ASSESSING THE IMPACTS OF REFUGEE SETTLEMENT ON WETLAND COVER CHANGES IN RHINO REFUGEE SETTLEMENT– ARUA DISTRICT, NORTHERN UGANDA

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A RESEARCH DISSERTATION SUBMITTED TO THE FACULTY OF ARTS AND SOCIAL SCIENCE IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF A DEGREE OF MASTER OF GEOGRAPHY OF KYAMBOGO UNVERSITY

MAY, 2021

DECLARATION

I hereby declare that this research work is my original work and has never been submitted to any institution for award and all sources quoted and referred to herein have been acknowledged in both text and references.

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APPROVAL

We hereby certify that this dissertation is an original piece of work organized by the student in the name of ISABIRYE AHMED and that the student closely consulted us during the process of his work. We therefore approve it for further steps.

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Second supervisor

DEDICATION

I dedicate this piece of work to my lovely mother Mrs. Namulondo Madina who provided me a foundation which is the basis of this work.

I also dedicate this work in loving memory of my sister Nabirye Faridah who mattered a lot in my education.

ACKNOWLEDGEMENT

Great honour and gratitude goes to the Almighty God for His great kindness and inspiration. I thank him for instilling in me the zeal to nature this work with care, endurance and dedication.

I am deeply grateful to my supervisor Dr. Barasa Bernard, for his ever-objective spirit, great love, competence, empathy and professionalism. Thank you so much for being constant in your enthusiasm to guide, inspire, encourage and support me all through this work. May the Almighty bless you and reward you abundantly on this earth and here after.

Much appreciation goes to my mother, Namudu Hadijja, father Kasira Siraji and my Aunt Babirye Zubeda who were my first teachers and role models.

I extend sincere gratitude to my young brother Nsadha Kadir and my sister in law, Babirye Hannah for their support during my struggle, thank you so much may God reward you abundantly.

Special thanks go to the family of late Dr. Musana of Kaliro road Iganga for the great support, prayers encouragement and resources.

Special thanks go to my lovely wife Mrs. Namuluta Zalika for standing with me during this long and sometimes arduous process. Thank you for your prayers, endurance and encouragement.

To my fellow students especially Joel, Alice, Alex and Mwiru, thank you for all that we shared and for all the ways we contributed to each other's needs and growth.

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LIST OF ACRONYMS

CFR:	Central Forest Reserve
DEM:	Digital Elevation Modal
DOS:	Dark Object Subtraction
DRC:	Democratic Republic of Congo
FAO:	Food and Agricultural Organization
FDGs:	Focused Group Discussions
GIS:	Geographic Information
MEA:	Millennium Ecosystem Assessment
NEMA:	National Environment Management Authority
NFA:	National Forest Authority
NGOs:	Non-Government Organization
SPSS:	Statistical Package for Social Science
SLM:	Sustainable Land Management
UBOS:	Uganda Bureau of Statistics
UNHCB:	United Nations High Commission for Refugees
UTM:	Universal Transverse Mercator
USGS	United States Geological Survey

ABSTRACT

Wetland use and cover changes are a serious problem in many areas of Uganda, as in the Rhino camp of Arua where Refugee settlement and local community have induced wetland degradation and rapid cover change. This study assessed the implication of Refugee settlement on wetland cover changes in the Rhino settlement. Specifically, the study to assessed the magnitude of wetland cover changes; determined the effect of wetland use on spatial landscape structures and examined the determinants of fire wood and charcoal production as a major proxy of wetland use. In this study, Using non-supervised classification algorithm and the post-classification change detection technique in GIS, the magnitude of wetland cover changes were investigated. With the Fragstats software, it was possible to quantify the changes of the spatial landscape structures in the Rhino settlement for the five years period (2015-2019). Socioeconomic data was collected using questionnaire guide, key information interview guide, focus group discussion guide and observation guide. It was used purposely to generate both qualitative and quantitative data. It was also intended to get deeper views and perceptions of respondents about the study variables. The findings indicated that wetland in the Rhino settlement decreased by 7% at the expense of subsistence farming and built up that increased by 15% and 1.3%, respectively. Analysis of landscape metrics generally indicated that natural wetland cover has been destroyed during this period along with increasing anthropogenic impacts for example the class area (CA) reduced by 37.4% signifying changes in biodiversity. Degradation and replacement of natural cover with human activities is considered undesirable development on the Rhino wetland. It is therefore recommended that the government through the environmental officers and all environmental activists including NGOs, stand together to monitor and control the unfavorable anthropogenic activities in the Rhino wetland. In addition, the government through NEMA should demarcate the boundaries of Rhino wetlands, which should be out of bound from human activities so as to maintain its functionality.

CHAPTER ONE:

INTRODUCTION

1.1 Background of the study

In the last two centuries, the impact of refugee settlement on wetland eco-system has grown enormously, altering entire eco-system with ecological consequences like biodiversity loss, deforestation, soil erosion and desertification: (Allen et al., 2018). Extractive activities of refugees in wetlands have induced climatic variations which led to wetland degradation and cover change on an unprecedented scale. The global number of refugees, which is estimated to be 65,000,000 people (Kyozira et al., 2019) have put additional stress on the natural eco-system, for example international wetlands like the plate basin of South America, Peat land in Russia and Saharan wetland system, their functioning, supporting and provisioning services have been destroyed (World Commission on Dams, 2000). As of 2009, the world lost 33% of its wetland area related to refugee encroachment (Hill et al., 2017). The increasing Syrian refugee influx in Jordan has raised the population to 6.6 million people (Tumusiime et al., 2018).

In African region, wetland ecosystems have experienced rapid and extensive extinction due to the numerous transformation caused by refugees. (UNHCR, 2017) Over the last 200 years, over 20% of wetlands in Africa have been drained, dredged, filled and leveled for urban, agricultural and settlement (Stevens et al., 2015). There has been an increased war in Africa which has increased in the rate of refugees of which 85% live in marginalized areas like wetland for livelihood (Kreibaum, 2016). This has put pressure on the fragile ecosystem hence causing wetland cover change and degradation hence, altering its provisioning, supporting and functioning services offered by wetlands (Malaeb and Wahabs, 2018).

In Uganda, wetlands have declined from an estimated 13% of the total land area in 1994 to 10.9% in 2008 (Nsubuga et al., 2014). The constant wars in the neighboring countries of DRC, Rwanda and Southern Sudan have forced millions of refugees to come to Uganda for the safety of their lives. In reaching Uganda, they end up encroaching on the wetlands for their livelihood (UBOs, 2016). As a result of increased influx of refugees, there has been an increase in the frequency of vegetation clearance, draining, diversion of water flow, crop cultivation and exposing the soil to erosion (MWE, 2013). Consequently, the subsequent conversion of wetlands by refugees into anthropogenic activities has caused wetland cover change, degradation, biodiversity loss, reduced water storage and supply for the livelihoods of the people (Cesar et al., 2013.

Arua district host some of the largest refugee camps in Uganda for example the Rhino refugee settlement which accommodates nearly 1.1 million refugees from Southern Sudan and DRC (Wanzira, 2018). Such influx of refugees, have put additional pressure on the Rhino wetlands thus resulting into depletion of functioning, provisioning and supporting services offered by the Rhino wetlands to the people and environment. This is evidenced by subsistence farming conducted by refugees, which has converted the wetland into agricultural land and hence loss of its natural originality especially in the Western part of the wetland. Such disturbances of the refugees, have driven the Rhino wetlands to a diverse critical threshold thus degradation and wetland cover changes (Farrier et al., 2000), which need to be solved immediately thus, the urgency of the study.

1.2 Statement of the problem

Wetland use/cover changes have been a severe problem since the 1970's, despite the multiple value of the eco-system services to humanity (Turyahabwe et al., 2013). Today, wetland use / cover changes are occurring more rapidly than in any other eco-system due to drainage, dredging, conversion and filling of the wetlands for human activities (Webb et al., 2017). Nearly two thirds of the wetlands in the world have been lost according to the great lakes' information networks. This has caused tremendous environmental problems like flooding, spread of desertification, severe soil loss, among others.

Unregulated refugee activities are considered as disruptive to the integrity and functionality of the wetland ecosystem (Webb et al., 2017). Rhino wetland sub catchment located in Arua district was greatly affected by these recurrent anthropogenic episodes caused by refugee influx. The functioning, provisioning and supporting services of Rhino wetland ecosystem has depleted thus facilitating wetland cover changes and degradation (Behan et al., 2018).

Therefore, as wetland use increases, the corresponding wetland degradation worsens at an accelerated rate, thus affecting water quality, causing loss of water reservoirs, increasing water logging and flood risks (Yang et al., 2016) so the consequences of wetland use and encroachment by refugees have made the Rhino wetlands vulnerable to degradation and cover changes (Islam et al., 2010). So if nothing is done to curb the situation, the Rhino wetland is going to disappear and cause natural disaster to the people in the area.

Despite the continued increased frequency of wetland cover changes in the Rhino wetlands (Goa, 2010), their silent effects on the community have received limited attention and research. In particular, no comprehensive study has been done to assess the impact of refugee settlement on wetland cover changes in Rhino settlement. Previous studies paid attention to how human activities of refugees influence environmental degradation (Kakuru et al., 2018), but they scantly addressed wetland cover changes. It was against this background that this study was set out to assess the impact of refugee on wetland cover changes in Rhino settlement, Arua district.

1.3 Objectives

The overall objective of this study was to establish the implications of refugee settlement on the wetland use/cover changes in Rhino settlement, Arua district.

1.3.1 Specific objectives

The specific objectives of this study were:

1. To assess the magnitude of wetland use /cover changes in the Rhino refugee settlement
2. To determine the effect of wetland use /cover changes on the spatial landscape structure of the ecosystem.
3. To examine the determinants of firewood and charcoal production as major proxies of wetland use / cover changes.

1.4 Research questions

The study was guided by the following key questions.

1. What is the magnitude of wetland use / cover changes in the refugee settlement?
2. What are the effects of wetland use /cover changes on the spatial landscape structure of the ecosystem?
3. What are the determinants of firewood and charcoal production as a major proxy of wetland use / cover changes?

1.5 Scope of the study

In this section, three (3) areas were considered, that is: - the geographical scope, content scope and time scope.

The study was carried out in the Rhino refuge settlement in Arua district, West Nile. This area has been selected because it accommodates a big number of refugees that is, 116, 00 refugees mostly from South Sudan, Rwanda and DRC as were reported by UNHCR, (2017).

The study was limited to the period 2015-2019. This was the period within which the Rhino camp experienced a massive inflow of refugees from Southern Sudan, Rwanda, DRC and Burundi causing a controversial socio-economic impact on the host communities (Taylor, 2016).

The study hinged on the study of "Impacts of refugee settlement on wetland use /cover changes in the Rhino settlement". The study specifically focused on the magnitude of wetland use / covers changes, the effect of wetland use / covers changes on the spatial landscape structures of the ecosystem and determinants of firewood and charcoal production as major proxies of wetland use / cover changes in the Rhino settlement. The study covered a period of five years (2015-2019) in which, the Rhino settlement experienced an increased influx of refugees and substantial wetland use / cover changes due to increased anthropogenic activities (UBOs, 2019), which reduced the extent of wetland, destroyed the spatial landscape structure and increased on the production of firewood and charcoal that contributed to wetland cover changes.

1.6 Significance of the study

The study will help environmentalist in key positions of authority to improve on management of Rhino wetlands by regulating refugee activities in a way that refugees learn how to tap the wetland resources so as to appreciate, co-exists and preserve the Rhino wetlands. The academia world may also take keen interests in this study for inspiration and reference purposes in the future, for further research and hypotheses formulation. There's the likelihood that even wetland intruders may be inspired by this research and may provoke in them a change of attitude and instead take an active involvement in fighting against wetland depletion.

The study would help policy law makers of National and local level such as National Environmental Management Authority, Ministry of water on how to make appropriate policies with regard to conservation, restoration and maintain all wetland resources for both the present and future generation.

The research findings would help the citizens and refugees to adjust and limit their destructive activities in the wetlands in order to sustain the provisioning, functioning and supporting services of wetland ecosystem to people's livelihood.

As Rhino wetland is endowed with various natural resources which provide variable functioning to the livelihood of the people in the area, this research findings would inspire government, organizations and development partners in making sure that the means to conserve, restore and maintain the Rhino wetland are improved, maintained and strengthened.

1.7 Conceptual Frame Work

A conceptual framework refers to a network of interlinkages of themes in a phenomenon under study (Amin, 2005). Figure 1.1 below shows the conceptual framework derived from the literature review for the impacts of refugee settlement on wetlands use / cover changes in Rhino refugee settlement in Arua district. It is based on the objectives and themes of study. It shows that the independent variable is refugee settlement measured in terms of wetland cover changes, spatial landscape structures and underlying determinants of firewood and charcoal production. The independent variable is wetland use /cover changes measured in terms of vegetation loss, reduced surface water flow, and increased water body pollution, loss of soil productivity and nutrients. The intervening factors between refugee settlement and wetland use /cover changes are subsistence farming, settlement, fuelwood production, animal rearing and infrastructural establishment.

A conceptual framework shows refugee settlement on wetland use /cover changes.

