

THE EFFECTS OF LAND USE COVER CHANGE ON RANGELAND ECOSYSTEMS IN
KAKOOGE SUB-COUNTY NAKASONGOLA DISTRICT, UGANDA.

BY

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DECLARATION

I hereby declare that this report is my own work and has never been submitted to any University for the award of Master's Degree in Land Use and Regional Development.

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DEDICATION

I dedicate this work to my Father and Mother, Paul and Resty Mbaziira who have contributed to my education, uplifting my moral and social life.

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LIST OF ACRONYMS

AI	ARIDITY INDICATOR.
EAWS	EAST AFRICAN WILDLIFE SOCIETY
FAO	FOOD AND AGRICULTURE ORGANIZATION.
GIS	GEOGRAPHICAL INFORMATION SYSTEMS
HA	HECTARE
ICRAF	INTERNATIONAL COUNCIL (CENTER) FOR RESEARCH IN AGRO-FORESTRY.
ILWIS	INTERGRATED LAND AND WATER INFORMATION SYSTEMS.
IIED	INTERNATIONAL INSTITUTE FOR ENVIRONMENT DEVELOPMENT
KDP	KAKOOGA DEVELOPMENT PLAN
MWE	MINISTRY OF WATER AND ENVIRONMENT
MDGS	MILLENNIUM DEVELOPMENT GOALS
MEA	MILLENNIUM ECOSYSTEM ASSESSMENT
MUIENR	MAKERERE UNIVERSITY INSTITUTE OF ENVIRONMENT AND NATURAL RESOURCES
MPED	MINISTRY OF FINANCE, PLANNING AND ECONOMIC DEVELOPMENT
MWE	MINISTRY OF WATER AND ENVIRONMENT
NDFA	NAKASONGOLA DISTRICT FARMERS ASSOCIATION
NDER	NAKASONGOLA DISTRICT ENVIRONMENT REPORT
NEAP	NATIONAL ENVIRONMENT ACTION PLAN
NEMA	NATIONAL ENVIRONMENT AUTHORITY
WRI	WORLD RESOURCE INSTITUTE
WSSP	WETLAND SECTOR STRATEGIC PLAN
NARO	NATIONAL AGRICULTURAL RESEARCH ORGANIZATION.
NFA	NATIONAL FOREST AUTHORITY
UBOS	UGANDA BUREAU OF STATISTICS
UTM	UNIVERSAL TRANVERSE MERCATOR
UNEP	UNITED NATIONS ENVIRONMENT PROGRAM
WPIA	WOODY PLANT INVENTORY ASSESSMENT

ABSTRACT

Land use and land cover change is driven by human actions and also drives changes that limit availability of products and services for human and livestock, and it can undermine environmental health as well. Therefore, this study was aimed at understanding land use and land cover change in region, Nakasongola District. Two time-series satellite images that included Landsat TM, and ETM+ which covered the time frame between 1987 to 2005, were used. Socio-economic Survey and review of documents was carried out to understand historical trends, collect ground truth and other secondary information required. Analysis of data and other data was accomplished through integrated use of ILWIS 3.3 version and GIS software packages along with Microsoft office analytical tools.

Remote sensing analysis revealed landscape level change of cultivated land to have a net increase while a decline is found for Woodlands. However, socio-economic surveys showed that household level cultivated land has decreased from 2.2ha to 1.8ha over the last 18 years. Major contributing factors included population increase, occurrence of drought, land redistribution, and land degradation. Similarly, average land holding per household has decreased from 1.6ha to 1.5ha. This has jeopardized the capacity of individuals to provide land for their siblings further leading to landlessness, which is becoming a common phenomenon among rural youths.

In Kakooge, dense woodlands decreased at an annual rate of 3.4. %, while open grass land increased at a rate of 0.68%; as opposed to this, dense shrub/bush land decreased at a rate of 0.11% and wetlands declined at annual rate of 0.83%; Built up showed a net increase at a rate of 45.7% due to population increase. Along with the observed decrease in vegetation cover, Limited availability and extinction of some tree/shrub species is also reported and research is required to quantify changes and understand the real impacts brought about. Key words: Land Use and land Cover Change, Land degradation, satellite imagery, implication for management of rangelands ecosystem, Kakooge ,Nakasongola District Uganda.

CHAPTER ONE

GENERAL INTRODUCTION

1.1: Background

Rangelands are sensitive ecosystems which could be adversely affected by inappropriate land uses (Kisamba- Mugerwa, 2001). An estimated 60% of the world's ecosystems were on decline by 2000 (NEMA, 2004/5). According to the UNDP (2007), Land degradation is widespread in Uganda and most pronounced in the dry corridor which stretches diagonally from northeast through the central to the South western parts of the Country, indeed the UN commissioned Millennium Ecosystem Assessment (2005) found out that increasing demands on ecosystem services over the past 50 years have been fulfilled at the cost of ecosystem degradation and loss of diversity.

Globally rangelands cover over 47% of the land surface area, with 60% area coverage in Sub-Saharan Africa in 2005 (Marlow, 2000; Kalema, 2010). In Uganda rangelands cover is estimated at 8400km² which is approximately (40%) of the total land area in 2000, (Kisamba – Mugerwa, 2001).

Rangelands comprises of Savanna grasslands or woodlands which form an important structural diversity for plants, animals and other organisms, (Lumbin et al, 2000). Savanna woodlands are reported to be vitally important in ecological and economic services that sustain local livelihoods and national economies; These ecosystem services include among others; erosion protection, micro-climate amelioration, habitat for a wide range of organisms, carbon sequestration, timber, food, and fodder for animals (FAO, 2005). In Uganda particularly rangeland ecosystems contribute considerably to household livelihoods by providing fuel, fodder, and medicine, products of cultural importance and food security, (Kalema, 2010).

The land use patterns of a region are an outcome of socio-economic factors and Rural households use of natural resources for; Fuel wood and other biomass fuels will rise by more

than 40% by 2030 (Arnold & Persson, 2003). Besides, Land is becoming a scarce resource due to immense agricultural and demographic pressure (Lambin, et al., 2001).

Hence, information on land use / land cover and possibilities for their optimal use is essential for the selection, planning and implementation of land use schemes to meet the increasing demands for basic human needs and welfare. This information also assists in monitoring the dynamics of land use resulting out of changing demands of increasing population.

Land degradation in the rangelands has led to lowering of economic livelihood options and increased poverty among pastoralists and agro-pastoralists (UNDP, 2007). In East Africa rangelands are under threat due to human related pressures (USAID, 2002); in some areas the rangelands conditions are affected by over grazing coupled with vegetation destruction and soil erosion (NEMA, 2004/5).

Besides, rangeland areas are experiencing increasing population growth rate, livestock changes, under varying climatic conditions and divergent environmental policies in Uganda (NEMA, 2004/5). In addition woody plants are easily destroyed thus their quality and quantity can be maintained through proper management,(Kisamba- Mugerwa,2001).

Rangelands are regarded as the second most fragile ecosystem in Uganda after the highlands but limited research has been conducted on the threats to rangelands (NEMA, 2007). The studies conducted don't produce a comprehensive estimate of land use cover change as well as the patterns of change for the rangelands of Uganda over time (Buyinza, 2004). The few existing studies have reported change of bush and woody into grazing lands at a magnitude of between 25% to 75% (Byenkya, 2004; Zziwa et al.,2011). Although many factors including; cultivation, grazing, fire, charcoal burning, population increase, political instability and climatic variations are cited among the notable drivers of land use cover changes (Zziwa et al.,2011), however assessments of the patterns and magnitudes of change, disaggregation of drivers and spatialization of their effects still subtle in the rangelands of Uganda.

However, despite the multiple roles of rangeland ecosystems, not many have been conserved for instance in Central Africa, which has the largest part of Africa's rangelands, only about 4 to 5%

is conserved or in a government plan to gazette. alarming poverty. Rangelands are at a risk because of rising population living with in or around the rangelands, making the conflicts inevitable between usage and conservation.(Kisamba- Mugerwa, 2001).

Therefore, Land use cover data provides basis for resource planning and management. The advancement in the concept of vegetation mapping has greatly increased research on land use land cover change thus providing an accurate evaluation of the spread and health of the world's forest, grassland, and agricultural resources. Viewing the Earth from space is now crucial to the understanding of the influence of man's activities on his natural resource base over time. In situations of rapid and often unrecorded land use change, observations of the earth from space provide objective information of human utilization of the landscape. Over the past years, data from remote sensing satellites has become vital in mapping the Earth's features and infrastructures, managing natural resources and studying environmental change.

Geographic Information System (GIS) is now providing new tools for advanced ecosystem management. The collection of remotely sensed data facilitates the synoptic analyses of Earth - system function, patterning, and change at local, regional and global scales over time; such data also provide an important link between intensive, localized ecological research and regional, national and international conservation and management of biological diversity (Wilkie and Finn, 1996). This study quantifies the land use cover of Kakooge between 1987 and 2005 to understand the rate of land use and cover changes, drivers and the effects that arise from their spatial and temporal variations.

1.2 : Statement of the problem

The land use cover patterns of Kakooge have changed in the last decades (Kisamba- Mugerwa, 2001); as studies in rangelands have attributed the spatial and temporal land use and land cover changes to highly efficient traditional farming methods (Lambin et al., 2001).

In Uganda the productivity of rangelands is declining and NEMA 2004/5 reported a decline of more than 44% by 2002. This drop is partly attributed to the increasing pressure from the population (Zziwa et al, 2011). As woodlands productivity continues to decline, the population is forced to depend more on wetlands, extending the cultivation into marginal areas (NARO, 2005).

Hence, to attain ecosystem sustainability in Uganda there is needs to evaluate the magnitude, pattern, and type of land use cover changes and projecting the consequences of such change (FAO, 2004; MEA, 2005b). Furthermore, planning sustainable management of existing land uses in the area requires studies of the structure, composition, and ecological functioning and understanding of the influence of land use practices and environmental factors on patterns of land cover, composition and changes is of great importance in the process of land use and management, as it aids effective conservation, planning and management (Walker & Stefan, 1996).

Although understanding the contexts for how people respond to and shape periods of land use cover change and how society follows up change seems to be alargely neglected and still less understood issue. It is hoped that this study will provide information for decision makers and development practitioners about the magnitude and dimensions of long term land use and land cover changes, their drivers, impacts and community mitigating strategies in the study areas and surroundings. Understanding such changes is critical for formulating effective environmental policies and management strategies (Agarwal et al., 2002). Therefore, based on the information generated, issues that need immediate action were identified and prioritized. In addition, the study gives an overview of the various ranges of local knowledge and practices within the study areas from which planning and formulation future projects could be based.

1.3: Study objectives

Main objective

To contribute to our understanding of the drivers and impacts of land use cover change on rangeland ecosystems.

