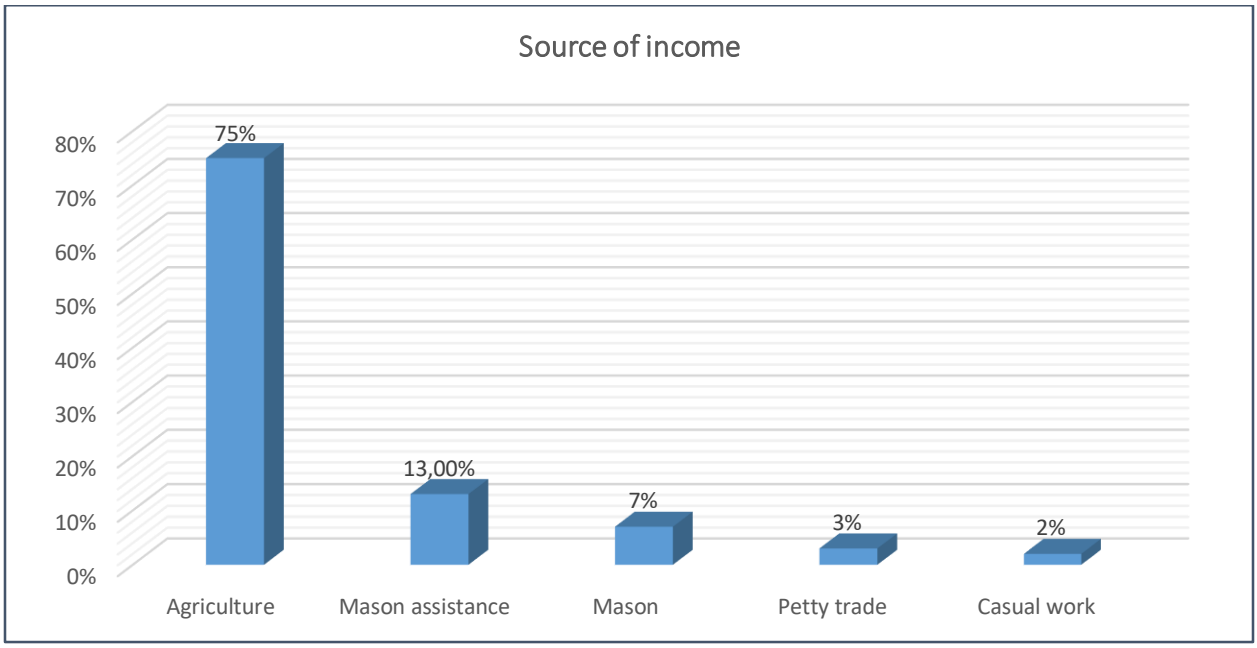

Figure 4: Household Source of Income among Local Farmers (Field Survey, August 2018)

4.1.4. Land Ownership

Land is vital for poverty reduction; most rural households rely on it for the survival of present and future generations (Amone & Lakwo, 2015). Ownership of the land is a very important aspect of development as it determines the availability of spaces where any specific development can take place. According to EICV3, One of the major inputs in agricultural production is land. From our discussions, majority of the respondents were the original natives of the area and could therefore be relied upon to provide useful information about land, land ownership and use of land

in the area. Findings show that 95% of the residents own the land and only 5% of the respondents do not own the land.

The findings show that 67% of the farmers acquired the land through inheritance and therefore have some cultural attachment to the land. The other 27% of household rent land, this means that they pay the land owner so that they can cultivate the plot. Only 5% of the residents bought the land. The implication of this is that people have the authority to be able to use their land for various socio-economic activities thus increasing the ability to sustain their lives. The land in the wetland is 100% rented as the wetland is managed by the district level. The table below gives a summary of how land was acquired by the respondents in the study area.

Table 2: Mode of Land Acquisition in the Study Area

Mode of land acquisition		
Land Acquisition Method	**Upland**	**Wetland**
Inherited	67%	0%
Rented	27.60%	100%
Purchase	5%	0%
	100%	100%

Source: Field Survey (August 2018)

All interviewed farmers have farmland in Bahimba wetland and in uplands thus undertake both wetland and upland cultivation. Upland cultivation only is done by a relatively low number. This shows that wetland cultivation is undertaken by a substantially high proportion of the population. The high proportion of wetlands utilization comes from the fact that the wetland is fertile and has adequate availability of water throughout the year which assures more yields. This is because both wetland and upland complement each other as an important source of livelihood.

The findings showed that the majority of farmers (98%) have plots of less than 1ha in upland areas as this is highlighted by MINAGRI (2012) that average land holding per farm household is 4 plots totaling 0.76 hectares, but 56.8% of households own less than half a hectare of land. Similar observations by Ali & Deininger (2015) that smallholder farming in Rwanda is

characterized by a mean of 0.37 ha (or a median of 0.17 ha) and a maximum of about 2 ha, small by global standards with most plots smaller than 0.25 ha. The figure 5 bellow shows that the 100% of farmers in Bahimba wetland have small portions of farms less than 1ha in wetland because of huge demand of these farmlands associated with their productivity.

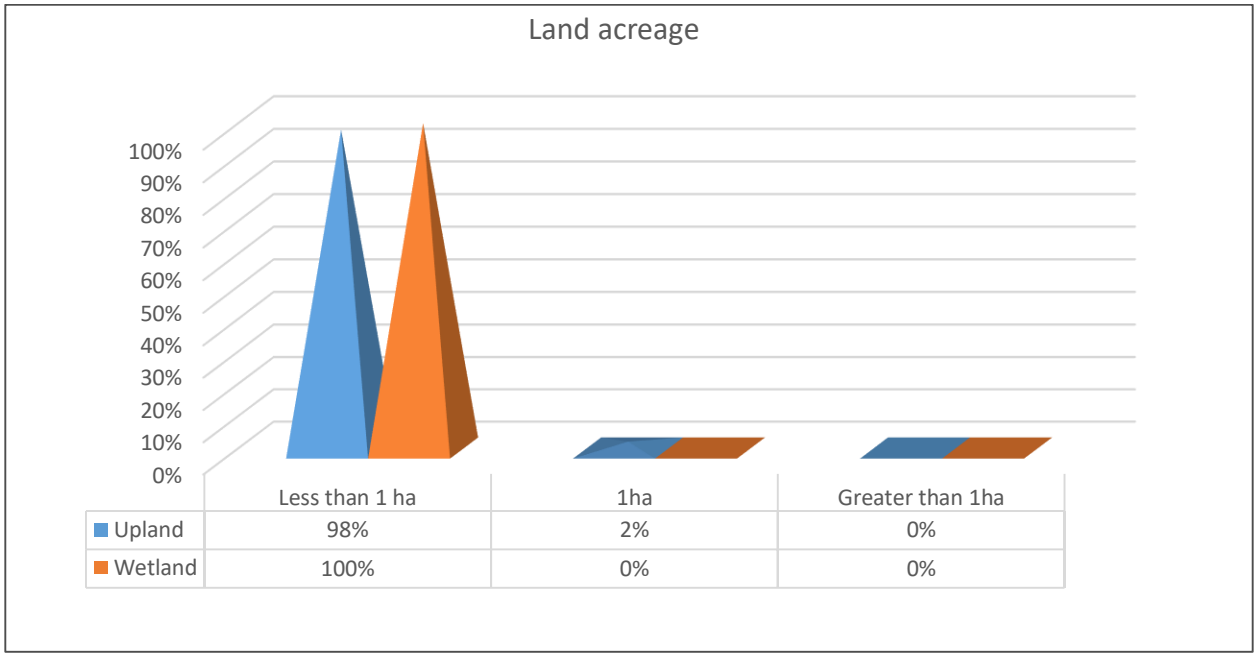

Figure 5: Size of Land owned by Local Farmers (Field Survey, August 2018)

4.2. Wetland Agriculture and Environmental Conservation

Given the land shortage in Rwanda, wetlands have been put under intensive cultivation for crops such as sugarcane, rice, flowers, sweet potatoes, and Eucalyptus. Other uses include conversion of wetlands into livestock grazing areas. This has however, been reduced due to the zero-grazing policy being enforced by Government. In addition, more than 50% of the wetlands have already been converted into agriculture to secure food for the growing country's population (WCS, 2019).