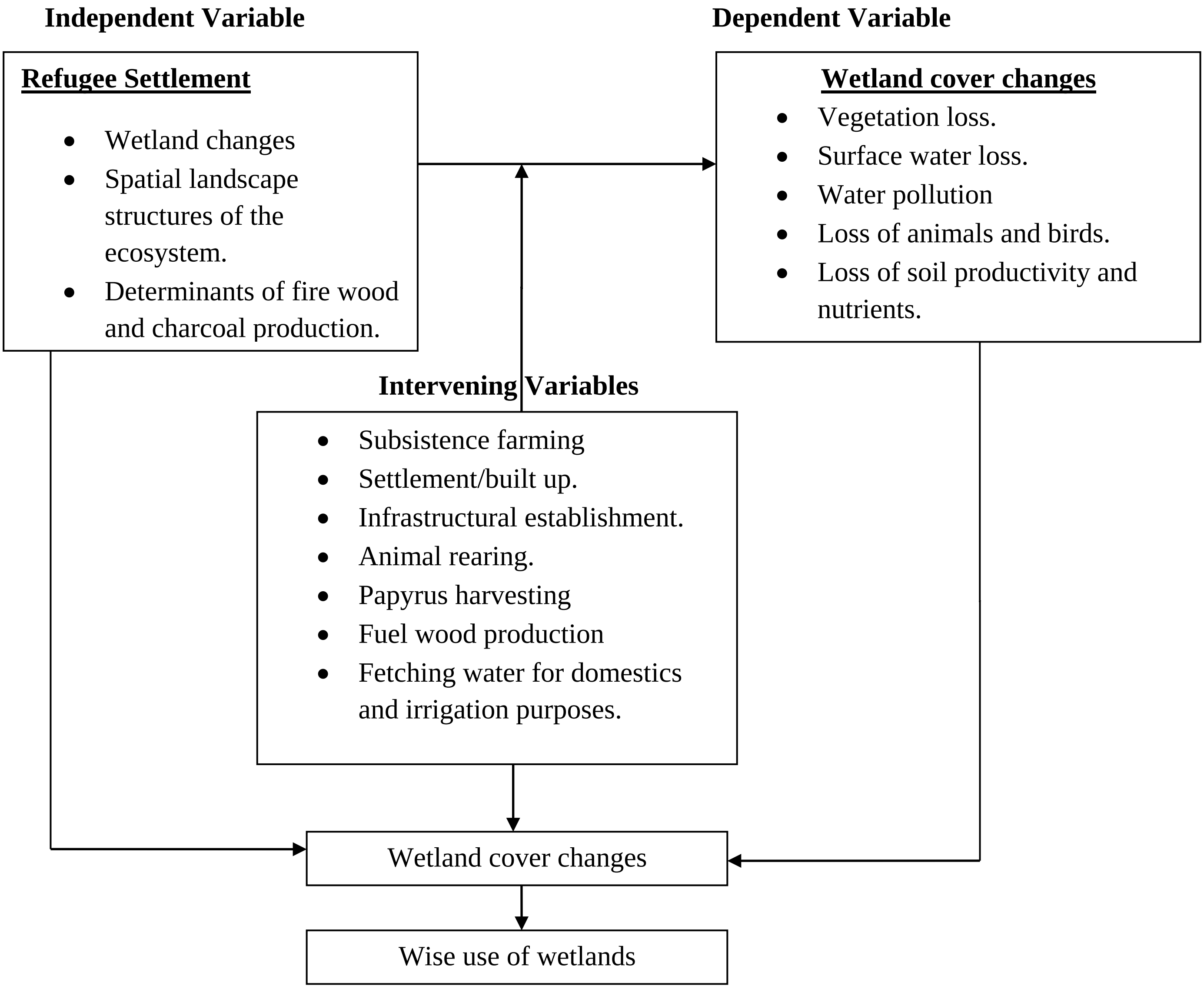

Figure1.1 Conceptual Frame Work (Derived from Literature Research)

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter explores the conceptualization of the study as derived from the study background and the available literature. Literature is presented using themes which are derived from the research objectives and research questions.

2.1 Global Status of Refugees

According to the United Nation's 1951 conversion, relating to the status of refugees attempted to define refugees as people fleeing their home country into another due to fear of political violence, wars and oppression (Handmaker, 2017). Globally, refugees' situations are increasingly characterized by multiple waves of displacement especially women, children and elderly men (Tatah, *et al.,* 2016). An unprecedented 70.8 million people have been forcibly displaced worldwide and 37,000 people are forced to flee their homes every day due to conflicts or persecution (Monde, 2019). Such massive displacements of people have put additional pressure on the ecosystems and often lead to conflicts with the host communities (Lecterer, 2018).

In many refugee-hosting communities or countries like Uganda, refugees are allowed to work and move freely. The aim of this is to integrate them economically and socially into the host communities (Kreibaum, 2016). Though refugees have rights for protection by states or host communities, they are often under looked and not given assistance and respect they deserve from the government and host communities (Ginsberg, 2020). The World must feel at heart that the earth is the home of all humanity.

Globally, refugees mostly move to low and middle income earning countries for example thousands of refugees are moving to Uganda from neighboring countries like DRC, Burundi, Somalia, South Sudanese who are settling in different refugee camps like Rhino Refugee Settlement, West Nile Nakwale (Okumu, 2018). Such refugees majorly depend on NGOs, UNHRC and hosting government for their survival (UNHRC, 2019).

At present, about half of the world's refugees live in urban areas where they get greater employment to improve on their standard of living. This has added pressure on the eco-system in urban center especially in developing countries (Thompson, 2020).

2.2 Status of Refugee settlement and host communities

After World War II, Refugees that were displaced as a result of war became a global concern on the host communities (Stroja, 2017). Today 18 million refugees and estimated 22 million internally displaced persons in the world over are in developing countries where they are associated with the heavy toll taken on the environment. This has imposed a population shock on the host communities which cannot withstand the strain on the natural resources (Jacobsen, 2016). It has been observed, that refugee settlement has become an economic burden to the host communities since it depends on international aid which is an external shock hindering development (Laszlo and Schmidt, 2018).

The growing burden and impacts of refugees have forced developed countries to change their attitude towards refugees. They have gone to the extent of closing their borders to refugees forcing low and middle-income countries to receive the majority of them (Allen, 2018). Germany for example which hosts the most refugees and asylum seekers among the countries classified as high income, received only 669,500 refugees in 2016 raising the total number of displaced people it hosts to 1.4 million. Comparatively, Turkey has received 3.5 million refugees while Uganda a low-income country received 1.4 million, Lebanon hosting 1 million refugees (UNHCR, 2008).

Violence like genocide in developing countries has caused social and economic sabotage, which force people to flee their country. In reaching the hosting country, they end up encroaching on the wetlands for survival thus putting stress on the natural wetlands (Bosma et al., 2017).

This has been the case in Uganda where Refugees have put additional stress on the fragile wetlands for survival. In Uganda, Refugees have settled up in various areas, which include, Bidibidi, Imvemp, Rhino, Lobule, in West Nile, Nakivale in Insingiro District, Kiryandongo in Kiryandongo District, Rwamwanja settlement in Kamwenge District, among others (UNHCR, 2020). Uganda has faced many challenges in hosting refugees amidst the limited resources. There has been protracted refugee situation, increase in refugee number with their associated evils, limited resources and little International support, security and environmental, burden (UNHRC, 2017). This has made Uganda stress its limited resources for the livelihood of Refugees.

In Uganda refugees live in camps and few self-reliant, settle in urban centers. Refugees majorly rely on foreign aid from UNHCR and host countries, which provide land for settlement and agriculture. Refugees are always marginalized by the host communities because of their low income levels. Therefore, they are ever discriminated in society as foreigners. They live in fragile areas such as wetlands and slums which are considered cheap for their survival, they also involve in casual activities like mending of shoes, collecting and selling brooms among others (UBoS, 2016).

In relation to this study, the increased influx of refugees in the Rhino settlement has put pressure on the fragile ecosystem in order to increase productivity to meet their livelihood. At the end, this has led to loss of biodiversity, surface water, fauna and soil with its nutrients (UNHCR, 2017). However this study did not give a solution to mitigate the problems. With this current study, it is essential to formulate wetland policies matching with the existing situation for sustainable wetland management.

2.3 Status of Wetland use / cover changes

Wetlands are among the world's important natural resources and vulnerable ecosystem (WU, 2018). Recently, the Millennium Ecosystem Assessment (MEA) report revealed that the degradation and loss of wetlands exceed that of all other ecosystems mainly due to their use for agriculture and food production (Yikii, 2017). Therefore the use of wetlands for food security is the primary reason for wetland degradation and cover changes.

Wetland use / cover changes and degradation has been severe and is still occurring at a faster rate in Australia due to economic development in wetland, bureaucratic obstacles and lack of information or poor access to information and poor general awareness of the values and benefits derived from wetlands (Taylor et al., 2016). Also, an influx of migrants who access wetlands for subsistence farming has caused them to undergo degradation due to continuous cultivation and grazing of animals (Tumusiime et al., 2018)

Globally wetlands continue to decline both in area and quality as a result the ecosystem services provided by wetlands to society are diminished (Dahl, 2017). It is estimated that the extent of global wetlands has declined greatly to about 20% of the total land area (Waekes, 2017)

Wetlands play a great role in the environment that is, they are fertile ecosystems and form a suitable habitat for a wide variety of flora and fauna (Constanza et al., 2011). They have hydrological functions such as regulation of water regimes, storage of water, prevention of floods, coastal stabilization, control of erosion, acquisition of groundwater, deposition of sediments and pollutants. It is also a critical habitat for many migrating birds (Buechley et al., 2018). They are also important in the cultural heritage of mankind (Li et al, 2015). Wetlands are among the most important ecosystems in terms of carbon emission (Meng, 2016). However, despite of such valuable functions of wetlands, natural and anthropogenic activities in the long term spoil their wellbeing, making their management a crucial one (MWE, 2013).

The trends observed in Arua, Rhino wetlands are similar to those in the literature. Despite the provisioning, supporting and functioning services offered by the Rhino wetland, over the recent years, there has been an increase in clearance and subsequent conversion of the wetland into subsistence farming and built up by refugees, which has led to wetland cover changes and degradation which has deprived many human activities of important ecosystem services (Gardner et al., 2015). It is worthy while noting that no studies on the implication of refugees on wetland cover changes in Rhino settlement has ever been done in Uganda. This study has now provided the, would be missing literature which could be used as a source of reference for future researchers.

2.4 Methods of Assessing Wetland use / cover changes

Given the limited funding, labour and a variety of wetland conversion pressure, GIS and Remote Sensing is the most important integral tool in monitoring wetland use /cover changes (Sawyer, 2018). Remote Sensing (RS) and Geographic Information System (GIS) are modern tools of technology used for detecting, monitoring and management of wetlands (Garg, 2015).

Imaging spectroscopy application has been used in Louisiana to assess wetland vegetation distribution and coastal resiliency. AVIRIS – NG offers a high spatial and spectral resolution data that can be integrated with the external dataset to measure, monitor the study area. Therefore, it gives information pertaining vegetation mapping and biomass estimation (Jensen et al., 2018).

In Prcurieothole region of North America, a method of mapping wetlands using an automated object-based approach was developed for a regional watershed in Alberta (Zhang et al., 2019). The method improves upon existing wetland mapping methods by effectively mapping small wetlands and better capturing the convolution of wetland edges. Wetland use / cover changes estimates were obtained by applying a wetland area versus frequency power – law function to the wetland inventory (Serran and Creed, 2016).

Still remote sensing and GIS was used to monitor and evaluate wetland use/cover changes in the Rhino wetlands. Unsupervised classification a logarithm was used to determine wetland uses in the Rhino that is, open water, wetland, woodland, subsistence farming and built up (Wu, 2017). Therefore this study has developed a set of guidelines on how to valuate the services provided by Rhino wetland, arguing that a unified model for valuing ecosystem services derived from wetlands can help establish their worth and ensure sustainable use. This would be important for future researchers.

2.5 Application of GIS and Remote Sensing in Monitoring Wetland use/ cover changes

Remote sensing (RS) and Geographic Information Systems (GIS) are modern tools of technology used for detecting, monitoring and management of wetlands (Garg, 2015). Analyzing and extracting reliable and consistent information via RS technology enables to form a base dataset to be used for monitoring and mapping wetlands (Musaoglu et al., 2018).

Wetland maps and inventories can provide crucial information for wetland conservation, restoration and management. Geographic Information System (GIS) and Remote Sensing technologies have proven to be useful for mapping and monitoring wetland resources. With advanced technologies, remotely sensed imagery with a better and finer spatial, temporal and spectral resolution for wetland mapping and monitoring (WU, 2017) has been used. Remote Sensing and GIS technology is widely used for detecting and delineating surface water and its dynamics (Pal and Talukdar, 2018). This has helped to detect wetland use /cover changes in terms of hydrological loss (Dessu et al., 2020).

Remote sensing and GIS has enabled the monitoring of wetland changes with unprecedented accuracy. In particular, the availability of high resolution light detection and ranging (LIDAR), synthetic aperture radar (SAR), hyper spectral and multispectral data and the introduction of multisensory and multistage data fusion techniques hold great potential for improving large scale wetland mapping and monitoring (McCartney and Wood, 2019).

Remote sensing techniques have been primary used to generate information on land cover /use changes. Remote sensing and GIS technologies have been used in the classification and monitoring of the spatial and temporal changes in land use types. GIS software can be used to analyze land cover on wetland purposely to determine their loss (Papastergiadou et al., 2008).

The GIS System of Multi-Criteria Spatial decision Support System (MCSDSS) are often employed to evaluate how best to restore or enhance a particular wetland (Gamir et al., 2017).

These methodologies are employed to establish a course of action which will maximize the overall restored ecosystem services even when this wetland in question is faced with extreme drought and degradation (Maleki et al., 2019)

Numerous studies have focused on land use/cover and change detection by using satellite data (Wu, 2017), applied classification algorithms to thirty-seven Landsat MSS/TM/ETM satellite image dated 2010 and the SPOTS image dated 2005 to obtain spatial-temporal analysis of wetland landscape pattern characteristics for yellow River Delta.

GIS and remote sensing are used to capture, monitor and analyses the impact of Katupalong refugee camp in Bangladesh on the environment. (Braun et al., 2019). The study suggested a workforce based on space-born radar imagery to measure the expansion of settlement and the decrease of the forest.

In this study, remote sensing techniques enabled the detection of wetland us/changes in Rhino settlement. A variety of anthropogenic wetland conversion was mapped to show the risks (Sarkar et al., 2016). Therefore subsistence farming remained the dominant form of land use accounting for wetland change. This study has shown how refugees have drained the Rhino wetland to increase agricultural land for food production. If the trend continues for about 10 years, Rhino wetland integrity will continue to be degraded, depriving people of the benefits derived from it for their livelihood and the environment. Such disturbances, has driven the wetland to adverse critical threshold.

2.6 Drivers of Wetland use/cover changes

The main drivers of wetland cover change in Uganda, and Arua in particular include draining, over exploitation of wetland resources, burning and conversion to other uses like cultivation, settlement and urban sprawl (Bosma et al., 2017).

Wetland resources have been subjected to over exploitation and intensive use due to population pressure especially increased influx of refugees in Arua who involve in over harvesting of plants for mulching their gardens, thatching, craft materials, firewood and conversion of the wetland into agricultural land (Namulema, 2015).

Wetland degradation and cover changes are one of the merging challenges against sustaining such worthy environmental capital having plenty of goods and services. In Barind tract of India and Bangladesh, wetland conversion is one of the greatest drivers of wetland cover changes (Pal and Talukdar, 2018).

Wetland degradation and cover changes have been greater primary due to six drivers that is infrastructure development, land conversion, water withdrawal, and pollution, overharvesting and overexploitation and introduction of invasive species. Therefore wetland degradation is often caused by multiple drivers, some of which are site base, while others are regional or global in scope. This makes wetland degradation difficult to reverse (Galatowitschz, 2018).

The major forces of wetland use /cover changes in Beijing – Tianjia – Hebei Region are gross farm production, total aquatic products and irrigated areas were the top three drivers of the decrease in natural wetlands (Zhang et al., 2019).

The loss and degradation of wetland in the Mekong, Delta has been caused by a combination of human activities (social systems) and natural event (ecological systems). It is the social-ecological factors affecting wetland cover change (Nguyen et al., 2017). Wetlands health and resilience can easily be compromised by climate change impacts. Extreme drought causes a decline in water flow and vegetation loss. Such a change in the hydrological regime impacts negatively on human survival.