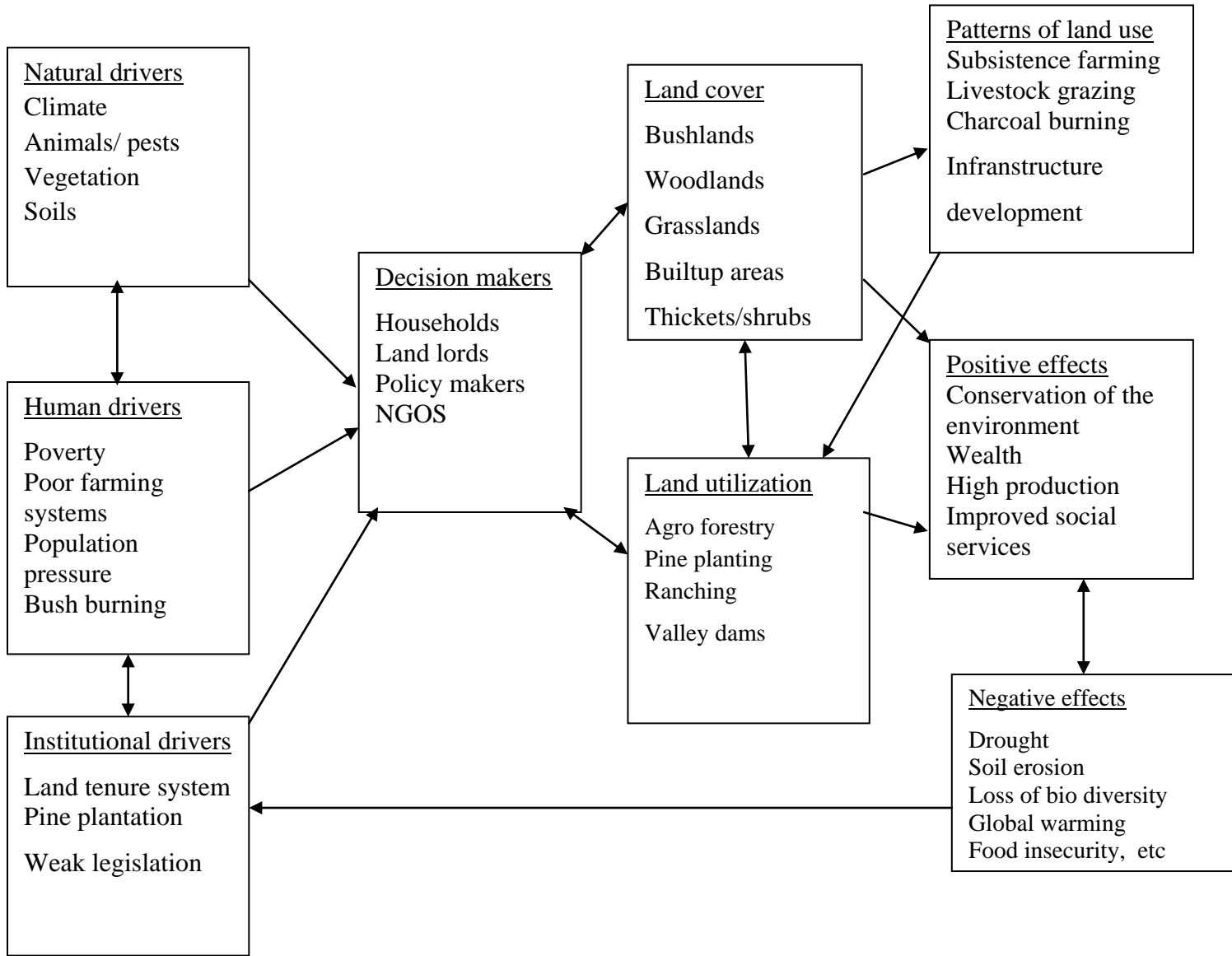
Specific objectives

- i. To analyze the land use and land cover changes in Kakooge Subcounty.
- ii. To establish the driving forces of land use and land cover changes in Kakooge SubCounty
- iii. To analyse the effects of land use and land cover changes on bio- physical components in the ecosystem of Kakooge sub county.

1.4: Conceptual Framework

The problem of the study was conceptualized by looking at the possible network land use and land covers, drivers and their effects on the bio-physical components of the rangeland ecosystems in Kakooge Sub-county, three variables were identified; background factors (drivers), adaptation strategies and possible feedback (impacts).

Figure 1: The conceptual frame work showing land use cover and the effects on bio-physical components of the rangelands ecosystem.



1.5: Research questions

In order to obtain the necessary information from the field basing on the conceptual frame work the following questions were advanced:

- i. What are the spatial and temporal landuse and land cover changes in Kakooge sub county?
- ii. Where are the key causes and drivers of land use cover change in Kakooge Subcounty?
- iii. What is the effect of land use and land cover changes on ecosystem biotic and abiotic components?

CHAPTER TWO

LITERATURE REVIEW

2.1: Introduction to Land Use and Land Cover Change

Land cover is defined by the attributes of the earth's land surface captured in the distribution of vegetation, water, desert and ice and the immediate subsurface, including biota, soil, topography, surface and groundwater, and it also includes those structures created solely by human activities such as mine exposures and settlement (Lambin et al., 2001). On the other hand, land use is the intended employment of and management strategy placed on the land

cover by human agents, or land managers to exploit the land cover and reflects human activities such as industrial zones, residential zones, agricultural fields, grazing, logging, and mining among many others (Zubair, 2006; Chrysoulakis et al., 2004).

Land use change is defined to be any physical, biological or chemical change attributable to management, which may include conversion of grazing to cropping, change in fertilizer use, drainage improvements, installation and use of irrigation, plantations, building farm dams, pollution and land degradation, vegetation removal, changed fire regime, spread of weeds and exotic species, and conversion to non-agricultural uses (Quentin et al., 2006).

Land use and land cover changes may be grouped into two broad categories as conversion and modification. Conversion refers to changes from one cover or use type to another, while modification involves maintenance of the broad cover or use type in the face of changes in its attributes (Baulies and Szejwach, 1998).

According to Lambin (2001) sustainable resource use refers to the use of environmental resources to produce goods and services in such a way that, over the long term, the natural resource base is not damaged so that future human needs can be met.

One of the most significant global challenges in this century relates to management of the transformation of the earth's surface occurring through changes in land use and land cover (Mustard et al., 2004, cited in Daniels et al., 2008). It is estimated that undisturbed areas represent 46% of the earth's land surface. Forests covered about 50% of the earth's land area 8000 years ago, as opposed to 30% today. Agriculture has expanded into forests, savannas, and steppes in all parts of the world to meet the demand for food and fiber (Lambin et al., 2003). Based on data from diverse sources, the Global Forest Resources Assessment 2000 estimated that the world's natural forests decreased by 16.1 million hectares per year on average during the 1990s, which is a loss of 4.2% of the natural forest that existed in 1990, (Lambin et al., 2003).

Land use in East Africa has changed swiftly over the last half-century: expansion of mixed crop-livestock systems into former grazing land and other natural areas and intensification of agriculture are the two largest changes that have been detected (Olson and Maitima, 2006).

Accordingly, land cover classification has recently been a hot research topic for a variety of applications (Liang et al., 2002). A great deal of research has been conducted throughout the world in an attempt to understand major shifts in land use and land cover and to relate them to changing environmental conditions. According to Baulies and Szejwach (1998), during the next decades, land-use dynamics will play a major role in driving the changes of the global environment. Hence, global mapping of irrigated and dry land agriculture, semi-natural areas and forest cover, reflecting their dynamics, can contribute to the assessment of the biophysical implications of land use and land cover change within the Earth's system.

Generally, agriculture is found to be the major driver of land cover change in tropical regions (Lambin et al., 2001 cited in Daniels et al., 2008). Over the past 50 years in East Africa, there has been expansion of agriculture at the expense of grazing land (Olson and Maitima, 2006). Before 1950, semi-arid and sub-humid areas were predominantly pastoral with scattered settlement and cultivation but from then onwards, there has been significant transformation of grazing land to mixed crop-livestock agriculture. Understanding the mechanisms leading to land use and land cover changes in the past is crucial to understand the current changes and predict

future ones. These changes occurred at different time periods, paces, and degrees of magnitude and with diverse biophysical implications (Baulies and Szejwach, 1998).

Therefore, Land use and land cover change research needs to deal with the identification, qualitative description and parameterization of factors which drive changes in land use and land cover, as well as the integration of their consequences and feedbacks (Baulies and Szejwach, 1998). However, one of the major challenges in LUCC analysis is to link behavior of people to biophysical information in the appropriate spatial and temporal scales (Codjoe, 2007). But, it is argued that land use and land cover change trends can be easily assessed and linked to population data, if the unit of analysis is the national, regional, district or municipal level.

Land use and land cover changes result from various natural and human factors within social, economic and political contexts. Hence, the local human activities expressing the drivers can be determined by measuring the rates and types of changes and analyzing other relevant sources of data like demographic profiles, household characteristics and policies related to land resources administration.

To achieve this, it is crucially important to consider multiple sources of information and to acquire temporal, spatial and other non-spatial forms of data. This is due to the fact that land use attributes are complex and the boundaries between different types of data are quite diffuse (Baulies and Szejwach, 1998). LUCC studies have been designed to improve understanding of the human and biophysical forces that shape land use and land cover change. Thus, linking human behavior and social structures to biophysical attributes of the land is a fundamental aspect of LUCC research (Baulies and Szejwach, 1998). Land use and land cover plays an important role in global environmental change and sustainability, including response to climate change, effects on ecosystem structure and function, species and genetic diversity, water and energy balance, and agro-ecological potential (Codjoe, 2007).

Land use and land cover mapping is one of the most important and typical applications of remote sensing data (Chrysoulakis et al., 2004). Remotely sensed data are a useful tool and have scientific value for the study of humanenvironment interactions, especially land use and land cover changes (Dale et al., 1993 cited in Codjoe, 2007).

Few studies have been conducted to understand land use and land cover change and other related issues in the proposed study areas. Zziwa et,al., (2011) has done satellite image analysis of the the district between 1985/86 and 2001/03. He found that croplands increased by about 4.2%, which largely occurred at the expense of grasslands and shrub lands. Furthermore, forest cover was found to have decreased by about 0.23% in the same time frame. Analysis of satellite images and aerial photos of 18 years provide evidence of changing land cover. It was found that the vegetation of the wetland catchment was almost gone by 2000, although it was covered by dense woody vegetation in the time between 1986 and 2004 The wetland showed continuous increment and was completely flooded around 2000, whereas it was almost dry around 1990. Furthermore, the numbers of houses in Kakooge town, near the wetland have greatly increased in this period of analysis.

2.2: Land use cover change in rangelands

Land usecover change is part and partial of human history in most parts of the world resulting from human populations and civilizations changes (Perlin, 1989; Turner et al., 1990). In Uganda, land use and cover changes include the conversion of forests, wetlands and grasslands to cultivation, grasslands burning and clearing of woodlands for grazing and fuel wood (Zziwa etal., 2011; NEMA, 2007). Currently major transition occur from grass to woodlands (Owoyesigire et al., 2008).

Land cover can be altered by natural events such as weather, flooding and fire. Globally, land cover today is altered principally by direct human use: by agriculture and livestock raising, forest harvesting and management and urban and suburban construction and development. There are also incidental impacts on land cover from other human activities such as acid rain from fossil fuel combustion and crops near cities damaged by troposphere ozone resulting from automobile exhaust (Meyer, 1995).

