

**EFFECTS OF HUMAN ACTIVITIES ON PLANT SPECIES DIVERSITY IN  
A WETLAND ECOSYSTEM  
A CASE STUDY OF KOGA WETLAND, IN RIVER RWIZI, MBARARA DISTRICT**

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AWARD OF MASTER OF ARTS IN GEOGRAPHY DEGREE  
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**DECEMBER, 2018**

**DECLARATION**

I declare that this dissertation is my original work and has never been submitted to any University or other institution for any award.

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**APPROVAL**

I certify that this dissertation entitled: the effects of Human Activities on plants species diversity in a wetland ecosystem, a case study of Rwizi wetland in Mbarara District has been done under my supervision and is submitted with my approval as the official University supervisor.

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## **DEDICATION**

I dedicate this piece of work in loving memory of my parents; Mr. Longor Simon Peter, a passionate educator who, during his role as head teacher in the 1960<sup>th</sup> and for over thirty years grabbed the Karamojong children from the kraals, grazing fields and forced them to stay in school. Great appreciation goes to Mrs Longor Elizabeth, for being such a great support to my Dad during moments when no one understood him in society for promoting education in Karamoja region.

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## **LIST OF ACCRONYMS & ABBREVIATIONS**

<b>NEMA</b>	:	National Environmental management Authority
<b>NGOs</b>	:	Non Gorvermental Organization
<b>GIS</b>	:	Geographical Information System
<b>SRTM</b>	:	Shuttle Rader Topographic Mission
<b>DEM</b>	:	Digital Elevation Model
<b>UBO</b>	:	Uganda Bureau of Statistics
<b>IV</b>	:	Independent Variables
<b>DV</b>	:	Dependent Varibales

## ABSTRACT

Wetlands are the most productive life support systems in that they provide diverse wildlife habitats. In Uganda 50% of the wetlands have been interfered with by human activities to support livelihoods either through direct consumption or sale of wetland products. The overall objective of this study was to examine the effects of human activities on plant species diversity in river Rwizi with a focus on Koga wetland which is 23km long and 4km wide. The wetland was purposely selected as a representative sample because it was characterized by a majority of human activities taking place in river Rwizi wetland in Mbarara District.

Google Earth map and Geographical Information System tools were used to identify and map human activities and it was found out that the dominant human activities were Brick making, animal grazing, crop growing and settlement. Nested plots of varying sizes were used to determine plant species diversity; 2500 m<sup>2</sup> nested plot, 400 m<sup>2</sup>, 4 m<sup>2</sup> and 1 m<sup>2</sup> were used for trees, shrubs, herbs and grasses respectively. counts, percentages and twin comparisons of plant species in the disturbed and the undisturbed study sites were determined and recorded. Simpson's Diversity index was used to measure plant to measure the plant species index.

Findings of the study revealed that, among the dominant human activities carried out in the study area, all human activities were destructive to the population of the plant species, in that the cropped area had only 6% of the plant species, the bricked had 9% while the settled had 35% and the grazed 36% indicating that there were very slight differences in their effects.

This study further determined the differences in diversity score of plant species diversity among the disturbed and the undisturbed sites by use of Simpson's Diversity Index. The study revealed that the bricked site had 0.65(65%), followed by the undisturbed site with 0.59 (59%), The grazed site ranked third with 0.53 (53%) diversity score, then settled came fourth with 0.50(50%) and cropped ranked last with the least diversity score of 0.46 (46%).

Based on the findings, the study concludes that there are no much differences among the effect of the human activities on plant species diversity and thus all activities affect the plant species diversity. So, there is an urgent need for government and environmental activists to mitigate this situation. From the findings, it is recommend that future researchers need to consider qualitative studies such as in-depth interviews with wetland invaders.

# CHAPTER ONE

## INTRODUCTION

### 1.0 Overview

This chapter involved the back ground to the study, problem statement, objectives, research questions, the scope of the study, conceptual frame work and the operational definitions of the key terms used in this study.

### 1.1 Background to the Study

Wetlands are “areas of marsh, fern, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six meters” (Bhatia & Goyal 2014). Worldwide, wetlands cover an area that is 33% larger than the entire United States of America (Kingsford, Basset & Jackson, 2016). Africa has 7% hectares covered by wetlands, varying in type from saline coastal lagoons in West Africa to fresh and brackish water lakes in East Africa (Amler, Schmidt & Menz 2015). To Junk (2013) wetlands cover approximately 7% of Africa with East Africa wetlands covering 3% hectares while in Uganda wetlands originally covered up to 13%. About 50% of the nation’s wetlands are reportedly under human activities to support livelihoods through either direct consumption of wetland products (including cultivation of crops) or sale of wetland products to generate cash (Turyahabwe, Tumusiime & Yikii 2017).

Wetlands are the most productive life support system on the planet since they provide diverse wildlife habitats. Streams, rivers and wetlands are unique habitats for plant species diversity and are among the most fertile and productive ecosystems in the world because flowing water create conditions that are constantly changing. Marine habits are exposed to constant ocean waves, currents and tides and therefore plants living in such environment must be well adapted to survive (Bailey 2009). In the United States of America, for example, there was an estimation of 150 species of birds and 200 fish species and animal species. The Nariva swamp alone is a habitat for varied animal species that include crustaceans, insects, Arachnids, Molluscs, fish, Amphibians, reptiles, birds and mammals.

In East Africa, for instance, Lake Nakuru wetland in Kenya, one of a series of saline–alkaline closed basin wetlands in the Eastern Rift Valley is inhabited by millions of flamingos and is considered the World’s bedrock to tourism. However, over the last 40 years, Nakuru wetland has been heavily settled, extensively cultivated, urbanized and industrialized. Human activities such as poor agricultural practices, animal grazing, sand mining which attract pollution, wildlife mortality/morbidity, human/wildlife conflicts, poverty, ethnic tensions, land clashes and lack of adequate legal and policy framework have disrupted the plant and animal species diversity (Raini, 2009).

In Uganda, wetlands have been classified as lakes and estuarine wetlands, riverine swamps and flood plains. The lakes and estuarine wetlands comprise Lakes like; Victoria, George, Edward, Albert, Wamala, Bisina, Opeta, Kyoga, Kwania and Bunyoyi. The riverine swamps and flood plains include the Okole, Kafu and Nile systems (Opiro, Saarman & Caccone, 2017). River Rwizi ecosystem falls under the riverine wetland. River Rwizi wetland connects to Lake Victoria thus filtering contaminants that drain into it. River Rwizi wetland originates from Buhweju hills and stretches across ten districts in South –Western Uganda covering approximately 8,000 km<sup>2</sup> with various tributaries originating from various Nkore hills including those from Ntungamo and Sheema hills which join it. It pours its water in Lake Victoria via the drainage systems of Lakes Mburu, Kachera and Kijanebalola. The river supplies water for both domestic and industrial use; and its wetland supports various economic activities such as; crop growing, livestock rearing, fish farming and touristic purposes like the case of Lake Mburu National Park, establishment of local industries especially brick making, sand mining, motor vehicle washing, wide spread growing of eucalyptus trees and it avails various plants for consumption, medicine, making mats and art pieces ( Musasizi, 2015).

River Rwizi wetland is a habitat of species diversity, like any other Wetlands River Rwizi wetland is rich in plant life as it runs across the Districts of Mbarara, Ntungamo, Isingiro, and Kiruhura. The River Rwizi wetland plays a big role in the survival of plants species diversity in that, it prevents flooding and acts as a giant sponge reducing flood damage of plant species. It contributes to diverse plants by providing nutrients that support a wide variety of plants; wetlands protect stream banks from erosion which can endanger plant species diversity. In general, the growth of wetland plants species and algae is nourished by nutrients from detritus wetlands (Rao, Khobragade & Sahany . 2017).

Indeed Wetlands deliver a wide range of critical, important services as wetland vegetation and forests are used for commercial, touristic, aesthetical value; several wetland plant species are used for fuel, textile, leather, dyes, cloth, food and beverages. Wetlands render unique functions that contribute to human well-being such as nutrition, climate regulation, coastal protection, feeding and nesting sites and recreational opportunities. Wetlands also act as natural sponges absorbing and storing excess rain water therefore reducing flooding. In the dry season they release the stored water delaying the onset of drought and water shortage (Akello, Turyahabwe & Sseguya 2017). Moreover, Aminu, Matori & Yusofl (2015) affirm that wetlands act as natural filters for nutrients and contaminants that originate from the catchment area, thereby protecting the water quality.

Cognizant of the valuable roles of wetlands and wetland resources, human beings have continually failed to balance the drive to exploit the wetlands and the value of co-existing with them; instead, there is an ever increasing human encroachment on wetlands through crop growing, animal raring and other activities. This intense use of wetlands has resulted into major human impacts that include alterations of water flow and barriers to water movement. These result into interference with the nature of wetlands leading to recurring patterns of flooding or patterns of reduced water volumes that may even lead to water scarcity. Human activities also causes changes in water chemistry; water pollution, land degradation, habitat changes and interruptions of the plant species, leading to low plant species diversity. It is against this background that this study was conducted to assess the effects of various human activities on the plant species diversity with the aim of recommending sustainable wetland use.

## **1.2 Problem Statement**

It is globally accepted that unregulated human activities can be disruptive to the integrity and functionality of the wetland ecosystem. Increase in human population and activities have led to encroachment on the Rwizi Wetland leading not only to the indiscriminate destruction of the ecosystem but also the beautiful scenery (Mugonola, Wanyama & Isabirye, 2015). The human activities such as cropping, brick making, animal grazing and settlement in the wetland have also resulted into adverse weather changes that have led to water shortages, high costs of water

treatment, flooding, pollution and the gradual extinction of plant species diversity (Ryken, Vanmaercke & Wanyama 2015).

To salvage the situation, efforts have been undertaken by the government and by the NGOs to prevent further destruction and to restore River Rwizi wetland. These efforts have included the move by Mbarara group of activists working at grass roots levels known as “Citizen Uganda to save River Rwizi wetland” who carry out the eviction of encroachers, (Nahamya, 2017). NEMA has also worked together with district leaders to recover the Rwizi wetland. Of recent, 118 acres of the wetland from Buhweju district was recovered. Besides, there is sensitization of the community and efforts to enable them to manage the wetland; for example there is support from Revolt, GIZ, National Water and Sewage Cooperation and NEMA, intended to provide alternative livelihoods for people living close to the wetland. Compensation money has also been offered by for instance the government, the Coca Cola Company to convince locals to quit and allow regeneration of the swamp. The ministry has also gazetted a buffer zone of 100 meters from the banks along its twenty-five meter stretch. In addition, a twenty-two member committee comprising environmental activists, local leaders, Members of Parliament, and government officials has been created and charged with the overseeing the protection and recovery of Rwizi wetland (Muhangi, 2016).

Despite efforts undertaken to overcome wetland encroachment, human activities continue to escalate on river Rwizi Wetland leading to continual degradation of the wetland with its adverse effects on plant species diversity like gradual extinction of plant species diversity. The problem has become so serious that some have suggested that military interventions are required to save Rwizi wetland (Muhangi, 2016).

In particular no comprehensive study has been done to examine the effect of a combination of human activities on plant species diversity in river Rwizi Wetland. Previous endeavors paid attention to how land use activities generally impact wetlands (Shackleton, Hurley & Dahlberg, 2017), but these scantily addressed plant species diversity. A specific study on River Rwizi Wetland was carried out to assess the extent to which brick making had affected wetland plant species diversity (Akwongo, 2009). But this study concentrated on brick making, water quality and soils but paid little attention to plant species diversity. Even then the findings of the study are limited to brick making yet, different kinds of human activities do not necessarily have equal

effects on plant species diversity in the area. It was against this background that this study was set out to assess the effect of human activities on plant species diversity in river Rwizi Wetland in Mbarara District.

### **1.3 Objectives**

At the end of the study, the following objectives were achieved:

#### **1.3.1 General Objective**

The overall objective of this study examined the effect of human activities on plant species diversity in river Rwizi wetland in Mbarara district.

#### **1.3.2 Specific Objectives**

- i. To identify and map the different human activities in Koga wetland in river Rwizi;
- ii. To determine the differences in plant species diversity in the disturbed and undisturbed areas in Koga wetland in river Rwizi.
- iii. To find out the most detrimental human activity on plant species diversity in Koga wetland in river Rwizi.

### **1.4 Questions**

1. What are the different human activities found in Koga wetland, in river Rwizi?
2. How can human activities be mapped in river wetland?
3. What are the differences in plant species diversity in the disturbed and the undisturbed areas in Koga wetland in river Rwizi ?
4. Which one is the most detrimental human activity to plant species diversity in Koga wetland in river Rwizi?

### **1.5 Scope**

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

### **1.5.1 Geographical scope**

The Geographical scope is Koga wetland which is found at the border of Mbarara and Sheema district, the wetland is 23km long and 4km wide. The area was preferred because it has the highest number of human activities.

### **1.5.2 Content scope**

This study focused on two variables. The independent variable (IV) was human activities such as brick making, crop growing, animal grazing, and settlement while the dependent variable (DV) was plant species diversity. Specifically, the study located the distribution of human activities in River Rwizi Wetland, compared the plant species in the disturbed and the undisturbed sites, and then found out the most detrimental human activity on plant species diversity in the disturbed areas of River Rwizi wetland.

### **1.5.3 Time scope**

The planned research activities were slated to cover a period of nine Months commencing September 2017 without counting holiday time. Data was collected from late March to mid April 2018. Data was collected within the time of visit since the study was a descriptive survey. Also, related literature considered 10 years way back from 2018. This period was regarded to generate recent information.

## **1.6 Significance**

Looking at the effects of human activities on plant species diversity in Koga wetland in river Rwizi will help environmentalist in key positions of authority to improve on management of Rwizi wetland by possibly regulating the human activities in a way that humans learn how to tap the wetland resources so as to appreciate, coexist, and preserve the River Rwizi Wetland.

As Koga wetland in River Rwizi wetland is endowed with various vegetation cover which provide valuable functions noted, this research may inspire governmental organizations and development partners; in making sure that means to reclaim and protect River Rwizi Wetland are improved, maintained and strengthened.