Apart from drainage, wetland hydrology has been modified by the construction of channels, ditches and levees to achieve flood control, irrigation, timber harvest, navigation, transportation, and industrial activity. Channelization increases the speed of water moving into and through wetlands (Baumert, 2016). As a result, patterns of sedimentation are altered and wetland functions and values that depend on the normal slow flow of water through a wetland can be affected. Also, it alters in-stream water temperature and diminishes habit suitable for fish and wildlife (Gibbs, 2017).

Sedimentation; Excessive sediment inputs, usually coming mostly from erosion of agricultural soils, has potential to severely impact wetlands, sedimentation impacts include increased turbidity that reduces the depth of the photic zone and increases sediment fallout which may cover primary producers, invertebrates and clog wetland vegetation. Excessive sediment input thus potentially alters aquatic food webs as well as basic wetland functions related to water quality improvement, nutrient cycling, water holding capacity and processes that transform and sequester pollutants. In addition, this sediment usually contains high levels of fertilizers and pesticides that contribute to water pollution and eutrophication (Hansen et al., 2017).

The expected increase in extreme weather events and water temperatures will affect aquatic organisms, which are especially sensitive to these changes and have specific water level requirements (Dahl, 2017). Species that are heavily tied to water will not be able to move easily to reach new areas with adequate climate conditions. On contrary, the spread of invasive species, better adapted to the new conditions, is likely to be aggravated. In short, species composition of wetland will change in the future due to changing climate and hydrology.

Sewage treatment works are not always as efficient in removing pollutants from water. In some cases, they lack a tertiary treatment to further stabilize oxygen-demanding substances or to remove nutrients. If the treatment is deficient, the levels of organic matter may also be still too high in the effluent (Akpor & Muchie, 2011). In most cases, the effluent is still rich in nutrients such as ammonium, nitrate and phosphate. This effluent is discharged in rivers, streams or directly in lakes and wetlands, raising the concentrations of these substances above the natural levels and contributing to eutrophication (Angell et al., 2016).

Point-source industrial pollution such as that coming from paper, textile, energetic and chemical industries, among others, is increasingly coming under control in the EU, strictly regulated by directives and policies. Still, there are occasions where specific pollution events can have a major impact on a wetland, with effluents being released into the watershed carrying high levels of pollutants many different types and, sometimes raising water temperature (Sharley et al., 2017).

In addition, the high amount of impervious surfaces in the watershed created by increasing urbanization and industries prevents rainfall from percolating into the land and hence increases erosion and the transport of higher amounts of sediments and pollutants into wetlands (Angell et al., 2016).

A further point-source of pollution is dumpsites and landfills nearby wetland areas. Although these sites are supposed to be properly designed to avoid percolation into land and ground water, leakage or surface water contamination can occur sometimes (Farmer et al., 2016).

Such literature is in line with the study variable for example the replacement of wetland vegetation with crop fields has led to biodiversity loss and decline in wetland functions (FAO, 2014). In this study, Rhino wetland cover changes have been attributed greatly to increased influx of refugees who have put more pressure on the wetland for their livelihood for example most part of the wetland has been drained for subsistence farming.

2.7 Importance of assessing the magnitude of Wetland use /cover changes

As wetlands provide various ecological and socioeconomic services, they are however losing their vigor at an alarming rate due to unwise management. There's an agent need to monitor and assess wetlands to identify the major drivers of its degradation and provide information for management decisions. Increasing human disturbances such as livestock grazing, farming and eucalyptus plantations around wetlands have contributed to its degradation, decrease in macro invertebrate richness, diversity and reduced its extent (Salafsky et al., 2008; Lelterer et al., 2018). This in turn has an adverse effect on food security and poverty alleviation with considerable impacts on refugees who heavily depend on wetland products for their livelihood. However, Gezie and his friends looked at only wetland drivers; they did not look at wetland policy formulation to safeguard the wetland ecosystem hence creating the content gap.

Therefore, it is essential to formulate wetland policy for achieving wise use goals and necessary legal and institutional backup for sustainable wetland management. Many migrants in China have put additional pressure on wetlands which constitute 10% of the World's total (Xu et al., 2019). Many wetlands have been turned into industrial zones and built up to accommodate the migrants. This has greatly reduced the extent of wetlands in China by 26,066km^2. However Xu and his friends analyzed wetland changes between 2000 and 2015, yet this study looked at 2015 and 2019. In addition, Xu and his friends carried out the study in China yet this study was conducted in Rhino settlement, Arua district in Uganda, thus creating both time and geographical gap.

Land use influences the livelihood and degradation of fragile ecosystems. The extents of these changes were investigated in Lake Bunyonyi catchment area (Kiiza et al., 2017). The dynamics and magnitude of land use and cover changes were accessed using Landsat satellite images which were used to cluster and quantify land use and cover changes. The study assessed a period between 1987 and 2014. However, this study was carried out in the southwestern Uganda which is different from the area where this study was conducted that's in the Rhino refugees' settlement Aura West Nile. Still, the study assessed a period between 1987 and 2014 while this study looked at the period between 2015 to 2019 hence creating geographical scope and time gap which this study addressed.

Estimation of the rates of wetland use /cover changes are important to safeguard the functionality of the ecosystem. In Alberta wetland use /cover changes were assessed using digital topographic analysis and calculating wetland area vs. wetland frequency power laws (Serran et al., 2018). The results indicate that as of 1993, 49.4% of the numbers of wetlands were temporarily lost which increased in 2011 to 56.8%. However, this study used digital topographical analysis and frequency power law in assessing the magnitude of wetland uses /cover changes. The study used GIS and remote sensing to assess the wetland cover changes hence creating a methodological gap which this study addressed.

2.8 Effects of wetland use/cover changes on the spatial landscape structure pattern (vegetation and abundance distribution)

Environmental stressors like animal grazing, farming, bush burning tend to limit community composition and abundance distribution of vegetation species in wetlands (Nsor et al., 2019). The study used the prevalence index method to categorize plants and wetland species. In addition, geometric series were used to quantify community structural assemblages. A total of 3034 individuals belonging to 46 species from 18 families were registered across the 6 wetlands. Grasses, hubs and woody species constituted 42.2%, 42.2% and 15.8 % respectively, indicating that wetland use / cover changes negatively affect the spatial landscape structure of the ecosystem. However, this study used prevalence index method and geometric series to quantify the vegetation species which is far different from what this study used that is Frag stat software package (Kelly *et al.,* 2011) which was used to assess analyze and monitor the dynamics of vegetation patterns within the settlement hence creating methodological gap which this study addressed.

Wetlands in East Africa harbor large biodiversity and provide diverse ecosystem services. However, the increasing agricultural production has negatively affected biodiversity and provision of ecosystem services (Behn et al., 2018). Disturbed wetlands are converted into crop lands hence affecting the abundance distribution of vegetation. However, this study only looked at one anthropogenic activity of agriculture in wetlands which negatively impacts on the spatial landscape structure of the ecosystem. It left out other important anthropogenic activities like settlement, industrialization, animal rearing, and the infrastructural establishment which equally have negative impacts on vegetation distribution in wetlands hence creating a content gap which this study addressed

Anthropogenic activities like road construction, pollution, channelization and wetland cover change have caused degradation of South African palmiet wetlands (Rebelo et al., 2018). Palmiet wetland has lost its original vegetation communities and functions. In addition, the loss of alluvium, typically resulted in a completely new plant community, composed of pioneer species and several alien species. However, this study was not dealing with the spatial landscape structure of the ecosystem in Rhino refugee settlement in West Nile, Arua District. It was carried out in South Africa palmiet wetlands, thus creating a geographical scope gap, so the need for this study.

Land conversion and fragmentation threaten the resilience and biodiversity of wetland ecosystems (Taddeo et al., 2019). The structure, composition and abundance distribution of vegetation species were greatly reduced in wetland sites surveyed by the U.S.E.P.AS National Wetland Condition Assessment. Landsat 5 and 7 were used to assess vegetation structure, composition and spatial distribution. However, this study did not look at the bit of wetland use / cover changes on the spatial landscape structure of the ecosystem. It only emphasized vegetation structure and composition hence creating a content gap, which this study addressed.

Intensification of land use practices and climate change have resulted in extensive wetland loss and decline of native submersed aquatic vegetation species cross North America. (Gross et al., 2019). The intensified land use practices result into loss of natural submerged aquatic vegetation species and wetlands. However, this study was carried out in the semi-permanent wetlands of North America between 2015 and 2017, creating both geographical and time gaps, which this study addressed.

2.9 Determinants of Firewood and Charcoal Production as Major Proxies of Wetland use /cover changes

Firewood collection and charcoal production are the top two important proximate drivers of land cover changes in Ethiopia, between 1991 and 2015. In Ethiopia, most of the household about 88.2% use three stones open fire stoves. This kind of domestic cooking stove enables households to use more firewood there-by exacerbating deforestation and wetland degradation thus influencing cover change (World Bank, 2017). However, this study took place in Ethiopia and it looked at general land cover change contrary to wetland cover changes in the Rhino settlement, Arua thus creating both geographical and content gap which this study tried to address.

Firewood and charcoal are the main sources of energy for refugee and host communities in Northern Uganda and the key determinants is the diet which is dominated by dry beans which consume a lot of wood fuel (UBOS, 2018). This has caused severe destruction of forests, woodland, bushland and wetlands causing cover change. However, UBOS looked at the whole of Northern Uganda yet this research is specifically looking at Rhino settlement in Arua district in the period 2015-2019, thus creating both geographical and time gap which this study solved.

The use of charcoal and fuelwood for energy in Dehdez area of Zagros Mountain in Iran is triggered by high poverty level and low coverage of electricity as an alternative source of energy. Approximately 90% of the population in the region relies on wood fuel. This explains the wetland and forest cover changes in the region (Fattahi, 2002).

However, Fattahi carried out the study in Dehdez area of Zagros Mountain in Iran yet this study took place in the Rhino settlement hence the need for this study.

The demand for firewood is increasing with the rapid inflow of tourist in the Dehdez area of Zagros Mountain in Iran, firewood is needed in plenty to prepare meals for the incoming tourists (FAO, 2009), hence causing land cover change in the high lands. However, this study looked at the tourists as the key determinants contrary to this study which looked at the refugees thus creating a content gap which this research discussed.

The refugee influx has reportedly had to arrange of environmental impacts and associated challenges that is including land degradation and woodland changes resulting in inadequate access to energy for cooking and competition for natural resource (UNHCR, 2018). Labour is also available in terms of children and women who collect head load firewood daily hence exerting pressure on available natural resources. However, this study generalized the whole of Northern Uganda and used household survey method to capture data, yet this method was conducted specifically in Rhino settlement in Arua and used household survey, FGDs and key informants interview to capture data hence creating both geographical and methodological gap which this study addressed.

2.10 Literature Gap

Most researchers recognized that there is still a significant gap related to refugee settlement and host communities and their role with the extent of wetland cover changes (Paraskeyas et al., 2019). Therefore, the studies bridged this information gap by assessing the impacts of refugee settlement and host communities on wetland use / cover changes especially in Rhino settlement.

CHAPTER THREE

METHODOLOGY

3.1. Introduction.

This chapter contains information about the study area, research design, and study population, samples size, sampling techniques, data collection and analysis method.

3.2. Description of the study area.

This includes a description of the location, climate, relief, drainage vegetation, soils, topography and social-economic activity.

3.2.1. Location.

The study was carried out in Arua district which is located in northwestern Uganda, in the west Nile region. Arua district is bordered by Moyo District to the East, Nebbi district to the South, Koboko District to the North and Gulu District to the South East (Fig. 3.1). Arua district covers an area of 7830 square kilometers (UBOS, 2016). The district comprises of two refugee settlements that is Rhino refugee settlement and IMVEP refugee settlement with refugee's population of 34,215 & 17,900 respectively. Arua was chosen because it is home to about 113,176 refugees of whom 97% are south Sudanese while others come from Rwanda, DRC and Burundi. The study concentrated on the Rhino refugee settlement.

3.2.2. Rhino Refugee Settlement

The settlement is located in Arua district which is part of West Nile sub-region of north western Uganda. The Rhino settlement was first established in 1980, it has expanded in size since as new waves of refugees fled violence in neighbouring countries. The settlement covers an area of more than 85 square kilometers. The Rhino camp covers six parishes /zones that are Anipi, Awuvu, Bandili, Eramwa, Gbulukuatuni and Manago. The settlement currently hosts more than 116,000 refugees mostly south Sudanese. The Rhino camp is managed by UNHCR in collaboration with the Ugandan government's office of the prime minister.

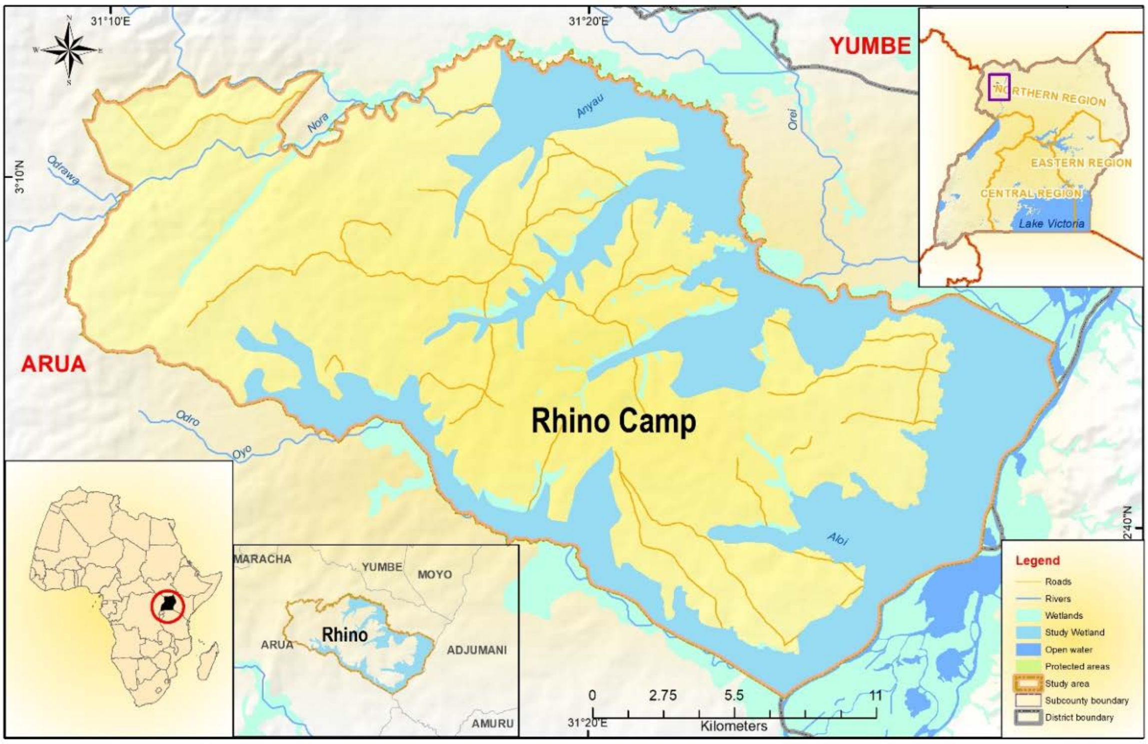

Figure 3.1 Extent of Rhino Settlement

3.2.3. Climate

The Rhino camp Sub-county, like other parts of Arua district, experiences a bimodal rainfall pattern, with the first rain season starting in March and ending in May. The second rains start in July and go up to November. The wettest months are normally August and September which receives an average 120mm. The area receives a mean annual rainfall of about 1250mm per annum and has a mean annual temperature of about 24˚C-30˚C.In the dry season that is December –March, temperatures are usually high ranging between 28˚C -30˚C. The humidity level in the atmosphere is not well circulated, it covers about 52% (NEMA, 2016) therefore the climate is tropical.