There has been a change in the Forest cover in the rangelands East Africa since 1980, from 71.4 million (ha) at the end of 1980 to 65.5 million ha at the end of 1990, with a loss of 0.6 million ha (0.9% per annum, (FAO, 2010).

Decrease in grasslands over time, indicates that there has been expansion of other land use cover patterns in rangelands seen through increased in the woody vegetation cover (Coppock 1994, Smith, 2004). Grasslands are the main source of feed for livestock (Zziwa et al., 2011). Leading to severe soil degradation through grazing as evidenced by expansion of bare lands in most rangelands (Mugerwa, 2012). The critical level of grasslands degradation reached irreversible condition making woody vegetation expand (Smit, 2004).

Subsistence croplands has been changing overtime with the average farm size of about 1 - 5 hectares (NLP, 2007). Coverage of cultivated land has been increasing annually in African rangeland since 1960's, indicating that many interventions were undertaken in crop production over years aimed at expansion of annual crop production to meet food security as perceived by the communities (Getachew et al., 2010).

Coniferous plantations form another element and an alien land use in most rangelands, most plantations (pines and eucalyptus) have been established in areas formally under bush lands, grasslands, crop lands and woodlands. (Zziwa et al., 2011). Bare land coverage declining, due to increasing patterns of land covered by planted forest vegetation that hide the visibility of land from the air (Smit, 2004); Though barelands are still a problem in agricultural, pastoral and settled areas (Ayana, 2007).

Built up land use cover show consistent (but different rates) increase in most rangelands, (Muluneh, 2003). Increases in most settlement land relates with an population size (Smit, 2004). Thus continued population pressure pose pressure on most rangelands resources through permanent, settlements reduced mostly the bush lands, woodlands and wetlands (Kalema, 2010).

2.3: Drivers of Land use cover Change

Land usecover is a fundamental variable that impacts and links many parts of human and physical environments and regarded as the single most important variable of global change affecting ecological systems (Kalema, 2010). The prevailing land use patterns in Africa's rangelands do not represent optimum resource management, yet the sustainability the ecosystems depends heavily on trees and other woody plants. Hence, in a country like Uganda to attain sustainable management of important rangeland ecosystems needs to evaluate the magnitude, pattern, and type of land use cover changes and projecting the consequences of such change to their conservation (FAO, 2004; MEA, 2005b).

The outcome of the land use cover changes depends on the expression of the fundamental principles of nature, i.e. time, species, place, disturbance and landscape (Dale et al., 2000). Thus Land-use shifts are widely caused by external and internal drivers that have influenced many traditional resource management regimes in the area (Muwanga, 2006).

2.3.1: Social drivers

The primary cause of land cover and land use change world-wide is the human population and the way people use and manage land (Kalema, 2010; and Gobin et al., 2001). It is also pointed out that the most potent forces for changes acting on rangelands are the effects of changing land use arising from direct effects of an expanding human population (MEA,2005b). Besides the role of population growth or poverty, there are other more important complex forces of tropical deforestation (Lambin et al., 2001). Although results of careful surveys about tropical deforestation support the view that population growth is never the sole and often not even the major underlying cause of land use and land cover change (Kisamba- Mugerwa, 2001)

Increased emigration of people into the area of Nakasongola after the 1986 bush war (Zziwa et al., 2011). This increases built up areas, leading to decline in bushland cover, woodlands (Lambin et al., 2001). This peaceful situation seem to be areliable reason to why built up areas even in Kakooge sub county are on arise.

Globalization is yet a driving force of land use cover change; by removing regional barriers and strengthening global ties at the expense of national connections (Lambin et al., 2001). Rapid land use coincides with the incorporation of a region into an expanding world economy where global forces increasingly replace or re-arrange the local factors determining land uses, though global-scale linkages, connects the sources of demand from the location of production threatening local diversity in land use and land cover patterns (NEMA, 2007).

Urbanization, occupies less than 2% of the earth's land surface (Lambin et al., 2001). This cause land use cover change elsewhere through the transformation of urban-rural linkages for example, urban inhabitants depend on forest, agriculture, wetland, lake and marine systems that constitute an area about 1000 times larger than that of the urban area proper (Verburg et al., 2000). Given that urban life-styles tend to raise consumption expectations and that 60% of the world's population will be urban by 2025 (UNDP, 2005); the rural-urban linkage or the urban "ecological footprint" is critical to land use and land cover assessments (Kalema, 2010).

Fires from charcoal burning, shifting cultivation and intentional burning of old dry grass and killing ticks by livestock keepers (MEA, 2005b). Indeed, fire is a pivotal ecological factor that influences the functional response of woody plants in habitats prone to such disturbance (Clarke et al., 2005). However, the impacts of fires on ecosystem functions and dynamics are influenced by fire intensity and frequency of the vegetation within which they occur (Kalema, 2010). Frequent burning for most equatorial African savannas, can be a major constraint for reproduction of woody species and reducing top-soil organic matter and nitrogen (Kafeero, 2007). Excessive intensity and frequency of fire can also lead to irreversible changes in ecological processes such as loss of soil organic matter, erosion, loss of biodiversity, habitat changes for many plant and animal species (MEA, 2005b).

2.3.2: Economic drivers

Shifting cultivation, grazing and burning play a key role in the modification and transformation of rangelands ecosystems (Kalema, 2010). Other forms of shifting cultivation lead to deforestation with attendant loss of top-soil organic matter and available phosphorus causing loss of soil productivity (Buyinza, 2004); Manipulation of vegetation through land use practices that

cause loss of habitat quality may result in loss of income, environmental services, national food security and tourism revenues, habitat degradation and biodiversity loss (MEA, 2005a).

Poverty encourages people to increase reliance on the woodlands for additional agriculture and pasture land (Chipika et al., 2000). Also such conditions provide an incentive to rural communities to increase harvesting of woodland products for sale to supplement incomes, hence causing deforestation and/or degradation of the woodlands (Kalema, 2010).

The high dependency on firewood and charcoal for cooking is one of the major causes of deforestation (Ezzati et al., 2001); It is estimated that extraction of wood from tropical forest/woodlands for timber, charcoal production and fuel wood constitute 68% of the proximate causes of deforestation in Africa by 2000, 89% in Asia and 51% in Latin America (Lambin et al., 2001). It has been shown that impacts of wood harvesting of woodlands are usually higher close to the village and decrease with distance from settlements (Luoga et al., 2002).

2.3.3: Ecological drivers

Forests and grasslands, in particular, have undergone large scale changes (Kafeero, 2008), and it is estimated that between 1700 and 1980, the area under forests and woodlands decreased globally by 19%, and grasslands by 8%, while croplands increased by 466% (Richards, 1990). Land use changes that alter natural disturbances are likely to cause changes in abundance and distribution, community composition and rangelands ecosystem function (Yarie et al., 1998).

Unreliable Rainfall and temperature extremes might be contributing to woody encroachment (Zziwa et al., 2011); There has been notable changes in Nakasongola between 1961 and 2010 and with a strong bearing on woody encroachment (Kigenyi, 2002); as the years of woody encroachments are years of drought leading to death of shallow rooted grasses and water is only accessed by long tap rooted trees (Shackleton et al., 2002).

The termites feed on fresh vegetation competing with livestock and patches of bare soil (Zziwa et al, 2011); termites damage is equivocal in both grasslands and croplands since they resort to feeding on fresh vegetation due to scarcity of dry materials and are thus regarded as a major

threat to foliage availability in Nakasongola District (Mugerwa et al, 2011). This implies that there is intensification of termites activities in rangelands of Uganda.

2.3.4: Policy drivers.

Division of ranches into small farms and individualization of the land in 1994 in Nakasongola led to increased fencing and further subdivision of land into smaller patches, that could no longer support livestock grazing hence the adoption of crop production (Zziwa et al., 2011). The ranching system restrict mobility of animals, lead to overstocking thus limiting regeneration of pastures/ bushes (Mugerwa et al., 2011).

Land use and land cover observed on landscapes is a reflection of aggregated land use decisions at the household level (Lambin et al., 2001). Land use and cover changes and environmental quality, however, are also associated particularly with the management practices applied on given land use types (NEMA, 2004/5).

2.4: The effects of land use and land cover change

Human population derive essential food and fibers from rangeland ecosystems, this influence affects the magnitude, pace and temporal continuity, (MEA, 2005b). Land use cover change directly affect biotic diversity (Zziwa et al.,2010); which in turn affects the a biotic components (IPCC, 2007).

2.4.1: Effects of land use cover change on the plants and animals

Land use and cover change also contributes to regional and global changes in atmospheric composition , affecting the quality and quantity of primary production (IPCC, 2007). Changes in atmospheric composition directs new forms of plant growth and chemical composition that not only affect livestock production, but also influence trophic interactions that may accelerate further land use changes (Buyinza, 2004).

The subsequent conversion of land cover patterns alters ecosystem functionality so greatly and shift them to a different stable state (Lambin et al., 2001). Consequently, the livelihood of communities that depend on the integrity of natural ecosystems for products and services become

increasingly threatened,(IPCC, 2000); as the biomass study per district, the rate of timber/ deforestation between 1990 to 2005 reduced total forests by 60% in Nakasongola District (NDER, 2009).

According to the Uganda Land Use Policy (2007), land use cover affected by over-grazing lead to bush encroachment and other obnoxious plants that in turn reduces the available pasture; during dry spell water and foliage are scarce, pastoralist move over 2.5kms to access them, affecting livestock quality (Vanegas et al., 1992).

2.4.2: Effects on Soils and Climate

Land use cover changes contribute to global climate warming (IPCC, 2007), local and regional climate change and variability (IPCC, 2001). Changes in the rangelands cover lead to erratic, highly seasonal, and torrential downpours resulting into flooding (Zziwa et al., 2011). While most part of the rangelands region receives significantly more rain (750mm) allows crop cultivation, (Kisamba- Mugerwa, 2001; MAAIF, 2002); The large-scale deforestation lead to reduced rainfall and increasing temperatures, (NEMA, 2009).

Temperature variations depends rain seasons and cloud cover on the skies (FAO, 2007). In parts of the cattle corridor, the effects of drought tend to be very severe reflected in the less cloud cover. (Kisamba- Mugerwa, 2001). While accumulation of smoke from bush fires contribute to the buildup of atmospheric carbon dioxide and that contributes to global climate change. (NDER 2007, NEMA, 2009). Generally global temperatures are bound to rises by 2100 by between 1.8 and 4.0 °C. With approximately 20-30 % of plant and animal species expected to be at risk of extinction in the rangelands (FAO, 2007).

Land use conflicts particularly between agricultural and forestry sectors, (Getachew et al., 2010). Low agricultural productivity, deforestation for arable land expansion has been the principal land use conservation employed in Uganda particularly in Nakasongola District for centuries (Buyinza, 2004).

Soil degradation (Ezzati et al., 2007). The seasonal burning of grass and bushes exposes land to water and wind erosion (NDER, 2009). Just like droughts exposes soil to the vagaries of land degradation by water and wind erosion (Muleneh, 2003).