The law makers, policy makers, both at the national and local level such as the National Environmental Management Authority, Ministry of Health will be able to restore and maintain

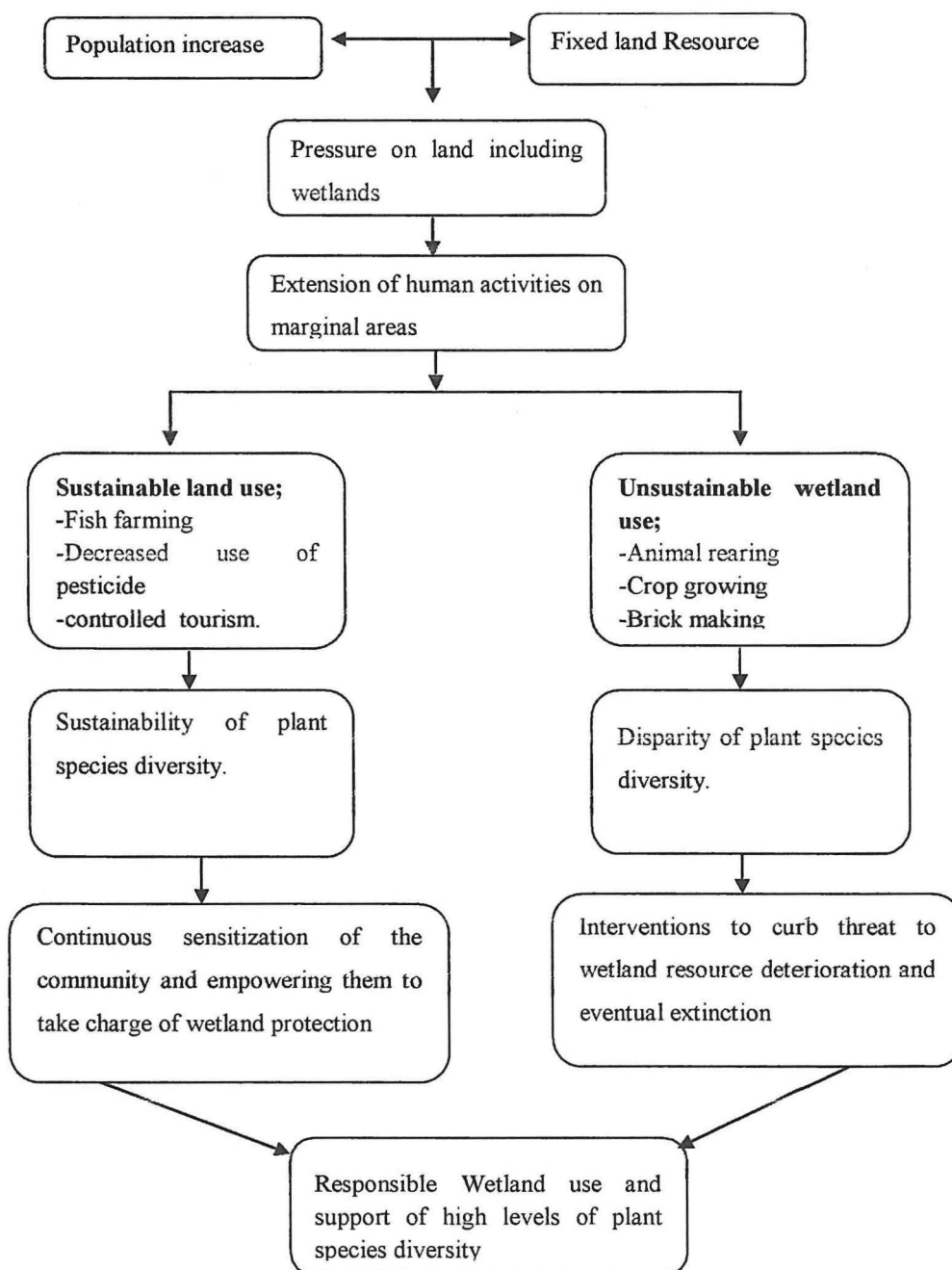
all wetland and environmental resources at large, for both the present and the coming generation.

The academia world may also take keen interest in this study for inspiration and referencing purposes in future, for further research or re-investigations and hypothesis formulation. There is likelihood that even wetland intruders may be inspired by this research and may provoke in them a change of attitude and instead take active involvement in fighting against the wetland depletion as Wetland destruction has become an environmental concern which needs to be handled. Furthermore, various human activities in the wetland is one of the major causes of intermittent flooding and low water levels we are witnessing and therefore, this study is coming in at a well desired time and it is hoped that such effects would be mitigated.

Various studies have been conducted on river Rwizi wetland depletion due to uncontrolled human activities. The outcry by NEMA officers for the lost beauty of river Rwizi wetland has hitherto been not listened to (Tumwebaze, 2018). The findings of this study may be relevant in that it is in line with what NEMA and Environment Office Authorities have done regarding management of river Rwizi wetland, NEMA has even spent heavily on demarcating the NEMA buffer zone, but the authority has not critically looked at localizing and mapping human activities so as to critically identify the effect of human activities on plant species in the undisturbed compared to the disturbed ecosystems in the wetland (Nsubuga, Namutebi & Nsubuga-Ssenfuma, 2014). Already, NEMA and the Municipal Environment Offices are struggling with river Rwizi wetland buffer restoration (Tumwebaze, 2018). This study therefore, will help show the places of highest human activity and their effect on plant species diversity.

Furthermore, new knowledge will/is added to the existing body of knowledge through publications.

## 1.7 Conceptual framework



**Figure 1.1: Conceptual framework**

**Source:** Ideas adapted from NEMA (Wetlands, River Banks & Lake shores management) regulations, ( 2000), and modified by the recorder.

Figure 1 conceptualizes the cause and effect relationship and what intervention would be done to reduce degradation of plant species diversity. The rapidly increasing population is interacting with fixed land size, causing populations of people to occupy marginal land including wetlands. Whilst in the marginal land some part of populations may practice sustainable wetland use and heed to sensitization for responsible wetland use leading to support of plant species diversity, while others may tend to indiscriminately carry out activities such as crop growing, animal keeping, settlement, brick making, and this consequently results into wetland degradation inclusive is disappearance of plant species diversity and richness.

Interventions bring about the rehabilitation of wetlands through sustainable land use activities like fishing using traps, spears, and baskets or other methods other than wires, any cultivation where the cultivation is not more than 25% of the total area of the wetland, harvesting of papyrus, medicinal plants, trees and reeds, hunting subject to the supervision of the wildlife Act, Cap 200. (NEMA ,2000); Coupled with community support and empowerment to take charge of wetland regeneration, sustainable use (Muhangi, 2016), which could encourage responsible wetland use and support of high levels of plant species diversity of which wetland preservation is the ultimate goal.

### **1.8 Operational definitions of key terms**

**Disturbed area:** Places in the wetland where intruders have penetrated to conduct activities such as crop growing, animal grazing, settlement and brick making.

**Undisturbed areas:** Places in the wetland where wetland intruders have not conducted land use activities.

**Wetland:** Area where water covers the soil, or is present either at or near the surface of the soil all year or for varying periods of time during the year.

**Grass:** vegetation consisting of typically short plants with long, narrow leaves, growing wild or cultivated on lawns and pasture, and as a fodder crop.

**Herbs:** is any plant with leaves, seeds, or flowers used for flavoring, food, medicine, or perfume,, it can also be any seed-bearing plant which does not have a woody stem and dies down to the ground after flowering.

**Shrubs:** a woody plant smaller than a tree, usually having multiple permanent stems branching from or near the ground. The British Dictionary also defines shrubs as a woody perennial plant, smaller than a tree, with several major branches arising from near the base of the main stem.

**Trees:** a woody perennial plant, typically having a single stem or trunk growing to a considerable height and bearing lateral branches at some distance from the ground.

**Species diversity** is sometimes referred to as species heterogeneity and it is the number of different species that are represented in a given community or in a particular area

**Plant species richness** refers to the number of different species represented in an ecological community, landscape or region.

**Detritus wetlands:** debris, wetlog, silt etc

## CHAPTER TWO

### LITERATURE REVIEW

#### 2.0 Introduction

The chapter presents the literature review. It is divided into three major sections. The first section presents review on identification and mapping of human activities on the river shores. The second section presents a review of the distribution of plant species diversity in the undisturbed area on the River Rwizi shores. The third section presents a review on the comparison of the effect of human activities on the distribution of plant species diversity on the river shores.

#### 2.1 Wetlands

Wetlands are diverse environments which are defined by several factors; these include the soil type, hydrology, topography, climate and vegetation. Natural and human landscape disturbance activities could potentially negatively affect the above mentioned factors. Abiotic and biotic characteristics of a wetland are controlled by the hydrology of that wetland. Wetlands have a scientific and legal definition. A scientific definition was provided by Cowardin *et al.* (1979) cited by Edwin (2014) who defined wetlands as “lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface”. Moreover, the legal definition of wetlands under the Clean Water Act is: “those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas (Martínez, 2014). Basically, there are three natural wetland types which are open water, marsh, and wet meadow (Zhang, Ma, & Fu, 2010).

#### 2.2 Importance of Wetlands

The importance of protecting biodiversity is receiving also growing political attention since the convention on biological diversity and key services to societies (Zotos, Meli, Rey Benayas,

Balvanera, & Martinez Ramos, 2014). Wetlands provide important wildlife habitat in many landscapes, and the functional connectivity of reserves and other suitable habitat patches is crucial for the persistence and resilience of spatially structured populations (Uden, Hellman, Angeler, & Allen, 2014).

Humans are dependent on a large number of species of animals, plants, fungi, and microbes that provide indispensable ecosystem functions and produce essential goods. Apart from the economic valuation of the direct and indirect benefits of biodiversity, people place existence values on biodiversity, i.e. they consider the existence of particular species, regardless of the services they provide. There is also a general recognition that species diversity indicates the status of the ecosystem or community, and thus the quality of the living environment. Nevertheless, Ecologists also agree that humans are degrading the earth's ecosystems and leading biodiversity to extinction (Maturó & Di Battista, 2018).

### **2.3 The Concept of Species Diversity**

Biodiversity or biological diversity is a term that describes the great variety of living beings on earth. It is described as degree of variation of life on earth. Biodiversity also refers to the number, or abundance of different species living within a particular region. Plant cover refers to the relative area covered by different plant species in a small plot (Damgaard, Ehlers, Ransijn, Schmidt, & Svenning, 2018). Also, plant cover could synonymously be referred to as the abundances of plant species that are often measured. Point intercept method is the commonly used method to estimate cover, that is ; use of single points, points that are arranged on transect, in point frames or on quadrates, whereby the number of hits on a canopy vegetation or soil surface depending on the type of cover that one is trying to estimate is recorded ( Abbott, 2018).

Species diversity is sometimes referred to as species heterogeneity and it is the number of different species that are represented in a given community or in a particular area (Cardinale, Gonzalez, Allington, & Loreau, 2018).

Plant species distribution is regarded as the manner in which a given plant species is spatially arranged in the study area (Tucić, Budečević, Manitašević Jovanović, Vuleta, & Klingenberg, 2018), while Plant species dominance is the degree to which a plant species is more numerous than other plant species in a particular wetland ecosystem (Tucić *et al.*, 2018). A given species

was regarded as the most dominant when it occupies the biggest portion of the area under investigation. For example, it has been revealed that in many examples of wet woodland in western Europe, the dominant tree is *Alnus glutinosa* (Squires, 2018).

Kipkenboi and Van Dam (2016) point out that, Papyrus (*Cyperus papyrus*) is typical tropical wetland sedge that can grow up to a height of 5–6 m under optimal conditions. It is dominant vegetation in many wetlands in central, southern and eastern Africa, the Nile valley and in some parts of the Mediterranean in the Middle East and southern Europe. Papyrus is one of the most productive wetland sedge and is structurally and physiologically adapted to permanently and seasonally flooded wetlands.

#### **2.4 Human Activities in Wetlands**

(Arizpe, Juarez, Cruz, & Torres, 2018) Human activities in wetlands vary depending on a variety of factors (Arizpe *et al.*, 2018). They also revealed that area of recreation of local population, tourism national and international, and for activities of birds watching interfered with wetland coverage. To Arizpe *et al.* (2018) high environmental deterioration was caused by human activities and in turn was increasing the vulnerability in the last decade. It was reported that in Mexico there was a reduction by more than 40% in the last 15 years due to the unplanned tourism development. This resulted into a big deterioration of plant species diversity due to increased pollution and fires. Also, there has been report showing a decline in tourist interest declared in 2014 in Baja California Sur wetland, Mexico.

Recently, Timbiti (2018) analyzed various authors and revealed that commercial brick-making are, for instance, visible in the Kawanda wetland in Wakiso district on the Kampala- Luwero road was the most human activity destroying wetlands in Uganda. Besides, the clay extraction was also cited. He attributed loss of plant diversity to brick burning and clay mining to the increased demand of building materials. He further explained, results in gas emissions from fuel combustion. The demand for bricks has resulted into the demand for wood energy to burn the bricks causing massive deforestation, reducing the amount of rainfall and lowering the water levels in Lake Victoria. Apart from carbon emissions, brick-burning, over the years, destroys the fertility of wetlands and affects the vegetation cover. However, the researcher presumed that there could be a difference in wetland use since Ankole region is rural compared to the high

urban setup in nearby Kampala. Besides, in Ankole agriculture especially cattle keeping are a pronounced treasurable activity for economic and household upkeep.

Safari (2008) was conducting the study aimed at assessing the extent of lowering the water quality in Nyaruzinga wetland, Bushenyi-Ishaka Town Council, Western Uganda found out the major activities carried out in the wetland are; subsistence agriculture, livestock management, mud fish (Safari, 2008).

Reclaiming wetlands following open pit mining for industrial soil extraction is challenging due to the physical and chemical conditions of the post-mined landscape and its adverse effects on the plant community composition of wetlands. (Roy, Foote, & Ciborowski, 2016).. The sediment of created wetlands will have significantly less moisture, total nitrogen, and organic content than the natural wetlands. Most significantly, the basin morphometry of created wetlands was significantly different from that of naturally-formed wetlands in the region, and this appears to partly explain difference in vegetation composition. We also demonstrate that species richness alone is not a useful measure in wetland monitoring. Instead, plant community composition is a better indicator of wetland conditions.

Pope Francis (2015) referred to as “Our common home” He laments on the loss of forests and woodlands which entail the loss of species which constitute extremely important resources in the future, not only for food but also for curing disease and other uses. He emphasizes that different species contain genes which could be key resources in years ahead for meeting human needs and regulating environmental problems. He continues to say that: “it is not enough to think of different species merely as potential “resources” to be exploited, while overlooking the fact that they have value in themselves. Each year sees the disappearance of thousands of plant and animal species which we will never know, which our children will never see, because they have been lost forever.

As wetlands provide various ecological and socioeconomic functions, they are however losing their vigor at alarming rate due to unwise management. Hence, there is an urgent need to monitor and assess these resources so as to identify the major drivers of its degradation and to provide information for management decisions. Increasing human disturbances such as livestock grazing, farming and eucalyptus plantation around the wetland have contributed wetland degradation and decrease in the macroinvertebrate richness and diversity (Gezie, Anteneh, Dejen, & Mereta,

2017) . These alterations could also reduce the availability of wetland products (sedges, craft materials, etc.) and the related ecosystem services. This in turn has an adverse effect on food security and poverty alleviation with considerable impact on communities who heavily depend on wetland products for their livelihood. Therefore, it is essential to formulate wetland policy for achieving wise use goals and necessary legal and institutional backup for sustainable wetland management.

## **2.5 Species Diversity in the Disturbed and Undisturbed Wetlands**

Literature available indicates that there are variations in plant species biodiversity across the globe (Jetz et al., 2016). Besides, there has been unrecognized source of biomass in wetland ecosystems with different rates of net primary productivity. For example, papyrus is emergent sedge with C<sub>4</sub> photosynthesis which is native to the wetlands, river valleys and lakes of central, eastern and southern Africa has showed great variations in plant species diversity. The mean standing dry matter of culms and umbels measured at a number of locations throughout East Africa is  $38.3 \pm 21.6$  tDM ha<sup>-1</sup> and the aerial net primary productivity ranges between 25.9 and 136.4 tDM ha<sup>-1</sup> yr<sup>-1</sup>. Papyrus vegetation can be harvested by hand and stacked on the rhizome mat for partial air-drying, and it has been demonstrated that an annual harvesting regime has no negative impacts on long-term productivity. The use of papyrus as a biofuel for cooking and heating depends on converting it to a suitably combustible form, such as compressed or carbonized briquettes with a calorific value approximately one-third less than wood charcoal.

Ettagbor (2010) conducted a study in two sites of the Cross River within the Lebialem-Mone forest landscape of Cameroon in which one of the sites faced with human activities (test site) and the other with no human pressure (control site). Fish communities living within these 2 sites were compared after collecting fish from them using gill nets within 2 months of sampling (September-October 2009). Shannon index is also for both sites was calculated to obtain the species diversity and it was found out that fishing and deforestation constituted the main factors affecting the fish communities on both sites as over 55 % of the river catchment in the test site has been deforested.

In Mbarara, access to clean and safe water and improved sanitation facilities and practices are pre-requisites to a healthy population and therefore have a direct impact on the quality of life and

productivity of the population (Ojok, Wasswa & Ntambi, 2017). However, the study does not indicate the locations of the activities that are detrimental to the wetlands.