3.2.4. Topography

The Rhino camp refugee settlement lies inside the shallow Western rift valley and is located in Arua district. The general topography of the area is hilly, with deep valleys which creates interconnected drainage system in dendritic patterns (Miller & Ulfstjerne, 2020). The average elevation is 700m above sea level. Some areas consist of gently rolling hills and plains.

3.2.5 Drainage

The sub-county is also endowed with many rivers and streams which pass through the areas and provide water for domestic and irrigation use. Such rivers include; Myagak, Nyara, Aji and Ajugi. These rivers are interconnected drainage system in dendritic patterns. (Okethwangu et al., 2019).

3.2.6 Social Economic Activities

The predominant livelihood is agriculture, whereby 54% of refugees are provided with plots of land equivalent to 20 – 30 square meters for agricultural production. Trade is primarily cash-based with 68% of the population using cash purchase items and 31% of the population engage in barter trade (Jailor et al., 2016). Market centers are established in the settlement and host community towns. Most houses hold items and preferred food items such as cassava, sorghum, millet, beans, maize and various vegetables are available (Glassman, 2017). A small percentage involves them in animal rearing, that is, they look after goats, sheep and poultry for subsistence. It should be noted that about 58% of the refugees are currently not engaged in any form of economic activity. Instead they rely entirely on food assistance from UNHCR, NGOs and Government of Uganda for survival (Adaku *et al.,* 2016).

3.2.7 Soils

The soils of the study area are classified as Farrallitic (Loam and Sandy loam). This type of soils is fairly productive with loose structures, which are easily eroded, and leached (Reed and Stringer 2016). Some areas have acidic soils whose texture varies from place to place for example Bandili Parish has sandy soils while other parishes have brown loamy soils (Okethwangu, 2019).

3.2.8 Vegetation

The vegetation covers in the study areas is typically savannah woodland which is characterized by three species like Shea nut, butter trees, locally called “awa” and many others. The western higher altitude area has higher tree vegetation cover than the eastern and is where the National Forest Authority (NFA) central forest reserve (CFR) is located (Herbert and Idris, 2018).The area also comprises of savannah grasslands characterized by grass species like spear grass, elephant grass and papyrus vegetation in the wetlands.

3.3 Study Population

The target populations for this study include the refugees from the three parishes of Bandili, Eramwa and Anipi, district environment officers, LC 1 chairpersons and UNHCR officials in Arua. These would be considered key participants in the study to have enough and credible knowledge about the impacts of refugees on wetland use /cover changes in the Rhino refugee settlement, Arua District. Their experience was captured in order to evaluate the extent of wetland cover change within the Rhino settlement.

However, the population of refugees in the Rhino camp has kept on increasing drastically and steadily. The settlement currently host more than 116,000 refugees mostly South Sudanese (UBOs, 2016).

3.4 Research design

This study adopted a cross sectional study design because it sought to investigate views of stakeholders on the implication of refugee settlement on the Rhino wetland cover changes thus, the need to generate as much primary data as possible. The study used both qualitative and quantitative approaches to get deeper views and perceptions of respondents about the study variables. The two approaches were used to collect, present and interpret data. This allowed triangulation which enhanced the validity and reliability of the study.

3.5.1 Magnitude of wetland use /cover changes in the Rhino refugee settlement

Sentinel-2 satellite images (20m) were adopted to evaluate the magnitude of wetland use / cover changes in the Rhino settlement. The images were chosen because of high satellite repetitive coverage, better resolution, and free image availability. A total of two sets of image data source were downloaded from United States Geological Survey (USGS) data portal (glovis-www.glovis.usgh.org) for years 2015 and 2019 with the cloud cover ranging from 1-19% taken in the dry season. The downloaded images were geometrically collected and geocoded by projecting those using WGS 1984 UTM zone 36North Coordinate System.

3.5.1.1 Image pre processing

The geometrically collected images were atmospherically corrected using Dark Object Subtraction (DOS) method in QGIS using the semi-automatic classification plugin to represent the landscape as realistic as possible. The images were later masked to the study area using Rhino camp data set. A composite image was created by selecting bands and combining the bands to form an image with natural colors for Rhino camp. For this case band, 4.3.2 was used to represent Red, Green and Blue colors (RGB) that form a composite image with natural colors. Rhino and study wetland was later delineated using a digital elevation model; Rhino sentinel composites and NFA wetland.

3.5.1.2 Image Processing /Classification

Image classification was based on wetland cover use/cover changes in the study area. The unsupervised classification algorithm was chosen to determine strata for ground truth. In the study area, differences in the spatial resolution of images, which varied from 30m to 79m, were considered in designing the classification scheme. The classified images were cleaned to reduce reflectance noise by performing majority filtering method. Similar clusters were merged together to form wetland use/cover classes. Five (5) separate wetland use/cover were identified: open water, wetland, and woodland, subsistence farming and built-up. All satellite data were studied using spectral numbers and spatial profiles to ascertain the digital numbers (DNs) of different wetland use/cover changes. Training samples were selected from the reference data to train the images. Training samples include 5-10 subclasses for each class. The training samples were then refined, renamed, merged and detected after evaluation of the class isogram and statistical parameters. Un supervised classification algorithm was then applied to each image thus dark blue color represented open water, light blue wetland, green woodland yellow subsistence farming and red represented built up which spread all over the study area

3.5.1.3. Post Classification/ Accuracy Assessment

Image classification accuracy assessment is important in determining the adequacy of the classification approach using ground truth points. Accuracy assessment was determined using the kappa coefficient, overall accuracy, producer and user accuracy, which were derived from the error (confusion) matrix. Considerations were made to ensure that the images were captured at comparable phonological dates during the study period. In addition, historical images (2015 and 2019) were further visually interpreted taking into account image tone, texture, shape and class patterns.

Error matrix is the foundation of accuracy assessment. Therefore an error matrix analysis was used to assess change detection accuracy. The classified results in table 4.3 were used to calculate the percentage of accuracy assessment using the error matrix formula:

$$Accuracy = \frac{Diagonal\ sum\ of\ classified\ classes}{Total\ classification} \times 100$$

For this study the total accuracy was:-

$$Accuracy = \frac{13 + 19 + 17 + 27 + 20}{109} \times 100$$

$$Total\ Accuracy = 88.07\%$$

3.5.2 Effects of Wetland Loss on the spatial landscape structure of the ecosystem

Fragstat is software which measures the spatial structure of wetland cover metrics in terms of composition (number, proportional frequency and diversity of landscape elements within the landscape) and configuration (spatial position and distribution of the elements within the landscape). To calculate landscape metrics, wetland cover maps were converted into grid format using ERDAS imagine and introduced into the Fragstat software.

Land cover change map (2015-2019) represented the source of land cover change indicators, which aim at the location of the areas of change and the evaluation of the extent of changes for the total study area and each land cover class. These indicators measure also the land cover transition direction and the gains and losses for each class during the study period.

The entire set of wetland cover (metrics) has been set up to answer the following questions. Where are the wetland cover changes (location?), which is the magnitude of wetland cover changes extension?), which is the direction of wetland cover changes (direction?) and which are the spatial characteristics of landscape change (structure?).

Patch analyst plugin (Fragstats software programme) which is an extension in Arc GIS was used to compute the landscape and class metrics for vectors using the spatial statistics tool. To assess the effects of wetland use/cover changes on the spatial landscape structure of the ecosystem, fifteen metrics were computed that is the class area (CA), Total landscape area (TLA), Number of patches (NumP), Mean patch size (MPS), Medication patch size (MedPS), Patch size coefficient of variance (PSCV), Patch size standards deviation (PSSD), Mean shape index (MSI) Area weighted mean shape index (AWMSI), Mean perimeter-Area ratio(MPAR), Mean patch fractal dimension (MPFD), and Area weight mean patch fractal dimension (AWMPFD) at Class level to determine the spatial landscape structure of the ecosystem in Rhino settlement. Table showing selected metrics were generated with the corresponding value for the study period of 2015 and 2019. Metrics which were standardized per unit area to carry out a comparison between two years of 2015 and 2019 were selected. This method proved useful for quantifying complex spatial vegetation abundance distribution in the Rhino settlement.

The patch-based metrics used in qualifying the composition and configuration of spatial landscape structures are summarized in Table 3.1.

Table 3.1 The patch based metrics and formula

S/N	Patch base metrics	Formulas	Meaning of the formula
1.	Total Edge (TE)	$TE = \sum_{k=1}^{m} e_{ik}$	e_{ik}=Total lengths (m) of edge in landscape involving patch type (class) ij includes landscape boundary and background segments involving patch type i
2.	Edge Density (ED)	$ED = \frac{\sum_{k=1}^{m} e_{ik}}{A}(10{,}000)$	e_{ik}=Total length (m) of edge in landscape involving patch type (class) *i:* includes landscape boundary and background segments involving patch type *i*. A= total landscape area (m^2)
3.	Class (CA)	$CA = \sum_{j=1}^{n} a_{ij}\left(\frac{1}{10{,}000}\right)$	a_{ij} = area (m^2) of patch ij.
4.	Total Land Area (TLA)	$TA = A\left(\frac{1}{10{,}000}\right)$	A = total landscape area (m^2)
5.	Number of patches	$NP = N$	N = total Number of patches in the Lands
6.	Shannon's Diversity Index (SDI)	$SDI = \sum_{i=1}^{m}(P_i * InP_i)$	P_i = proportional of the landscape occupied by patch type i.
7.	Shannon's Evenness Index	$SEI = \frac{\sum_{i=1}^{M}(P_i * InP_i)}{Inm}$	Pi =Proportional of the landscape occupied by patch type m = Number of patch types (classes) present in the landscape.
8.	Patch size standard deviations (PSSD)	$PSSD = \frac{X_{ij} - \bar{X}}{S}$	X_{ij} =Value of a patch metrics for patch ij. $\bar{X}$ = Mean value of the corresponding patch metrics across all patches in the landscape. S = Standard deviation of the corresponding patch metric for all patches in the

			landscape
9.	Mean patch size (MPS)	$MPS = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n}X_{ij}}{N}$	$MPS =$ the sum, across all patches in the the landscape of the corresponding patch metric value divided by the total the number of patches. MPS is given in the same units as the corresponding patch metric.
10.	Median patch size (Mead PS)	$MeadPS = X_{50\%}$	$MeadPS =$ the value of corresponding patch metric for the patch representing the midpoint of the rank order distribution of patch metric value based on all patches in the landscape.
11.	Patch size coefficient of variance (PSCoV)	$PSCoV = \frac{SD}{MN}(100)$	$SD =$ Standard deviation $MN =$ Mean It is then multiplied by 100 to convert to a percentage for the corresponding patch metric.
12.	Mean perimeter Area ratio (MPAR)	$MPAR = \frac{P_{ij}}{a_{ij}}$	$P_{ij} =$ Perimeter (m) of patch ij. $a_{ij} =$ Area (m^2) of patch ij
13.	Mean shape Index (MSI)	$MSI = \frac{25P_{ij}}{\sqrt{a_{ij}}}$	$P_{ij} =$ Perimeter (m) of patch ij. $a_{ij} =$ Area (m^2) of patch ij
14.	Area Weighed means size Index (AWMSI)	$AWMSI = \sum_{i=1}^{m}\sum_{j=i}^{n}\left[X_{ij}\left(\frac{a_{ij}}{\sum_{i=1}^{m}\sum_{j=1}^{n}a\right.\right.$	$AWMSI =$ the sum across all patches in the landscape, of the corresponding patch metrics value multiplied by the proportional abundance of the patch (i.e., patch area (m^2) divided by the sum of patch area).

3.5.3 Determinants of firewood and charcoal production as a major proxy of wetland loss/cover changes.

To achieve this, a cross-sectional study design was used which involved both quantitative and qualitative participatory approach because it gives a deeper view and perceptions about the study variables.

3.6 Sample Frame/Design

The field study was carried out in Arua district in the sub-county of Rhino camp. This sub county consists of six parishes or management zones of which three was chosen that is Bandili, Eramwa and Anipi. In each of these parishes, three villages were selected (Figure.3.2.). These villages were purposively selected on the basis of having wetlands and wetland destruction.

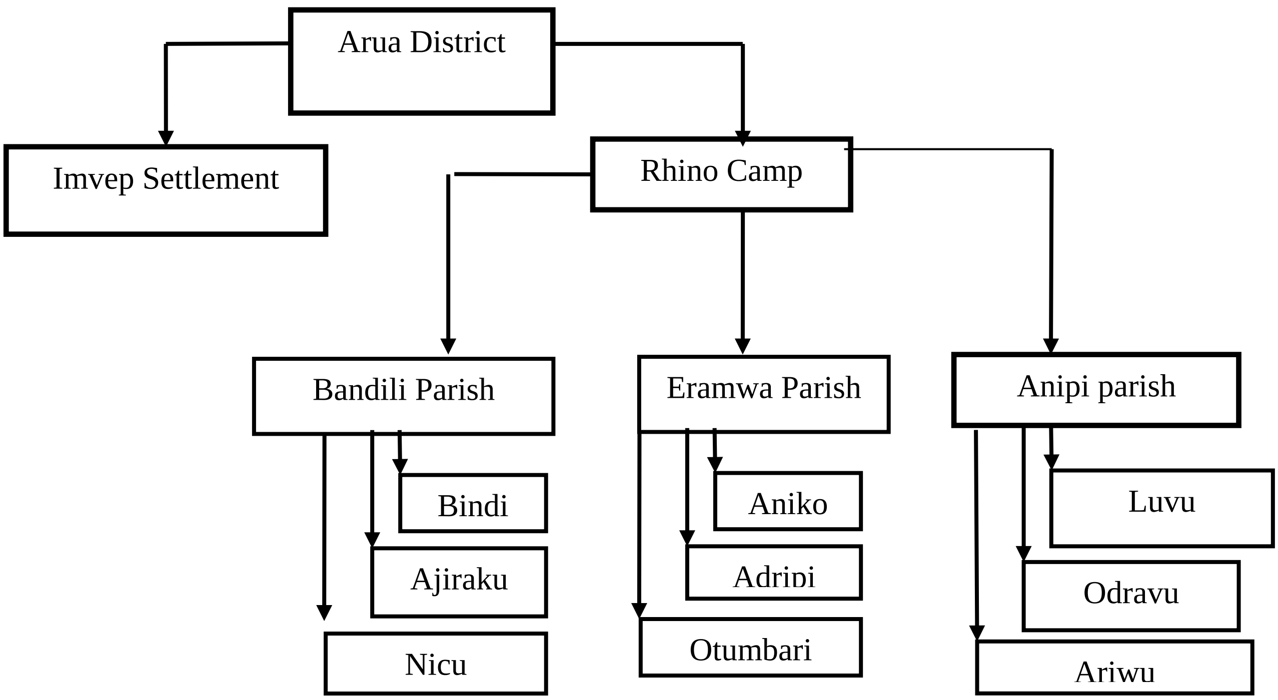

Figure 3.2 Sample Design

3.7 Sample Size.

According to UBOS (2019), the Rhino camp currently hosts about 116,000 refugees mostly from South Sudan. Simple random and purposive sampling was used to select individual household, head of zones, UNHCR officials, and District Environmental Officers to form a sample size of 398 respondents. Using proportionate sampling 125 respondents (house hold) were selected from each parish, then 05 district environmental officers, 12 head of zones (04 from each parish) and 06 UNHCR officials were selected as key informant. This is summarized in Table 3.2.