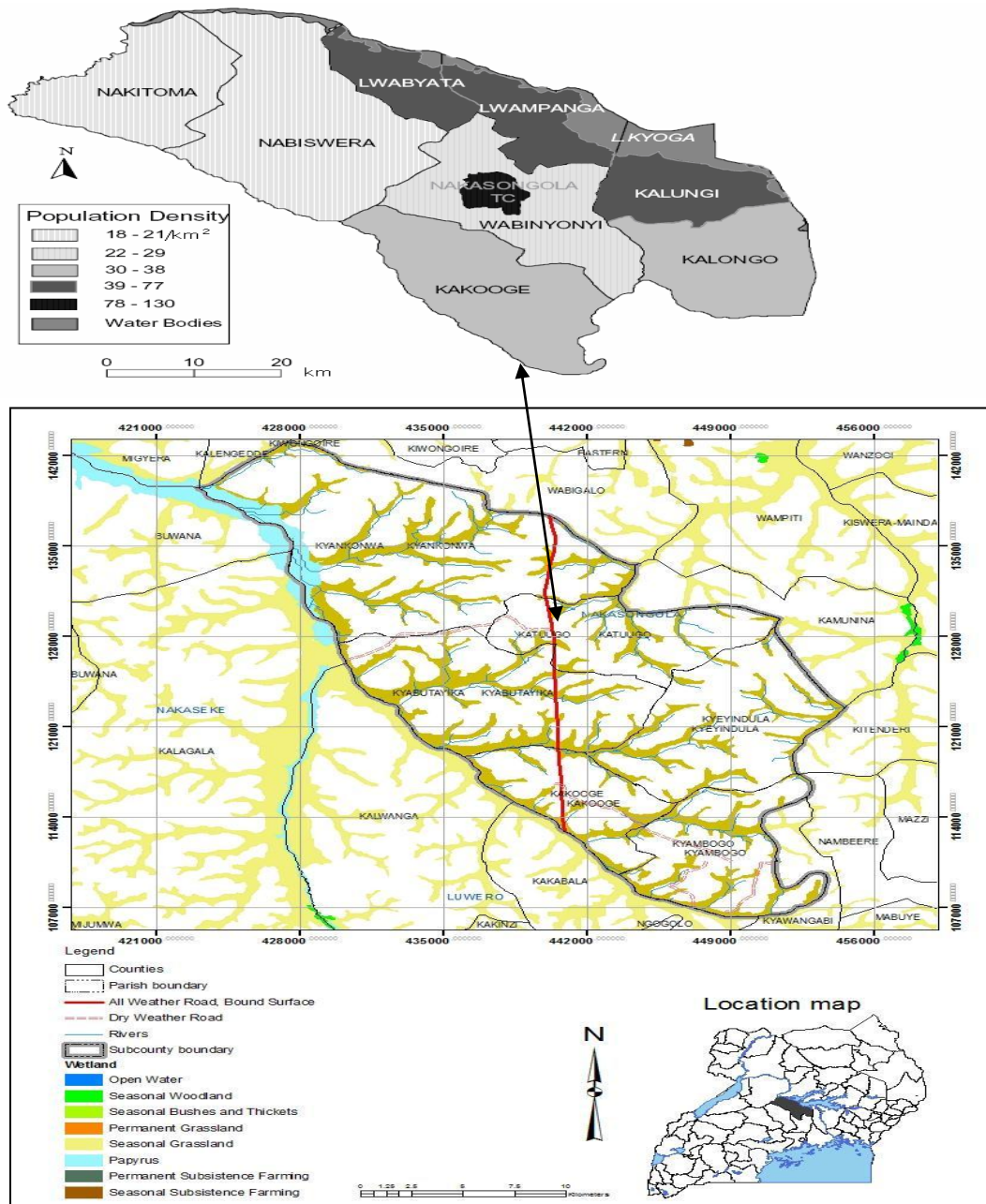
CHAPTER THREE

METHODOLOGY

3.1: Location of the study area

The study was conducted in Kakooge Subcounty located to the south of Lake Kyoga in central Uganda, and lying at $0^{\circ} 57' 44.89''$ to $1^{\circ} 40' 42.76''$ North latitude and between $31^{\circ} 58' 03.77''$ and $32^{\circ} 48' 00.29''$ East longitude.

Figure 2: The location of Kakooge Sub- county in Nakasongola District.



3.2: Population and the economic activities

Kakooge Sub county has a total of 4241 households, a population density of 43 persons per square kilometers with population growth rate of 3.2 % per year. The total population in 2002 was 20622 people; 10,296 males and 10,151 females (UBOS, 2002; estimates 25,174 people UBOS, 2009) found in six parishes with in Kakooge namely; Kakooge TC, Katuugo, Kyeyindula, Kyankowa, Kyabutayika and Kyambogo, that constitute the sub county (UBOS, 2002). About 95.3% of the total population lives in rural areas and entirely depend on the land resources (UBOS, 2002). The major ethnic groups include the Baganda (70%) and Baruli (28%).

Agriculture is the prime activity with 83% of the population depending on subsistence farming, livestock grazing (cattle population by 2008 was 114000 heads) while Charcoal burning is conducted to supplement income (KDP, 2011).

3.3: Relief, soils and vegetation

Kakooge lies on the central plateau between 1000 metres and 1400 metres above sea level, characterized by extensive uniform undulating plains with broad seasonal swamps and outcrop rocks of Mesozoic sedimentary series and Tertiary basalt flows, (NDER, 2009). The soils are mainly weathered basement complex formations of the Precambrian era consisting of gneisses and granites, (petricplinthosols type of soils) (Buyinza, 2004). Kakooge has about 475km² of woodland and grasslands and 32 km² are of open water and wetlands (KDP, 2011).

3.4: Climate

The area receives a bi-modal rainfall regime with the first rainy season occurring in the months of March–May while the second in September–November. The mean annual rainfall ranges between 500 mm and 1600 mm with seasonal variations and prolonged droughts at an interval of 8 – 12 years. The mean daily minimum temperature ranges between 15⁰C and 20.9⁰C while the mean daily maximum temperature ranges between 25.4⁰ C and 33.7⁰ C. Average humidity ranges from 80% in the morning to 56% in the afternoon. The potential evapo-transpiration remains high through the year (~130 mm/month and ~1586 mm/annum) and shows less variability unlike the rainfall.

3.5. Field Survey and Data Collection methods

The ultimate purpose of the field survey conducted was to collect qualitative and quantitative information to help to better understand, explain, and interpret the land use and land cover change, which is the core issue of this study. Hence, understanding trends in resource changes required historical information, which can be achieved using qualitative and quantitative data collected through interview and group discussion with selected informants believed to have a good understanding of the issues of interest. Accordingly, detailed individual interviews and group discussions were conducted with 33 selected key informants from each study parish to collect the data required.

Sample plots were also established to create an inventory of woody plants existing in Kakooge Sub-County to guide on how the woody plants have been used and secure the effects of their use on diversity. In this case Kyeyindula, Kakooge and Katuugo parishes were selected purposively to act as sample parishes in conducting an inventory. To establish sample plots in the above parishes, a transect of 65 m was laid on ground in the respective forests in each parish where a control point acted as a center for the sampling plot was demarcated. After locating the centre 50 m radius was measured using a tape measure and a sisal rope from the center of each and the plots demarcated on ground. The radius measured was rotated around while putting tree pegs to demarcate the boundary, using the same procedure, two sub plots near and far away from settlements were established along the same transect using a sisal rope radiating from the center each with a radius of 20 m to assess poles and saplings respectively. Plot establishment and enumeration was conducted with the help of the local community members. The woody plants identified were recorded in the local languages with their number in woody plant assessment form as mature or saplings for further analysis.

A purposive sampling technique, involving the targeting of individuals who suited the subject and nature of study using predetermined selection criterion, was used to select the participants through consultation with Development Agents of the respective study areas. A questionnaire (see Appendix I) covering a wide range of topics relevant to the central issue of interest was developed. It was also pre-tested so as to evaluate the understandability of the questions and modifications were made accordingly. Ground Control Points (GCPs) were collected to aid

different steps of image processing and classification for change detection. Besides this, field observation was made to have better information about the nature of the various land use and land cover classes prevailing in the area.

Table 1: Population and sample size for Kakooge sub county

Parish	Total population	Villages	Cultivators	Livestock	Charcoal burning	Local councils	Total sample size
Kakooge	4574	9	12	13	6	02	33
Kyeyindula	2915	11	15	08	08	02	33
Kyambogo	4016	10	16	11	06	02	33
Kyabutayika	3099	12	14	10	07	02	33
Katuugo	3384	8	13	10	08	02	33
Kyankonwa	2632	8	16	09	06	02	33
Total	20622	58					

3.6: Description of Land Use Cover Classes

Based on field observation and general historical information gained from Participants during the survey, it was decided to focus on the following major Land use cover classes summarized below:

Wetlands

Formed the largest land cover ecosystem of the land surface area (80%). The category of wetlands encompasses those areas located in the plain which experience frequent flooding and immersion in water and are covered by wetland vegetation including grasses. The ultimate use of such land was as a grazing and holding place for livestock. Currently, such areas have been converted to cultivated land for growing food crops and other cash crops.

Subsistence farmlands

These formed areas used for rainfed cultivation practiced by agro pastoralists, basically involving growing of food crops like maize, cassava beans etc.

Commercial farmlands

These are characterized by plantations of coffee, large scale maize gardens and the ranches in closed and open grasslands especially in Katuugo and Kyeyindula parishes with Ekitangala ranch as demonstration center.

Built-up/ settlements

These were both rural settlements and permanent settlements within the trading centers. The rural settlements were dominated by houses from mud (semi-permanent) especially in the pastoral areas, whereas areas where commercial farming, forest plantations and trade is carried out enabled people to earn income that enables them to improve on the housing.

Grasslands

The grasslands were areas with permanent grass cover used for grazing; this indicated grazing area outside tree canopy.

Bushlands

These formed Bushy grasslands covered about 20% of the land area, in form of bush or shrub cover, there were scattered trees, tall grass and some thorny trees in the areas of Kyankonwa, katuugo.

Woodlands

This formed the land cover class number three and part of class 4; consisted of areas with hard wood trees mixed bushes and scrubs, wooded thickets ,in other areas the woodlands are covered by spaced and closer tree canopies. Woodlands covered 1200 hectares with savanna mountain tree species like: Combretum, Terminalia, Acacia brevispica, Canthium lactescens, Grevia mollis, Teclea nobilis and Vernonia brachycalyx. The dominant grass species is mainly Hyparrhenia rufa (KDP, 2011 and Mugerwa, 2011).

Forest plantations

This category comprised of planted pines and eucalyptus trees. Over 1600 hectares of pine that have been planted since the 1990's, 13.436ha are of forest reserves with Katuugo forest covers (3.138ha) and Kasagala forest reserve (10.298ha), (KDP, 2011).

3.7: Steps in Analysis of Satellite Images For Land Cover Change

In order to cover the intended period of study, different type of images originating from different types of sensors were used. Hence, landsat Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) from beginning of 1987, and 2005 respectively along with ILWIS 3.3 Software and GIS were used for a time series of images for the land use cover change study.

3.7.1: Image Classification

The landsat image for 2005 was the very recent image available for study areas and served as a reference image. Hence, it was possible to undertake field visit and collect GCPs and supervised classification was preferred. The two landsat images; TM and ETM+ images were also included to meet the preferred time horizon of study. Meanwhile, it must be noted that effort has been made to integrate few historical information acquired from surveys to minimize complete reliance on spectral information and solve mystery of spectral similarity of different land cover classes in order to improve classification accuracy.