Moges *et al.* (2017) investigated the full range of vegetation diversity in six wetlands under different land uses of Ethiopia. In total, 122 vascular plant species that belong to 86 genera and 37 families were identified. The family Poaceae and Asteraceae contributed the highest number of species. The beta and Shannon diversity ranged from 3.7 to 10.7 and 1.5–3.4 and differed significantly across wetlands. When considering the land uses, the agricultural and urban wetlands could even be more diverse than the forested wetlands and therefore, are not significantly different. The ranges of plant species diversity among the impaired wetlands were observed to be related to disturbance and competitive exclusion processes, and environmental heterogeneity. However, the study did not compare the disturbed and the undisturbed population of plant species biodiversity.

Similar to Catford *et al.* (2012) while using the intermediate disturbance hypothesis (IDH) that predicts a hump-shaped pattern between community diversity and disturbance, and is central to understanding patterns of species diversity. Here, IDH in the context of alien plant invasions was examined. IDH can offer insight into the role of disturbance in facilitating plant invasions and the effect of these invasions on floristic diversity. Early stages of succession are most susceptible to invasion because resources and colonization opportunities are elevated after disturbance. This trend is accentuated by human-mediated dispersal, a bias towards early successional species in the alien species pool, the tendency for fast-growing species to profit most from enemy release, and increased disturbance levels in human-modified habitats.

Human disturbance, coupled with plant introductions, extends the diversity–disturbance curve and shifts peak diversity towards higher disturbance levels. However, invasive aliens can reduce native diversity at the community scale, especially in mid succession where competitive interactions structure communities were considered.

Certain invasive plants may have higher impacts because they overcome some life history tradeoffs as a result of their association with humans or novel evolutionary histories, e.g. enemy release. This may directly or indirectly (e.g. through plastic reallocation of resources from defence into growth) enable invasive plants to colonise earlier or persist into later stages of succession. By modifying disturbance regimes, invaders that transform the environment may

also interfere with succession and precipitate low diversity communities. Low introduction rates of late successional species may currently limit impacts of aliens under infrequent disturbance.

Irwin et al. (2010) earmarks that taxonomic groups vary considerably in which proximate factors are most important in that, several groups show differing responses within different ecoregions. Whether these differences are consistent across groups requires further testing. then, related species often have divergent reactions to disturbance, even within lower taxonomic groupings (families or genera). Thus, we cannot rely on phylogenetic relatedness or even ecological similarity to infer similarity in responses.

Finally, disturbance typically reduces species diversity (especially of native and/or endemic species), but also causes species turnover, typically with forest specialists replaced by grassland generalists, and endemics replaced by non-endemics (including invasive). Given these knowledge gaps.

We stress the urgency of applied studies that assess species' ecology, behavior and health across disturbance gradients, including purely anthropogenic landscapes. Remaining natural vegetation and protected areas will be unable to preserve Madagascar's biodiversity under the impact of climatic change; we must understand zresponses of plants and animals to disturbance in order to create buffer zones and corridors combining secondary, degraded and natural habitats.

Ayorekire (2016) while conducting a study that aimed at establishing land use conflict between pastoralism and wildlife conservation in Lake Mbuoro area, its effect on the environment and attitude formation reported that the largest number of respondents (21.0%) considered that of overgrazing (19.2%) and over stocking (16.5%) was the major human activities in River Rwizi catchment area. Also, 12.0% cited bush burning and 10.2% improper cultivation on steep land as the causes of degradation.

Hitherto, Akwongo (2009) investigated the effect of brick making on the plant species biodiversity on River Rwizi. However, a variety of activities were not considered and yet brick making was not the only detrimental human activity on the degradation of River Rwizi. Despite the outcry on the disappearance of some plant species in the Rwizi wetland, the differential disappearance of various activities is not known. One major issue in previous research on River Rwizi wetland was failure to consider the variations of plant species in the disturbed and the undisturbed area in River Rwizi.

## 2.6 Effects of Human Activities on Plant Species Diversity in wetlands

The disproportionate disappearance of wetlands has been greatly blamed on uncontrolled human activities (Jones, Kansime & Saunders, 2018). Above all, the primary source of energy for over 80% of the households of sub-Saharan tropical Africa is biomass (Jones *et al.*, 2018). Human activities and predominantly in the form of charcoal or wood which is used mainly for cooking and heating have escalated the loss of plant species diversity. Besides, fuelwood remains the main source of domestic energy for the rural poor but charcoal is the major source of energy for the urban poor and even though the share of the energy source provided by biomass is declining, the numbers dependent on it continue to grow.

In the study conducted to find out the impact of brick making practices on Bujaga Wetland in Mbarara District, South-Western Uganda, it was found out that undisturbed area had the highest population of trees (95.7%) followed by shrubs (94.3%) and grasses (64.0%) following post abandonment period of five years (Akwongo, 2009). However, it was reported that the herbs were very few (11.8%) and she then showed that shrubs were absent in the brickd area compared to the undisturbed area where there were no trees but very many herbs.

Borah, Athokpam, Garkoti, Das, and Hore (2014) reported significant differences in the structure, composition and regeneration of tree species in undisturbed and disturbed tropical forests in Bhuban hills in southern Assam, India. The study area was selected since it was part of one of the globally recognized biodiversity hot spots and in spite of the increasing human activities in these forests, so far no information is available on their impacts on plant assemblages in the area. In each forest, the vegetation was analyzed through 50 quadrats (10 m × 10 m) in a belt transect of 500 m × 10 m. A total of 49, 47 and 42 tree species were recorded in disturbed forests and 62, 61 and 60 species in undisturbed forests. After conducting a t-test, it was found out that there were significant differences between the plant species diversity in the undisturbed compared to the disturbed forests ( $p < 0.05$ ). However, limited information was presented on the effect of various human activities that were responsible for the differences in plant species diversity.

Bao *et al.* (2018) while conducting a study in Brazilian Pantanal in an extensive wetland with heterogeneous habitats, primarily due to the river-floodplain system and plants with differential

adaptations and reproductive strategies, while assessing the influence of biogeographic patterns in this system for six areas along the Paraguay River, including residual relieves, verifying the pattern of similarity, and effects of distance and altitude, they recorded 356 species in 87 families, mostly perennial (75%), and some annuals (15%) and pluriannuals (5%).

Similar to the findings in this study, Bao et al. (2018) reported herbaceous plants as the most represented (48%), followed by arboreal (23%), shrubby (15%) and epiphytic (14%) habits, only 12% being endemic to Brazil. Regarding the life cycle, about 75% are perennial, 15% annual, and 5% pluriannual. The herbaceous habit was the most represented (150 species in total), followed by arboreal (83), shrubby (74), and lianas (48). It was further reported that plant species of Poaceae, Cyperaceae, Euphorbiaceae, and Asteraceae showed the highest representativity within the herbaceous stratum, in which *Steinchisma laxum* was the most frequent species among different sampled areas.

This contradicts the study by Auma, (2012) which revealed that the Landsat image of (2010) showed that between 1985 and 1988, the papyrus area increased by 3.2 km<sup>2</sup> (2%). On the other hand, bare ground and farming area decreased from 21% in 1985 to 15% in 1988. There was very minimal anthropogenic interference of the papyrus ecosystem in terms of settlement, cultivation, burning and papyrus harvesting. This was due to seasonal flooding that made the swamp inaccessible. This implied that the local community was involved in terrestrial agriculture and alternative sources of income like fishing, tailoring and masonry, among others.

Whereas Moges et al. (2017) observed that human activities such as drainage, overgrazing, cultivation and pollution cause disturbances that result into reduced plant diversity through removing sensitive species, and increase species diversity through creating diverse habitats suitable for invader species. The dominant species of each wetland showed that the urban and agricultural wetlands were highly degraded when compared to forested wetlands. The principal component analysis revealed highest similarity between Boye and Merewa wetlands and this could be explained from their extensive environmental heterogeneity. Moreover, these altered wetlands were invaded by upland weeds by outcompeting socioeconomically and ecologically important native species. Thus, data of species and their environmental stresses in wetlands of Ethiopia could be used to prioritize and develop management strategies for east African wetlands.

Further on, Auma (2012) in her studies found out that, the area that was covered by papyrus decreased by 13.96 km<sup>2</sup> (9%) between 1988 and 1995 and that it was because more land (42%) was either put to farming or settlement, and this might have resulted in clearing of papyrus hence the decline in area covered by papyrus. Alternatively, the rate of papyrus utilization might have increased due to increase in human population and hence more papyrus was harvested from the landward side of the swamp creating room for settlement. Nevertheless, with all these increased activity, the local community might have not put any measures in place to conserve the swamp ecosystem.

River Rwizi wetland has been experiencing detrimental human activities despite lack of information regarding the characterization of the effect of various human activities on plant species diversity (Bamutaze, Wanyama, Diekrugger, Meadows, & Opedes, 2017). Besides, in spite of the existing legislation, the community continues to drain and convert wetlands sometimes due to lack of information on the effects of unregulated human activities on plant species diversity. This forms the basis for conducting a study on the effect of various human activities on Rwizi wetland in Mbarara District.

## **CHAPTER THREE**

### **MATERIALS AND METHODS**

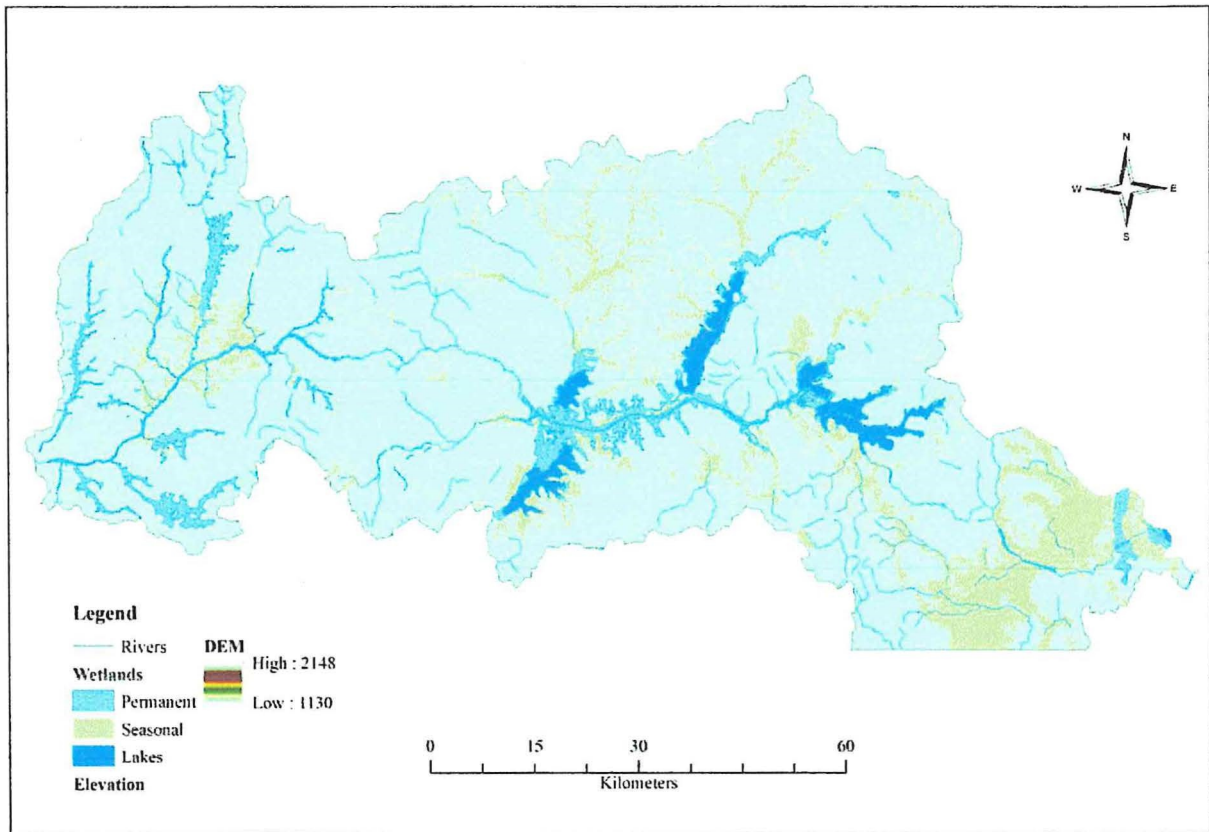
#### **3.0 Introduction**

This chapter presents the study area and the methodology used during the study period like research design, study population, sample size, sampling techniques and procedure, data collection methods, data collection instruments, procedure of data collection, data management, data analysis, measurement of variables and ethical considerations used in the study.

#### **3.1 Study Area**

##### **3.1.1 Location**

The study was conducted in Koga wetland in river Rwizi, Mbarara district. Mbarara is approximately 266 kilometers from Kampala City along the Kampala-Kabale highway and is located in the southwestern region of Uganda. It is the main commercial centre and houses the political and administrative headquarters. Mbarara lies west of Masaka on the road to Kabale, near Lake Mburo National Park. Mbarara District is bordered by Kiruhura District to the east, Ibanda District to the north, Isingiro District to the southeast, Sheema District to the west, Ntungamo District to the southwest and Buhweju district to the northwest (Uganda Bureau of statistics, 2017). Its exact location can be geographically determined as longitude 30°37' east and latitude 0°36' south (Mbarara Municipal Council, 2007) as shown in figure 3.1.



**Figure 3. 1: Extent of River Rwizi Catchment**

*Source: 30X30 meter SRTM DEM- USGGS website and UBOS shape files*

### 3.1.2 Relief and Altitude

Mbarara District covers a land area of 1,778.4 square kilometres (686.6 sq mi), with an average elevation of about 1,800 metres (5,900 ft) above sea level. There is a mixture of fairly rolling and sharp hills, fairly deep and shallow valleys and flat land (Mbarara District Local Government, 2009). Mbarara Municipality itself is built on hilly areas separated by short, small, generally shallow valleys. It lies on an elevated basin forming part of the East African rift valley.



**Figure 3. 2: Relief of River Rwizi wetland**

*Source: 30X30 meter SRTM DEM- USGGS website and UBOS shape files*

### 3.1.3 Climate

Mbarara Municipality experiences two rainy seasons which are separated by two dry seasons in a year. The average annual rainfall is 1,125mm, while the average annual temperature is 25°C. Temperatures range between 17 °C (63 °F) and 30 °C (86 °F). The climate of Mbarara Municipality is comprised of weather changes in which June is usually the coldest month with an average of 20°C, October being the wettest month with an average rainfall of 177.4mm and annual rainfall of 1362.2 mm (World Clock, 2018). Also, the windiest month is August with an average speed of 7km per hour.

### 3.1.4 Population and human settlement

Mbarara has a total population of 472, 625 residents. Besides, a total of 230, 078 (48.7%) are males while 242,547 (51.3%) are females. Mbarara is moderately densely built with predominantly low and medium income housing, followed by commercial premises located

mainly in the Central Business District and the lowest proportion being high-income housing (Mbarara Municipal Council, 2007). A series of industries have sprung up thereby contributing to rapid growth urban settlements. Human settlements can be seen as one moves towards the site.

### **3.1.5 Geology and Soils**

The soils are loamy fertile soils and suitable for cultivation (Mbarara District Local Government, 2009). However, the soils range from clay loams, sand loams to murram in most areas (Mbarara Municipal Council, 2007).

### **3.1.6 Livelihood activities**

Household based activities mainly include crop growing or/and livestock farming. A total of 20,610 (39.4%) are engaged in crop growing while 23,220 (44.4%) households are engaged in either crop growing or livestock farming. However, only 12,896 (24.6%) are engaged in livestock farming. Majority of the households grow beans, 18,246 (34.9%). (Mbarara District Local Government, 2015).