The formula for selecting individual respondents was $^{N}/_{4}$ implying that every forth respondent on the list was selected in each category to obtain the sample size as in table 3.2.

Table 3.2 Summarized sample size

Sample size	**Bandili Parish**	**Eramwa parish**	**Anipi parish**
375 Refugee house hold	125 respondents	125 respondents	125 respondents
	Bindi 41 Ajiraku 42 Nicu 42	Aniko 41 Adripi 42 Otumbari 42	Luvu 41 Odravu 42 Aliwu 42
12 LC I chairperson	**LC I Chairperson**	**LC I Chairperson**	**LC I Chairperson**
	Bindi 01 Ajiraku 01 Nicu 02	Aniko 01 Adripi 01 Otumbari 02	Luvu 01 Odravu 01 Aliwu 02
05	District Environmental Officer		
06	UNHCR officials		
398	**Total sample size**		

3.8 Sampling Techniques

3.8.1 Purposive Sampling Techniques

This sampling technique was used to select key informants like LC I chairpersons for each village, District Environmental officer and UNHCR officials in Arua. They were selected because of their direct involvement in the implementation of government programmes and are believed to be reliable and knowledgeable about wetland cover changes.

Still, purposive sampling was chosen because it produces more reliable results with fewer errors. This is evidenced with the data collected from such key informants, which was reliable and authentic for example, one UNHCR official told the researcher that each refugee household head is provided a plot of land measuring 100x200mtrs in the Rhino wetland for cultivation which has contributed to wetland use/cover changes.

3.8.2 Simple Random Technique

The sample employed a random sampling method to select respondents for household interviews. The questionnaire was administered to 375 household heads in the three parishes of Bandili, Eramwa and Anipi. Additionally, the questionnaires were administered to respondents who were aged 18years and above and had lived in the area for at least one year and were implicit decision makers in the household. The outcome was coded down for further analysis.

This was used to select parishes and villages of study. This method is flexible, accurate, and cost-effective in terms of money and time-saving. The parishes in the Rhino camp sub county are six that's Anipi, Bandili, Eramwa, Awuvu, Gbulukuatun and Manago. Their names were written on a separate piece of paper each paper was folded and place in a bag. Then one piece of paper was picked at random and recorded. The process continued until the three parishes and villages were got. The names of the parishes and villages are shown in figure 3.2.

3.9.0 Data collection method and tools

3.9.1 Questionnaire method

The questionnaires were comprised of both open and closed-ended questions to gather information about the perception of the refugees on wetland cover changes and the determinants of these changes in Rhino settlement during the studied period (2015-2019). A questionnaire was preferred for study as it provides insight into the determinants of wetland cover changes (Gay, 1996).

It was used to generate both qualitative and quantitative data. Semi-structured questionnaire with both closed and open ended questions were administered to the selected respondents in the area of study. In order to generate quality data, questionnaires were only administered to district environmental officers, UNHCR officials and heads of zones. The open-ended items in the questionnaires enabled respondents to express their opinions freely and in detail about the subject under study without biasing them with predetermined answers by the researcher. This tool was used because data can be obtained fairly, easily and the questionnaire responses are easily coded to facilitate further analysis.

3.9.2 Focused group discussion method

Focus group discussion (FGD) and key informant interview were carried to triangulate the obtained information from the household interviews and gain an in-depth and detailed understanding of refugee's perceptions on wetland cover changes that had taken place in the Rhino settlement and associated underlying determinants perceived to have contributed to the changes. A total of 3 FGDs were carried out in the three parishes where household interviews were conducted each. FGD consisted of 10 people. A purposive sampling method was used to identify key informants based on their knowledge in the study area. In the study, key informants were exclusively technical members from Arua district and Rhino settlement; they were familiar with the issues in the study area. Theses technical members included the district environmental officers, head of zones community workers and UNHCR representing officials.

Therefore qualitative data was collected from key informants and FDGs while qualitative data was collected from the household survey approach among adult respondents.

3.10 Data quality control

This was handled to test the validity and reliability of research instruments used.

3.10.1 Validity

Validity is the extent to which instruments used in the study measures what it was supposed to measure (Amin, 2005). Supervisors of this research were requested to rate items as either relevant or irrelevant. This helped to get clear and proper judgments on the validity to execute the pilot run. The following formula was used to ascertain validity of the instruments.

The content validity index (CVI) as;

$$CVI = \frac{\text{Number of items rated relevant}}{\text{Total number of items}}$$

Items with validity co-efficient of at least 0.7 are accepted as valid in research (Kothan, 2004). The items in the questionnaire were rated to be relevant to the study.

$$CVI = \frac{26}{33} = 0.79.$$

The CVI was found to be 0.79 for the set of questionnaire making the items relevant to the study objectives. This was high enough for the concerned instruments to yields the required data. The instrument were consequently adopted and administered to the subject. Subsequently, the researcher used a number to corroborate each set of data to reduce errors and increase validity so as to confirm to the study conceptual framework. Qualitative validity was established through conformability of data. After transcribing data from the interview, the interviewee was given back the information for confirmation of the transcribed data to establish authenticity.

3.10.2 Reliability

Reliability of instrument was determined using Test-Retest method which refers to the degree to which scores are consistent over time (Gay, 1996). This method was to establish whether or not the score a person obtained on a test at some moment in time are same score that person would get if the test were administered some other time. The instruments were pilot-tested in non-study area of Kibaale Sub-county in Namutumba District which has similar rural characteristics to those in the study area. This area was preferred by the researcher because he is a native, so it was cheap, in terms of transport costs and time saving to test the instruments. Thirty household heads were selected in Nakyere and Bulimba villages by considering fifteen in each village and one village L.C.I Chairperson for pilot testing. The results of this are illustrated in table 3.3.

Table 3.3. Pilot testing results

Participants	Sample	Frequent of consistency	Percentage of consistency
Household heads	30	28	93.3
Village LCI chairperson	2	2	100
Total	32	30	93.8

Source: Researcher

A consistence level of 93.8% was considered high enough for the instruments to be reliable for the study.

3.11 Data analysis

Non-Parametric test - Binomial Test was used to analyse data in SPSS from the social-economic characteristic of respondents. The binomial test is a non-parametric statistical procedure for determining whether the frequency distribution of nominal scaled, dichotomous variables corresponds with an assumed distribution.

3.12. Ethical considerations

This study was carried out following ethical procedures. Commitment, openness to consult and honesty were maintained throughout the research process. An introductory latter was got from Kyambogo University introducing the researcher before respondents. Consent was sought from respondents before interviews, focus group discussion and questionnaires were conducted. Respondents were further assured of the confidentiality of the information provided and that the study findings were used for research purpose only. Plagiarism was avoided through recognizing authors by acknowledging them in the work. This means that, findings were presented in their origin form the way it was adopted in the field.

CHAPTER FOUR

RESULTS

4.0 Introduction

This Chapter presents and analyses findings from the study. The presentation and analysis of data was guided by objectives and research questions.

4.1 Magnitude of wetland use / cover changes

The results (Table 4.1) show that in 2015, subsistence farming with 22.2% wetland was the most dominant wetland use followed by built up (10%). The most dominant area cover was intact wetland (54.7%), followed by woodland (13.9%), then open water (8.2%). In 2019, the dominant wetland use was still subsistence farming (31.1%) followed by built up (1.8%). The dominant area cover was wetland (50.6%) followed by woodland (8.2%) and then opens water (8.4%). It is further observed in table 4.1 that subsistence farming increased by (8.8%), built up increased by (0.8%) and open water increased by (0.2%) while woodland decreased by 5.8% followed by wetland (4.1%). Thus over the assessed period, there was a decreasing trend of the area covered by intact wetland and woodland. The wetland use types increased at the expense of wetland cover types. In other words, wetland use gained more land while wetland cover lost its land due to anthropogenic activities hence contributing to wetland use /cover changes.

Table 4.1 Magnitude of wetland use /cover changes between 2015 and 2019

	2015		**2019**		**2019-2015 Gain/loss (use/cover changes)**	
Wetland use/cover	Area (Km^2)	Area (%)	Area (Km^2)	Area (%)	Area (Km^2)	Area (%)
Open water	13.67	8.19	14	8.39	0.33	0.2
Wetland (intact)	91.19	54.66	84.4	50.59	-6.79	-4.07
Woodland	23.29	13.96	13.62	8.16	-9.67	-5.8
Subsistence farming	37.01	22.18	51.81	31.05	14.8	8.87
Built up	1.68	1.01	3.01	1.8	1.33	0.8
Total	**166.84**	**100**	**166.84**	**100**	**0**	**0**

Source: Glovis portal

Figure 4.1 shows the spatial patterns of wetland use/cover for 2015 and 2019. In 2015, wetland, woodland, open water, subsistence farming and built up were the dominant wetland use/cover types spreading in all directions of settlement. In 2019, the wetland use/cover pattern reveals that subsistence farming and built up started expanding in all direction of the settlement primarily at the expense of wetland, woodland and open water areas. The rate of encroachment on wetland cover increased significantly, which clearly illustrated the transformation of wetland, woodland and open water into agricultural and settled areas. Consequently, areas under wetland cover declined markedly during the period 2015-2019.

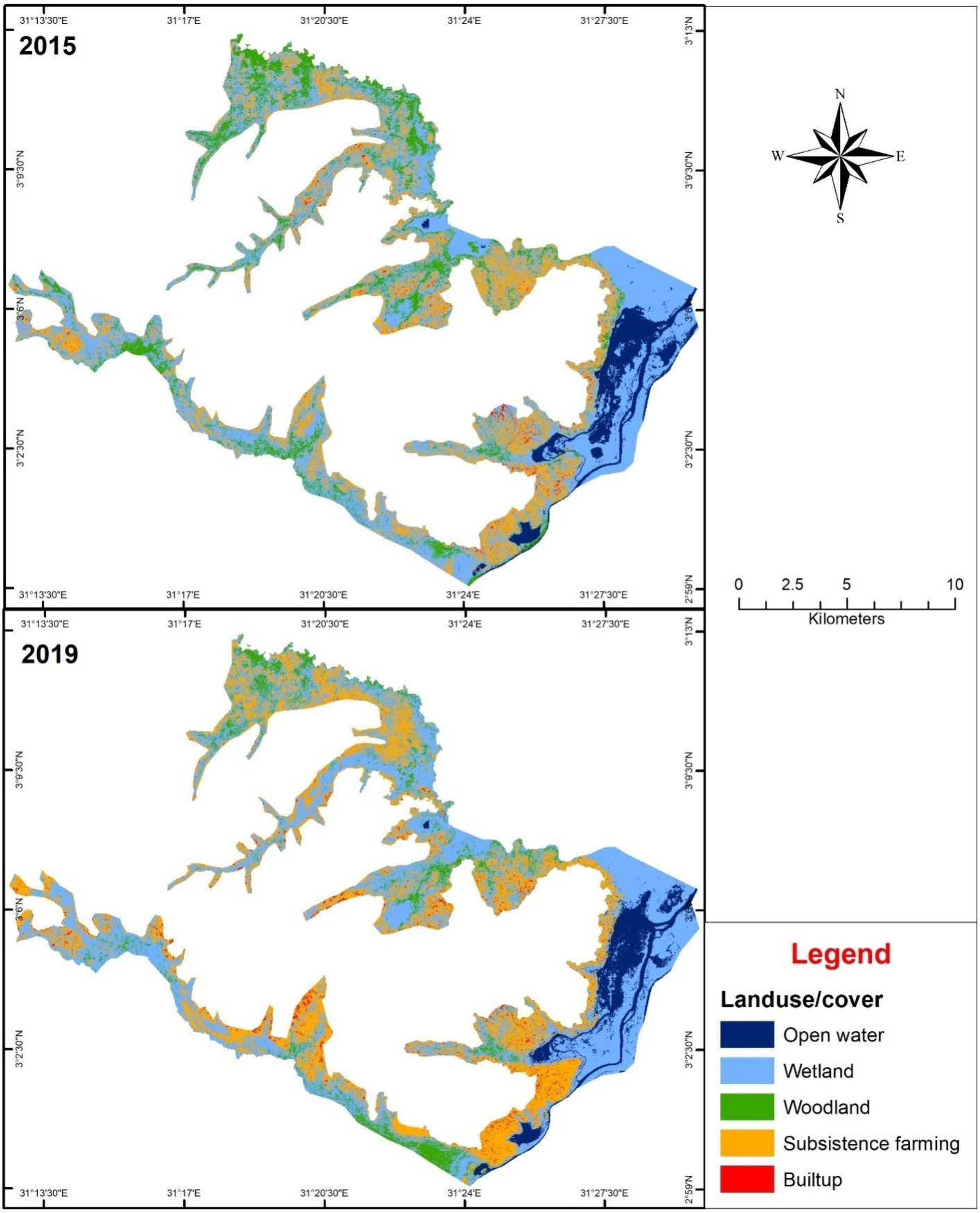

Figure 4.1 Changes in wetland use/cover on the Rhino refugee settlement; Arua district

4.1.1 Change Detection

Table 4.2, shows that increases in open water (0.32) was attributed to a decrease in wetland coverage due to overflow of water in the open water system. The result also reveals that intact wetland decreased by 6.67, from 2015 to 2019, which is attributed to an increase in subsistence farming and built up in the Rhino settlement. The woodland also lost its coverage by 9.64; this was also attributed to increased coverage of subsistence farming and built up. In the five years (2015-2019) period, subsistence farming and built up increased by 14.7 and 1.3 respectively. This was due to increased encroachment on the wetland and woodlands.