3.7.2: Supervised Classification

The Landsat (TM) and ETM+ images with 30m resolution and eight spectral bands; ILWIS 3.3 Software and GIS were used. The images were imported into the ILWIS 3.3 and transformed under the raster operation using the World Geodetic System 1984 datum (WGS 84) co-ordinate system. Images were subjected to supervised classification procedures conducted for image classification with 44 ground control points were derived from the images similar to ones used by the National Biomass Unit of Uganda in mapping Land use/cover of Uganda in 2003. Eight land cover classes were obtained for the study area. To determine the patterns of land cover change, a land cover change detection (Singh, 1989) was conducted in ILWIS 3.3 to identify the differences in the state of land cover over years using a post-classification change detection method (Yuan et al., 2005). Overlay of two raster maps was performed using the cross operation to compare pixels on the same positions. A cross table showing the combinations of input values, classes, number of pixels that occur for each combination and the area for each combination was obtained after ignoring all undefined values. Classes laid could radiate away from the source of disturbance as it was hypothesized that in villages where subsistence activities are paramount

there are gradients in resource availability, which decrease with increasing distance from the source of disturbance.

3.7.3 Approaches in Land Use Cover Change Detection

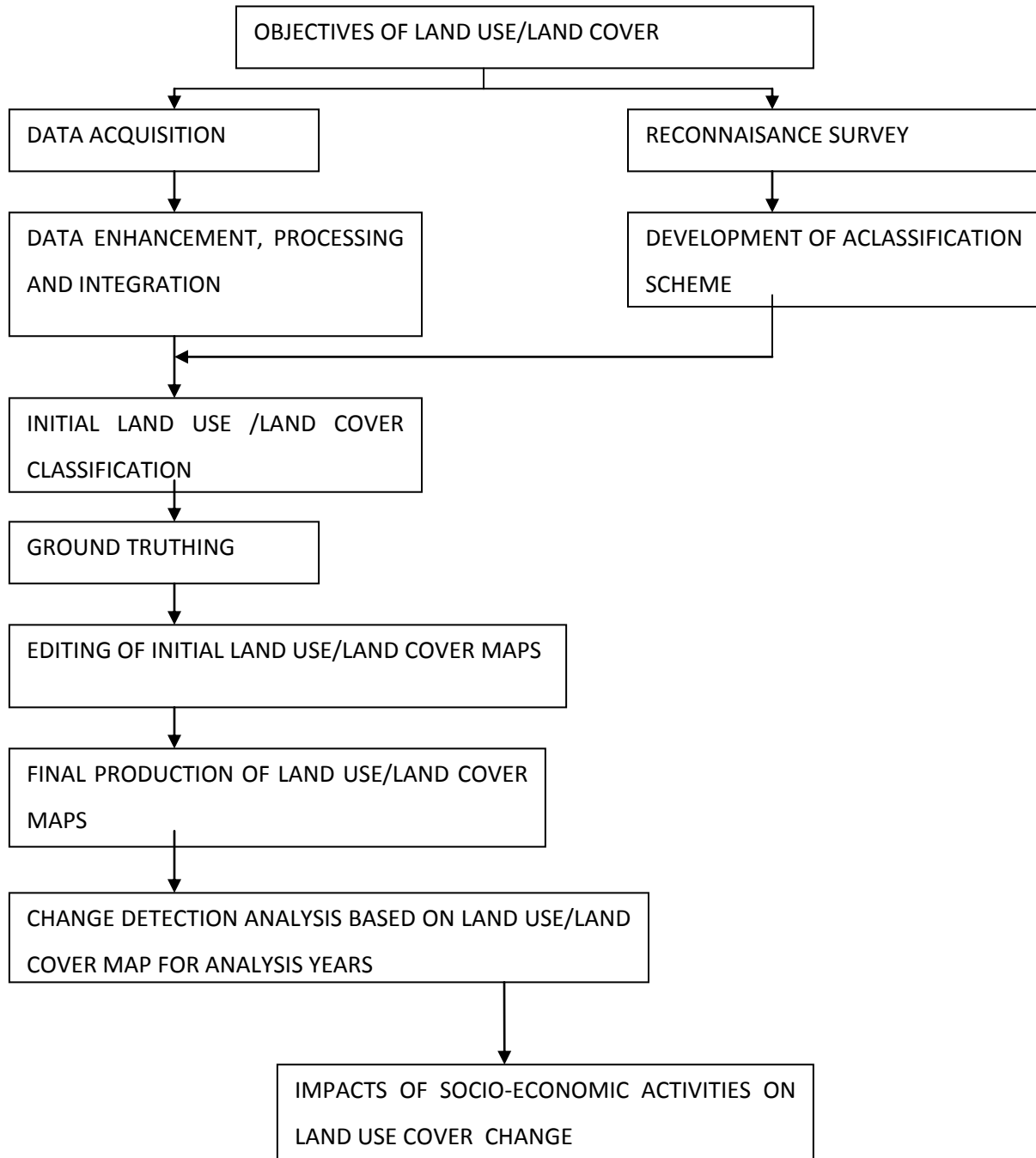
Research evaluating the comparative performance of various land cover change detection methods has indicated that no uniform combination of data types and methods can be applied with equal success across different ecosystems (Lu et al., 2004 cited in Lunetta et al., 2006). Despite this, a general approach to change detection is the comparative analysis of independently produced classifications. This approach is straight forward and employs independently classified images being converted to same projections. Furthermore, changes in landscape spatial pattern are more likely to reveal long term and long lasting land cover changes following image classification.

3.7.4: Image analysis

Three main methods of image analysis were adopted in this study.

- i. Landsat TM/ETM images.
 - Image enhancement, processing and integration was conducted followed by supervised classification for determining land use cover characterization. The land use and land cover classes include; subsistence crop cultivation, commercial farmlands, woodlands, bushlands, grasslands, built up, wetlands and forest plantations.
 - A reconnaissance survey was conducted for data acquisition followed by transects and data analysis.
 - Ground truthing and topographic sheets for classification accuracy based on control points. A flow chart of the imagery analysis steps is indicated in figure 3 below:

Figure 3: Flow Chart Showing Imagery Analysis



iii) Drivers and effects of land use cover change.

a) Measure of compactness for spatial expansion in population.

- $L.C.R = \frac{\text{areal extent in Ha}}{\text{population}}$

Where L=Land

C= Cover change

R= Rate

b) Measure of land use cover change per unit increase in population

$$L. A.C = \frac{A_2 - A_1}{P_2 - P_1}$$

Where;

L.A.C is the land cover annual change

A₁ and A₂ are the areal extents (in hectares) for the early and later years,

P₁ and P₂ are population figure for the early and later years respectively

c) Rate of change = $\frac{P_2 - p_1}{T}$

where;

r = average rate of growth

P₁ and p₂ = the population totals for the first and second reference years

T= is the number of years between the two census enumerations

*The formula given for the population estimate was developed by the researcher basing on the Deichmann 2001 steps of smoothing data.

f) Abundance and diversity of Woody plants was established using Shannon- Weiner diversity index (H') following Malimbui (1997)

$$H' = [- \sum_{i=1}^S (p_i \ln p_i)]$$

Where S = total number of species

P_i = proportionate abundance determined by dividing the number of individual species of that woody plant by the total individuals of all (species) in the sample group

\ln = natural logarithm of the proportion then multiply by -1

iv) ANOSIM

Compositions of species harvested for charcoal production were compared between sub-counties using the ANalysis Of SIMilarity permutation test based on a species respondent data matrix. The quantities of charcoal from charcoal production were calculated on a per household per annum basis and, then, extrapolated to sub-county scale. The quantities of charcoal produced by each household per annum were determined by the number of bags of charcoal produced per household multiplied by the number /frequency of production and then regressed.

v) Statistical analyses

SPSS and linear regression helped to determine the rate of changes and relationships among the drivers and the land use and cover patterns supplementing the data collected from landsat imagerys, interview and literature review.

3.8: Data management

Data management / control measures adopted to ensure near errors free data in the analysis. The interviews were conducted in the language in which a respondent understood well. The language included English, Luganda and Luluri. To eliminate any gaps in the data, before leaving the field all notes were transcribed and edited immediately after interviews. Gender bias was avoided by interviewing both female and male respondents, while the for imagery analysis.

3.9: Data editing.

Data was organized, edited and sorted out in relation to the set objectives to educe inaccuracy; here computer packages of micro-soft word excel were used to generate descriptive statistics. The textual data from the discussion were analyzed manually by identifying the major themes, sub themes and ideas under search.

CHAPTER FOUR

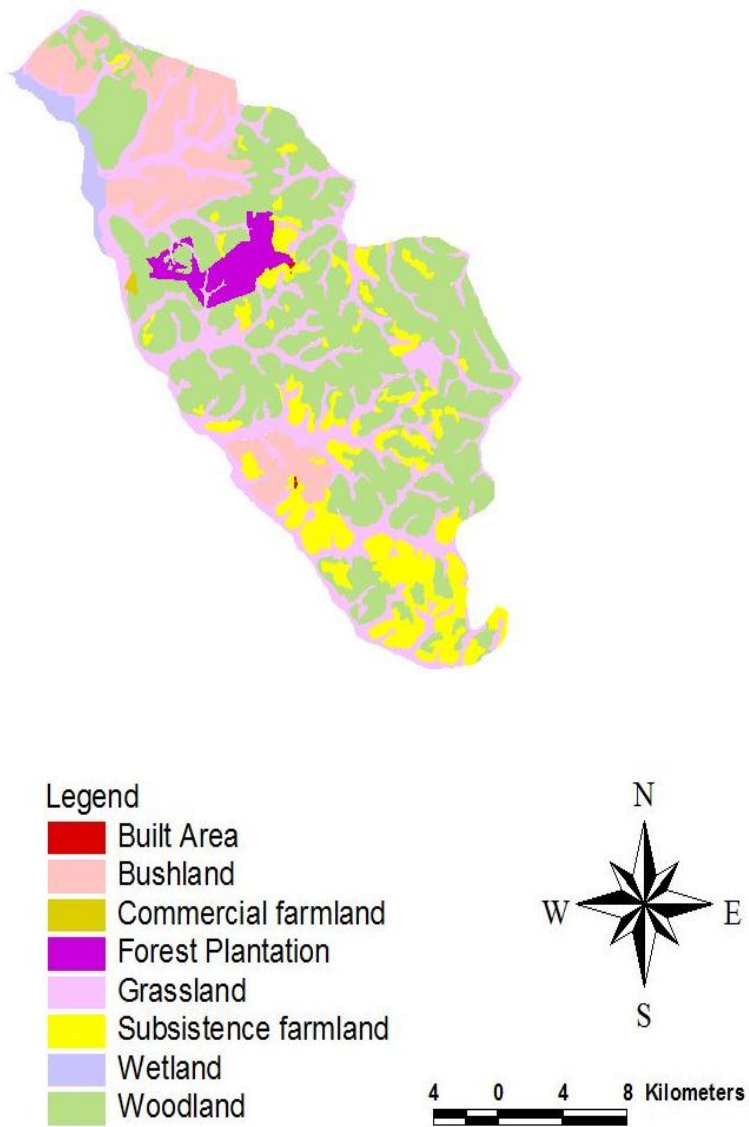
RESULTS

4.1: Land use cover changes

Based on information from local inhabitants, cultivated, built up, woodlands, wetlands, commercial farmlands, subsistence farmlands, forest plantations, and bush land were the major land use and land cover classes during the study periods. In Kakooge, before 1987, the relationship between land users and owners was based on a feudal system under which the ownership of land was limited to a few individuals. Most inhabitants were only eligible to get access to farmland through share cropping. During this period, it was highly likely that a portion of the land was left abandoned. The human population was relatively low with low pressure on the land and associated resources in general and with prevalence of fallow lands.