Furthermore, wetlands have been altered and or drained to support agricultural uses. Indirect impacts from agriculture pollutants can degrade and destroy wetlands. The loss and degradation of wetlands can result in a decline in important benefits that wetlands provide to society (REMA, 2010). Firstly, this section is going to present t wetland agriculture by taking into account crop

production in Bahimba wetland; secondary, it will present different factors affecting wetland crop productivity in Bahimba wetland and lastly, it will present environmental conservation by focusing on wetland conservation.

4.2.1. Crop Production in Bahimba Wetland

Wetlands are extremely harsh environments to which few species have adapted (hence the relative low diversity of plant species when compared to upland plant communities) as plants have three basic requirements: light, water and nutrients and they also need oxygen for respiration. Access to these resources is completely different during the alternating wet and dry periods in the life of a wetland. Obviously the degree of harshness decreases as one moves along the hydrological gradient from the wetter towards the drier end of the hydrological zones (Collins, 2005). For the period the survey was conducted (August), various types of crops were observed in the wetland. These were maize, sweet and Irish potatoes and cabbages. According to EICV3, 2015; Crop production constitutes the major part of agricultural production for the majority of Rwandese households, with households producing a wide diversity of crops. Nearly all cultivating households produce at least one staple crop and the majority also produce a range of fruit and vegetables.

According to Rwanda Agriculture Policy (GoR, 2018a), food crops is the dominant sub-sector taking up 58 per cent of the sector in terms of GDP contribution. Farmers in Bahimba wetland are organized under the cooperative called COVAMABA (Cooperative de Vulgarisation du Marais Bahimba) and the cooperative is composed of farmer groups where each group has to grow one different crop. Therefore, when you go around the wetland you perceive different crops grown by zone. The research further depicts that those farmers produce more than those who work individually because they receive much attention and support services from the government and other stakeholders. Two seasons were reported as very important in Bahimba wetland. The first is season A in which Maize crop is cultivated and the farming activities start from September to November and the harvest period is March to May, the second is season C which starts from June to October and the crops grown during this season are vegetables and Irish potatoes. Season B is not considerable as important in Bahimba wetland as it mainly meant for growing beans in upland farms.

Figure 6: Maize Production during the Season A in Bahimba Wetland (Credit: Author)

Figure 7: Crops Grown in Season C (Irish Potatoes and Cabbages) (Credit: Author)

The information obtained from field shows that various crops are grown in Bahimba wetland during the dry and wet seasons, implying that the wetland is being cultivated throughout the

year. Crops commonly grown include maize (40%), Irish potatoes (30%), beans (20%), and vegetables (Cabbage and Green pepper (10%) as ranked by the cooperative representative. These crops were leading because they are used for household food consumption and business purposes. Also, there were other crops, which were cultivated in small proportions such as sweet potatoes but are not among the main commonly known crops grown in Bahimba wetland. The type of crops the farmers grow and results are as shown in figure 8.

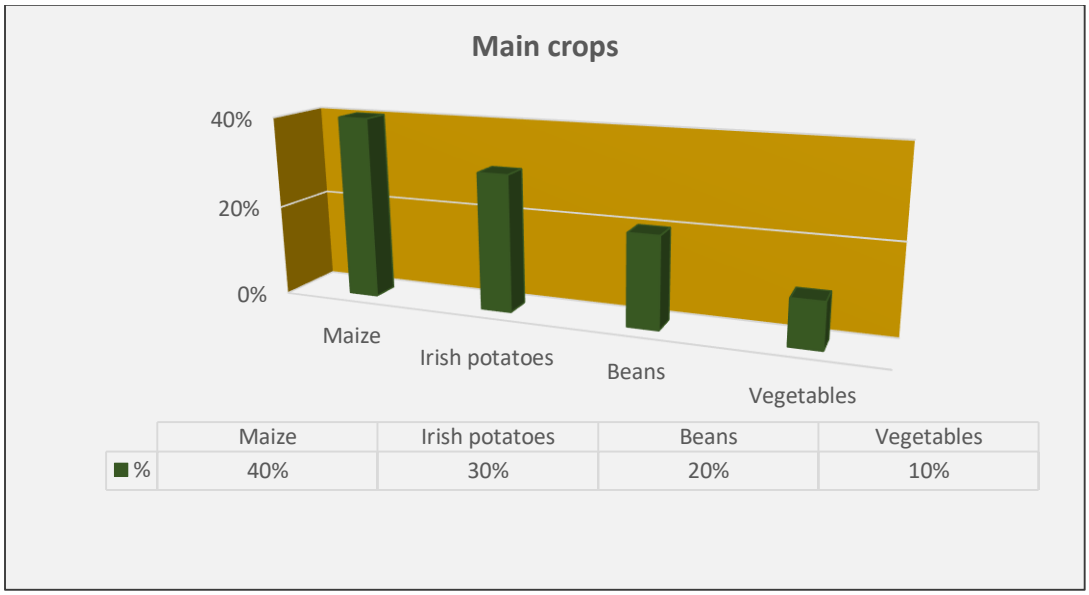

Figure 8: Main Crops in Bahimba Wetland (Field Survey, August 2018)

Furthermore, the crop productivity in Bahimba wetland depends on soil humidity, access to irrigation, use of fertilizers, crop protection and other factors. In addition, as mentioned earlier, family size plays a great role in terms of crop productivity as it is highlighted that available labour influence wetland productivity. This imply that household with large family sizes are likely to have more labour force enough to utilize effectively wetland resources than small family sizes (Yusuph, 2016) . Farmers has different size of farmland depending on one's ability to pay because they have to pay for plot they cultivate for the wetland is managed by the district as mentioned above.

A primary indicator of productivity is crop yields and their growth. In general, agricultural productivity in Bahimba wetland increased at a moderate rate between 2013 and 2017, although there are variations in the rate of growth in land and labor. Findings show that 95% of the

respondents own the land and only 5% of the respondents do not own the land. Differences in input use and capital intensities in agricultural production in the various farming systems also affect crop production. Crop productivity trends are presented in Figure 9 which displays the time series for crop production of some priority crops in Bahimba wetland, namely maize, Irish potatoes and beans over the period 2013-2017. Maize yields rise and then level off in 2014 while Irish potatoes and beans yields increase throughout the period. The use of improved seeds by farmers has contributed to higher yields, especially for maize.