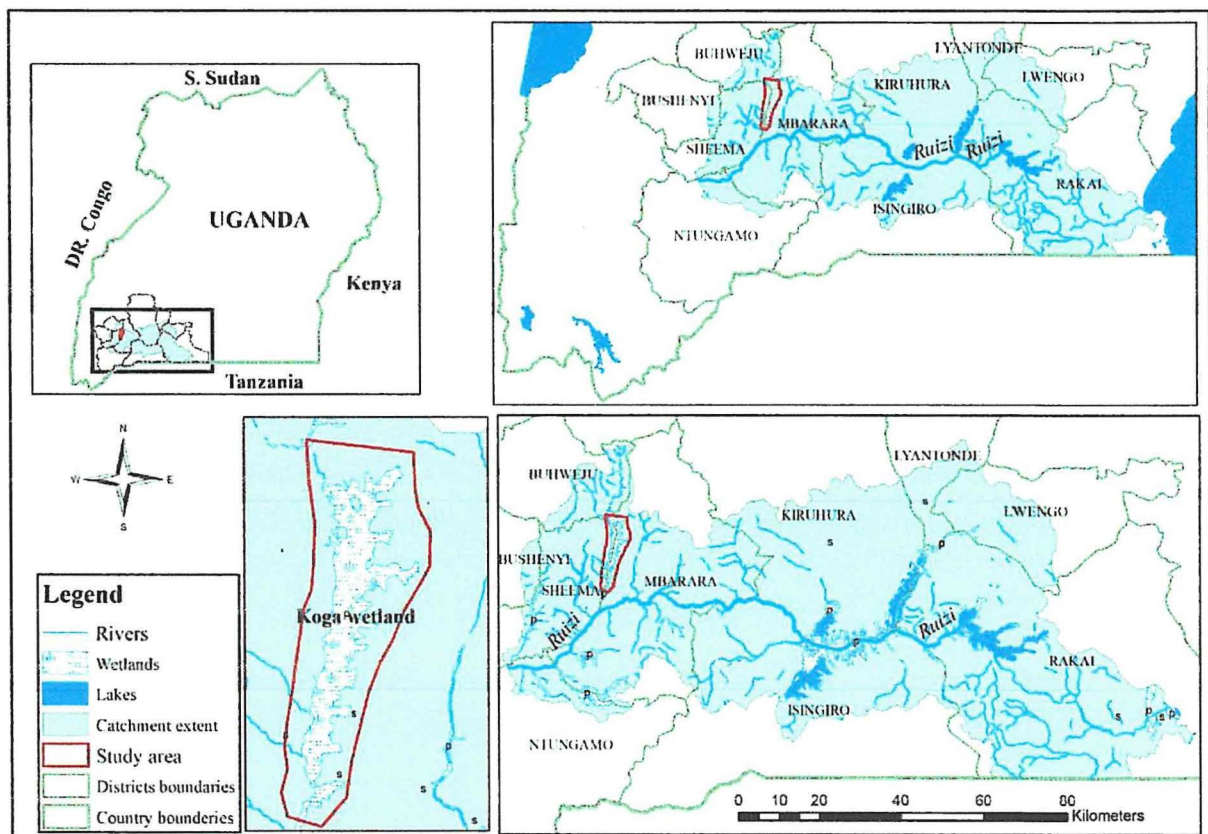
## **3.2 Research Design**

The study used a descriptive research design. A descriptive design is directed at making careful observations and detailed documentation of a phenomenon of interest based on scientific method (Bhattacharjee 2012). In this case, the study involved a scientific process of measuring sizes of plots in the different study sites, careful observation, identification, counting and comparing of the plants species of trees, shrubs, herbs and grasses. This design helped to focus on an area of study to gain an in-depth study of the problem with limited time scale (Amin, 2011). Therefore, this survey helped to save on time and resources during data collection. Quantitative methods were used because numerical information helped to present the extent of effect of human activities on plant species diversity.

## **3.3 Area Sample**

Covering a total land area of 8854sqkm, River Rwizi wetland runs through 11 districts. It originates from Buhweju hills in form of a wetland stretching across eleven districts in the

South-Western Uganda thus pouring its waters into Lake Mburo and eventually into the world's second largest fresh water lake, Lake Victoria (Opedel, 2018). This study was carried out in Rwizi section, Koga wetland in Mbarara District. To arrive at the decision of carrying out the study in Koga Wetland, the Google Earth Map and ArcGIS (Geographical information system) were used to map and establish the current human activities along Koga wetland, after ground truthing, the common human activities were determined along Koga wetland; a few of the repeated activities were selected for study and a sketch map was developed of the selected areas. Koga wetland then, was purposely selected as a study area because most of the activities taking place in the river Rwizi catchment area were represented in the area. Koga wetland is located 20 km away from Mbarara Town along the Mbarara-Bushenyi high way; it is situated exactly at the boarder of Mbarara and Sheema Districts, located just after Bubare Sub-County and before Kogango Sub-County respectively. Figure 3.3 shows the area of the study.



**Figure 3. 3: Location of Koga Wetland**

*Source: UBOS, Google Earth Pro-shape files & Field data-2018*

Three quarters of Koga wetland is situated on the right hand side of the road while a bit of it is on the left side of the road.

### **3.4 Procedure of Data Collection**

After the approval of the proposal, the research study was given an introductory letter which served as an assurance to the key administrators and locals of the area that the researcher was authorized to carry out research in their area of operation. Appointments were made with all the research assistants. Dates were fixed for the interaction and training of research assistants, after the data collection, records, field notes, and photos were neatly organized for management and analysis.

### **3.5 Data Collection methods and tools**

Before collecting collection methods and tools were described according to the study objectives, as follows;

#### **3.5.1 Identifying and mapping of human activities on River Rwizi wetland**

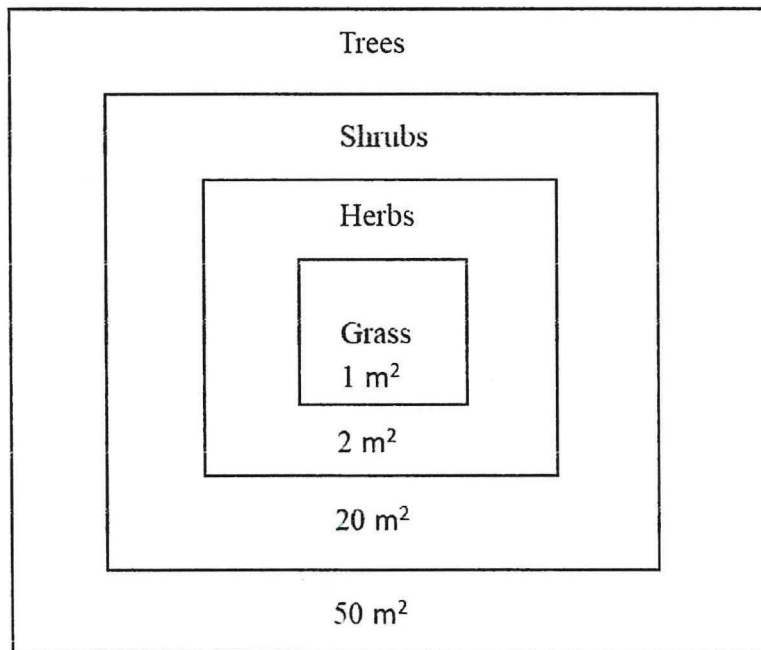
To identify and map human activities in the study area, Geographical Information System (GIS) techniques were employed with the help of ArcGIS software version 10.2. First, the study area was inspected on Google Earth Pro version 7.3.2.5491. Secondary, current landuses (shown on Google Earth Pro-2017) were compared with the landuse map of Uganda 2010 and thereafter the landuses were digitized in Google Earth Pro. The digitized shape files were imported into ArcGIS. Ground-truthing took place to establish the human activities along River Rwizi wetland. The final map was then created, indicating the different human activities in the study area. At the subsequent levels, Koga wetland was narrowed down to, for field plant species diversity investigation. Koga wetland was considered as an area of study because it constituted most of the human activities taking place in River Rwizi Wetland. Five study sites were considered, that is, undisturbed, bricked, cropped, grazed and settled sites. The disturbed areas were selected at the interface of Koga wetland.

### 3.5.2 Determining plant species diversity in the disturbed and in the undisturbed of Koga wetland

In order to be able to compare the plant species diversity in Koga wetland in river Rwizi, it was comparative to first of all determine the plant species in the disturbed and undisturbed study sites. Comparison of the plant species took place and there after the plant species diversity index was established.

#### (a) Plant species diversity in the disturbed and undisturbed

To establish the effects of human activities on plant species diversity in River Rwizi wetland, the Koga study site was purposely selected, that is at the interface of land uses and Koga wetland. A 50 m<sup>2</sup> nested plot was used to determine by direct counting the number of trees. Shrubs were counted in 20 m<sup>2</sup> plot while, 2 m<sup>2</sup> plot were used to obtain the numbers of herbs and then 1m<sup>2</sup> plot were used to obtain the number of grasses. This process was applied in the rest of different 4 study sites as shown in figure 3.4.

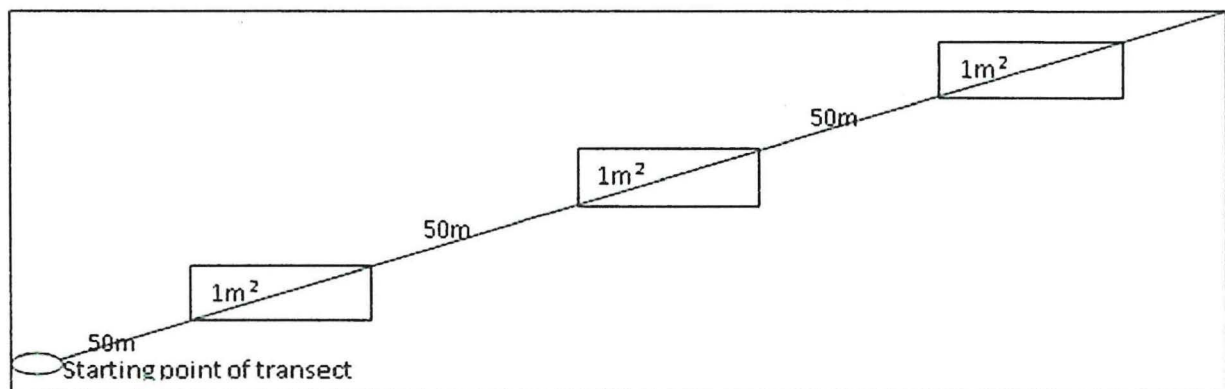


**Figure 3.4: Determination of plant species within a fifty and twenty meter- squared nested plots.**

Source: (Abbot, 2013).

As for the two last smallest nested plots, another method was used, in that the  $2\text{m}^2$  plots used to determine herbs and  $1\text{m}^2$  plots to determine the number of grasses was used three times in each study site. A straight line was made diagonally across the  $50\text{m}^2$  study site and the nested plots were positioned along the transect line; one plot at the edge, another midway, and one at the end. An average was derived to determine the number of herbs. The same process was used to determine the number of grasses. This was to cater for variations in occurrence of plant species. Because it is assumed that herbs and grasses have high frequency of occurrence (Abbot 2013).

Nested plots were used because vegetation changes and thus quadrat sizes cease to be ideal or appropriate for the species that are to be measured and therefore calling for adjustment to instead use nested plots (Abbot 2013).



**Figure 3.5: Determination of plant species within a one and two meter- squared nested plots.**

*Source: (Abbot ,2013)*

**(b) Determining plant species diversity between the disturbed and undisturbed study sites**

After data collection, data was cleaned, managed and presented in tables. Determination of the plant species was done in Tables by comparing plant species in each disturbed area with the plant species in the undisturbed site.

**(c) Diversity index of plant species diversity in the disturbed and undisturbed study sites of river Rwizi.**

Records which were obtained from the inventory of nested plots regarding the number of trees, shrubs, herbs, and grasses were subjected to Simpson's Diversity Index. Simpson's Diversity

Index is a measure of diversity in ecology to qualify the biodiversity of a habitat. It takes into account the number of species present as well as the abundance of each species.

Formula: 
$$D = 1 - \left( \frac{\sum n(n-1)}{N(N-1)} \right)$$
 Where;

D = diversity

N = the total number of organisms in the community

n= number of individuals in each species

$\sum$  = summation

Whereby, when the diversity Index tends to move towards zero (0), it implies that there is little or no diversity, and where the diversity index tends towards one (1), it means that there is infinite diversity ( Abbot, 2013)



In this study, indecies were used to determine diversity of wetland plant species under different disturbed areas. Thus, the brick ecosystem is diverse because there are higher chances (65%) of picking two or more species in the ecosystem. For this study, This is because the index percentage is tending towards one. The same process could be done for grazed and other ecosystems studied and comparisons be made.

### **3.5.3 The most detrimental human activity on plant species diversity in the disturbed areas of Koga wetland in river Rwizi.**

The diversity index in different disturbed areas of Koga wetland were compared by use of results derived from Simpson’s diversity index. This was to establish the most detrimental human activity among the disturbed sites of Koga wetland.

### **3.6 Ethical considerations**

Commitment, hard work, openness to consult and honesty were maintained throughout the research process in collecting, managing, reporting and analyzing of data/results. Professional

methods and procedures were used in order to avoid fabrication, falsification, or misrepresentation of data. All quotations that were used and sources consulted were clearly distinguished and acknowledged by means of in-text citation and referencing. A letter of authorization from the research coordinator in Geography Department of Kyambogo University was obtained for the official permission to conduct this study. This letter supplemented the research instruments and explained the purpose of this study.

## **CHAPTER FOUR**

### **RESULTS AND DISCUSSIONS**

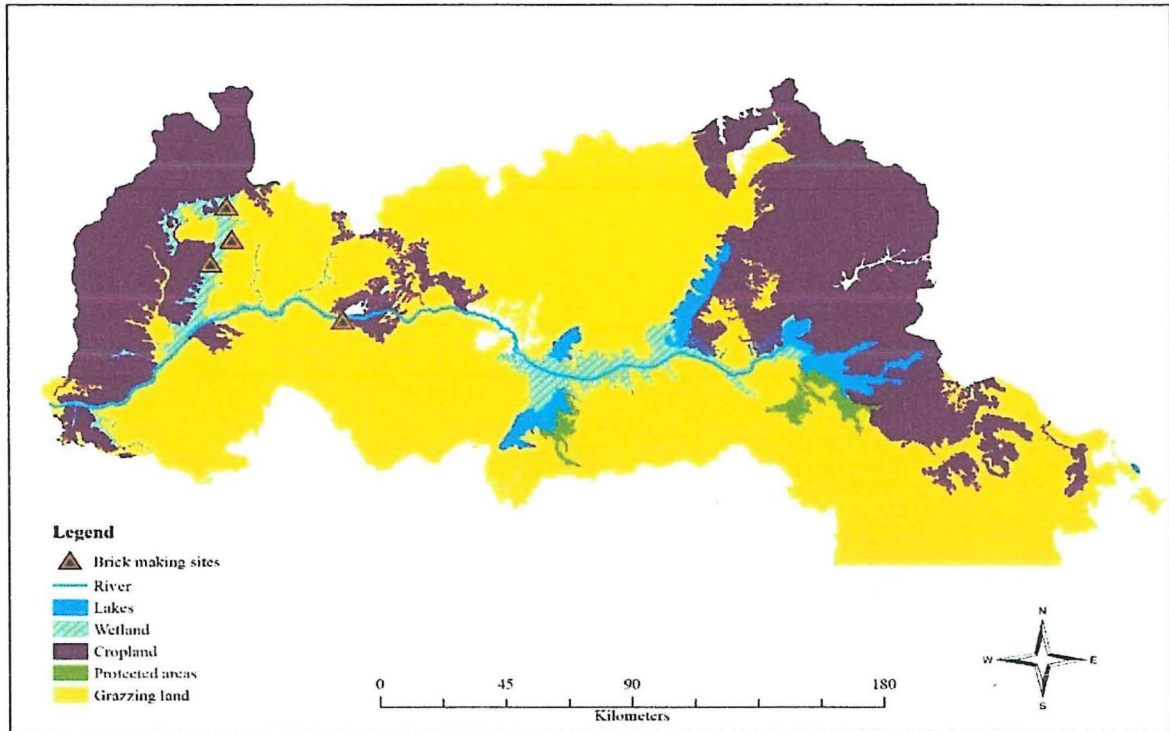
#### **4.0 Introduction**

This chapter presents and analyses findings from the study. The presentation and analysis of data was guided by the objectives and research questions. Different findings from the effects of human activities on plant species diversity and Simpson's text on diversity index was done; also a comparison of the plant species diversity in the different disturbed and undisturbed areas in River Rwizi wetland were reported and analyzed. The study started with identification and mapping of the existing human activities. Then, the distribution, frequencies, percentages, averages and comparisons of plant species diversity in the disturbed and undisturbed areas of River Rwizi wetland were derived and determined. Finally the most detrimental human activities were determined. The process went as follows;

#### **4.1 The Mapping of the Different Human Activities in the River Rwizi Wetland**

The first objective of the study was to identify and map the different human activities in the River Rwizi Wetland. ArcGIS, Google Earth and the land use map of Uganda 2010: (Kagera Agro-Ecosystems) were used to map the different human activities in the river Rwizi Wetland. A map was produced showing the dominant human activities taking place in the river Rwizi wetland.