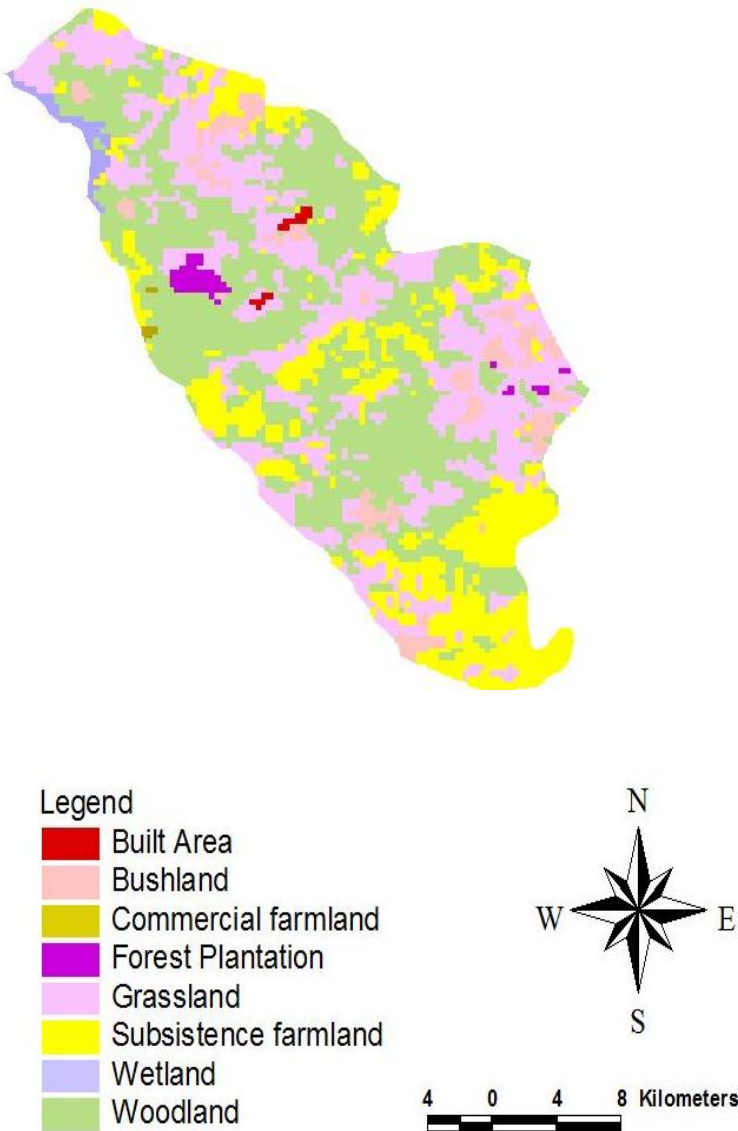
An image of 1987 was acquired, when crop harvesting had already started, and appear bare. Regarding vegetation, there were also relatively undisturbed areas that had been serving as a home for some wild animals with varying levels of density, ground cover and disturbance, according to respondents. Some of these areas were accessed and served as a source of wood and other products used for house construction, fuel wood, farm implements and fencing. Hence, for this particular study, such areas were broadly categorized as open and closed shrub/bush lands, depending on their level of ground cover. Analysis of the 1987 Image revealed that woodland constituted the largest proportion of land in Kakooge with a value of 45.7% (24,288ha), followed by grassland which accounts for 24.5 % (12,1929ha) (Figure 3). Dense shrub/bush land and subsistence farmlands constituted 12.1% (6431ha) and 12.7% (6749ha) respectively, while both built and commercial farmlands showed almost similar coverage values of 0.1% each.

Figure 4: Land use and land cover map of Kakooge in 1987



As can be seen in Figure 4 for the 1985 image of Kakooge, the proportion of land allocated for cultivation increased to 20.5% (10,914ha). Furthermore, grass lands expanded and covered 28.7% (15,236ha) and built up 0.3% (166ha) of the landscape. However, the proportions of bushland, woodlands and wetlands land have decreased to 5.5% (2,919ha), 42.7% (22,698ha) and 1.2 % (613ha) respectively. The forest plantations land cover that appeared in the previous classification is had also reduced tremendously by 1.05 (549ha).

Figure 5: Land use and land cover map of Kakooge in 2005



In accordance with the trends from the past, the cultivated land expanded again from 1987 to 2005. Hence, it can be seen in Figure 5 that cropland was again among the major land use class

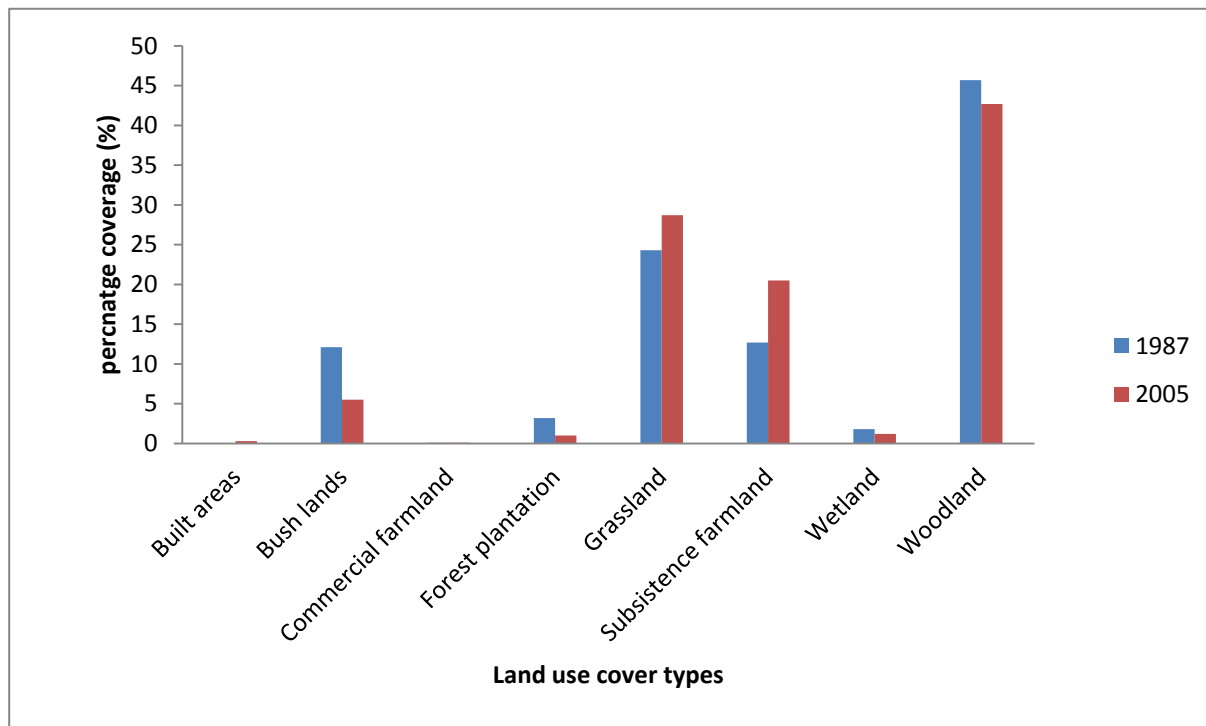
covering 20.5% of the landscape. Similarly, bush lands decreased to 5.5 %, as a result of the increase in agricultural. In 2005, the percentage of woodland has shown a slight decrease to 42.7% in 2005 (Table 2), this change in woodlands cover could be attributed to the implementation of a charcoal burning and agricultural expansions by the community at la

Table 2: The land use and cover change between 1987 and 2005

Land use/cover type	1987		2005		Change (1987-2005)	
	Hectares	%	Hectares	%	Hectares	%
Built areas	18	0.0	166	0.3	148	822.2
Bush lands	6,431	12.1	2,919	5.5	-3512	-5.5
Commercial farmland	67	0.1	66	0.1	-1	-1.5
Forest plantation	1,707	3.2	549	1.0	-1158	-67.8
Grassland	12,929	24.3	15,236	28.7	2307	17.8
Subsistence farmland	6,749	12.7	10,914	20.5	4165	61.7
Wetland	983	1.8	613	1.2	-370	-37.6
Woodland	24,288	45.7	22,698	42.7	-1590	-6.5

Source: Landstat Images for 1987 and 2005

Figure 6: Summary of land use and land cover change in Kakooge from 1987-2005



4.2: Description of Land Use Land Cover Change of the Study Area.

Land cover changes in Kakooge Sub County have been reflected in both temporal and spatial scales. Spatial changes in land cover changes include expansion of cultivated lands in natural vegetation types (grasslands, bush land, wetland and woodland), expansion of grasslands into bush land and woodlands, introduction and expansion of pine plantations into woodlands, bush lands and grasslands, encroachment of bushes and woodlands into grasslands and increase in bare ground, while temporal scales include the regeneration of woodlands on the same piece of land after some years of clearing. With the exception of bush and woody encroachment into grasslands all other spatial changes might have driven by direct alteration of man on natural ecosystem for food production, economic and social gains.

Woodland

There was 6.5% decline in the area covered by woodlands over eighteen year period from 242,88 ha in 1987 to 24,245.3 ha in 2005 (Table 2). Overlay analysis showed that 88% of woodland was converted into other land cover types particularly built up areas, grasslands by 0.6% and subsistence farmland by 1.3% between 1987 and 2005. However during the same period when woodland declined also other lands uses lost; bush lands (2.4%) and wetlands (1.4%) between 1987 and 200. This showed a greater diversity in their abundance of 2.01 (Table 9).

Woodlands were being converted to bushlands, bushy grasslands, shrublands and cultivated lands, (Table.2; The continued decrease in area covered by woodlands from 1987 to 2005 might have been basically attributed to increased anthropogenic activities that include cutting down trees for cultivation, planted forests, grasslands and charcoal production as has been the case elsewhere in the world (Lambin et al., 2001; Witkowski et al., 2008).

Built-up area

This included un-vegetated/ bare areas which occur concurrently. Built-up area covered relatively small area in 1987 and increased steadily by year 2005 (Table 2). High increment of 822.2% with an average annual increment of 8.2ha this resulted into a decrease in woodlands from 24288ha in 1987 to 24141.4ha in 2005 (61%); Wetlands reduced to 835.4 ha (2005) at a rate of 15%, forest plantations by 9% between 1987 (1707 ha) and 2005 (1559.4 ha) while bush lands decreased by 2% as subsistence farmlands gained more areas by 2.2%, (Table 2). Dominantly the built up areas have changed to bushlands and scrublands this was induced by human settlements and establishments between 1987 and 2005.