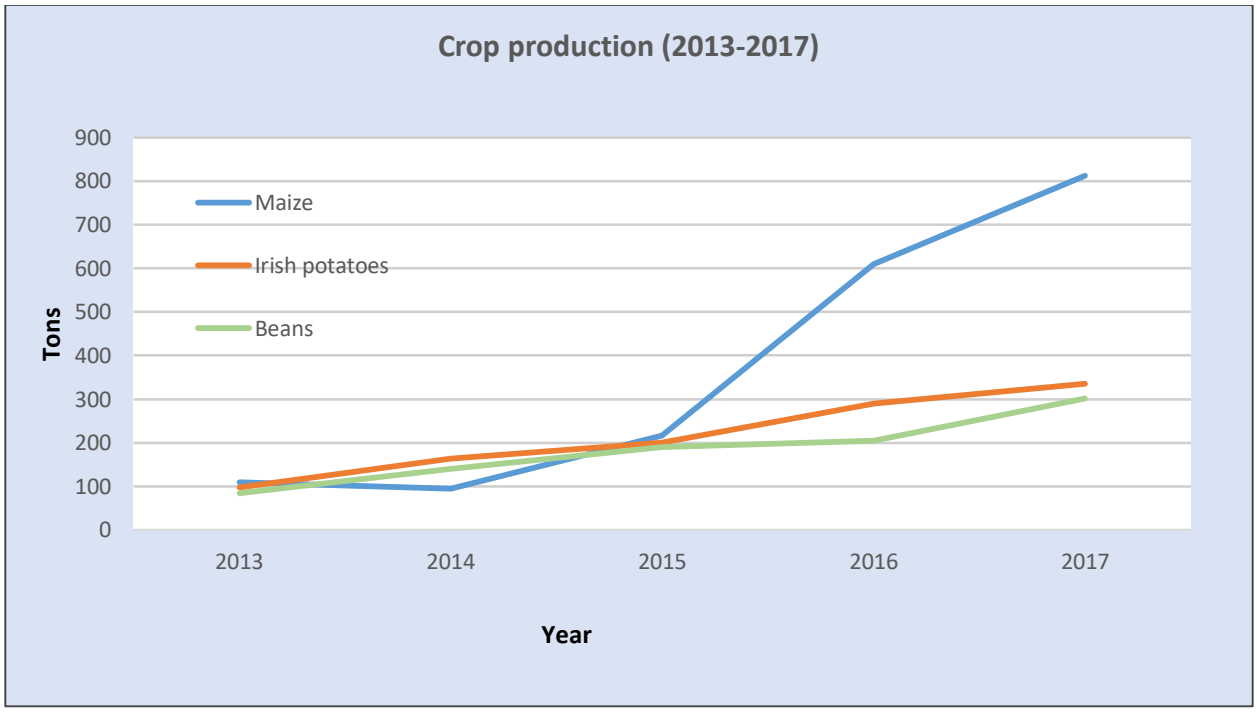

Figure 9: Trends of Crop Yields in Five Years in Bahimba wetland (2013-2017) (Field Survey, August 2018)

4.2.2. Factors Affecting Wetland Crop Productivity in Bahimba Wetland

Presently, all marshlands have been nationalized by the Rwandan government for development of the land (MINAGRI, 2012). A number of different factors can cause agricultural productivity to increase or decrease. It is important to note that productivity is not an absolute measure, but rather a reflection of the ratio between inputs and outputs. Moreover, agriculture crop productivity is a function of the usage of improved inputs such as seeds, fertilizers, water and

machineries (Kathiresan, 2011). During field survey local farmers in Bahimba wetland have mentioned the following as the main factors affecting their crop productivity.

4.2.2.1. Irrigation

Historically, irrigation has been an important agricultural technology with strong impact on crop productivity. On average, irrigated crop yields tend to be higher than those from un-irrigated land (Lascano and Sojka, 2007). Moreover, water is the most important use for agriculture which becomes impossible to start farming without water. According to Rwanda Irrigation Master plan (2010), Irrigation has long played a key role in feeding expanding populations and is undoubtedly destined to play a still greater role in the future. It not only raises the yields of crops, but also prolongs the effective crop-growing period in areas with dry seasons. This allows for multiple cropping (two, three and sometimes four crops per year) where previously only a single crop could be grown.

The security provided by irrigation is less risk of crop failure due to lack of water gives the farmers confidence to invest in additional inputs and activities that are needed to intensify production (pest control, fertilizers, improved seed varieties and better tillage methods) (GoR, 2010). Irrigated crop yields are frequently as much as 4 to 5 times greater than for the same crop without irrigation. All marshlands have become nationalized and the government is putting effort into its development. During dry season known as season C in Rwanda in which vegetables are the most cultivated in Bahimba wetland, the irrigation is practiced. Farmers use canal irrigation from Bahimba River. They work with water users group where they trace canals feeding water from the river into the wetland plots/ fields. In the plot located where the water can't reach through the canals, they use machines from cooperative to drive water from the river to the fields and they have to pay 50% to use machine as it comes from government support known as Nkunganire program.

Figure 10: Canal Irrigation in Bahimba Wetland (credit: Author)

4.2.2.2. Use of Fertilizers and Improved Seeds

Soil can't be forced to produce beyond capacity, although there are methods that can be used to improve production capacity, such as proper fertilizing to add nutrients to the soil so that it can support more crops. “Fertilizer” refers to any substance containing one or more recognized elements (s) that is used for plant nutrition and is designed for use in promoting plant growth (MINAGRI, 2014). The government of Rwanda (GoR) launched in 2008 a crop intensification program aiming at mobilizing farmers to adopt modern farming systems, including the use of improved varieties, fertilizers and pesticides (REMA, 2009).

The findings shows that Bahimba wetland has acidic soil as it was reported by farmers’ representative and to cope with that issue farmers use inorganic fertilizers in order to increase crop productivity. COVAMABA is agro-dealer itself and this implies that farmers get fertilizers and seeds from cooperative. Farmers get Maize and Vegetables seeds from cooperative as for the rest like Irish potatoes and Beans the farmers get them elsewhere. The commonly used fertilizers

are diamonium phosphat (DAP) and Urea for Maize, NPK for vegetables and Irish potatoes and only DAP for Beans. The use of inorganic fertilizers can be related to a high return on crop produce and thus a higher income level. According to MINAGRI (2014), the use of fertilizers and improved seeds have led to a national productivity increase of three and five fold for maize and wheat, respectively, and two fold for rice and Irish potatoes, contributing to improved food security and increased rural incomes. Fertilizer use increased from 4Kg/Ha in 2006 to 30Kg/Ha in 2013, while fertilizer availability increased from annual quantities of 8,000MT to 35,000MT.

4.2.2.3. Assistance from Extension Officers

Extension is a non-formal educational function that applies to any institution that disseminates information and advice with the intention of promoting knowledge, attitudes, skills and aspirations, although the term "extension" tends to be associated with agriculture and rural development. Various and distinct public sector agricultural extension reforms have occurred since the mid-1980s. It combines educational methodologies, communication and group techniques in promoting agricultural and rural development (Rivera, William Mcleod, 2003). Agricultural extension services have been instrumental in ensuring agriculturists stay abreast of new developments to improve their productivity and economic livelihoods (Mukembo & Edwards, 2016). In order to improve agricultural productivity as well as improving rural development, agricultural extension has a great role to play. For example, extension is the smallholder farmers' gateway to information on new farming technologies developed outside their narrow environments. Given the low level of literacy of smallholder farmers, the need for extension staff will continue in Africa for a long time (Msuya et al., 2017).

Referring to Rwanda Agriculture Policy (2018), Extension services are crucial for closing the gap between current productivity and potential productivity. An effective extension system disperses technologies and techniques to the farm-level that are tailor made to the realities on the ground. Extension officers play a huge role in assisting the farmers, members of cooperative to produce much because the government promote cooperatives as it easy to provide service such as trainings, workshops, financial support and other services. Farmers in Bahimba wetland receive support from cooperative extension officers and from sectors agriculture officers regarding the guidance and instructions about farming activities from field preparation, demonstration tests including use of fertilizers and pesticides depending on the crops, planting, harvesting,

production treatment, weighing and storage of the produce. The results in Figure 11 show that 22% of respondents indicated that extension officer's advice is very effective, while 78% indicated that extension officer's advice is effective to their farming activities and also in increasing their crop production.