Table 4.2. Change detection in the Rhino Refugee Settlement

		2019					
	Wetland use/cover types	**Open water**	**Wetland**	**Woodland**	**Subsistence farming**	**Built up**	**Total**
2015	Open water	9.80	3.78	0.01	0.07	0.00	13.66
	Wetland	3.80	56.51	6.05	23.73	0.88	90.97
	Woodland	0.19	13.80	6.81	2.40	0.04	23.24
	Subsistence farming	0.18	9.99	0.72	24.33	1.72	36.94
	Built up	0.01	0.21	0.02	1.09	0.35	1.68
	Total	**13.98**	**84.30**	**13.60**	**51.63**	**2.99**	**166.50**

Source: Glovis portal

4.1.2 Accuracy Assessment

Table 4.3 reveals that open water, subsistence farming and built up had higher producer's accuracies of 100%, 93% and 100% respectively while intact wetland and woodlands have poor producer's accuracies each containing 7.6% and 77% respectively. The table also shows wetland use/ cover with good user's accuracies, for example, open water, wetland, woodland, and subsistence farming hence good users' accuracies of 87%, 95%, 85% and 90% while built up has poor user's accuracy with 83%. Users and producers accuracies of individual classes in 2019 were consistently high (above 85%). Implying that, overall accuracy of change detection was 88.1%, and Kappa 85%.

Table 4.3 Error Matrix for 2019/ Accuracy Assessment

wetland use/cover	Open water	Wet land	Wood land	Subsistence farming	Built up	Classification Overall	Producer accuracy
Open water	13	0	0	0	0	13	480%
Wetland	1	19	2	2	1	25	76.00%
Woodland	1	1	17	1	2	22	77.27%
Subsistence farming	0	0	1	27	1	29	93.10%
Built up	0	0	0	0	20	20	100.00%
Truth Overall	15	20.	20	30	24	109	109
User accuracy	**86.67%**	**95.00%**	**85.00%**	**90.00%**	**83.3 3%**	**96**	
Overall accuracy	**88 07%**						
Kappa	**0.849**						

Source: Glovis portal

4.2. Effects of wetland use / cover changes on the spatial landscape structure of the ecosystem.

Table 4.4 shows that the wetland system had the highest CA. followed by substance farming then woodland, open water and finally built up with the least CA. Wetland still took the lead in MedPS followed by subsistence farming, woodland, open water and the least was built up. Furthermore .the wetland had the highest TE followed by subsistence farming. Woodland, then open water and built up with the least TE. Built-up was leading in MPAR followed by subsistence farming, woodland then wetland and open water with the least MPAR. The largest MSI recorded was for substance farming, followed by wetlands, woodland then built up and the least was open water. This implied that in 2015, the spatial landscape structures were still intact and dense, thus there were minimal disturbances on biodiversity by anthropogenic activities, which is evidenced by the highest-class area of wetland.

Table 4.4 Class Metrics 2015

Class	AWMSI	MSI	MPAR	MPAFD	AWMPFD	TE	ED	MPE	MPS	NUMP	MedPS	PSCoV	PSSD	TLA	CA
Open water	29.44	29.44	282.20	1.57	1.57	386120.00	23.09	386120.00	1368.48	1.00	1368.48	0.00	0.00	16721.56	1368.48
Wetland	215.23	215.23	798.20	1.72	1.72	9292900.00	436.14	7292900.00	9136.68	1.00	9136.68	0.00	0.00	16721.56	9136.68
Woodland	153.68	153.68	1127.90	1.74	1.74	2631280.00	157.36	2631280.00	2332.83	1.00	2332.83	0.00	0.00	16721.51	2332.83
Subsistence farming	220.44	220.44	1282.20	1.76	1.76	7462440.00	284.81	4762440.00	3714.19	1.00	3714.19	0.00	0.00	16721.51	3714.19
Built-up	78.78	78.78	2145.80	1.79	1.79	363460.00	21.74	363460.00	169.38	1.00	169.38	0.00	0.00	16721.51	169.38

Source: GIS (Flagstats software)

Key:

Class area (CA), Total landscape area (TLA), Number of patches (NumP), Mean patch size (MPS), Medication patch size (MedPS), Patch size coefficient of variance (PSCV), Patch size standards deviation (PSSD), Mean shape index (MSI) Area weighted mean shape index (AWMSI), Mean perimeter-Area ratio(MPAR), Mean patch fractal dimension (MPFD), Area weight mean patch fractal dimension (AWMPFD), total edge (TE), edge density (ED) and mean patch edge (MPE).

Table 4.5 shows that the wetland had the highest CA. followed by subsistence farming, open water woodland and lastly built up. Wetland had the largest MedPS, in the second position was subsistence farming followed by open water then woodland and built up with the least MedPS. Still, the intact wetland had the highest TE followed by subsistence farming, woodland, open water and then built up. Built-up and woodland recorded the highest MPAR respectively followed by subsistence farming while wetland and open water recorded the lowest MPAR respectively. MSI showed wetland to have had the highest value followed by woodland and subsistence farming then built-up while open water covered the least value. This implied that in 2019, the spatial land structures started diminishing at a faster rate due to increasing anthropogenic activities

Table 4.5 Class Metrics 2019

Class	AWMSI	MSI	MPAR	MPAFD	AWMPFD	TE	ED	MPE	MPS	NUMP	MedPS	PSCoV	PSSD	TLA	CA
Open water	46.83	46.83	443.70	1.62	1.62	621060.00	37.22	621060.00	1399.88	1.00	1399.88	0.00	0.00	16684.22	1399.88
Wetland	166.25	166.25	641.50	1.70	1.70	5414300.00	324.52	5414300.00	8440.29	1.00	8440.29	0.00	0.00	16684.22	8440.29
Woodland	162.73	162.73	1563.20	1.77	1.77	2128840.00	127.60	2128840.00	1361.89	1.00	1361.89	0.00	0.00	16684.22	1361.89
Subsistence farming	147.35	147.35	725.70	1.70	1.70	3759720.00	225.35	3759720.00	5181.01	1.00	5181.01	0.00	0.00	16684.22	5181.01
Built-up	83.56	83.56	1706.90	1.76	1.76	514020.00	30.81	514020.00	301.15	1.00	301.15	0.00	0.00	16684.22	301.15

Source: GIS (Flagstats software)

Key:

Class area (CA), Total landscape area (TLA), Number of patches (NumP), Mean patch size (MPS), Medication patch size (MedPS), Patch size coefficient of variance (PSCV), Patch size standards deviation (PSSD), Mean shape index (MSI) Area weighted mean shape index (AWMSI), Mean perimeter-Area ratio(MPAR), Mean patch fractal dimension (MPFD), Area weight mean patch fractal dimension (AWMPFD), total edge (TE), edge density (ED) and mean patch edge (MPE)

Table 4.6 shows that 2015 and 2019 had similar values for the Shannon diversity index (1.19) implying that the area consists of many patches. Similarly, the Shannon Evenness index (SEI) for the two classes is the same (0.74) meaning that the distribution of patches in the study area is regular. The two classes also had a similar number of patches (05) implying that the study area was fragmented into various activities. The two classes (2015 & 2019) had a difference of 38 class areas and 37.4 total land area, signifying changes in diversity. Also, the study period had a high value of total edge (10901740) implying that the study area was suitable for edge species. During the decade (2015-2019), the mean patch size (MPS) decreases in the study area, showing a trend towards an increasing diversity loss from the landscape.

Table 4.6 Comparison of class Metrics of 2015 and 2019

Class	SDI	SEI	AWMSI	MSI	MPAR	MPAFD	AWMPFD	TE	ED	MPE	MPS	NUMP	MedPS	PSCoV	PSSD	TLA	CA
2015	1.19	0.74	191.21	139.52	1127.26	1.72	1.72	1536200.00	923.13	3087240.00	3344.31	5.0	2332.83	93.32	3120.75	16721.66	16721.66
2019	1.19	0.74	148.58	121.34	1016.20	1.71	1.70	12437940.00	745.49	2487588.00	3336.84	5.0	1399.88	91.21	3043.48	16684.22	16684.22

Source: GIS (Flagstats software)

Key:

Class area (CA), Total landscape area (TLA), Number of patches (NumP), Mean patch size (MPS), Medication patch size (MedPS), Patch size coefficient of variance (PSCV), Patch size standards deviation (PSSD), Mean shape index (MSI) Area weighted mean shape index (AWMSI), Mean perimeter-Area ratio(MPAR), Mean patch fractal dimension (MPFD), Area weight mean patch fractal dimension (AWMPFD), total edge (TE), edge density (ED) and mean patch edge (MPE).

4.3 Determinants of firewood and charcoal production as a major proxy of wetland use/cover changes

4.3.1 Socio-economic characteristics of respondents

The socio-economic characteristics of respondents were grouped into gender marital status, education level, source of income, age and household. Descriptive statistics analysis was used in terms of frequencies and percentages to group them (table: 4.7).

Table 4.7 shows the socio-economic characteristics of respondents whereby the majority of respondents were females comprising of 71% while male were only 29%. Also, most of the respondents were married covering 75% followed by single (13%), widowed (165%), divorced (4%) and separated were the least with only 2%. Most of the respondents acquired primary education (56%) followed by those with secondary education (30%) then non-formal education (12%), those with vocational education (2%) and those with tertiary education were the least with (1%). Still, the majority of the respondents engage in subsistence farming representing 53% followed by casual labour comprising of 23%, then small scale business 19%, selling ration 2%, then formal employment and brewing of alcohol were the least each comprising of 1%. Also, most of the respondents were of mean age of 35 years and each household has a minimum of 6 people. Therefore, such socio-economic characteristics were instrumental in causing wetland use/cover changes by way of clearing the woodland, bushland in the Rhino wetland to acquire firewood and charcoal for their lively hood hence, leading to biodiversity loss.

Table 4.7: Socio-economic characteristics of respondents

Variables	Description	Frequency (N=398, %)
Gender	Male	117 (29)
	Female	281(71)
Marital status	Single	56 (13)
	Married	299 (75)
	Widowed	22 (6)
	Divorced	14 (4)
	Separated	7 (2)
Education level	Primary	221 (56)
	Secondary	118 (30)
	No formal education	47 (12)
	Vocational	9 (2)
	Tertiary	3 (1)
Source of Income	Subsistence farming	212 (53)
	Casual labour	93 (23)
	Small scale businesses	76(19)
	Selling ratio	9(2)
	Formal employment	5 (1)
	Brewing alcohol	4 (1)
Age	Mean	35
	Std. Deviation	+13.5
	Minimum	13
	Maximum	83
Number of households	Mean	6
	Std. Deviation	+3.6
	Minimum	1
	Maximum	48

4.3.2 Firewood Collection

Table 4.8 results reveals that in the very small families, the determinants of firewood collection were culture, weak enforcement of environmental laws, type of food cooked, and size of the storage house ($P<0.05$). Factors which did not influence firewood collection in the wetland were, methods of cooking, availability of labour, and high household income level ($P>0.05$).

In small families, the major determinants of firewood harvesting are a method of cooking, availability of labour and size of the storage house ($P<0.05$). The factor which does not influence firewood harvesting in small families include high household income level ($P>0.05$).

In the medium-sized families, the factors encouraging firewood production are four in number that is, culture, weak enforcement of environmental laws, availability of labour and size of the storage house ($P<0.05$). While the factors which do not influence firewood production include only high household income level ($P>0.05$)

In large families, the factors influencing firewood collection were ten in number that is, family size, culture, poverty, weak enforcement of environmental laws, type of food cooked, methods of cooking, availability of labour, size of storage house, high household income level and availability of wood ($P<0.05$).

Finally, very large families comprising of 12-15 members, the determinants of harvesting firewood is only poverty ($P<0.05$). While the factors which did not influence firewood harvesting are family size, culture, weak enforcement of environmental laws, type of food cooking methods of cooking and availability of labour ($P>0.05$).

Table 4.7 Determinants of firewood harvesting according to family size major drivers of wetland cover changes.

Category	Very small (1-3)				Small (3-5)		Medium (6-8)		Large (9-12)		Very Large (12-15)	
	N	Observed Prop.	Test Prop.	P-values	N	P-values	N	P-values	N	P-values	N	
Family size	45	1	0.5		49		44		24	0.000**	5	0.062
Culture	21	1	0.5	0.000**	29		25	0.000**	13	0.002**	4	0.125
Poverty	48	1	0.5		83		71		23	0.000**	6	0.0310**
Weak enforcement of environmental laws	19	1	0.5	0.000**	42		18	0.000**	10	0.039**	2	0. 5000
Type of food cooked	17	1	0.5	0.000**	61		41		15	0.000**	5	0.0620
Method of cooking	5	1	0.5	0.062	18	0.000**	35		10	0.002**	2	0. 5000
Availability of labour	5	1	0.5	0.062	18	0.000**	18	0.000**	6	0.031**	2	0. 5000
Size of the house	9	1	0.5	0.004**	15	0.000**	13	0.000**	6	0.031**		
High household income level	2	1	0.5	1.000	2	1.000	2	0.5	8	0.008**		
Availability of wood	3	1	0.5		3		27		11	0.001**		

**Significant at 0.05 level

4.3.3. Charcoal production

According to the respondents, nine determinants of charcoal production were identified that is family size, type of food cooked, poverty, methods of cooking, weak enforcement of environmental laws, culture, size of the household, High household income level and availability of labour (Table 4.9)

Table 4.9 shows that in very small families (1-3), charcoal production is determined by seven factors that is, culture, poverty, weak enforcement of environmental laws, type of food cooked, methods of cooking, size of the household and high household income level. This is because their P-value is less than 0.05. The factors which did not encourage charcoal production in very small families is only availability of labour because its P-value is greater than 0.05.

In small families, the factors influencing charcoal production include culture, poverty, weak enforcement of environmental laws, methods of cooking, size of the household and high household income level. This is because their P-value is less than 0.05. Also, the factors which do not influence charcoal production in small families are a type of food cooked and availability of labour whose P-value is greater than 0.05.

In medium-sized families comprising of 6-8 members, the factors influencing charcoal production are eight in number namely; family size, poverty, weak enforcement of environmental laws, type of food cooked, methods of cooking, availability of labour, size of the household and high household income level. This is so because their P-value is less than 0.05. While the factor which does not encourage charcoal production is culture whose P-value is greater than 0.05.

In large families, there is no factor influencing charcoal production since all factors like family size, culture, poverty, weak enforcement of environmental laws, type of food cooked, methods of cooking, availability of labour, size of household and high household income level their P-value is greater than 0.05.

Lastly, in very large families, the determinants of charcoal production are not there. This is because the P-value of family size (0.500), poverty (0.500), and high household income level (0.125) are greater than 0.05

Table 4.8 determinants of charcoal production according to family size as major drivers of wetland cover changes.