Bushland

Generally, the area under bush decreased from 6431 ha in 1987 to 2919 ha in 2005 representing 5.5% decline in bushland cover. The greatest decline of 195ha annually in bushlands was

observed between 1987 and 2005. Overlay analysis showed that between the year 1987 and 2005 when most bushland disappeared, major conversions were into woodland, followed by grassland, subsistence farm land, built-up, wetland and forest plantations (Table 2).

Forest plantation

This is an alien land use form in the area that was recognized in the satellite image of 1987 in Katugo and Kasagala forest reserves. The area under pine plantations has steadily decreased from 1707 ha in 1987 to 549 ha in 2005 at 67.8% (Table 2). Analysis indicated that forest plantations had been established in areas formally under bushland, grasslands, farmlands and woodlands but with major establishments of settlements show 9% loss of forest plantation (Table 2).

Grassland

The grassland area increased by 126ha from 12,927 ha in 1987 to 15,236 ha in 2005 (Table 2). There was a decline of 41% and 7.4% in grasslands during the period of 1986 -1990 and 2000 - 2004 respectively. However, there was an increase in grasslands of 68% between 1990 and 2000. Between 1987 and 2005, much of the grasslands were resulting from the conversion of woodlands, where grasslands gained by 0.68% from 12,929 hectares in 1987 to 14,513 hectares in 2005. Cultivation, bush and woody encroachment are the major land cover types taking over grasslands in the Sub county (Table 2).

However, the conversion of grasslands into bush and woodland is rather an ecological process that involves interplay of several factors that include management, climatic and atmospheric composition with complex feedback mechanisms involved. Overstocking and grazing, limited or complete elimination of fire as a rangeland management tool, increasing termite activity, frequent and prolonged droughts, high ambient temperatures and elevated levels of atmospheric carbon dioxide concentration are notable factors that lead to encroachment of grasslands by woodlands.

Subsistence farmlands.

This includes rural villages (dispersed settlements) and homesteads. The area under subsistence farming increased from 6749 hectares to 10,914 hectares between 1987 and 2005 making the

annual rate of increase of 231 hectares. Overlay analysis showed that subsistence farm lands, encroached on all cover types but with severe infringement on woodlands, bushlands and grasslands. Between 1987 and 2005, woodlands lost 8,333 ha to farming; while between 1987 and 2005, as built up area increased from 18 ha to 166 ha, subsistence farm lands gained by 2.2% (Table 2).

Commercial farmlands

Commercial farmland by 1987 was occupying 67 hectares but by 2005 had decreased by 66 hectares (Table 2). Division of ranches into small farms and individualization of land in 1994 led to increased fencing and further sub-division of land into smaller patches that could no longer support livestock grazing leading to the annual rate of decline as 1.5%.

Wetland

There was 37.6% decrease in the area covered by wetland between 1987 and 2005, wetland were converted to built up and cultivation . As built up areas increased between 1987 and 2005 wetland decreased from 983ha to 835ha (15%) respectively. Also as woodlands declined, wetland lost 382ha (2.6%), but the greatest changes in Wetlands were conversion to crop lands.

4.3. Social demorgraphic characteristics of the respondents

The respondents consisted of both male and female household heads. Over 52% of the respondents were males while the remaining 48% were females. Besides 32% were aged above 31years, 64% above 18years and only 4% were considered below 18years. Though, 60% had spent over 10 years in Kakooge Sub-County, only 30% had stayed in the area between 6-10 years, and only 10% of the respondents had stayed in the area for a period of between 1-5 years (Table 3).

Table 3: Showing the social demographic characteristics of the respondents.

Demographic Characteristics	No. of respondents	Percentage
Sex		
Female	97	48
Male	105	52
Age		
<18 years	8	4
18-30 years	130	64
31-42 years	40	20
>42 years	24	12
Years spent in the area		
1-5 years	20	10
6-10 years	60	30
>10 years	122	60

4.4: Drivers of land use cover change

The forces that drive land use cover change are a complex mixture of social, physical, economic and policy factors magnified by a high rate of population growth and rapid urbanization (National land use policy, 2007), about 70% of the community members, revealed that land use and cover decline were related to charcoal burning, fuel wood extraction, agriculture clearing, overstocking. The major land use changes represented in table 6 are a reflection both human and environment drivers broadly divided into socio-economic, ecological and policy drivers.

Table 4: Summary of the drivers of land use and cover change

Socio-economic Drivers	Frequency N= 98	Percentage
Poverty	40	41
Population pressure	35	36
Poor agricultural practices	10	10
Introduction of local brewing	6	06
Corruption in forest agencies	7	07
Drivers of wetlands reduction	Frequency N= 65	Percentage
Charcoal production	20	37
Seasonal bush burning	10	15
Overstocking	8	12
Shifting cultivation	12	18
Ranching	15	23
Ecological drivers	Frequency N= 55	Percentage
Drought	30	55
Seasonal rains	15	27
Soil exhaustion	10	18
Policy drivers	N = 20 Frequency	Percentage
Introduction of pine plantations	10	50

Ranching policy	4	20
Land tenure system	6	30

Source: Field data on drivers of land use and land cover changes 2011

4.5: Effects of land use cover change on the ecosystem components

Household dependence on rangelands land cover for charcoal burning, cultivation, and livestock grazing contribute to change in the land cover over time; leading to increased frequent drought conditions 98%, reduced soil fertility at 67%, wood fuel crisis 36%, food insecurity 33% and others (Table 5). In the process the ongoing human and environmental activities have a relationship with the existing land cover change effects presented in the conceptual frame work (Figure 1).

Table 5: Effects of land use and cover on the rangelands ecosystem.

Effect	Frequency	Percentages
Frequent drought conditions	47	98
Reduced soil productivity	32	67
Food insecurity	16	33
Wood fuel crisis	18	36
Wind destruction of crops	7	15
Poor water quality and scarcity	12	25
Animal destruction of crops	9	19
Resource depletion	6	13
Atmospheric pollution	3	6
High timber costs	3	6
Rampant flooding	1	2

Source: Field data on effects of land use and land cover changes on the ecosystem 2011

4.5.1: Changes Associated with Livestock grazing on Resources

As can be seen in Table 6, about 63 % of the respondents ranked natural pastures as a primary feed source, while 57% and 27 % of respondents gave it second and third rankings, respectively.

This could be attributed to differences between individuals in terms of preference, access, and ownership of the various plots of land, and individual's preference ranking did show a variation.

Table 6: Ranking of different animal feed sources/types in Kakooge (% of the respondents)

Feed resource	Rank (based on %)				
	1	2	3	4	5
Natural pastures	63	57	42	43	24
Grazing on reserves	25	27	32	14	16
Hay from private pasture	6	9	11	29	25
Tree fodders	6	7	15	14	33
Total	100	100	100	100	100

Sixty-four percent of the respondents reported that they own private grazing land, which expanded from 0.11 ha to 0.14 ha per household over the last 18 years. Furthermore, respondents indicated that 18 % of communal grazing land was converted to cultivated land during the last 30 years. Hay is one of the feed sources for livestock in Kakooge, only produced by farmers who own ranches. Hence, hay is used less as a source of animal feed compared to other sources, as most individuals prefer to cultivate crops on most of their land. Elephant grass is a type of grass harvested from private grazing reserves and serves in house construction. But, it is now becoming extinct and is found only in the schools' premises due to prevalence of free grazing, the substitution of corrugated roofing and sesame stalk for hut roof construction, along with conversion to cultivated land.

According to respondents, recent shifts in animal grazing strategies have included efforts to avoid free grazing and the promotion of controlled feeding systems that employ the collection of hay. Furthermore, after 1995, a rule has been enforced to limit grazing by locality, disallowing free grazing away from one's locality. This has created an increased shortage of grazing area and feed in some areas.

4.5.2: Effects of livestock grazing on plant species / cover.

Table 7 below, indicates that woody vegetation cover/ trees areas were greater in sites with no grazing while in other areas, shrubs, herbs and grasses supported more livestock than other land uses and became homes to different livestock this is due to significant differences (p- values) between the grazed and un-grazed plots, thus increasing the number of species that can co-exist in grazed sites compared to areas with no grazing in comparisons of percent plant cover of different growth forms in grazed and un-grazed sites. *Means significantly different at ($p < 0.05$), t-test

Table 7: The effects of livestock grazing on plant species / cover

Growth form	Grazed	Not grazed	p-value
Herbs and grasses	72.5	17.4	0.04*
Shrubs	40	62.5	0.04*
Trees	25	62.5	0.12

Source: Field data for Kyeyindula, Katuugo and Kyankonwa grazing sites 2011

4.5.3: Major changes associated with Livestock resource

Livestock plays a critical role for supporting communities involved in the mixed crop-livestock production system through its products and services. However, animal keeping tends to be affected by changing socio-economic, biophysical, and political, land cover and land use. Insight over trends in household level change of livestock holding population over 10 years period is revealed by the socio-economic survey (Table 8 and Figure 5).

Table 8: Summary of the average number of animals of different livestock types based on socio-economic survey

Study area	Livestock Holding Per Household (Number Of Animals)					
	Cattle		Small ruminants		Total	
	18 years	NOW	18 years	NOW	18years	NOW
Katuugo	3.43	3.43	0.18	0.79	3.61	4.22
Kyeyindula	5.82	4.09	5.91	4.55	11.73	8.64

Small ruminants include goats, sheep etc

As revealed by the interviews, the number of cattle holding in Katuugo parish remained the same while it decreased in Kyeyindula parish over the last eighteen years (Table 8). The average number of cattle holding in Kyeyindula parish 18 years ago was by far greater than Katuugo parish (Table 8). A sharp decrease was observed in Kyeyindula between 20 and 18 years ago, while a slight improvement was found in Katuugo parish due to changes made in land ownership policy and distribution of communal grazing areas for cultivation. As a result, cattle holding in both areas conveyed an average total livestock value of four animals per household 20 years ago. From that time onwards, population of cattle in Katuugo parish remained unchanged starting from the point of convergence up to 5 years ago and showed only a slight decrease up to recent years. Despite periodic variations, the overall trend of cattle holding decreased more in Kyeyindula parish than in Katuugo parish. This result corresponds well with the reported shrink and complete conversion of most grassland in Kyeyindula parish.

4.5.4: Land Use Cover Change and Climatic Variables as a Proxy

Climate variability in the area is attributed to changes in land use and land cover where mean annual temperatures, mean annual precipitation and potential rate of evaporation vary greatly (Table 9), this results in either escalating temperatures or precipitation leading to either prolonged drought or Elnino rains in the area where when the aridity indicator is greater than

0.50 there are higher chances of Eln'ino while when the aridity indicator is 0.0 - 0.49 implying a prolonged drought condition.