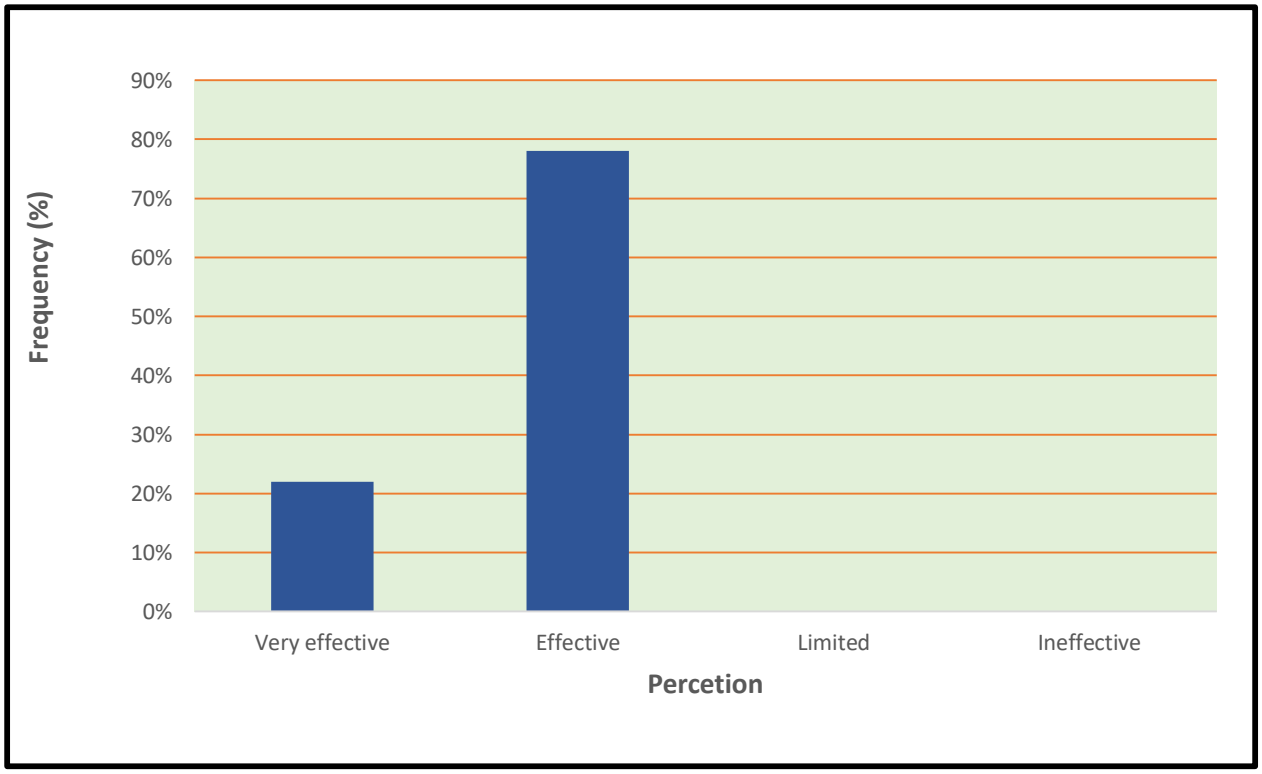

Figure 11: Efficiency of Extension Officer's Advice (Field Survey, August 2018)

The provision of agricultural extension is made to enhance farmers' knowledge and skills toward improved yield. The assistance plays great role in the improvement of farming activities. "*They help us with advices, how we use fertilizers about the appropriate quantity we may use so that our production should increase, they tell us about the crop we have to farm different to the previous. All of those advices help us in our farming activities because there are many things that we don't know as farmers*" said local farmer. During the survey, farmers were asked on whether they use extension services and their responses were analyzed as shown in the table 3 below.

Table 3 : Frequency of using extension officer's advise among local farmers.

Item	Frequency	%
Regularly	61	63
Quite often	30	31
Sometimes	6	6
Total	97	100

Source: Field Survey (August 2018)

4.2.2.4. Pests Control

Pest control implies a two-strand approach, which combines the use of technology (such as use of pesticides, and pesticide application equipment) with biological knowledge (informing where, when and how to apply the technology) to reduce pest impact (by killing the pest) (Dalip, 2016). Worldwide each year, despite the use of nearly 3 million tons of pesticides in the world, pests (insects, diseases, and weeds) destroy more than 40% of the potential world food production. (Pimentel, n.d.). Agricultural pest management control strategies are primarily concerned with food security and safety. Popular pest control methods include application of synthetic pesticides, biopesticides (plant extracts), non-chemical pest management and integrated pest management (IPM) (Eze & Echezona, 2012). The objective of managing pests and diseases in crop plantation is to keep them in a healthy and productive condition. Some initiatives to elaborate Integrated Pest management (IPM) strategies for the majority of pests of the priority crops in Rwanda, have been initiated by the Ministry of Agriculture (MINAGRI) and the Rwanda Environment Management Authority (REMA) (Rutikanga, 2016).

In addition to spoiling crops, pests can add significantly to the costs of producing a crop. During the survey, the most reported pest is known as “Nkongwa” which attacks Maize crops and cause damage to the maize grains hence the low production. There are other pests that attacks Cabbages and when farmers don’t use pesticides the crops are spoiled. Farmers know that they have to regularly splay pesticide once they notice the pests. "*I have to splay the pesticide at least three times a month on these cabbages otherwise I will harvest nothing*" said local farmer. To combat the pests and diseases, smallholder farmer needs appropriate pesticides that can reduce the impact on yields.

Figure 12: Local Farmer Spraying Pesticides on Cabbage Crops in Bahimba wetland (Credit: Author)

Farmers practicing agricultural activities in Bahimba wetland mentioned the main challenges that undermine their agricultural production including weather instability and the limited capital.

a. Weather variability: All interviewed farmers said that the main challenge that affect agricultural production is the weather variability. It was reported that during rainy season, the rain is highly abundant and Bahimba wetland experiences flooding and damage the planted crops which leads to the drainage of used fertilizers in the farmland. In the other side, during the dry season the sun is sizeable and the wetland experiences drought especially from May to August. These factors ruin crops and bring productivity down which leads to the reduced production cost that also adversely affects food security in the community

b. Soil Acidity: The constraints of sustainable agriculture can be partly attributed to continuous cropping, soil acidity and inadequate soil fertility management (Nduwumuremyi, Ruganzu, Mugwe, & Cyamweshi Rusanganwa, 2013). According to the same source, soil acidity is among the important environmental factors which can influence plant growth, and can seriously limit

crop production. Acid soils are defined as any soil that has a pH of less than 7.0 (neutral). Due to climate and geology, African soils can be relatively acidic and the vast majority of smallholder farmers in East Africa cultivate acidic soils (Nduwumuremyi et al., 2013). Soil acidification occurs because the concentration of hydrogen ions in the soil increases (Shreeja, 2017). Soil acidity negatively influences the availability and uptake of several essential nutrients and restricts root growth and access to water and nutrients, making land less productive.

In Rwanda, Soil acidity is covering about one third of arable soils (Nduwumuremyi et al., 2013). According to the government's state of environment report (2015), Soil acidity negatively influences the availability and uptake of several essential nutrients and restricts root growth and access to water and nutrients, making land less productive about three-quarters of Rwanda's soils are acidic, with a pH below 5.5 and a deficiency in nitrogen, or in phosphorus (GoR, 2018a). Soil acidity constitutes a threat to Bahimba wetland as it affects negatively crop production, consequently the use of much fertilizers without forgetting that adding fertilizers and pesticides (which may lead into the river system) further reduces the effectiveness of wetland in purifying water. Soils under long-term crop production become increasingly acid unless amended with acid-neutralizing agents such as lime. Soil acidity levels can be adequately monitored if representative soil samples are analyzed every four years (Wortman, Mamo, & Sharpiro, 2009).

c. Lack of Capital*:* capital is used by farmers to finance farming activities, such as buying production facilities/ inputs (seeds, fertilizers, and Pesticides), labor wages, and other operational costs. Some of local farmers in Bahimba wetland do not get inputs at time because of financial difficulties and this leads to the late farming which in turn leads to germination failure and reduced production.

d. Delay of inputs: During interview with famers, they said that sometimes they get inputs later compared to the time they started farming activities and that have impact on their crop production. "Sometimes the supplier delay to deliver us the fertilizers and seeds, and when that happens we can do nothing, we just wait for them until they deliver and that cause the late planting because of that delay. When they delay, farmer's activities also delay" said a cooperative representative.