The land uses in river Rwizi wetland are as shown on Figure 4.2; the biggest proportion of the land was under grazing in a savanna which was mixed woodland grassland ecosystem with trees being sufficiently widely spaced. This land was used for savanna livestock grazing. This type of grazing was taking place at the interface of the wetland. Another form of land grazing was wetland grazing which takes place in the wetland and was gradually transforming the wetland into a savanna or an arid environment.



**Figure 4. 1: Map showing the dominant Human activities in Rwizi catchment area**

*Source: Google Earth data, Field data 2018 land use map of Uganda 2010: Kagera Agro-Ecosystem.*

Plate 4.1 portrays animal grazing noted to be the most dominant human activity in river Rwizi wetland. Animal grazing took place in a wetland that gradually turned into a mixed woodland grassland savanna, an evidence of a wetland encroachment.



**Plate 4.1: Grazing in river Koga wetland**

*Source: Field work , Kanyigiri (2018)*

Some proportion of the land is used for cropping and it was observed that perennial cropping was recurrent in Koga wetland. Perennial cropping involved live year-round crops that live more than two years before dying and are harvested multiple times. These crops included mostly bananas and cassava. Land under Protected areas was used for some crop growing under arrangements. Similarly, some proportion of land in the catchment was under seasonal crops. These were mainly crops grown once or twice a year during the rainy season. These crops included finger millet, beans, maize, groundnuts and sorghum.

As observed from plate 4.2, the research assistants were walking on recently cleared swamp vegetation along Koga wetland, the wetland was being cleared, a lot of plants were being spread to dry for eventual burning, some grass was collected and hipped for eventual burning and this was to prepare the land for farming. Some thicker parts of the wetland were set on fire so as to pave way for clearing and to stop vegetation growth. Some of the people needed more land from the wetland as they practiced crop growing as well as animal rearing, as both activities were being sustained by the wetland grasses, water and fertile soils. It therefore meant that one could clear as much land as possible depending on one's strength and resources. These activities were intensive along and in Koga Wetland and were rapidly forcing the wetland to turn into a savanna and to an arid environment.



**Plate 4.2: Recent cleared wetland for crop growing and settlement.**

*Source: Field work at Kanyigiri (2018)*

This study also revealed that, brick making was common in Koga wetland, due to the brick industry, Koga wetland had reduced into huge gaping holes filled with dirty stagnant water which was rampantly destroying and altering the wetland resource through clay extracting for making bricks. This was due to the increasing demand of building materials around, near and also in nearby springing towns such as Mbarara and Bushenyi.

The holes that were dug in the process of extracting clay for brick making destroyed and affected the vegetation cover and soil fertility; it displaced plants in this area and disturbed the entire ecosystem. Brick burning also resulted into the demand for wood energy to burn the bricks hence causing massive deforestation in Koga wetland. Water filled pits like in plate 4.3 are a common sight in Koga wetland where clay for making bricks was dug.



**Plate 4.3 Brick making area in Koga wetland. Source: Field work at Koga (2018)**

Areas under brick making, crop growing and animal grazing were intertwined with other forms of land use but most especially with settlement. It therefore meant that, where there was any form of land use, automatically settlement took place.

Alongside the mapping exercise, this study determined the arial coverage of the activities taking place in river Rwizi wetland and the results are in table 4.1

**Table 4. 1: The percentage Arial coverage of the Human activities in Rwizi wetland**

<b>Land use types</b>	<b>Area in m<sup>2</sup></b>	<b>Percentage</b>
Grazing land	17,445,246,780	72.06
Cropping Land	6,749,648,570	27.93
Others	610,325	0.01
<b>Total</b>	<b>24,195,506,175</b>	<b>100.00</b>

From figure 4.1 and table 4.1, reveals that the most dominant human activities in river Rwizi wetland were mostly animal grazing (72.06%) whereas crop growing was (27.93%). There were other activities too which may have included sand mining, industry and were in small scale (0.01). All these activities were concentrated around the origins of river Rwizi and in the whole western part of Koga wetland. Animal grazing and brick making were done for commercial purposes to supplement and support livelihood necessities.

#### **4.2 Determining Plant Species Diversity in the Undisturbed and Disturbed areas in Koga wetland**

The second objective of the study was to compare the plant species diversity in the disturbed and the undisturbed study sites in Koga wetland. Descriptive statistics was used. This included the use of frequencies, averages and percentages to report the distribution and comparison of plant species in the areas of the undisturbed with grazed, cropped, settlement and brick making areas. The findings from the study were presented in tables ( 4.2, 4.3 4.4 and 4.5).

##### **4.2.1 Plant Species Diversity in the Bricked and Undisturbed of Koga wetland**

Comparison of the plant species in the disturbed sites and those in the undisturbed study areas was done to establish the effects of human activities on plant species diversity. Table 4.2 shows the comparison of the plant species in the brick making site with plant species in the undisturbed site.

**Table 4. 2: Determining of the plant species on the bricked and undisturbed areas in Koga wetland**

		BRICKED		UNDISTURBED			
Category	Name of species	Frequency	Percent	Name of species	Frequency	Percent	
Grasses	Papyrus	48	14.6	Papyrus	148	65.2	
	Coach grass	130	39.6	Star grass	47	20.7	
	spear grass	150	45.7	Nut grass	32	14.1	
<b>Sub-Total</b>		<b>328</b>	<b>100.0</b>		<b>227</b>	<b>100.0</b>	
Herbs	<i>Tridax procumbens</i>	51	15.0	<i>Tridax procumbens</i>	4	1.6	
	Wandering jew	151	44.5	wondering jew	8	3.3	
	<i>Pseudarthria hookeri</i>	5	1.5	Glycine	1	0.4	
	<i>C. vitellinum</i>	5	1.5	<i>Tragia benthamii</i>	5	2.0	
	<i>Ludwigia abyssinica</i>	25	7.4	Melanthera scandens	3	1.2	
	<i>Galinsoga parviflora</i>	39	11.5	Silver leaf des.	11	4.5	
	<i>Blumea alata</i>	63	18.6	<i>Oxalis coniculata</i>	13	5.3	
				Morning glory	14	5.7	
				Devil's H. whip	15	6.1	
				<i>Bothriocline longipes</i>	20	8.2	
				Water lilies	150	61.5	
	<b>Sub-Total</b>		<b>339</b>	<b>100.0</b>		<b>224</b>	<b>100.0</b>
	Shrubs	<i>Dombeya d.i Sprague</i>	85	48.6	<i>Dombeya Sprague</i>	D. 10	1.4
<i>Vernonia A. Del</i>		52	29.7	Tick berry	40	5.4	
<i>Crysanthemoides monilifera</i>		28	16	Kie apple	30	4.1	
<i>Hyophorbe lagenicaulis</i>		10	5.7	Hyphaene compressa	20	2.7	
				<i>Acanthus arboreus</i>	30	4.1	
				Wild egg plant	40	5.4	
				<i>Triumfetta rhomboidea</i>	90	12.2	
				<i>Indigofera arrecta</i>	100	13.5	
				<i>Sida rhombifolia</i>	380	51.4	
<b>Sub-Totals</b>			<b>175</b>	<b>100</b>		<b>740</b>	<b>100.0</b>
Trees	<i>Erythrina abyssinica</i>	6	60.0	<i>Erythrina abyssinica</i>	8	10.7	
	Eucalyptus	4	40.0	Fig tree	14	18.7	
				Palm tree	33	44.0	
				<i>Senna dybomotriva</i>	8	10.7	
				<i>Sesbania sesban</i>	5	6.7	
				<i>Dodonaea viscosa</i>	7	9.3	
<b>Sub-Total</b>		<b>4</b>	<b>100.0</b>		<b>75</b>	<b>100.0</b>	

Generally, table 4.2 shows that among the grass species in the undisturbed, papyrus was the most abundant 148 (65.2%) but the numbers of papyrus reduced to 48 (14.6%) in the bricked. Coach Grass and spear grass emerged as evasive grass species. The number of shrub and tree species decreased by more than 50% in the bricked study site. Hence the number of the wetland species reduced from 30(100%) in the undisturbed to 5 (16.7) species in the bricked, making a loss of 25 ( 83%) species. There were 11 ( 36.7) evasive species.

Data desegregation revealed that out of the eleven herb species sited in the undisturbed study site, only 2 (18%) species (*Tridax procumbens* and wondering Jew) persisted in the bricked site. Five new herb species emerged as noted in Table 4.2. Among shrubs, 1 (11%) out of the nine species (*Dombeya dawei* Sprague) persisted and only three species emerged as new shrub species. And out of six tree species just 1(16.7) ( *Erythrina abbysnica*) survived and one tree (*Euchalyptus*) emerged as new species in the brick making site. Generally the results from the study portray that plant species of herbs, shrubs and trees drastically reduced in the brick making area, Herb species reduced from 11 in the undisturbed to 7(63.6%) species in the brick making sites, shrub species from 9 to 4(44%) species and tree species reduced from 6 to 2(33%) species. So, the study showed that the reduction of species was mostly in shrubs and trees.

#### **4.2.2 Plant species diversity in the cropped and undisturbed sites in Koga wetland.**

The study also established a comparison of plant species diversity found in the cropped and in the undisturbed land; in Koga Rwizi wetland the results are presented in table 4.3. Generally, all grass species in the undisturbed were lost in the cropped area, 10(91%) herbs were lost out of 11 herb species, 5(45.5%) shrub species serviced out of 9 and 2 (33%) tree species survived out of 6. It meant that out of 30 species, 18 (60%) species were lost, 12(40%) survived and there were 11(36.7%) evasive species.

Globally all the plant species reduced in the cropped study site in that trees reduced from 100% in the undisturbed to 9.3 %, shrubs to 53%, herbs to 14.7% and grasses to about 50%.

As seen in Table 4.3, the study revealed that, all the grass species sighted on the undisturbed study site (Papyrus, Star and Nut grass species) were completely wiped out in the cropped study area. New grasses species (Coach, Congo signal and Guinea grass) emerged.

Among the herbs, out of the 11 herb species sited in the undisturbed study site, only 1 (9.1%) species (*Tridax procumbens*) survived in the cropped site. New herb species (*Clerodendrum rotundifolium*, Lions ear, *Bothriocline longipes* and Kidney weed) emerged.

Among the shrubs, 5(56.1%) out of 9 species (Tick berry, Kie apple, *triumfetta rhomboidea*, *indigofera arrecta* and *Sida rhombifolia*) persisted although most of them occurred in lower numbers in the cropped site. only *Sida rhombifolia* occurred in a larger number in the cropped site. New shrub species (Wild egg plant, Castor oil, *Hibiscus fuscus*, and Sodom apple) emerged.

Among the trees, 2 (33%) out of 6 tree species ( *Erythrina abbysnica* and palm tree) survived.

Globally among all disturbed study sites, this study revealed that the cropped site registered the least plant species of all categories that is of grasses, herbs, shrubs and trees. Results were as in table 4.3

**Table 4. 3: Determining plant species on the cropped and undisturbed areas in Koga wetland**

Category	CROPPED			UNDISTURBED			
	Name of species	Frequency	Percent	Names of species	Frequency	Percent	
<b>Grasses</b>	Coach grass	50	38.5	Papyrus	148	65.2	
	Congo signal	30	23.0	Star grass	47	20.7	
	Guinea grass	50	38.5	Nut grass	32	14.1	
<b>Sub-total</b>		<b>130</b>	<b>100.0</b>		<b>227</b>	<b>100.0</b>	
<b>Herbs</b>	<i>Tridax procumbens</i>	2	5.6	<i>Tridax procumbens</i>	4	1.6	
	<i>Clerodendrum rotundifolium</i>	3	8.3	wondering jew	8	3.3	
	Lions ear	2	5.6	Glycine	1	0.4	
	<i>Bothriocline longipes</i>	24	66.7	<i>Tragia benthamii</i>	5	2.0	
	Kidney weed	5	13.9	<i>Melanthera scandens</i>	3	1.2	
				<i>Silver leaf des.</i>	11	4.5	
				<i>Oxalis coniculata</i>	13	5.3	
				Morning glory	14	5.7	
				<i>Devil's Horese whip</i>	15	6.1	
				<i>Bothriocline Longipes</i>	20	8.2	
				Water lilies	150	61.5	
	<b>Sub-total</b>		<b>36</b>	<b>100.0</b>		<b>224</b>	<b>100.0</b>
	<b>Shrubs</b>	Tick berry	2	0.5	Tick berry	40	5.4
Kie apple		4	1.0	Kie apple	30	4.1	
<i>Triumfetta rhomboidea</i>		216	54.4	<i>Triumfetta rhomboidea</i>	90	12.2	
<i>Indigofera arrecta</i>		2	0.5	<i>Indigofera arrecta</i>	100	13.5	
<i>Sida rhombifolia</i>		153	38.5	<i>Sida rhombifolia</i>	380	51.4	
Wild egg plant		3	0.8	<i>Dombeya D Sprague</i>	10	1.4	
Castor oil		8	2.0	<i>Acanthus arboreus</i>	30	4.1	
Hibiscus fuscus		2	0.5	Wild egg plant	40	5.4	
Sodom apple		7	1.8	<i>Hyphaene compressa</i>	20	2.7	
<b>Sub-total</b>			<b>397</b>	<b>100.0</b>		<b>740</b>	<b>100.0</b>
<b>Trees</b>	<i>Erythrina abyssinica</i>	3	42.9	<i>Erythrina abyssinica</i>	8	10.7	
	Palm tree	4	57.1	Palm tree	33	44.0	
				Fig tree	14	18.7	
				<i>Scnna dybomotrya</i>	8	10.7	
				<i>Sesbania sesban</i>	5	6.7	
				<i>Dodonaea viscosa</i>	7	9.3	
<b>Sub-total (N)</b>		<b>7</b>	<b>100.0</b>		<b>75</b>	<b>100.0</b>	

#### 4.2.3 Plant species diversity in the Grazed and undisturbed sites in Koga wetland.

The research established the differences of plant species diversity in the undisturbed area and the grazed area of Koga wetland. Globally, among the grasses in the grazed, 1 (33.3%) grass species was lost, 2 (66.7%) survived and there were 4 evasive species. 8 (73%) herb species were lost, 3 (27.3%) survived and there were three evasive species. 6 (66.7%) shrubs were lost, 3 (33.3%) survived, and 6 (66.7%) were evasive species. 3 (50%) trees were lost, 3 (50%) survived and there were 2 (22%) evasive tree species. Hence, from 30 wetland species, 18 (60.7%) were lost leaving 9 (30.3%) only and 15 (50%) species were evasive.