	Very small (1-3)				Small (3-5)		Medium (6-8)		Large (9-12)		Very large (12-15)	
Category	N	Observed Prop.	Test Prop.	P-values	N	P-values	N	P-values	N	P-values	N	P-values
family size	35	1	0.5		28		12	0.000**	5	0.062	2	0.5
Culture	19	1	0.5	0.000**	12	0.000**	5	0.062	3	0.25		
Poverty	16	1	0.5	0.000**	16	0.000**	9	0.004**	3	0.25	2	0.5
weak enforcement of environmental laws	17	1	0.5	0.000**	13	0.000**	7	0.016**	3	0.25		
Type of food cooked	20	1	0.5	0.000**	34	1.000	9	0.004**	3	0.25		
Method of cooking	15	1	0.5	0.000**	20	0.000**	8	0.008**	2	0.5		
Availability of labour	4	1	0.5	0.375	8	0.109	1	0.021**	2	0.5		
Size of the household	11	1	0.5	0.001**	12	0.000**	7	0.016**	2	0.5		
High household income level	9	1	0.5	0.004**	10	0.002**	6	0.031**	2	0.5	4	0.125

****Significant at 0.05 level****

CHAPTER FIVE

DISCUSSION OF FINDINGS

5.1.0 Magnitude of wetland use/cover changes

The results in table 4.1 indicate that subsistence farming emerged as a dominant wetland use and the greatest source of livelihoods for refugees in Rhino settlement. The result further revealed that such farming practices had more disturbing and destructive effects on the wetland system than other wetland use like built up. This could be attributed to the fact that subsistence farming has destroyed natural vegetation cover at an alarming rate, encouraged wetland encroachment and exposed soil to erosion (Nunes et al., 2011, sham and Tiwari, 2016). The results further show that most land that belonged to the wetland and woodland class from 2015 was intensively converted to subsistence farming. Respondents in the study area also correctly perceived that subsistence farming had increased over the past years, with a decline in wetland and woodland coverage. Hence contributing to wetland use /cover changes in Rhino settlement.

The study also revealed (Table 4.2) that built up increased significantly during the study period (2015-2019), which swallowed up the fragile wetlands in Rhino settlement. This was attributed to the increased influx of refugees from neighboring countries especially Southern Sudan and DRC (UNHCR, 2017). Such an increased population encroached on the marginal wetlands for accommodation and cultivation. This was in agreement with the policy of Uganda and UNHCR to make refugees self-reliant and less dependent on relief items (Kamukasa, 2009).Therefore the findings show that built up extended further to all directions of the study area (Figure 4.1) and consequently the area of wetland and woodland declined markedly by 2019.

The results, (Table 4.2) also revealed that open water increased slightly during the study period. This could have been attributed to sedimentation into Rivers or Lakes and continuous heavy rainfall leading to flooding and overflow of Rivers that took up permanently the land that belonged to wetlands. Similar findings of other researchers show that wetland use /cover changes occurred in related settings for example wetlands declined by 08% between 1984 and 2013 in the Likangala River catchment in Malawi (Miranda et al., 2017). This was attributed to increased water volume which permanently swallowed up part of the catchment area. Therefore in this current study, the patterns of wetland use mapped revealed that open water expanded and swallowed up permanently some land that belonged to wetland and woodland hence leading to wetland use /cover changes.

The result (Table 4.2) of this study shows that from 2015-2019, the area of wetland related to production activities had increased greatly, while the area containing natural ecosystem had decreased to varying degrees, among which wetland displayed the most significant loss. It is commonly accepted that human activities are important factors in the formation and development of wetland degradation (Mondal et al., 2017). Therefore the finding concurred with such studies in that anthropogenic factors were dominant in the loss of wetlands.

5.1.1 Changes detection

The GIS analysis revealed that the area occupied by open water between 2015 and 2019 increased relatively while areas occupied by wetland and woodlands decreased, implying that part of the wetlands and woodlands were converted to open water due to overflow and flooding of the river and lakes in such area of Rhino settlement, especially in the western side. Similarly, the findings revealed that also subsistence and built up increased significantly at the expense of wetland and woodland (Table 4.2), meaning that part of wetlands and woodlands were converted to build up to accommodate the increased inflow of refugees. This led to the shrinking of wetlands and its spatial structures. Similar studies revealed that wetlands and forested areas intensively disappeared due to residential and agricultural commercial purposes (Kumar et al., 2020). Similarly, the reduction in the carrying capacity of wetlands is caused by anthropogenic activities which have caused the loss of biodiversity and food insecurity. Therefore, the findings concur with the two researchers whereby anthropogenic activities like subsistence farming, built up and infrastructural development have exerted pressure on the marginal wetland ecosystem of Rhino settlement thus reducing its magnitude. Household survey, FGDs and key informants also perceived that wetland encroachment increased significantly following the preparation of a master plan in 2017 and development infrastructures.

Researchers revealed that the use of satellite remote sensing in conjunction with GIS enables such changes to be monitored, mapped and analysed in timely and cost-effective manner (Jensen et al., 2018).

5.1.2 Accuracy Assessment for 2019

An error matrix and a kappa analysis were used to assess change detection accuracy and summarized in table 4.3. Kappa analysis yields an estimated measure of the accuracy of change detection (Lu et al., 2005). User's and producer's accuracies of individual classes in 2019 were consistently high above 85%, which gave expected overall change detection accuracy with kappa (Table 4.3). This implied that the conversion of wetlands and woodland to agricultural (subsistence farming) and settled land (built-up) was detected accurately in the study area. Additionally, as observed during field visits, demand for agricultural land and wetlands to be converted to residential land, provided an accurate data of wetland cover change detection in the Rhino settlement, confirming the results interpreted from remotely sensed data in the period of 2015-2019.

Cross-tabulation analysis on a pixel by pixel basis facilitated the determination of the quality of conversion from particular wetland cover class to another land use categorized and their corresponding area over the period evaluated (Alam and Rabbani, 2007). This was also employed to assess change detection in the study period 2015-2019, which revealed wetland use / cover changes. Additionally, the use of older respondent (>20 years) provided an accurate historical narrative of wetland use/cover changes in the study area confirming the results of the observed wetland use/cover changes interpreted from remotely sensed data in the period of 2015-2019. Therefore, the findings (Table 4.3) revealed that wetland use /cover changes in Rhino settlement was real since it was converted to agriculture and settlement due to the increasing influx of refugees that undermined the value of wetland ecosystem.

5.2. Effect of wetland use/cover changes on the spatial landscape structure of the ecosystem.

5.2.1 Class metrics

Fragstat, the spatial pattern analysis software program for quantifying the composition and configuration of landscape McGarigal et al., (2009), was used to quantify the spatial landscape structure of Rhino settlement. A set of fifteen metrics (Table 4.5 and 4.6) quantified in this study, proved useful for quantifying complex spatial landscape structure was used as an effective means of monitoring wetland use/cover change. The approach of landscape assessment and monitoring by select metrics has been recommended and adopted by many authors (Schindler et al., 2008).

Fragstats analysis has been widely used in different fields of study demonstrating great ability to estimate the distribution of species and ecological patterns (Carvajal et al., 2018). This tool has been employed in this study to produce a more accurate estimation of spatial landscape structure distribution so that it could be useful to planners to identify zones with environmental suitability and those which have exposed to high levels of vegetation degradation.

Wetlands and woodland have been shrinking in coverage during the study period about 696.4 ha (CA) of wetland and 971 ha (CA) of woodland are actively affected by anthropogenic pressure of subsistence farming and built up which has lowered the biodiversity in the Rhino settlement. Biodiversity changes in the Rhino settlement and Arua, in general, is indicated by the decline in woodland, forests, and bushland which is the biggest threat ever inflicted by man on the wetland ecosystem. Just like this study, Martens & Wonneck, (2013), indicated that man's action through land conversion affected the density of the spatial landscape structure of the ecosystem.

The results (Table 4.5) indicated that the spatial landscape structure of the ecosystem in Rhino settlement has changed in terms of total edge, edge density and mean shape index. This implies that the landscape structure of the ecosystem is undergoing tremendous decay and fragmentation, which is creating more patches, reducing on biodiversity coverage and connectedness. Several studies have noted that in more densely populated areas where natural resources are less abundant, the demand for land and other resources can lead to a higher degree of degradation especially the spatial landscape structures (Hagen et al., 2012). This is in line with the current study whereby, limited natural resources has forced refugees in Rhino settlement to put more pressure on the wetland ecosystem for survival which has resulted in severe negative environmental ramification.

In the study period, the findings (Table 4.5) show that wetland use in terms of subsistence farming increased vigorously by the refugee who led to wetland and woodland destruction. This was due to increased class area under wetland use in 2019 as compared to class area under land cover in 2015. This implied that by 2019, the number of patches/classes had increased and consumed most of the marginal land of the ecosystem thus contributing to deforestation, loss of wetlands, biodiversity and increased carbon emissions. This is in line with Millennium Ecosystem Assessment, (2005), which concur with the current study that wetland destruction has resulted into the prolonged dry spell as a result of climatic change, which enhances the loss of spatial landscape structures and food insecurity in the Rhino settlement.

The findings (Table 4.6) show that Rhino settlement has undergone a severe transformation in terms of built-up, agriculture and infrastructure setup, which has encroached on the fragile ecosystem. The implications of this resulted in the loss of spatial landscape structures and depletion of habitat for wild animals and birds. This is evidenced by the reduced total land area under wetland cover. Similar studies also revealed that land use and land cover changes in the Murchison bay catchment of Lake Victoria basin Kiggundu et al., (2018), indicated that, the area had also undergone a massive transformation in terms of built-up, agricultural expansion and open water conversion. This has resulted into the reduced extent of the catchment area. Therefore, in either case, depletion of natural land cover in terms of grasslands, woodlands, wetlands, and bushland increased greatly. Also Msofe & Lyimo, (2019), concur with the two findings which result in biodiversity loss and increased sedimentation and turbidity, which requires a concrete strategy to overcome.

The most rapid loss in the Rhino wetland spatial structure occurred in the South, North and East (Figure. 4.1) such areas were largely cleared by refugees to create land for subsistence farming and settlement during the last five years. These areas showed different spatial patterns of destruction and edge effects with varying consequences on the vegetation cover (spatial landscape structure). Similarly, other studies revealed that crop farmers have destroyed natural vegetation cover at an alarming rate, encouraged wetland encroachment and exposed soil to erosion (Nuner et al., 2011). Thus leading to wetland use /cover changes.

The loss of natural vegetation cover in the study area is attributed to poor farming methods and land use practices involved in the crop production such as clearance of tree cover coupled with the use of fire to prepare land for crop production (Sham and Tiwari, 2010). This has led to the decimation of forests, bushland and woodland which are the critical spatial structure of the wetland ecosystem.

The findings (Table 4.5) also revealed that the rapid loss of spatial landscapes structure (tree cover) and degradation of Rhino wetlands and the adjacent landscape are associated with exponential human population growth, for instance, the refugees' population grew from 15,304 people to 53,153 individuals as of 30th June 2011. Within just seven years the population of refugees multiplied by 3.5 times (Malkki, 2012). Such increased influx of refugees exerted pressure on the marginal wetland and destroyed the spatial wetland structures thus leading to depletion of the wetland ecosystem.

Diversity and composition indices for wetland ecosystem in the landscape showed an obvious zonation and patches. The main patch size being subsistence farming and built up, wetland and woodland had relatively large size but diminishing in successive images. Rhino wetlands are rich in diversity as observed in central forest research (CFRs), (Nampindo et al., 2011). However, Uganda's present policies and legislation for the management of natural vegetation outside protected areas (pa) is inadequate. The existing land tenure system of land holdings, especially customary holdings after little incentive for protection and management of vegetation outside protected areas and maintenance of natural vegetation is at the mercy of individual landowner. The findings concur with such studies, in that most of the spatial wetland structure in terms of vegetation cover has been cleared and converted to human use for agriculture, settlement and infrastructural development

5.2.2 Landscape Metric

In comparison, the period 2015-2019 shows that the class metrics parameter for 2015 were higher than those of 2019 (Table 4.6) implying that in 2019 wetland cover changes increased significantly which affected landscape structure. In a nutshell, the analysis of chosen metrics between 2015 and 2019 revealed that wetland and woodland in the Rhino settlement were greatly fragmented in 2019 hence affecting the spatial landscape structure of the ecosystem. This is because much of the vegetation was cleared in preparation for subsistence farming and built up (settlement). Some land was swallowed up by open water during flooding. Anthropogenic pressures are the key drivers of wetland cover changes (Vasconcelos et al., 2012).

5.3 Determinants of firewood and charcoal production as major proxies of wetland cover changes.

These proximate drivers (Table 4.7) were triggered by family size, poverty, weak enforcement of environmental laws, type of food cooked, method of cooking, availability of wood, availability of labour and household income level.

Among the perceived important determinants of firewood and charcoal production as a major proximate of wetland cover changes is poverty (Table 4.8). The majority of the refugees in

Arua district are characterized by a high level of poverty and lack of alternative livelihood sources (Hunter, 2009). Harvesting and selling of woodland, wetland and bushland products like firewood and charcoal are among the sources of income for most of the refugees. Such over-dependence and unsustainable extraction of natural resources without alternative economic strategies has resulted into serious environmental problems including biodiversity loss and degradation of wetlands (Tweheyo et al, 2012) thus contributing to wetland cover charges.

Firewood and charcoal are the main sources of energy for refugees in the Rhino settlement. According to FAO and UNHCR, (2016), the increased inflow of refugees has inevitability increased pressure on natural resources. This is directly associated with the methods of cooking which involves the use of three-stone open fire stoves. This was according to 92% of the interviewees. This kind of domestic cooking stove enables households to use more firewood thereby exacerbating deforestation and wetland degradation (UNHCR, 2017). Household surveys, FGDs and key informants perceived that each household collects more than three head loads of firewood per week which has accelerated wetland cover changes in the Rhino settlement.

This study (Table 4.8 and 4.9) has further revealed that the increased use of biomass as the main source of energy for the majority of the refugees in the Rhino settlement is trigged to the type of food cooked. It was observed that the diet of the refugees is dominated by dry beans, which are provided by UNCHR and NGOs requiring along cooking time hence consuming a lot of biomass. It has been noted by UBOs, (2018), that average daily consumption of firewood by refugees is 1.6kg per person and charcoal is 1.8kg per person. This has forced refugees to encroach on woodlands, bushland, wetlands to search for firewood and charcoal production for both domestic and commercial use which has led to degradation of biodiversity and wetland cover changes in the Rhino settlement.

Among the perceived important determinants indirectly contributing to wetland coverage in Rhino settlement is weak enforcement of environmental laws. Turyahabwe, (2012), noted that environmental laws of NEMA have only remained on papers but not in practice. This has given an open opportunity to the refugees and local communities to encroach on the wetlands, woodland, bushland to harvest firewood and charcoal production purposely for domestic use, brewing, alcohol distillation, tobacco curing and brick making hence leading to biodiversity loss.

The majority of the household survey felt that increased family size per household during the study period of 2015-2019 contributed to wetland cover changes CIESIN, (2016), noted that the bigger the family size the greater the consumption of fuel wood energy for cooking and heating. It has been observed that during the study period 2015-2019 refugees' inflow increased rapidly in Rhino settlement thus increasing on the demand for charcoal and firewood harvesting hence acting as a contributing factor for wetland cover changes.