4.2.3. Environmental Conservation

Unreliable rainfall has caused many farmers to resort to wetlands which have a steady water supply. Meaning that wetlands with freely flowing water are now under stress and destruction from agriculture and other productive activities (REMA, 2011). The destruction of wetlands do not only lead in a reduction in biodiversity and the endangerment of species which depend upon them, but also leads to a loss in social and economic benefits for the local people who depend on such wetlands and their biodiversity. There are many ways in which poorly managed agriculture can negatively impact wetlands. This can lead to changes in the ecological character of a wetland and the possible permanent loss of its benefits to people. Intensive agriculture activities often lead to increased loads of pollutants such as pesticides, fertilizers, antibiotics and disinfectants. Not only do these affect the ecological character of both inland and coastal wetlands, they also have impacts on human health and the quality of drinking water supplied from wetlands. Agricultural activities which can disturb wetland functions and ecosystem services include the drainage and conversion of wetlands to cultivated land or aquaculture; the introduction of invasive plant and animal species; the introduction of human and animal disease vectors; and the disturbance of breeding, migration and feeding patterns of wetland fauna. (RAMSAR, 2014).

The use of fertilizers and agricultural chemicals has polluted water; and agricultural activities and general mismanagement of the wetlands have further degraded and destroyed them. The Government is aggressively pursuing measures for soil erosion control. These measures include terracing, increasing soil cover and integrated management approaches such as agro-forestry and zero-grazing. There have been increases in the area under radical terracing. However, small scale farmers lack the capacity to respond to the control of soil erosion because the anti-erosion measures are expensive (Nabahungu, 2012).

The intensive agricultural policy is geared towards increasing the use of mineral and organic fertilizers, pesticides and selected seeds. As part of the strategy to reduce soil nutrient loss, the Government is currently subsidising fertilizers. However, since the misuse of agro-chemical products have harmful consequences on human and ecosystem health, the policy has to be accompanied with training on the control and management of the negative impact of agro-chemicals. Conservation of wetlands in vital particularly in protecting and promoting wetlands normal functions.

According to Uwiragiye (2016), the floods are more serious in Bahimba wetland due to unprotected watersheds and accidented relief that intensify run-offs during rainy seasons hence causing overflow of Bahimba wetland and floods in wetlands. The Bahimba wetland is surrounded by steep slope mountains watershed. The non-protection of Bahimba wetland and its watershed, contributes to a steady degradation of environment and biodiversity. There are some project about plantation of trees and make local people aware to the environmental issues, protect the 10 meters buffer zones along Bahimba river, planning maps production, implement the exploitation and use of peat from Bahimba wetland to reduce the tree energy domestic use.

4.2. Wetland Agriculture and Poverty Alleviation

Rwandan agriculture is primarily undertaken at the subsistence level, providing little surplus for local markets (GoR, 2010). In Rwanda, the productivity of the agricultural land on hillsides is no longer sufficient to provide food security for the majority of poor farmers due to (i) dramatic changes in farm size, currently on average less than one hectare, (ii) soil erosion processes and (iii) the limited use of fertilizer (Ansoms and MacKay, 2010). The response by Rwanda's farmers to these trends has been to expand their agricultural activities into fragile wetlands (Nabahungu and Visser, 2011). Changes or trends in agricultural productivity over time can shed light on the relative sources of agricultural growth as well as on resource and factor constraints to increasing agricultural production sustainably. Because improvements in agricultural productivity are important for reducing poverty and achieving other development objectives (Benin, 2016). This section is going to present the impact of wetland agriculture in poverty alleviation by focusing on its contribution to food availability and increase of income at HH level.

4.3.1. Improvement in Household Food Availability

Recent estimates suggest that wetland cultivation in East Africa provides between 10 to 40% of the annual food needs of the rural population. However, during food shortage periods, its contribution can rise to 100% in some areas (Schuijt, 2002; Rebelo et al., 2010). In the highly populated humid highlands and mid-hill areas, in particular, the dependence on wetlands for food security is larger than in the more sparsely populated lowland plains in the semi-arid zones (Dixon and Wood, 2003) cited in (Kamiri, 2014). The benefits of Bahimba wetland can be determined by considering the values accruing from agricultural crops cultivated in the wetland. For this study, the use of Bahimba wetland ensures food

supply throughout the year for majority of the adjacent communities. About 80 % of local farmers produces food from the wetland fields all the year round. It was reported that the months where households experience food shortage are September and October and during this times most of households depend on root crops especially sweet potatoes which were grown in the upland fields.

Figure 13: Harvested Irish Potatoes for Household Food Consumption in the Study Area (Credit: Author)

During data analysis, it was revealed that the majority of famers state that from the period they started farming in wetland, their household nutritional level has improved 84.5% (see Figure 14) compared to the time before stating farming in Bahimba. At the same time, only 15.4 % reported that there is no change in their nutritional status and none reported there was decline in nutrition among the interviewed farmers. Results findings have also shown indicated that the majority of the interviewed farmers (87.6 %) eat twice a day in their households and this is because they rely on food crops grown in Bahimba wetland the whole year; while the remaining farmers (12.4 %) eat only once a day.

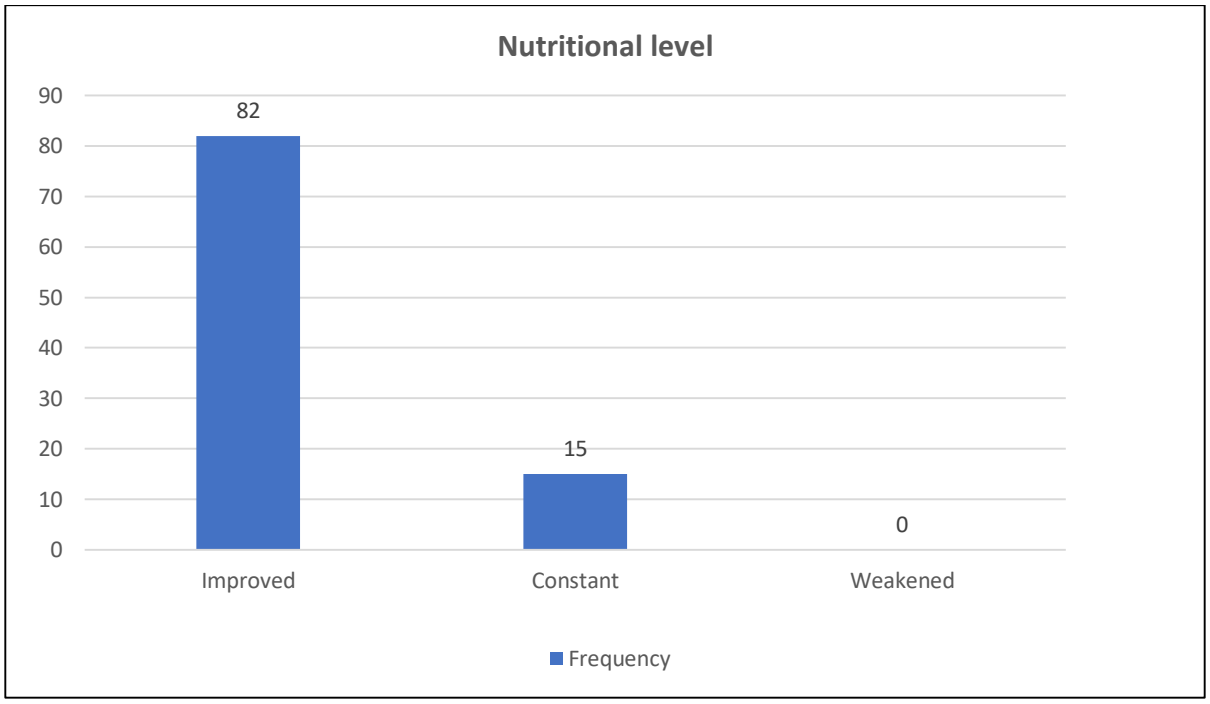

Figure 14: Status of Household Nutritional Level in the Study Area (Field Survey, August 2018)