From Table 4.4, it can be seen that, two grass species (Nut and star grass) out of three species, sighted in the undisturbed persisted in the grazed area, papyrus was completely wiped out of the grazing area. New grasses species (Coach, Elephant, pasparum, and Nandi grass) emerged in the grazed site and the number of grass species shot up in the undisturbed by 50% in the grazed study area because of the new species like Nandi grass, Elephant grass, pasparum and coach grass. This can be attributed to the adaptive stages of succession of plant species due to human disturbance and the introduction of other grass for the compound aesthetics and for fodder.

The study further revealed that, out of the eleven herb species sited in the undisturbed study site, only three species (*Bothriocline Longipes*, Glycine and , Silver leaf des.) survived in the grazed site, also out of nine species, three shrub species (Tick berry, wild egg plants and *triumfetta rhomboidea*,) persisted although the numbers reduced a great deal, for example *triumfetta rhomboidea* reduced from 90 to 2% species in the grazed area. Three other species (*Ludwigia abyssinica*, *Commelina benghelesis* and kidney weed) emerged and surprisingly the *Triumfetta rhomboidea* number of herb species rose by 50% in the grazed area probably due to man's introduction of herbs for fodder. For the shrubs, 33.3% species (Tick berry, Wild egg plant and) persisted in the grazed study sites, 6 new species emerged.

Out of six tree species, three (*Erythrina abyssinica*, Fig trees and *Senna dybomotrya*) survived in the grazed site.

Therefore, it was observed that, in the grazed area, shrub and tree species decreased, shrub species reduced from ten times., while the Tree species also decreased 2.4 times. in the site.

**Table 4.4: Determining of the plant species on the grazed and undisturbed areas in Koga wetland.**

Category	GRAZED			UNDISTURBED		
	Name of species	Frequency	Percent	Name of species	Frequency	Percent
Grasses	Nut grass	174	11.8	Nut grass	32	14.1
	Star grass	6	0.4	Star grass	47	20.7
	Nandi grass	23	1.6	Papyrus	148	65.2
	Elephant grass	50	3.4			
	Paspalum	534	36.2			
	Coach grass	690	46.7			
<b>Sub-total</b>		<b>1477</b>	<b>44.5</b>		<b>227</b>	<b>100.0</b>
Herbs						
	<i>Bothriocline Longipes</i>	2	0.1	<i>Bothriocline Longipes</i>	20	8.2
	Glycine	31	1.8	Glycine	1	0.4
	Silver leaf des.	191	11.0	Silver leaf des.	11	4.5
	<i>Ludwigia abyssinica</i>	1	0.1	wondering jew	8	3.3
	Kidney weed	1514	87.0	<i>Tridax P.</i>	4	1.6
	<i>Commelina benghalensis</i>	1	0.1	<i>Oxalis conticulata</i>	13	5.3
				Morning glory	14	5.7
				<i>Devil's H. whip</i>	15	6.1
				Water lilies	150	61.5
				Melanchthera scandens	3	1.2
				<i>Tragia benthamii</i>	5	2.0
<b>Sub-total</b>		<b>1740</b>	<b>100.0</b>		<b>224</b>	<b>100.0</b>
Shrubs						
	Tick berry	35	49.3	Tick berry	40	5.4
	Wild egg plant	8	11.3	Wild egg plant	40	5.4
	<i>Triumfetta rhomboides</i>	2	2.8	<i>Triumfetta rhomboidea</i>	90	12.2
	<i>vernonia lastopus</i>	5	7.0	<i>Indigofera arvecta</i>	100	13.5
	Hibiscus fuscus	3	4.2	<i>Sida rhombifolia</i>	380	51.4
	<i>Acanthus arboreus</i>	2	2.8	<i>Dombeya Sprague</i>	D. 10	1.4
	Sodom apple	6	8.5	<i>Acanthus arboreus</i>	30	4.1
	Acacia	2	2.8	<i>Hyphaene compressa</i>	20	2.7
	Ferns	8	11.3	Kie apple	30	4.1
<b>Sub-total</b>		<b>71</b>	<b>100.0</b>		<b>740</b>	<b>100.0</b>
Trees						
	Erythrina A	1	6.5	<i>Erythrina A.</i>	8	10.7
	Fig tree	1	3.2	Fig tree	14	18.7
	<i>Senna dybomatrya</i>	1		<i>Senna dybomatrya</i>	8	10.7
	<i>Dodonaea viscosa</i>	3	9.7	Palm tree	33	44.0
	Eucalyptus	3	9.7	<i>Sesbanta sesban</i>	5	6.7
		22	71.0	<i>Dodonaea viscosa</i>	7	9.3
<b>Sub-total</b>		<b>31</b>	<b>100.0</b>		<b>75</b>	<b>100.0</b>

#### 4.2.4 Plant species diversity in the Settled and undisturbed sites in Koga wetland.

In general, in the settled area, among the grasses, papyrus was lost, 2(66.3%) wetland species survived, and there were 50% evasive species. 8(73%) herbs vanished, 3(27%) survived and there was 1(9%) evasive species. 7(78%) shrubs were gone and 2(22.2%) survived. 5(83.3%) trees were lost, 1(17%) survived and there were 2(33.3%) evasive species. So, from 30 wetland species, 21 ( 70%) were lost and there were 8( 27%) evasive species.

The study further reveals that, 2 (66.7%) grass species (Nut and star grass) out of 3 species, sighted in the undisturbed persisted in the settled area. Among the plants which resisted, the number of nut grass shot up twenty four times in the settled land. The two other reduced in number. papyrus was completely wiped out of the settled area. New grasses species (Coach, pasparum, Congo signal,, Elephant, and Nandi grass )were introduced and the number of grass species shot up nine times the settled study area.

For herbs, out of the 11 herb species sited in the undisturbed study site, only 3 ( 27.3%) species (*Bothriocline Longipes*, water lilies and the wondering jew.) survived in the settled site. Among the shrubs, out of 9 species, 2 (22.2 %) shrub species (Tick berry, and *Sida rhombifolia*,) persisted in the settled area and were the only shrub species in the settled site and the number of *sida rhombifolia* increased double in the settled area while tick berry species also four times in the settled site. For trees, out of six tree species , only one tree species (Fig trees ) survived in the settled site. Therefore, the number of grass, herbs and shrub species increased and the number of Tree species decreased from 75 ( 100%) in the undisturbed to only 9 (12 %) tree species in the settled study site.

In general, There was variation in plant species diversity across all sites, among all the activities, grazing had the highest number of plant species (39.09%) while the cropped study site had the lowest number of the plant species(6.2%).

Settled area of River Rwizi wetland and the result are presented as in Table 4.5.

**Table 4.5: Comparison of the plant species on the settled and undisturbed areas in Rwizi**

Category	SETTLED			UNDISTURBED		
	Name of species	Frequency	Percent	Name of species	Frequency	Percent
<b>Grasses</b>	Nut grass	760	36.4	Nut grass	32	14.1
	Star grass	31	1.5	Star grass	47	20.7
	Congo signal grass	50	2.4	Papyrus	148	65.2
	Nandi grass	5	0.2			
	Elephant grass	6	0.3			
	Pasparum	834	39.9			
	Coach grass	404	19.3			
<b>Sub-total</b>		<b>2090</b>	<b>100.0</b>		<b>227</b>	<b>100.0</b>
<b>Herbs</b>	<i>Bothriocline</i>	12	5.2	<i>Bothriocline Longipes</i>	20	8.2
	<i>Longipes</i>					
	water lilies	1	0.4	Water lilies	150	61.5
	wondering jew	14	6.0	wondering jew	8	3.3
	Kidney weed	205	88.4	Glycine	1	0.4
				Silver leaf des.	11	4.5
				<i>Tridax procumbens</i>	4	1.6
				<i>Oxalis coniculata</i>	13	5.3
				Morning glory	14	5.7
				Devil's Horese whip	15	6.1
				<i>Melanthera scandens</i>	3	1.2
				<i>Tragia benthamii</i>	5	2.0
	<b>Sub-total</b>		<b>232</b>	<b>100.0</b>		<b>224</b>
<b>Shrubs</b>	Tick berry	200	22.1	Tick berry	40	5.4
	<i>Sida rhombifolia</i>	707	77.9	<i>Sida rhombifolia</i>	380	51.4
				Wild egg plant	40	5.4
				<i>Triumfetta</i>	90	12.2
				<i>rhomboidea</i>		
				<i>Indigofera arrecta</i>	100	13.5
				<i>Dombeya dawei</i>	10	1.4
				<i>Sprague</i>		
				<i>Acanthus arboreus</i>	30	4.1
				<i>Hyphaene compressa</i>	20	2.7
			Kie apple	30	4.1	
<b>Sub-total</b>		<b>907</b>	<b>100.0</b>		<b>740</b>	<b>100.0</b>
<b>Trees</b>	Fig tree	1	11.1	Fig tree	14	18.7
	Guava	5	55.6	<i>Erythrina abyssinica</i>	8	10.7
	Eucalyptus	3	33.3	<i>Senna cybomotriva</i>	8	10.7
				Palm tree	33	44.0
				<i>Sesbania sesban</i>	5	6.7
				<i>Dodonaea viscosa</i>	7	9.3
<b>Sub-total</b>		<b>9</b>	<b>100.0</b>		<b>75</b>	<b>100.0</b>

#### 4.2.5 Determining differences in plant species diversity in the disturbed and undisturbed areas of Koga wetland.

To determine as to whether there are differences in species diversity between the disturbed and undisturbed sites of Koga wetland, Simpson's Diversity Index was calculated according to the formula in 3.6.2 (c). Whereby, when the diversity Index tends to move towards zero (0), it implied that there was little or no diversity, and where the diversity index tended towards one (1) it meant that there was infinite diversity. This was to assess the differences in the diversity index of plant species in all the study, the findings are as in Table 4.6.

**Table 4.6: Determining Diversity Index of plant species between the disturbed and undisturbed study sites.**

Plant Species	Bricked		Cropped		Grazed		Settled		Undisturbed		Total	%
	No.	%	No.	%	No.	%	No.	%	No.	%		
Grasses	328	8	130	3	1477	35	2090	49	227	5	4252	46
Herbs	339	13	36	1	1740	68	232	9	224	9	2571	28
Shrubs	175	8	397	17	71	3	907	40	740	32	2290	25
Trees	4	3	7	6	31	24	9	7	75	60	126	1
Total	846	9	570	6	3319	36	3238	36	1266	14	9239	100
Diversity Index	0.65	65	0.46	46	0.53	53	0.50	50	0.59	59	100	

In general there were 3319 (36%) number of species in the disturbed sites and a total of 9239(100) species in all the study sites. The grazed and the settled sites had the highest percentage of species (36%) while the cropped site had the lowest percentage of (6%). Regarding grasses, settlement had the highest percentage of grasses (49%) and grasses were lowest in the cropped site (3%). Herbs were highest in the grazed area (68%) and lowest in the cropped again by (1 %). For Shrubs, the settled site had the highest percentage of shrubs (40 %) and shrubs occurred in low percentage in the grazed (3%). Trees in the undisturbed site were in high percentage (60) while the bricked site had the lowest percentage of trees (3%). In general, there were variations in the plant species and the cropped site had the lowest number of species.

This study further determined the differences in diversity score of plant species diversity among the disturbed and the undisturbed by use of Simpson's Diversity Index. Table 4.6 revealed that the bricked area had 0.65(65%), followed by the undisturbed area with 0.59 (59%), The grazed site ranked third with 0.53 (53%) diversity score, then settled came fourth with 0.50(50%) and cropped ranked last with the least diversity score of 0.46 (46%).

Therefore, among all the areas studied, the bricked had the highest diversity score of 65%, as compared to the undisturbed area which had 0.59 (59%). However, it must be noted that, 80% plant species were lost in the bricked area and 36.7% evasive species were introduced. In fact among all the disturbed study areas, the bricked area lost the highest number of the wetland vegetation, the settled lost 70%, while the grazed and cropped lost 60% wetland species. So, although the Simpson's Diversity index score indicated that the brick area had very high diversity, it must be emphasized that the brick study area took a lead losing the highest number of wetland vegetation replacing it with 36.7% species of evasive species.

According to Simpson's calculations, the grazed study area ranked second in having high diversity index of (53%), when compared with the undisturbed, this study revealed that out of 30 wetland plant species in the undisturbed area, 60% species were lost and 50% evasive species were introduced in the grazed area - a figure which is almost equivalent to that of the lost wetland vegetation in the undisturbed. Thus, much as results showed that the grazed area had rich diversity, it must be considered that the wetland vegetation was lost and evasive species were introduced making the study area rich but not necessarily in wetland vegetation.

Looking at settlement area, the test revealed that the study area had 50% diversity score. When compared with the undisturbed, the study discovered that out of 30 wetland species found in the undisturbed area, settled area lost 70% species and introduced 27% evasive species. So, in this case, much as the settled area was seen to be rich in diversity, it is paramount to note that this study revealed that species richness was more of evasive plant species and that settlement robbed the wetland of 70% wetland plant species.

Lastly the cropped area was ranked least in plant diversity and scored 46% diversity . However, the results reveal that out of 30 wetland plant species in the undisturbed, the cropped study area lost 60% wetland plant species which were found in the undisturbed.

### 4.3: Determining the most detrimental human activity on plant species diversity among the disturbed study sites in Koga wetland

This study progressively attempted to find out the most detrimental human activity to plant species diversity and so during the mapping of the human activities in river Rwizi wetland, this study discovered that, whereas crop growing occupied almost the least ( 27.79%) of the total areal coverage of human activities, results from comparing of the plant species among the disturbed and the undisturbed sites revealed that, human cropping was characterized by the lowest percentage of plant species of 6%, followed by brick making (9%). This is portrayed in Table 4.6. It therefore meant that crop growing and brick making were found to be the most detrimental human activity to plant species diversity.

Still, Further analysis was made to find out the most detrimental human activity to plant species diversity, data was subjected to Simpson's Diversity Index, this was to assess the most and the less diverse study area among the disturbed study sites. Table 4.7 contains results from Simpson's Diversity Index of measuring plant diversity.

**Table 4.7: Determining the most detrimental human activity to plant species diversity in Koga wetland.**

Plant Species	Bricked		Cropped		Grazed		Settled	
	No.	%	No.	%	No.	%	No.	%
Grasses	328	8	130	3	1477	35	2090	49
Herbs	339	13	36	1	1740	68	232	9
Shrubs	175	8	397	17	71	3	907	40
Trees	4	3	7	6	31	24	9	7
Total	846	9	570	6	3319	36	238	36
Diversity Index	0.647	64.7	0.46	46	0.53	53	0.499	50

Looking at Table 4.7 in relation to the results from comparing the plants species among the disturbed and the undisturbed study areas, analysis revealed that, the land use activities affected the wetland plant species each according to its dynamism and non of the activities spared the vitality of plant life and the integrity of Koga wetland. The bricked area for example lost 24 (80%)wetland plant species, and was left with 5(16.7%), the settlement area lost 21 (70%)

wetland species and was left with 8(26.7%) species, while Grazed and cropped each lost 18(60) species and were also left with 8 (26.7%) species each. All study sites were invaded by evasive species which was high in the grazed study areas 15(50%). These evasive species included plants like Nandi grass, elephant grass, pasparum, and coach grass, kidney weed which had turned the wetland into arid savanna vegetation. As mapped in figure 4.2, Koga wetland was formally a hug wetland but has been progressively shrunk by human activities, to date its size is 4 by 23 kilometers and will continue to diminish if nothing is done to rescue it.