This study has further revealed that among main socio-economic determinants, the culture which calls for the use of charcoal and firewood as the main source of energy (Mwaura et al., 2016). High household income level calls for the high demand of charcoal than firewood since such families use charcoal stoves and availability of labour in terms of refuges collects firewood and produce charcoal almost on daily basis. All these determinants have left no woody vegetation in the wetlands of Rhino settlement thus contributing to wetland cover changes (Hansen et al., 2013).

The findings (Table 4.8 and 4.9) revealed that the wood fuels are the primary source of energy in the study area which has contributed to wetland cover change. This finding was in agreement with one of the key informants who had this to say: "People in this area largely depend on firewood for survival. Women and children encroach on woodland, bushland, forest and wetlands on daily basis to collect firewood either for domestic use or sale, others end up collecting dry maize and sorghum stems for preparing meals and brewing. This has put pressure on the environment".

The findings (Table 4.8) show that most of the refugees use firewood for domestic use since they cannot afford other sources of energy. A recent study by UBoS (2018), concur with these findings. UBOS noted that the primary source of energy for more than 90% of households in Uganda and an even higher proportion of refugees is firewood. This has caused a lot of environmental havoc like wetland degradation, loss of biodiversity and open water conversion. Therefore, there's a pressing need to develop strategies for sustainable energy access and wetland resource management targeting both refugees and host communities.

The findings further revealed a steady increase in degradation and vegetation loss. Compulsion revealed increased land cover changes in the Rhino wetlands and woodlands. The areas within the settlement and the buffer zone of five kilometers around their boundaries have been subjected to changes after the refugees' arrival. This has left most parts of the wetlands bare and exposed to degradation. The high demand for firewood and charcoal production has left most of the woody vegetation cover cleared. The findings by Openshaw (2012), also reveal that the significant decline in wetlands and vegetation cover was due to intensive farming and wood fuel collection. There has been a marked change in wetland cover during the study period. The study revealed that intensive collection and production of firewood and charcoal resulted in widespread of environmental degradation, habitat and biodiversity loss. This calls for better management and sustainable use of the wetland ecosystem and related natural resources.

It was observed that the inefficient production and unsustainable use of biomass energy sources in the Rhino settlement adversely contribute to environmental degradation such as wetland cover loss, deforestation, desertification, and soil erosion. In relation to above, one respondent had this to stay: "The persistence electricity blackouts (8-24 hours) in this area have encouraged refugees to over depend on charcoal and firewood to meet the increased demand for fuel in the area".

This, therefore, explains the wetland cover changes in the study area between 2015 and 2019. Still, the findings revealed that proximity of Rhino settlement to Arua town and other neighbouring centers offers a market for wetlands and forest products and this exacerbates the correction of illegal firewood and charcoal production from gazetted wetlands and forest reserves. This has finally caused severe destruction of landscape structures in terms of woody vegetation, which led to widespread of desertification condition in the study area. This calls for sustainable strategies to overcome such ecosystem depletion.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusion

This study assessed the magnitude of wetland use/cover change in Rhino settlement using remote sensing data in conjunction with GIS. The magnitude of wetland use /cover changes was quantified for the last five years using the post-classification comparison technique. The Rhino settlement was found to have experienced rapid changes in wetland cover, particularly in swampy and woody vegetation. The analysis revealed that subsistence farming increased by 9% built up by 1% and open water increased by 0.2% during 2015-2019 periods. This resulted in a substantial reduction in the area of wetland. Therefore, the conversion of wetland to subsistence farming and built up has caused extensive and varied environmental degradation in the study area.

Use of Fragstat analysis was used to determine the effect of wetland use/cover changes on the spatial landscape structure of the ecosystem. A set of fifteen metrics at class level was used to quantify complex spatial landscape structure of the ecosystem in the study area. The Fragstat analysis revealed that the metrics parameters for 2015 were higher than those of 2019 implying that during the five years there was a substantial decline in wetland covers especially swampy and woody vegetation hence leading to the subsequent loss of biodiversity in the Rhino settlement.

The study has examined the determinants of firewood and charcoal production as a major proxy of wetland change using socio-economic data analysis delivered from household survey FGDS and key informant interviews. Family size, poverty, weak enforcement of environmental laws, type of food cooked, methods of cooking, availability of wood, availability of labour, culture and household income level were ranked as the important determinants perceived by local communities to be responsible for increased production of firewood and charcoal, which has caused wetland cover changes in the study area. Therefore, the assessment indicates a steady increase in the degradation of wetlands and its spatial landscape structures in the Rhino settlement.

6.2 Recommendations

In view of the findings of this study, the following recommendations are made in an effort to improve and conserve Rhino wetland in Arua district:

The results revealed that wetland use in the Rhino Sub-county in terms of subsistence farming and built up increased greatly at the expense of wetland cover thus, reducing its magnitude. It is therefore recommended that the government through the environmental officers and environmental activists including NGOs, stand together to maintain and control unfavorable anthropogenic activities in the Rhino wetland. In addition, the government through NEMA should demarcate the boundaries of Rhino wetlands, which should be out of bound from human activities so as to maintain its functionality.

The class metrics shows that the spatial land structures in Rhino wetland started diminishing at a faster rate due to increasing human activities of the refugees and community around. Therefore, the environmental managers like NEMA and Environmental activists need to continue reinforcing the restoration of Rhino wetland by carrying out programmes like Buffer, relocating or even a victim human who continue to encroach on the Rhino wetland. This is paramount if Rhino wetland is to continue existing.

The study revealed that, increased use of Biomass as the main sources of energy by refugees contributed to the destruction of the biodiversity in the Rhino wetland. Therefore awareness should be raised about the importance of sustainable wetland management and the business potential of wood energy plantation, agroforestry systems and enhancement of energy efficiency to ensure full understanding and support among the refugees and host communities. So, sensitization of society to the values of biodiversity in Rhino wetlands needs to be recognized and re-enforced. This may only be done through education and knowledge transfer to various levels to all stakeholders.

6.3 Suggested Areas for Further Research

Based on results, the study recommends further studies to investigate the impact and consequences of wetland cover changes on the rural livelihoods of the studied area so that landscape management decisions and strategies are made based on scientific findings.

This study was conducted in the Rhino refugee settlement in Arua. Related studies need to be conducted in another refugee camp in Uganda for purposes of comparison. This may enable the study to carry out observational wetland use and magnitude of wetland use / cover changes. This will bring out studies to enrich and complement this study.

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Appendix A: Questionnaires

Dear esteemed respondent, my name is ISABIRYE AHMED conducting study on the impact of refugee settlement on wetland use /cover changes in Rhino refugee settlement- Arua district. This is intended to facilitate the researcher in writing research report for academic purposes, which will lead to award of Master of Arts degree in geography of Kyambogo University. It is my humble request that your answers to the questions should be honest and without fear or favor. I give assurance to keep your responses confidential and that all or part of it will never be used for any other purpose other than research.

Section I: Social-Economic Characteristics

1. Date of interview Day ……… Month…….. 2019

Refugee settlement

2. Zone/village……………………………..… Parish……………………..……..…
3. Sub county……………………………..….. District……………………………..…
4. Refugee from which country of origin

A. Sudan
B. DRC
C. Rwanda
D. Burundi
E. Somalia
F. Others (specify)…………………………………..

5. Household position

A. Father
B. Mother
C. Son
D. Daughter
E. Grand father
F. Others (specify)………………………

6. Gender responded

A. Male
B. Female

7. Age (years) of respondent…
8. What is your marital status?

A. Single
B. Married
C. Separated
D. Divorced
E. Widowed

9. What is your level of education?

A. Primary
B. Secondary
C. Vocational
D. University
E. None

10. How many household members stay in your house?
11. Who collects firewood in this household?

A. Women
B. Husband
C. Children
D. All

12. What is the main use of wood fuel?

A. Heating
B. Cooking
C. Others (specify) ………….

13. What is your main source of livelihood?

A. Farming
B. Formal
C. Casual labor
D. Business/ trading
E. Others (specify)………………

14. What is your average monthly income?…….
15. What is the size of your plot?....................................

Section 2: Wood Analysis

Measures

1. Wood
16. Daily head weights of wood fuel consumed wet / green?............(kgs)
17. Daily head weights of wood fuel consumed (air dried)? ………….(kgs)
18. What is your perception on the burning quality if wood?

A. Very good ☐ C. Moderate ☐
B. Good ☐ D. Poor ☐

19. What do you use wood fuel for?

A. Heating ☐ C. Others (specify)………..
B. Cooking ☐

20. Number of trips to pick firewood in a day

A. During dry season ☐ B. During wet season ☐

21. What is the average length of wood fuel?......................
22. What is the duration of collecting wood fuel?.................
23. What is the source of wood fuel?

A. Woodlands ☐ D. Wetlands ☐
B. Bush lands ☐ E. Gardens ☐
C. Tree plantation ☐ F. Others(specify)…………

2. **Charcoal**
23. Daily weights of charcoal consumed ………….(kgs)
24. What is the distance of charcoal collection?
25. What is your perception in the burning quality?

A. Very good ☐ C. Moderate ☐
B. Good ☐ D. Poor ☐

26. What do you use the charcoal for?

A. Heating ☐ C. Others (specify)…………
B. Cooking ☐

27. What is the average size of charcoal?.................
28. Number of trips to pick charcoal…………..
29. What is the duration of collecting charcoal?.............. Hours
30. What is the source of charcoal used in your household?

A. woodlands ☐ D. Wetlands ☐
B. Bush lands ☐ E. Gardens ☐
C. Tree plantation ☐ F. Others (specify)……………

Wood moisture sampling

31. What is the wood fuel moisture content wet (green)?.............
32. What is the wood fuel moisture content (air dried)?........
33. What is the weather of the day?

A. Rainy ☐ C. Cloudy ☐
B. Sunny ☐ D. Other (specify)………….

34. What is the season?
A. Dry season ☐ B. Wet season ☐
35. What is the type of wood fuel storage)
A. Permanent house ☐ C. Grass thatched house ☐
B. Tent ☐ D. Other (specify)…..………………
36. What is the name of the tree species?(in local language)

Section 3: Determinants Of Wood fuel Use

Use the Keynotes:

1- Family size, 2- Culture, 3-Poverty 4- Weak enforcement of laws 5- Type of food cooked

6- Method of cooking 7- Availability of labor 8- Size of house for wood, storage

9- High income 10- Availability of wood

37. Influence of household size on wood fuel demand

Household	**Family size**				
Parameters	**1-3 very small**	**3-5 small**	**6-8 medium**	**9-12 large**	**13-15 very large**
Fire wood					
Charcoal					

Section 4: Constraints and Opportunities to Wood Fuel Access, Storage and Use

Constraints

1- No Funds 2- Long distance 3- Limited awareness 4- Wild fire 5- Indiscriminate Cutting

6- Strict forest laws 7- Rape 8- Wild animals 9- Conflicts 10- Land tenure

Opportunities

i) Available forests
ii) NGOs

iii) Other specify……….

38. What are the constraints to wood fuel access storage and use?

Constraints	**Family size**				
Type of wood fuel	1-3 very small	3-5 small	6-8 medium	9-12 large	13-15 very large
Fire wood					
Charcoal					

39. What are the opportunities to wood fuel access, storage and use?

Opportunities	**Family size**				
Type of wood fuel	1-3 very small	3-5 small	6-8 medium	9-12 large	13-15 very large
Fire wood					
Charcoal					

SECTION 5: Measures to regenerate degraded vegetation and increase wood fuel
Use;

i) Tree planting
ii) Briquettes
iii) Use of energy saving stoves
iv) Others (specify)………

40. What measures have been put in place to regenerate degraded vegetation in order to increase wood fuel?

i) ……………………………………………………………………………………………
ii) ……………………………………………………………………………………………
iii) ……………………………………………………………………………………………

Thank you very much

Appendix B: Interview Guide to Key Informant.

1. What do you understand by the term wetland loss?
2. Comment on the status of wetlands in the Rhino Refugee settlement about 5 years ago compared to how it is now.
3. Why do you think wetlands are steadily losing its values or services?
4. What are the major activities threatening the existence of wetlands in the Rhino refugee settlement?
5. What are the impacts of Refugees on wetland cover changes in your area?
6. What are the determinants of firewood and charcoal production in this camp?
7. What is the wetland use changes taking place within the Rhino Refugee settlement?
8. What natural condition has contributed to wetland cover changes in the Rhino refugee settlement?
9. What is your take to safe guard the wetlands in this camp
10. What are the effects of wetland cover changes on the spatial landscape structure of the ecosystem?
11. Which vegetation species are common in these wetlands?

Thank you very much

Appendix C Focus Group Discussion Guide

1. Mention some of the wetlands in your locality.
2. How beneficial are these wetland to you?
3. Can you talk about the nature of these wetlands now compared to how they were about 5 years ago
4. What are the major economic activities taking place in these wetlands?
5. Do you see any future from these wetlands after those anthropogenic activities?
6. What is your role in causing wetland cover changes?
7. How many of you live within or settle near wetlands?
8. What circumstances forced you to settle within or near the wetlands?
9. What harmful activities have you carried out in the wetlands?
10. What positive impacts have you carried out in wetlands?
11. What forces people to involve in firewood and charcoal production in the Rhino camp

Thank You

Appendix D Observation Check List

1. Settlement area near or within the wetlands
2. Gardens within the wetland.
3. Mining sites within the wetlands.
4. Grazing sites in the wetlands.
5. Papyrus harvesting in the wetlands.
6. Infrastructural development within the wetlands.
7. Garbage disposal sites in the wetlands.
8. People fetching water for domestic use and irrigation in the wetlands.
9. Waste dumping sites by industries

END

Appendix E: Morgan and Krejcie's Sampling Table

Table 3.1

Table for Determining Sample Size of a Known Population

N	S	N	S	N	S	N	S	N	S
10	10	100	80	280	162	800	260	2800	338
15	14	110	86	290	165	850	265	3000	341
20	19	120	92	300	169	900	269	3500	346
25	24	130	97	320	175	950	274	4000	351
30	28	140	103	340	181	1000	278	4500	354
35	32	150	108	360	186	1100	285	5000	357
40	36	160	113	380	191	1200	291	6000	361
45	40	170	118	400	196	1300	297	7000	364
50	44	180	123	420	201	1400	302	8000	367
55	48	190	127	440	205	1500	306	9000	368
60	52	200	132	460	210	1600	310	10000	370
65	56	210	136	480	214	1700	313	15000	375
70	59	220	140	500	217	1800	317	20000	377
75	63	230	144	550	226	1900	320	30000	379
80	66	240	148	600	234	2000	322	40000	380
85	70	250	152	650	242	2200	327	50000	381
90	73	260	155	700	248	2400	331	75000	382
95	76	270	159	750	254	2600	335	1000000	384

Note: N is Population Size; S is Sample Size *Source: Krejcie & Morgan, 1970*