4.3.2. Increase of Household Income

Wetland agriculture is often a major economic pursuit among rural communities; since they provide suitable cultivation conditions for a range of crops such as rice, maize and various vegetables (Nabahungu, 2012). Some rural households increasingly use wetlands to supply local markets with irrigated vegetables and other products which generate income. For these households, wetlands represent a development opportunity which can lead them out of poverty (Matthew et al., 2010a). Apart from food consumption, wetland agriculture production in Bahimba plays significant role in income generation among local farmers. The main crops are grown for market like Maize, Irish potatoes, Beans and Vegetables. Compared to upland agriculture production, income from wetland crop production is higher. During the interview with cooperative representative, it was reported that income from wetland agriculture lies between two hundred and three hundred Frw per year (200,000-300,000 Frw) per HH while income from upland agriculture lies between eighty hundred and one hundred and fifty Rwandan francs per year (80,000-150,000 Frw). The reasons behind such differences could be explained

by the fact that most respondents invest more in wetland than upland because of availability of more fertile soil and adequate water in the wetland.

The 80% of total wetland crop production is for market while the remaining 20% is for household consumption and this is applicable to all main crops grown in Bahimba wetland. Local farmers get income from the sale of their farm produce. The farmers supply the first quality of maize produced to the "Shisha Kibondo Factory" with which the cooperative has a sale contract. The rest is `supplied to the local markets the same to the other crops. It was reported that vegetables produce gives farmers' high income because its price is not changing compared to other crops and the market for vegetables is available. The other reason is that for other crops most of the time they are harvested at the same time as in the other parts of the country and that leads to the decrease of the price, contrary to the vegetables prices that are not changing. Although the maize is ranked as the first crop to be cultivated in this wetland, their income to local farmers is not high compared to the costs of input and efforts made and the price at which the production is sold. From the income gotten from their wetland farm produce, local farmers are able to afford the basics of life and pay bills like medical care and school fees. They now save part of the earnings with local savings as they have the saving and credit schemes.

4.2. Major Challenges Related to Wetland Management and Proposed Solutions

4.2.3. Major Challenges

Enormous pressure, over the recent years, has been exerted on the water and wetlands resources through various emerging and increasing uses driven by the growing population. Some of these threats include agricultural intensification, pollution, invasive species, overuse and an inadequate institutional framework to manage the wetlands. Some of these threats, in the case of water, have affected both the quantity and quality of water available. Climate change is also contributing to degradation of swamps. With decreasing amounts of rainfall, the hydrological regime of wetlands is being threatened. Besides, cultivation of swampland affects their chemical, physical and hydrological nature. The use of chemical fertilizers, fungicides and insecticides has modified the chemical composition of these hydrologicaly-connected water resources. Research findings have shown that 47% of respondents indicated that flooding is a major challenge, 35% indicated

that soil infertility is the main challenge to this wetland, while 18% reported soil erosion as the key challenge. The above-mentioned challenges affect the wetland as well as their agricultural production. However, the fundamental challenges from which other are derived are well explained in the following paragraphs

4.2.3.1.Lack of Proper Watershed Management

Watersheds are complex systems where water, soil, geology, flora, fauna, and human natural resource use practices interact. Hence, watershed degradation has environmental and socioeconomic effects far beyond the more obvious on-site and downstream impacts. For the same reasons, watershed management interventions may bring local, regional, and global environmental benefits (Darghouth et al., 2008). Watershed Management refers to a set of actions taken in a given geographic area by taking into account human, natural and ecological factors surrounding a water body to achieve desired social economic objectives (MINIRENA, 2011a). The main challenge facing Bahimba wetland is the lack of proper watershed management and this is most evidenced in seasonal flooding and soil erosion. The floods in Bahimba wetland is due to unprotected watersheds and accidental relief that intensify run-offs during rainy seasons hence causing overflow of Bahimba wetland and floods in the wetland.

Figure 15: Flooding Phenomenon in Bahimba Wetland (Credit: Uwiragiye)

Soil erosion on hills, in particular, is one of the most serious problems in Rwandan agriculture. Since most hillside land has already been developed as crop land, soil is easily eroded by rain,

which causes very poor land fertility (MINAGRI, 2012). Soil erosion is caused by inadequate of measures to control it on the hills surrounding Bahimba wetland and this affect quality of water as well as destroying the wetland due to residue driven from the fields and reach into the river. During the interview with District Agriculture Officer, he said that erosion is strongly influenced by activities in the surrounding catchment, mainly from the upland agriculture and other activities. In addition, farmers apply agrochemicals in Bahimba wetland farming in order to increase yields. Therefore, the cropland is subjected to soil erosion and pollution (due to pesticides) into watercourse (Bahimba River).

4.2.3.2.Inadequate Institutional Framework for Wetlands Management

Wetlands are dynamic and complex ecosystems. They keep on changing in shape and size as water balances change. In addition, Wetlands move, expand and contract with seasons and intensity, which makes them difficult to manage in a sustainable way (Keddy et al., 2009). Relevant technical know-how is very crucial in planning how to manage natural resources. Unfortunately, such knowledge is lacking in most of the African countries (Kangalawe and Liwenga, 2005). Increased awareness about the adverse environmental and socio-economic consequences of the unwise exploitation of wetlands has resulted in worldwide calls for the sustainable management of fragile resources. However, the sustainable use of wetland resources has increasingly proven to be an extremely difficult and frustrating task in many developing countries.

Wetland management has not been successful in many developing countries that prefer socio-economic development over wetland conservation. This is due to the fact that communities have little knowledge about the value and benefits wetlands provide (Mbabazi, 2010). The level of awareness of the environmental effect of agriculture measured by the scale of 'knowledge' is low among farmers. Experience has demonstrated that initiatives aimed at wetland conservation and management must be recognized as a long term process that aims at building a strong knowledge base. Capacity for wetlands management must be built at all levels to address institutional sustainability, ownership, user rights and access. The wetlands Management Department is the lead agency on wetlands in the country. In addition to addressing mounting pressures on wetlands, it is also mandated to develop the capacity of its stakeholders in wetlands management, such as the districts to effectively manage wetlands issues at the local levels. However, the

resources available to the Department are inadequate, including human resources. Despite having an institutional framework for wetland management together with policies and legislations, the rate of wetland degradation is still high and a challenge. This cannot be attributed to one single aspect, but interplay of political, economic, social and other factors. Currently, there are considerable weaknesses in the institutional set-up for wetlands management, particularly at the district level and poor facilitation has hampered the implementation.

According to REMA (2010), although wetlands management is prioritized in some Districts Development Plans, distances along river shores of respectively 10 metres for crops and 20 metres for housing are not always respected. Around some marshlands, buffer zones of 50 metres have been delineated and agro-forestry species have been planted, still annual crops often continue to be planted between trees and even between the wooded strips and in the marshlands and the buffer zones cannot serve their purpose of erosion control and protection against flooding.