Therefore, regarding the most detrimental human activity to plant species diversity, this study found out that The cropped, the bricked and the settled study areas were left with only 8 (26.7%) wetland plant species each while the bricked was left with 5 (16.7%) wetland plant species, revealing that there are no outstanding differences in the effects of human activities on wetland plant species. It is therefore affirmed that all activities are detrimental to wetland plant species diversity and if wetlands are to be preserved, sustained and maintained, human activities have to be isolated from them.

There is therefore need for the government and environmental activists to regulate and if even relocate human activities in river Rwizi wetland.

#### **4.4 Discussion**

##### **4.4.1 Human activities in River Rwizi wetland**

This study located and documented on the map the human activities; Cropping, grazing and others, a limitation by Ojok, Wasswa & Ntambi, (2017) who did not indicate the locations of the activities that are detrimental to the wetlands, however they reported that in Mbarara, access to clean and safe water and improved sanitation facilities and practices are pre-requisites to a healthy population and therefore have a direct impact on the quality of life and productivity of the population.

This study found out that livestock farming and crop growing were the most dominant human activities near the shores of River Rwizi Wetland, Etagbor (2010) concurs when he observed in a study conducted in two sites of the Cross River within the Lebialem-Mone forest landscape of Cameroon, one of the sites faced with human activities (test site) and the other with no human pressure (control site), found out that fish communities living within these 2 sites were compared

after collecting fish from them, carried out deforestation and it constituted the main factors affecting the fish communities on both study sites as over 55 % of the river catchment.

While this study found out that animal grazing and crop growing were the most dominant human activities in Rwizi wetland, this finding agrees with Safari (2008) who reported subsistence agriculture, livestock management and mud fish in Nyaruzinga wetland, Bushenyi-Ishaka Town Council, Western Uganda . He further revealed that agriculture greatly affected water quality and could also affect the plant species there in.

Similar to the findings in this study is the work of Ayorekire (2016) who conducted a study that aimed at establishing land use conflict between pastorals and wildlife conservation in Lake Mburo area, its effect on the environment and attitude formation reported that the largest number of respondents (21.0%) considered overgrazing (19.2%) and over stocking (16.5%) as the major human activities in River Rwizi, Koga wetland area. Also, 12.0% cited bush burning and 10.2% improper cultivation on steep land as the causes of degradation.

Contrary to the findings in this study in which farming was the most abundant human activity in Rwizi wetland, Timbiti (2018) after analyzing various authors reported that commercial brick-making are, for instance, visible in the Kawanda wetland in Wakiso district on the Kampala-Luwero road. This can be attributed to the development and expansion of towns and cities with a big demand for building materials such as bricks. Besides, the activity that was considered to be gravely affecting the wetland environments was clay extraction. This was attributed to the fact that brick burning is rampant due to the increased demand of building materials, he explains that, in the urban setting, results in gas emissions from fuel combustion are destructive to plant life. The demand for bricks has resulted into the demand for wood energy to burn the bricks causing massive deforestation, reducing the amount of rainfall and lowering the water levels in Lake Victoria. Apart from carbon emissions, brick-burning, over the years, destroys the fertility of wetlands and affects the vegetation cover. The difference in wetland use is explained by the high urban setup in nearby Kampala compared to rural setup in Ankole where crop growing and cattle keeping are treasurable activities for economic and household upkeep.

#### 4.4.2 Determining the plant species in the disturbed and the undisturbed study sites

In the bricked making area, this study portrayed that plant species of herbs, shrubs and trees drastically reduced in the brick making area. Herb species reduced to 64% species in the bricked study site, shrub species reduced to 44% species and tree species reduced to 33% species. Similarly, in the study on the impact of brick making practices on Bujaga Wetland in Mbarara District, South-Western Uganda, found out that undisturbed area had the highest population of trees followed by shrubs and grasses following post abandonment period of five years (Akwongo, 2009).

However, Akwongo, (2009) reported that shrubs and trees were absent in the brickd area. This could be attributed to the fact that this particular study was done in the area where brick making was in progress compared to the abandoned area for 5 years in the study conducted by Akwongo, (2009). This study revealed that, all the grass species sighted on the undisturbed study site (Papyrus, Star and Nut grass species) were completely wiped out in the cropped study area. In relation to these findings, previous literature noted that, the disappearance of papyrus is emergent sedge with C<sub>4</sub> photosynthesis which is native to the wetlands, river valleys and lakes of central, eastern and southern Africa attributed to variations in plant species diversity.

Jetz *et al.*, (2016), however, explained that the disappearance of papyrus vegetation was due to being harvested by hand and stacked on the rhizome mat for partial air-drying, it has been demonstrated that an annual harvesting regime has no negative impacts on long-term productivity and the use of papyrus as a biofuel for cooking and heating, this study found out that preparation of wetlands for low to high savannah livestock farms dominated the reduction in papyrus vegetation in the Rwizi wetland.

Out of six tree species just one (*Erythrina abyssinica*) survived in the cropped site. However, much as other alien species were introduced generally, the results from the study portray that the number of all plant species of grasses, herbs, shrubs and trees drastically reduced in the cropped area. This differs from Catford *et al.* (2012) study who, while using the intermediate disturbance hypothesis (IDH) that predicts a hump-shaped pattern between community diversity and disturbance, and is central to understanding patterns of species diversity, found out that alien species increased the plant species diversity. This was attributed to the adaptive stages of

succession. Human disturbance, coupled with plant introductions, extends the diversity disturbance curve and shifts peak diversity towards higher disturbance levels.

In the grazed study site, this study found that grazing is the dominant activity in Koga wetland (72.06%). It involved burning, trampling on plants and the hardening of the grounds by the roaming animals which drink a lot of water too, these grazing activities gradually subjected the wetland to transform into being an arid or bare grounds. In such condition, this study found out that papyrus was completely wiped out. New grasses species (Coach, Elephant, pasparum, and Nandi grass) were introduced and the number of grass species shot up from 5%, in the undisturbed to 35%. This concurs with the study by Auma (2012) who used Land sat aerial image on Kusa swamp and found out that the area that was covered by papyrus in 1995 decreased by 13.96 km<sup>2</sup> (9%) between 1995 and 1998. This was because more land (42%) was either put to farming especially grazing of animals with limited settlement for the herders, and this might have resulted in clearing of papyrus hence the decline in area covered by papyrus. Alternatively, the rate of papyrus utilization might have increased due to increase in human population and hence more papyrus was harvested from the landward side of the swamp creating room for settlement. Nevertheless, with all these increased activity, the local community might have not put any measures in place to conserve the swamp ecosystem

Similarly, Catford *et al.* (2012) while using the intermediate disturbance hypothesis (IDH) that predicts a hump-shaped pattern between community diversity and disturbance, and is central to understanding patterns of species diversity, found out that alien species increased the plant species diversity. This was attributed to the adaptive stages of succession. Human disturbance, coupled with plant introductions, extends the diversity–disturbance curve and shifts peak diversity towards higher disturbance levels. However, invasive aliens were not explained in this study.

In general, although it was noted previously that the grass and herb alien species increased, the number of shrub and Tree species decreased in the disturbed sites; the shrub species decreased from 32% in the undisturbed to 3% in the grazed, while the Tree species also decreased from 60% in the undisturbed to 24% in the grazed site. Likewise, Ayorekire (2016) while conducting a study that aimed at establishing land use conflict between pastoralism and wildlife conservation in Lake Mburo area, its effect on the environment, revealed that 12.0% of respondents cited bush

burning and 10.2% improper cultivation on steep land as the causes of degradation. However, to him, overgrazing (19.2%) and over stocking (16.5%) were the major human activities in River Rwizi catchment area.

In the settled area, papyrus was completely wiped out, new grasses species ( Coach, pasparum, Congo signal,, Elephant, and Nandi grass ) were introduced and the number of grass species shot up from 5%, in the undisturbed to 49% in the settled study area. This contradicts the study by (Auma, 2012). The area that was covered by papyrus in 1988 was 68.9 km<sup>2</sup> (43% of the total area), while bare ground and farming occupied 24.44 km<sup>2</sup> (15%) (Figure 4.3). This implying that between 1985 and 1888, the papyrus area increased by 3.2 km<sup>2</sup> (2%). On the other hand, bare ground and farming area decreased from 21% in 1985 to 15 % in 988. There was very minimal anthropogenic interference of the papyrus ecosystem in terms of settlement, cultivation, burning and papyrus harvesting. This was due to seasonal flooding that made the swamp inaccessible. This implied that the local community was involved in terrestrial agriculture.

In general, the number of grass, herbs and shrub species increased and only the number of tree species decreased from 6% in the undisturbed to only 0.3% tree species in the settled study site.

There was variation in plant species diversity across sites affected by human activities. This finding is supported by Bao *et al.* (2018) who while conducting a study in Brazilian Pantanal in an extensive wetland with heterogeneous habitats simulated that primarily due to the river-floodplain system and plants with differential adaptations and reproductive strategies; although Bao *et al.* (2018) further assessed the influence of biogeographic patterns on the six areas along the Paraguay River, including residual relieves, verifying the pattern of similarity, and effects of distance and altitude. This study identified 9239 plant species whereas Bao *et al.* (2018) recorded 356 species in 87 families, mostly perennial (75%), and some annuals (15%) and pluriannuals (5%).

Furthermore, contrary to the findings of this study Akwongo, (2009) who investigated the effect of brick making on the plant species diversity on River Rwizi, this study established that, besides brick making was included in the the other activities. Other human land use which include; settlement, animal grazing, crop growing which were more detrimental to the plant species diversity. This study in addition to limited study of brick making brings forth the outcry on the disappearance of plant species in the Rwizi wetland, the differential disappearance and

appearance of various activities has mainly been attributed to settlement, animal grazing and crop growing too.

#### **4.4.3 The most detrimental human activity to plant species diversity**

This study revealed that there was drastic reduction of plant species in the cropped study site had (6%). Yet there were 9% species in the bricked, 36 % in the grazed site and 35% in the settled site. Besides, Simpson's diversity index revealed that, The cropped, the bricked and the settled study areas were left with only 8 wetland species each while the bricked was left with 5 wetland species, meaning that there were no outstanding differences in the effects of human activities on plant species diversity, all activities affect the plant species.

Findings in this study concur with the findings by (Irwin et al. (2010)) in which it was revealed that taxonomic groups vary considerably in which proximate factors are most important. Third, several groups show differing responses within different eco regions. Whether these differences are consistent across groups requires further testing. Fourth, related species often have divergent reactions to disturbance, even within lower taxonomic groupings (families or genera). Thus, we cannot rely on phylogenetic relatedness or even ecological similarity to infer similarity in responses.

Finally, disturbance typically reduces species diversity (especially of native and/or endemic species), but also causes species turnover, typically with forest specialists replaced by grassland generalists, and endemics replaced by non-endemics (including invasive). Given these knowledge gaps, we stress the urgency of applied studies that assess species' ecology, behavior and health across disturbance gradients, including purely anthropogenic landscapes. we must understand responses of plants and animals to disturbance in order to create buffer zones and corridors combining secondary, degraded and natural habitats.

Also, the results derived from testing Diversity Index of plants also revealed that cropping is the most detrimental activity on all species. Similarly, Wuver and Attuquayefio (2006) carried out a study on the impact of Human Activities on Biodiversity Conservation in a Coastal Wetland in Ghana, they used the methodology that involved interviews with a cross-section of the local people, the organization of durbars, and focus group discussions (FGD). Their results indicated that, among the various human activities undertaken in the area, fuel wood harvesting, bushfire

setting, hunting, and farming had the greatest impact on biodiversity conservation through degradation of the wetland over the years.

Besides, again noted in appendix 4 that the wetland where human cultivation was characterized by the lowest average number of plant species. This could be explained by selective uprooting of grasses during cultivation coupled with weeding. However, much such cropping has ranked highest in plant species elimination, all the activities need to be regulated so as to preserve, sustain and even reclaim not just wetlands but what Pope Francis (2015) referred to as “Our common home” . He laments on the loss of forests, woodlands which entail the loss of different species that contain genes which could be key resources in years ahead for meeting human needs and regulating environmental problems. The great majority become extinct for reasons related to human activity” indeed, these studies conquer with his as these activities are detrimental to plant life in that animals drink a lot of water and trample on vegetation, soils structure and gradually drain the wetland environment and eventually create bare grounds in what used to be a green water lodged environment and forcing it to transform into an arid environment.

## CHAPTER FIVE

### CONCLUSIONS AND RECOMMENDATIONS

#### 5.0 Introduction

This chapter involved the conclusions, recommendations and suggested areas for further research.

#### 5.1 Conclusion

The findings and discussion in chapter four brought forth the following conclusions:

The study located and documented on a Map the human activities along River Rwizi Wetland. The study found that the common human activities were Animal grazing, crop growing, also brick making and settlement. These activities were concentrated along and around river Rwizi wetland.

Papyrus which was the dominant grass species in the undisturbed area ranked lowest in the bricked area and was wiped out in the rest of the disturbed study sites that is, in the cropped, grazed and settlement areas.

Coach Grass became dominant in all the disturbed study sites. Paspalum and nut grass in the grazed and settlement sites respectively. Many of the herb species found in the undisturbed study sites were threatened to extinction. Many of the herb species found in the undisturbed were completely wiped out in all the disturbed areas such as morning glory, *Melanthera scandens*, *Tragus benthamii* and Devil's Horse whip.

Regarding shrubs, the highest number was in the settlement area and the least number was in the grazed study area. The highest number of trees was in the grazed area and the least number of trees was in the bricked area.

In general, the settlement study area had the highest number of species while the cropped area has the lowest number of species.

Results from Simpson's Diversity Index of measuring plant diversity revealed that, among all the areas studied, the bricked area had the highest diversity score, as compared to the undisturbed area. So, although the Simpson's Diversity index score indicated that the brick area had very high

diversity, it must be emphasized that the brick study area took a lead losing the highest number of wetland vegetation replacing it with evasive species.

Regarding the most detrimental human activity to plant species diversity, this study revealed that The cropped, the grazed and the settled study areas were left with only 8 wetland species each while the bricked was left with 5 wetland species, revealing that there are no outstanding differences in the effects of human activities on plant species diversity. It is therefore affirmed that all activities are detrimental to plant species diversity and if wetlands are to be preserved, sustained and maintained, human activities have to be relocated, isolated or prohibited altogether.

It was therefore concluded that there is urgent need for the government and the passionate environmental activists to mitigate human activities in river Rwizi wetland.

## **5.2 Recommendations**

The Environment Managers and Activists need to continue to reinforce the restoration of Rwizi Wetland by carrying out the programs like making buffer zones; relocating or even evicting humans who continue to encroach on River Rwizi wetland, this is crucial if river Rwizi wetland is to continue to exist.

The results from the mapping of the human activities in Koga revealed that although human cultivation was only 27.93% of the total areal coverage of the human activities, it was proved that there were low numbers of plant species where human cultivation had taken place, (Table 4.1), it is therefore urgent that the government through the environmental officers and all environmental activist including NGOs, stand together to combat the unfavorable human activities to plant life.

The mapping of the different human activities in Koga wetland revealed the actual land use types and how each is destructive to plant life; with such knowledge, one is in position to take a clear and firm stand uncompromisingly to support wetland protection. So, dissemination of such knowledge and information could be used to sensitize society and influence their attitude and zeal to protect the wetland ecosystem. For example, short and précised workshops can be organized and people can be taken through the process of understanding which plant species are threatened to extinction and by which activity. This perhaps could awaken in many the fear of

the eventual loss of the wetland ecosystem and thus instill in them the desire and commitment to save and protect wetlands and their valuable resources..