4.2.3.3.Over-Exploitation of Wetland Resources

The over-exploitation of plant and animal biodiversity in wetlands is also an issue impacting negatively on the services of the swamps. The reduction of vegetation cover leads to evaporation of water by direct radiation, a reduction of the function of sediments retention and flood control, a gradual erosion of biodiversity. The predominant anarchic development of marshlands and wetlands has led to environmental crisis that the country is facing. The factual effect of such crisis on water resources management is the disturbance of hydrological table, the lowering of water level in the lakes, erosion and sedimentation (Hategekimana & Twarabamenye, 2007).

The principal threats to wetlands of Rwanda are linked to the agricultural (mainly rice) and livestock activities, mining activities, human settlements, exploitation of clay and sand quarries. Agricultural pressure is particularly important since most of the population depend on agriculture. There is pollution from sources such as domestic effluents, waste leachates, industries, agro-chemicals and storm water. The impacts are the harmful effects on the wetlands ecosystem observed as biodiversity loss and disturbance of the ecological functions of wetlands. The capacity of the wetlands to deliver services to the community is also greatly affected by the degradation (REMA, 2009).

Apart from an agricultural function, wetlands are used for many other functions. The use of wetland for hydropower generation and as mine for sand, gravel, clay and peat forms the most direct threat for the wetlands. According to Dixon and Wood (2003), multiple land use can both ensure the maintenance of the wetland hydrological functions and sustain production of a range of benefits such as dry season harvests, construction and thatching material and medicinal plants. The main threat in the multiple use of wetlands lies in the uncontrolled use, which may result in overexploitation (Nabahungu, 2012).

4.2.4. Proposed Solutions towards a Sustainable Management of Bahimba Wetland

Wetland management is the only practice that can mitigate wetland degradation in developed and developing countries. However, this does not preclude wetlands from being utilized; on the contrary, wetland management promotes the partial conversion of wetlands in order to meet economic needs of societies. A balance has to be struck between the environmental functioning of wetlands and their use for livelihood purposes thus promoting sustainable wetland management (Mbabazi, 2010).

Sustainable management of wetlands is critical to the livelihoods of many African communities. The protection of wetlands, however, reflects the protection of numerous goods and services that have an economic value not only to the local population living in their periphery but also to communities outside these wetland areas (Schuyt, 2005). One of the objectives of this study was to suggest the alternative solutions for the sustainable management and wise use of Bahimba wetland based on findings in the case study.

4.2.4.1.Effective Watersheds and Catchments Management

Hillside protection aims to prevent soil erosion due to inappropriate development of the area and to avoid flooding in the wetland. This may be based on measures to increase water retention and infiltration. The susceptibility of the wetland to erosion depends on several factors, including the erodibility (stability) of the soil, slope, and landform setting. Most of the water in a wetland originates from the catchment surrounding the wetland. Therefore, when assessing the impacts of off-site land uses on wetlands one needs to look at how the land-uses change the hydro period of the wetland and how this, in turn, affects the functioning and benefits of the wetland. Soil

conservation practices benefits wetlands as well as the farm. Using a watershed approach appears to be the best strategy for the management and rehabilitation of wetlands in Rwanda. Such an approach would be designed to (i) restore the protection benefits; (ii) limit negative effects on transboundary water resources; and (iii) conserve biodiversity in both natural and modified environments (Chemonics International Inc. 2003). One of the successful techniques to fight soil erosion on agricultural land is radical terracing, and agroforestry. The radical terracing involves the work of isolating the topsoil and re-working on the subsoil, in order to create the reverse-slope bench over which the topsoil is spread to sustain the agricultural practices. Moreover, the edges of this agricultural structure are planted with plants such as runner grass, for stabilization. This is a technique which can be easily adopted by smallholder farmers, as it can be done manually with hoes and shovels (WCS, 2019).

According to Glatzel et al. (2014), soil erosion can be a serious problem, especially on fields with steep slopes, but also on slightly sloping fields with coarse-textured top soil. Soil organic matter and nutrients are lost in eroded soil, which may substantially reduce the agronomic efficiency of applied inputs. Several measures can assist in controlling erosion, including planting of live barriers such as grass strips, construction of terraces and stone bunds or applying surface mulch. Hillside protection should be done using the following suggested measures:

- Upstream forestation and agro-forestry;
- River border protection with gabion walls and construction of storage ponds;
- Using effective contour bank alongside the wetland to manage run off concentration and provide protection against soil driven erosion;
- Best practice of upland tillage techniques;
- Soils analysis;

In addition, the construction and reparation of bridges across the wetland are among the suggested solutions to water resource management in Bahimba wetland. Furthermore, beside construction of terraces, a systematic programme of soil conservation needs to be implemented throughout the country. Soils are easily degraded and lost and good soils are the basis of successful agriculture. Soil erosion results in decreased soil depth and loss of plant nutrients and

therefore this strategy proposes soil protection and management programs at the watershed level which encompass both cultivated and uncultivated lands (MINAGRI, 2013).

4.2.4.2.Effective Framework for Wetland Resources Governance/Management

The government of Rwanda has established clear structures that support proper governance of these important ecosystems both at national, sub-national and local levels. Several national policy and legal documents were also developed and enacted and the country ratified a number of international agreements that are conducive to proper protection of wetlands. One of these international instruments is the Ramsar Convention which is an international treaty whose stated mission is to promote the conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world. Given this competitive uses of wetlands in a land-scarce environment such as Rwanda, the country has taken a pro-active step to classify its wetlands into different categories and allocate each class to a type of use that maximizes its benefit to the environment, economy, and communities. For the 'protected wetland' class, more measures were taken to further maximize their integrity through various restoration and protection interventions such as conducting required research, establishing buffer zones, conducting public awareness campaigns and, developing alternative livelihoods for adjacent communities (MINIRENA, 2011b).

4.2.4.3.Equitable Wetland Resources Use

The interests of different resource users need to be balanced to attain optimal and sustainable benefits. The user of wetland resources has to consider potential impacts on other users and ecosystem preservation. Management plans can ensure equitable utilization and conservation by defining rules and regulations.

The (Ramsar Convention, 1991) declared the wise use of wetlands to be ―their sustainable utilization for the benefit of humankind in a way compatible with the maintenance of the natural properties of the ecosystem. Thus the wise use of wetlands will serve human interests and at the same time conserve natural values. It involves conservation of the ecosystems while ensuring benefits amongst the local communities especially the weaker section of the society on long-term

basis. It also involves provision of maximum benefits to the people of the current generation who depend on these resources and at the same time keeping its potential for the future generations. The concept of wise use is closely related to the concept of sustainable development. The concept of wise use emphasizes on integration of economic, social and ecological dimensions in the management of resources (Jyoti P. & Hemant D., 2003).

Chapter 5. Conclusion and Recommendation

5.1. Conclusion

This research analyzed the linkage between Wetland Management, Agriculture Production and Poverty Alleviation in Rwanda, with a case study of Bahimba wetland in Rulindo district. All objectives of this research were attained in analyzing the current linkage between wetland management and agriculture production in Bahimba wetland; contribution of wetland production to livelihood options and food security among local farmers; identification of major challenges and proposition of sustainable solutions towards the wise use of Bahimba wetland for future generations.

Bahimba wetland agriculture contribute significantly to the welfare of the people farming in this wetland. Due to its productive soil and reliable moisture all the year round compared to the upland cropped land, Bahimba wetland has been found to be the most ideal resource for agricultural production and as such it is being cultivated in order to produce food crops to ensure food security and cash income to meet their daily requirements. The findings show that the linkage between wetland management and agriculture production can be seen through supporting the development of farming activities and the use of wetland resources management strategies as their purpose are not far different. A well-managed wetland can contribute highly on economic development and improve farmers' livelihood through agriculture. This is can be done by protecting hillside of the wetland through radical terracing and agroforestry and improving farming system. Nevertheless, engaging local farmers in managing and controlling the use of fertilizers and pesticides in a way that may not harm water resources play a significant role in terms of wetland management and agriculture development.

The results of this study also demonstrate the importance of wetland agriculture in alleviating poverty by improving the farmer's livelihood in terms of food security and income generation. This is explained by the fact that the majority of farmers 84.5% reported that their household nutritional level has improved since they start farming in Bahimba wetland and it was recorded that 87.6% eat twice per day in their household because the food is available thanks to the Bahimba wetland which is cultivated all the seasons.

In addition, the income in terms of money earned from wetland crop production is greater than what they earn from upland crop production as 80% of the wetland crop production is market oriented. Agricultural productivity in Bahimba wetland increased at a moderate rate between 2013 and 2017 and the use of improved seeds and following advices from extension officers by farmers has contributed to higher yields, especially for maize. Furthermore, cooperative members get the benefit in their saving groups which is an added value to them because it helps in different family needs.

Despite their benefits to the community, Bahimba wetland as other wetlands in Rwanda still face environmental issues. Flooding and soil erosion were among the reported main challenges in Bahimba wetland due to the lack of proper watershed management and the hillside protection through radical terracing and agroforestry was identified as the key solution to those challenges. Besides, soil acidity was scored the second challenge and measures for soil acidity minimization were proposed including liming. Moreover, overexploitation of wetland resources; inadequate institutional framework were identified as the source of many challenges. Therefore, there is need for a management strategy that accounts for both peoples' livelihoods balanced with conservation initiatives. This calls for an improvement of participatory management approach involving the local community, Government and other stakeholders. This approach will have to integrate the technical, socio-economic, environmental and legal aspects of the wetland resources management. Bahimba wetland supports a variety of livelihood activities, which are economically beneficial among the adjacent communities. Understanding the benefits from the wetland may encourage farmers in adhering to more sustainable practices in sustaining their livelihoods. This knowledge would also be useful in understanding the relationships between human activities and observed environmental changes.

5.2. Recommendations

According to Wood (2003), water and food security are not completely in conflict but have aims in terms of wetland management which overlap. These different aims can be achieved in part through supporting the development of multiple land use in wetlands, and the use of a catchment or landscape approach to resource management and livelihood planning. However, faced with increasing socio-economic, environmental and government policy pressures, there is a need to strengthen local communities and their capacity to address wetland management issues. This will

involve improved dissemination of existing local knowledge and traditional practices appropriate for sustainable wetland use, helping communities build on and develop that knowledge, especially linking to catchment management, and supporting the development of local community-level institutions which can help empower communities.

Based on the research findings, the following recommendations are formulated for the sustainable management and wise use of Bahimba wetland.

- Wise use activities for ensuring Bahimba wetland catchment management through promoting tree planting and upland cropping management to prevent disturbance to wetland.

- Good farm planning to minimize environmental problems that can be often more cost-effective than fixing problems once they have harmed Bahimba River. And this can be done through: i. mapping of the farm and neighboring areas; ii. Location of any sensitive environments, including water resources; iii. Analysis of soil characteristics and climatic factors and iv. Provides for effective management of ongoing risks and opportunities.

- Areas of current or potential land degradation should be identified such as salt affected, eroded and waterlogged areas induced by past land practices.

- The fertility of leached soils may be improved by the addition of treated manure or approved industrial processing by-products management of soil acidity in Bahimba wetland.

- Farmers in Bahimba wetland should assess the possible on and off site environmental impacts of their farm management practices and take all reasonable and practical steps to minimize detrimental effects.

- Farmers should ensure that all activities are in accordance with relevant Environmental Protection Act policies and use best practice management

- The Rwandan Government should inform farmers on the range of benefits that can be derived from Bahimba wetland and encourage farmers to adopt farming methods that conserve the wetland, that might offer an agreeable solution for the farmers to recognize the value of their wetland.

- Further studies on the linkage between wetland management and agriculture production are important.

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Appendices

Appendix 1. **Questionnaire for Household Survey**

I. **Identification**

1. Questionnaire number:
2. Sector:

II. Questions related to socio-economic aspects

Gender	1=Male			2=female	
Family size	1=1	2=2-3	3=4-5	4=6-7	5=Above 7

5. Do you possess the land in this region? 1=Yes ☐ 2= No ☐

6. How did you get your land?

- 1=By inheritance ☐
- 2=By rented ☐
- 3=Purchase ☐
- 4= Gift ☐
- 5=By Government ☐
- 6= other (specify)……

7. How many plots/fields do you have.....

8. What is the location (topographical) of your plots/ fields?

1= Wetland 2= Upland 3=both sides

9. What is the total size of your farmland? (Ha)

a) Wetland…… b) Upland……

10. What are your main sources of income?

1=Agriculture production	
2=Trade	
3=Handcraft	

4=Renting lands	
5=State agent	
6=Other (specify)	

III. Agricultural activities in Bahimba wetland

11. What are the main wetland crops do you produce?

Crops	**Main purpose of production**		
	Cash	HH food consumption	Both
Maize			
Irish potatoes			
Vegetables			
Beans			
Fruits			
Others (specify)			

12. How do you compare the agriculture production in 5 years?

Period	**Crop production (Kgs)**				
	Maize	Irish potatoes	Vegetables	Beans	Others
2013					
2014					
2015					
2016					
2017					

13. What are the factors affecting wetland crop productivity?

0.1 lack of capital

0.2 lack of appropriate water management

0.3 water logging

0.4 Prolonged drought

0.5 Other (specify)……...

14. How effective or adequate are the extension officer's advice?

Very effective	Effective	Limited	Ineffective
1	2	3	3

15. How often do you use the extension officer's advice?

Regularly	Quite often	Sometimes	Not at all
1	2	3	4

IV. The role of wetland agriculture in increasing livelihood options and reducing food insecurity

16. Where do you depend much on obtaining food for your livelihood?

1= Wetland 2= upland 3= both

17. How many times per day do you eat food?

1= 1-Once 2=2-Twice 3= 3-Three times 4=4-Other (Specify)

18. How do you compare the nutritional level before and after practicing farming in Bahimba wetland?

1= Improved 2= Constant 3= Weakened

19. Which months of the year you normally experience food shortage in your household?

20. What do you normally do to cope with the food shortage situation?

Coping strategies	
1=Sell assets and buy food	
2=Skipping meals	
3=Reduce food consumption	
4=Changing diet	
5=Support from relatives	
6=Food support from government	
7=Other (specify)	

21. How much cash income do you generate from agriculture production?

Agriculture			
Wetland Crop farming	Cash income	**Upland crop farming**	Cash income

	(Rwf)/ per year		(Rwf)/per year
Maize		Maize	
Vegetables		Vegetables	
Sweet potatoes		Sweet potatoes	
Tomatoes		Tomatoes	
Irish potatoes		Irish potatoes	
Other (Specify)		Other(Specify)	

V. Challenges related to agricultural activities in Bahimba wetland

22. What are the main challenges/problems in Bahimba wetland?

a. Erosion
b. Flooding
c. Soil infertility
d. Other (Specify)

23. What can you suggest on how this wetland can be conserved sustainably so that can continue to benefit you?

Appendix 2: INTERVIEW GUIDE TO LOCAL AUTHORITIES IN CHARGE OF WETLAND MANAGEMENT, SECTOR AND DISTRICT LEVELS.

1. What could be a reason for people to cultivate in Bahimba wetland?

……

2. What is the total annual average income per household from wetlands agriculture products……? (In Rwf)

i. From wetlands agriculture products……
……

ii. From uplands agriculture products……

3. Which season do people depend on wetland agricultural products for food consumption?

4. At which time (month) in the year do food shortages of any kind commonly occur?

……

5. What is the average size of wetland a household can hold in terms of?

0.1 Ha ……. 0.2 number of plots …….

6. What are the challenges to Bahimba wetland management?

……
……

7. What could be the solutions to those challenges?

……
……

!! THANK YOU FOR YOUR COOPERATION!!