Simpson's Diversity Index of assessing plant diversity affirmed that among the human activities, the brick making area had the highest diversity score of 65%, whereas a deeper analysis proved that in fact, 24 out of 29 wetland species which were in the undisturbed were lost in the brick making area, 11 evasive species were introduced which may have choked the growth of the wetland species. This implied that what seemed to be high in diversity score in the bricked area was actually highly detrimental to wetland plant species. It is therefore recommendable that deep analytical studies on wetland resources be encouraged and if possible funded so as to generate genuine and consistent knowledge which will help in wetland reclamation, protection and sustainability.

The test also affirmed that all human activities are detrimental to wetland plant species and so there is urgent need for the authorities together with the environmental activists to prohibit all human activities in the wetland ecosystem, short of that, we shall be robbed of the wetland services such as control of flooding, regulation of temperature, provision of its scenic view, water, food, medicine, habitat, craft materials for craft industry; all these and many others will disappear.

### **5.3 Suggested Areas for further Research**

This study was conducted in Koga wetland in River Rwizi catchment area. Related studies will need to be conducted in other wetlands in the area for comparison purposes. This may enable the study to carry out the observational studies to identify the common human activities, distribution of the plant species diversity and the effect of human activities on the plant species diversity in the wetland. This will bring out another study to enrich and compliment this study.

This study did not involve qualitative study and perhaps it might be a good idea to recommend that future studies need to consider qualitative studies such as in-depth interviews with wetland invaders to find out their view on the wetland use.

This study also recommends that, the future studies could be directed in making sure that, when studying a disturbed area, he or she should have the undisturbed area adjacent to each human activity. This would take care of other variables that affect plant life such as the soils and slope.

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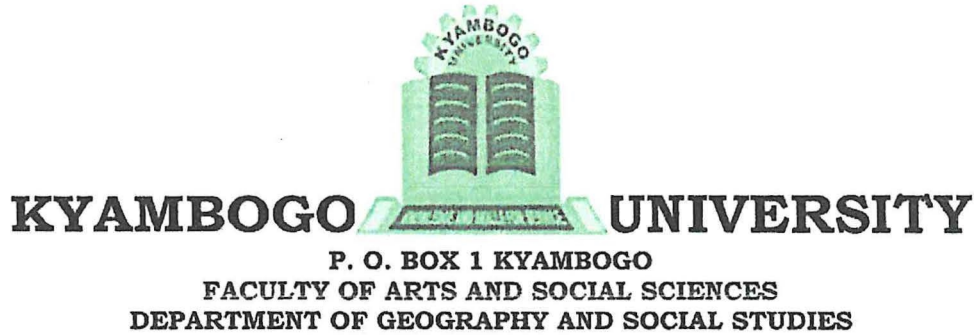
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## APPENDICES

### Appendix 1: Authorizing letter to go to the field for data collection



29<sup>th</sup> March 2018

**TO WHOM IT MAY CONCERN  
LOLEM LUCY CHEGEM  
14/U/13267/GMAG/PE**

This is to introduce to you the above named student who is pursuing a Master of Arts in Geography degree course at Kyambogo University. She is in her second and final year and she is supposed to conduct a research study entitled **Effects of Human activities on Plant Species Diversity in a Wetland Ecosystem: A Case of Rwizi Wetland in Mbarara District.**

Any assistance accorded to her will be highly appreciated.

Thank you.

  
**Nabbose Milly(Ms)  
RESEARCH COORDINATOR**

**Appendix 2: Data collection sheet**

<b>Plant species</b>	<b>Population</b>	
	<b>Disturbed area</b>	<b>Undisturbed area</b>

**Appendix 3: Names of the variant plant species in the study sites**

Local	English	Botanical	Family	Comments
Amatojo	Milkthistle	Acanthus arboreus		
Butabuta				
Ebitogo	Papyrus	Cyperus papyrus		
Ejubwe		Pennisetum purpureum		
Ekaasi				
Ekarabo	Sprangue	Dombeya dawei	<i>Stercukiaceae</i>	
Ekarwe		<i>Melanthera scandens</i> (Schumach. & Thonn.)		
Ekicuncu				
Ekikindo	Palm tree	Hyophorbe lagenicaulis		
Ekimucumu		Leonotis nepetifolia		
Ekishekashekye		Clerodendrum rotundifolium		
Ekyoganyanja		Bothriocline longipes		

Embatula				
Engenyeni	Stinging netal	Tragia benthamii	Euphorbiace ae	
Entutsi		Eukalytus globules	Myrtaceae	
Eteija	Wandering jew	Commelina benghelesis	Commelinac eae	
Kafumbe		Galinsoga parviflora		
Munokello		Tridax procumbens		
Omucundezi				
Omugabagaba	Candle bush	Senna dybomotrya		
Omujuma		Vernonia lasiopus		
Omukongorani		Pseudarthria hookeri		
Omukongorani		Pseudarthria hookeri	Papilionoide ae	
Omukooma		Hyphaene compressa		
Omukunyu				
Omunyamahwa				

Omunyaiza		Gardenia sokotensis		
Omuyeganyegye		Sesbania sesban		
Omusambya		Dodonaea viscosa		
Omusavu		Markhamia lutea		
Omusha				
Omusambya		Markhamia platycalyx		
Omushe		Urera hypselodendron		
Omusojwa	Spear grass	Imperata cylindrical		
Omusununu	Tridax	Crassocephalum vitellinum		
Omusigizi				
Omusinga		Hibiscus fuscus		
Omusinga-ngore		Ludwigia abyssinica	<i>Onagraceae</i>	
Omusoroza		Indigofera arrecta		
Omutoma		Ficus natalensis/ovate		

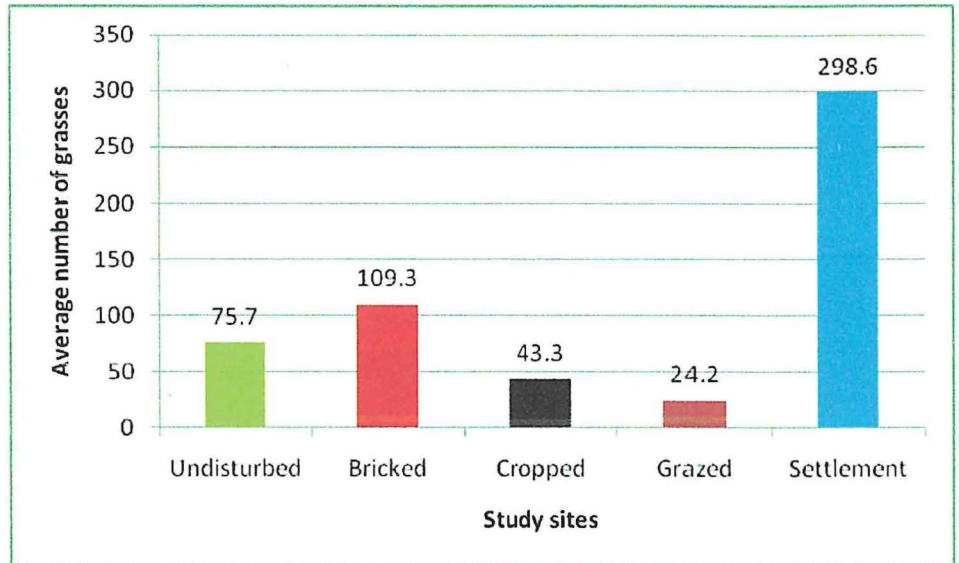
Omutoma		Pleiocarpa pynantha		
Oruhigura	Burr bush	Triumfetta rhomboidea		
Orumbugu	Coach grass	Cynodon dactylon	Poaceae	
Ssetaba		Blumea alata		
	Nut grass			
	Star grass			
	Congo signal			
	Nandi grass			
	Water lily			
	Guinea grass			
	Elephant grass			
	Paspalum			
	Spear grass			
Omuhukye	Tick bery	Lantana camara		
	Sodom apple			

	Acacia		Fabaceae	
	Castor oil			
	Fern		Pteridophyta	
	Kie apple			
	Wild egg plant			
	Kidnet weed			
	Lions ear			
	Glycine			
	Green leaf desmodium			Planted to increase milk yields
	Silver leaf desmodium			
	Oxalis corniculata			
	Morning glory			
	Devil's horse whip			
	Fig tree	Ficus exasperate		
	Guava			

**Appendix 4: Average number of plant species in the study areas**

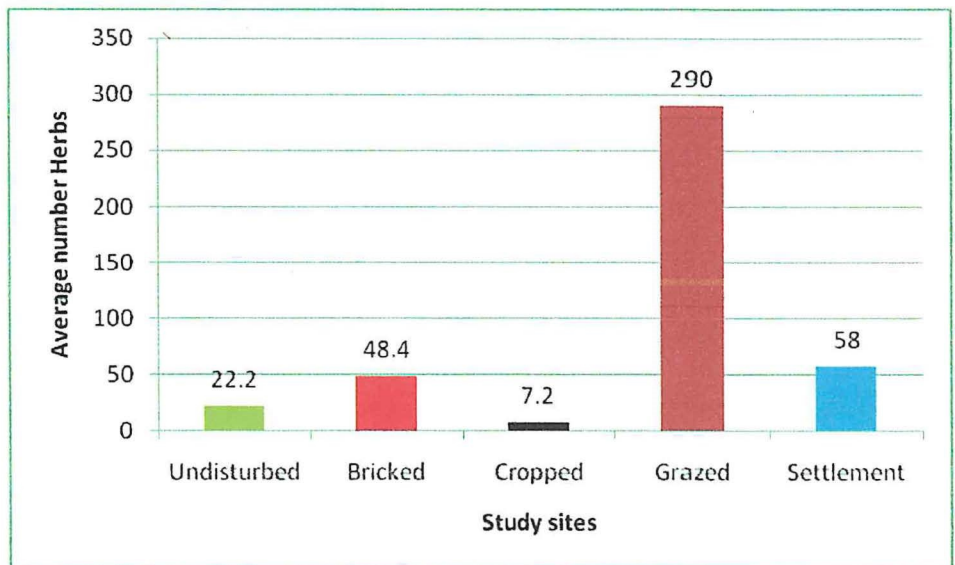
Grasses

Undisturbed	75.7
Bricked	109.3
Cropped	43.3
Grazed	24.2
Settlement	298.6



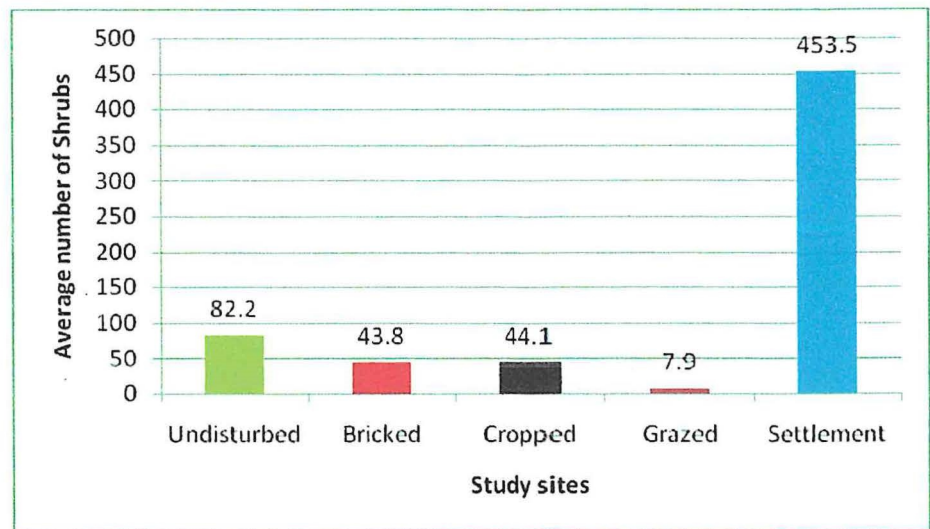
Herbs

Undisturbed	22.2
Bricked	48.4
Cropped	7.2
Grazed	290
Settlement	58



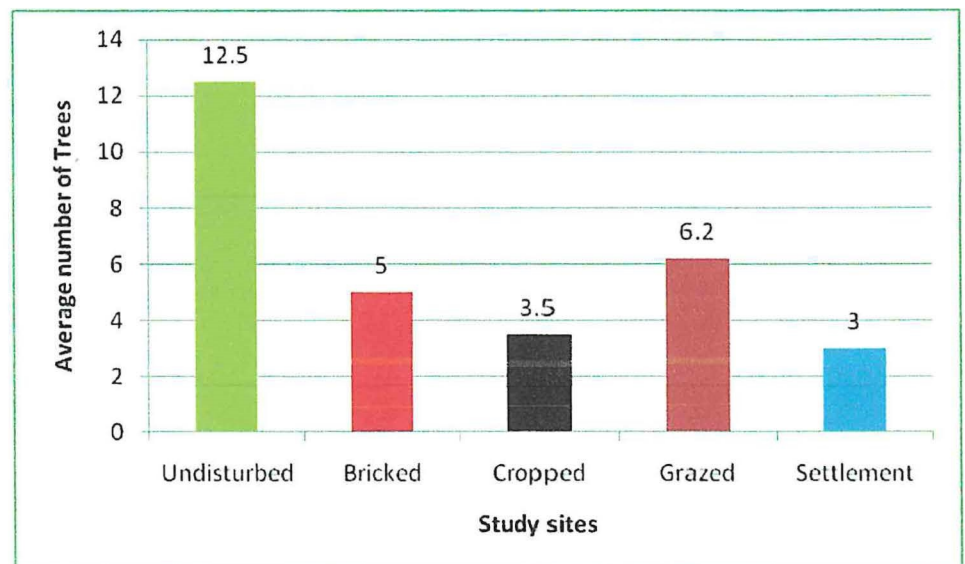
## Shrubs

Undisturbed	82.2
Bricked	43.8
Cropped	44.1
Grazed	7.9
Settlement	453.5



## Trees

Undisturbed	12.5
Bricked	5
Cropped	3.5
Grazed	6.2
Settlement	3



**Appendix 5 : Calculating Simpson's Diversity Index.**

Plant Species	Bricked		Cropped		Grazed		Settled	
	No.	%	No.	%	No.	%	No.	%
Grasses	328	8	130	3	1477	35	2090	49
Herbs	339	13	36	1	1740	68	232	9
Shrubs	175	8	397	17	71	3	907	40
Trees	4	3	7	6	31	24	9	7
Total	846	9	570	6	3319	36	238	36
Diversity Index	0.647	64.7	0.46	46	0.53	53	0.499	50

For Bricked;

$$D = 1 - \left( \frac{\sum n(n-1)}{N(N-1)} \right)$$

$$D = 1 - \left( \frac{328(328-1) + 339(339-1) + 175(175-1) + 4(4-1)}{846(846-1)} \right)$$

$$= 0.647 \approx 65\% \text{ Diversity index.}$$

For cropped;

$$D = 1 - \left[ \frac{130(130-1) + 36(36-1) + 397(397-1) + 7(7-1)}{570(570-1)} \right]$$

$$= 0.4596 \approx 46\% \text{ Diversity index.}$$

For Grazed;

$$D = 1 - \left[ \frac{1477(1477-1) + 1740(1740-1) + 71(71-1) + 31(31-1)}{3319(3319-1)} \right]$$

$$= 0.5267 \approx 53\% \text{ Diversity index.}$$

For Settled;

$$D = 1 - \left[ \frac{2090(2090-1) + 232(232-1) + 907(907-1) + 9(9-1)}{3238(3238-1)} \right]$$

$$= 0.4999 \approx 50\% \text{ Diversity index.}$$