Table 9: Use Cover Change and Climatic Variables as a Proxy

Year	MAT C ⁰	MAP(MM)	PE (MM)	AI	STATUS
1997	22.9	1161.6	1603	0.73	Elnino
1998	23.7	725.9	1659	0.44	Drought
1999	29.7	897.3	2079	0.43	Drought
2000	23.8	1007.5	1666	0.61	Elnino

AL= Aridity Indicator

4.6: Charcoal production and changes on woodlands diversity and abundance

Variations existed in diversity of the different in woody plants between parishes and within individual woody plants in the respective parishes where charcoal burning was dominant. The highest level of diversity was observed in Kyeyindula parish with a diversity of 3.37, followed by Katuugo parish with 3.09 and Kakooge parish had 1.31 woody plant abundance and diversity.

Table 10: Parishes with high variations in woody plant abundance and diversity

Parish	Saplings	Mature trees	Total	H'
Kyeyindula	1547	473	2020	3.3732
Katuugo	1193	375	1568	3.0960
Kakooge	1014	382	1396	1.3115
Total				7.7807

Source: Field data 2011

H' is the Diversity indices

Table 11: Diversity indices for the first 15 woody plants in Kyeyindula, Katuugo and Kakooge parishes for biomass extraction, timber, poles and environment value

Local name	Botanical name	Total species	Diversity indices
Ennongo	Albizia glaberrima	126	-0.2007
Mugavu	Albizia coriaria	101	-0.1749
Kibeere	Acacia camphylacantha	101	-0.1749
Endagi	Combretum molle	85	-0.1564
Kibengeya	Agave sisalana	84	-0.1552
Gasiya	Acacia nilotica	81	-0.1515
Kirundu	Antiaris toxicaria	77	-0.1564
Enkoola	Entandrophrogma utile	67	-0.1333
Omucuura	Senn adidymobotrya	63	-0.1277
Omululuza	Vernonica amygdalina	62	-0.1263
Kinkona	Veronica auriculifera	61	-0.1249
Kanzironzoro	Syzygium cordatum	37	-0.0874
Olukandwa	Fluggea virosa	36	-0.0856
Musaana	Acacia hockii	36	-0.056
Katazzamiti	Bridelia micrantha	34	-0.0821
Total diversity		1051	H²=hi* pi =2.0130

In the three parishes the most diverse woody plants with higher indices were Albizia glaberrima 0.2007; Albizia coriaria 0.1749, and Combretum Molle 0.1564; while lower density indices were recorded for Bridelia micrantha 0.0821, Acacia hockii, 0.056 and Fluggea virosa 0.0856

Table 12 indicates a relationship between the available trees, population density and the amount of charcoal produced. Parishes with high rate charcoal production had a low population density for instance Kyeyindula, Kyankonwa and Kyambogo most of the tree have been cut indicated by

the highest number of bags produced annually from each parish that is; 935,960 and 900 bags respectively.

Table 12: Showing total population, land area population density and number of villages the total number of charcoal bags produced **and** total production in tones per year

Parishes	Kakooge	Kyeyindula	Kyambogo	Kyabutayika	Katuugo	Kyankonwa
Respondents	5	38	10	18	12	14
2002 population	4574	2925	4016	3099	3384	2632
Land area Km ²	50	100	63	70	70	122
Population density/km ²	43	40	54	35	25	24
Villages	9	11	10	12	8	8
Charcoal production						
Tree and shrubs density in charcoal production	217±79	273±12	550±116	267±87	243±130	117±24
Bags of charcoal/ HH(mean ±SE)	41±10	85±12	90±33	20±4	72±16	120±12
No. of bags/ Parish/ year	369	935	900	240	576	960
Total prod. Tones /year						3820

Table 12 indicates that population density and the number of villages significantly determine the rate of charcoal production in Kakooge Sub-county explaining a great variability in the number of woody plants at 2.01(H').

Table 13: Showing the impact of population on the existing woodlands through charcoal production using linear regression.

Independent variable	Dependent variable	Sq.	r ²	T
Population density	Charcoal production bags/ villages	.197	.031	1.547
Number of villages	Charcoal production per parish	.007	.039	5.150

CHAPTER FIVE

DISCUSSION OF THE RESULTS

5.1: Drivers and impacts of Land Use Cover Change.

Land use cover changes in Kakooge Sub County have been reflected in both temporal and spatial scales. Spatial changes in land cover changes include expansion of cultivated lands in natural vegetation types (grasslands, bush land, wetland and woodland), expansion of grasslands into bush land and woodlands, introduction and expansion of pine plantations into woodlands, bush lands and grasslands, encroachment of bushes and woodlands into grasslands and increase in bare ground, while temporal scales include the regeneration of woodlands on the same piece of land after some years of clearing. With the exception of bush and woody encroachment into grasslands all other spatial changes might have driven by direct alteration of man on natural ecosystem for food production, economic and social gains.

The forces that drive land use cover change are a complex mixture of social, physical, economic and political factors magnified by a high rate of population growth and rapid urbanization (Uganda land use policy, 2007), thus from the research most respondents 70%, reported that there has been a decline in land use cover for the proceeding 18 years of analysis related to charcoal burning, , agriculture clearing, overstocking. The underlying causes of change and the consequences for the changes were drawn from responses of informants and the satellite images which show the linkage between the perceived drivers and the most important land-use cover changes between 1987 and 2005.

5.1.1: Charcoal production and land use cover changes

Variations existed in diversity of the different in woody plants between parishes and within individual woody plants in the respective parishes where charcoal burning was dominant. The

highest level of diversity was observed in Kyeyindula parish followed by Katuugo parish and Kakooge parish.

The increased harvesting of woodland reduces their diversity and abundance in the Subcounty as members derive their livelihood from charcoal production hence causing change as exhibited in the different parishes. Thus according to Kigenyi (2002); human demands leave woodlands changed rapidly leading to exhaustion. While issues of increased timber prices, reduced rainfall, soil erosion, woodfuel crisis reported in the area manifest a reduction in woodlands, and the time such issues are realised, the situation will have been worsened requiring stringent conservation measures to avert the situation (NEMA, 2001). However the best managerial strategy to avert the above scenario is the ability to predict catastrophe and notifying the warning signs through encouraging tree planting.

Reduction in herbaceous layer due to over grazing and high competition between grasses, shrubs and herbs in the favour of trees might have led to increased recruitment of saplings into mature trees and increased density of woody vegetation in former grass dominated systems, this is Similar findings were reported by (Brown and Archer,1999), Kraaij, 2006 and van Auken,1997) who noted that the co-existence of grasses and trees in the savanna ecosystem is as a result of competition for resources and that alteration in the competition to favour one of the components leads to its dominance in the system.

Wood fuel crisis has been reported to accrue from woodland depletion due to increased charcoal burning per parish where people move long distances searching for scarce wood fuel. The high dependency on firewood and charcoal for cooking is one of the major causes of deforestation (Ezzati et al., 2001); According to KDP (2011), women are primary collectors and users of woodfuel and they walk long distances. In Kakooge Sub-county, because of scarcity people even gather crop residues and a number of meals cooked have reduced to one, which greatly affect the elderly population. A number of strategies are thus required in the area to reduce woodfuel consumption and enhance conservation, this situation also confirms (NFA, 2009) report that, Nakasongola is among the districts in Uganda already experiencing a deficit of woodfuel with over 6110ha lost between 1990 and 2005.

Emergence of secondary vegetation in the area for instance by 2005 a reduction in woodland cover by 6.5% might have led to increase in grasslands these replaced the former *Combretum molle*, *Albizia glaberrima* affecting ecosystem replenishments which in turn forces farmers move long distances in search for mature trees for poles, and charcoal. However in some areas woodlands were replaced by alien trees like pines in 1987 in areas of Kasagala and Katuugo with the main purpose of providing wood fuel but in turn modify the temperatures of these areas.

Besides, charcoal production, the decrease in the area covered by woodlands over eighteen year period might have been basically attributed to increased anthropogenic activities that include cutting down trees for cultivation and planting pines; as has been the case elsewhere in the world (Lambin et al., 1999; 2001; Mwavu and Witkowski, 2008; Ebanyati et al., 2010; Maitima et al., 2010). The study period also overlapped with the 1990-2005 period when Uganda reportedly lost about 24.7% of its forest and woodland habitat (NEMA, 2007). On the other hand the Sub-county has a reliable road network linking it to various urban centres including Kampala City and Luwero in the south, whose residents highly depend on biomass energy as supported by MEA, (2005b) that road infrastructure plays a crucial role in deforestation by providing access to previously inaccessible forest areas, facilitating illegal harvesting of timber and non-timber products.

The high rates of woodland loss suggests lack of sustainable resource management practices, this is a common practice in many African woodlands (Dovie et al., 2004; 2005; MEA 2005a). Also the economic recovery that drove urban population growth and increased demand for timber, fuel wood, charcoal, and food crops and the decentralized system of governance that transferred powers for natural resource management to local governments (i.e. Districts); yet, at the local level, the need to access resources to alleviate poverty outweighs the desire to sustainably manage and conserve natural resources, and political interests outweigh the need to follow the approved laws and regulations (Mwavu and Witkowski, 2008). For instance in a bid to raise income, the local authorities issue licenses to people wishing to produce charcoal, without any clear guidelines on where, when and how much woody biomass should be harvested seasonally or annually. When local governments in the past have attempted to influence natural resource

conservation, the social and environmental outcomes have not always been positive, due to conflicts of interest among the sectors (Bazaara, 2003) and corruption by local government officials (Banana et al., 2007). Moreover, in areas like Kakooge and Kyeyindula parishes where demand for natural resources to sustain livelihoods seem to be acute, voting decisions are based on the perceived ability of the aspiring politicians to help local people (voters) access resources to increase their income thereby, exacerbating the problem.

Rainfall and temperature are among the climatic forces that might be contributing to woody encroachment in the area. There have been notable changes in the rainfall of Kakooge Sub-county between 1987 and 2010 and these must have strong bearing on woody encroachment since water is a major resource that determines tree existence in savanna ecosystems (Kraaij and Ward, 2006).

The years in which woody encroachment became a problem (1987 – 2005) are consistent with the years when droughts became more frequent and prolonged in the area. Since droughts lead to evaporation of all water in the grass root zone and subsequently lead to death of shallow rooted grasses, deep rooted trees recruit in numbers at the expense of grasses and thus become more dominant as observed by (Archer, 1997; Scanlon *et al.*, 2005). From 1990, the area has received high temperatures above a 50 year mean. At high temperatures, the evapo-transpiration rates of grasses reduce due to stomata closure. This reduces photosynthesis in grasses resulting into decreased performance of the grass component. The water stored in the soil therefore becomes accessible to only trees. This coupled with elevated carbon dioxide increases the performance and dominance of trees over grasses as suggested by Kafeero, (2005).

However, some of the forces driving reductions in woodland area have a positive feedback mechanism that drives more woody growth in the same area. The indiscriminate cutting down of sparse savanna trees often results into a dense stand of woodlands due to elimination of intra-species competition between tree saplings that gives an equal chance of all tree saplings to recruit into trees. (Buyinza, 2004)), Such forces therefore contribute to temporal and spatial variations in the area covered by woodlands.

5.1.2: Livestock grazing and land use cover changes

A socio-economic survey conducted from August 2010 to March 2011, involved interview of selected households and group discussion to generate information on household level change in land and livestock holding, and to get insight into various political, social, and environmental factors that influence decision on land use cover change at household for Livestock grazing.

During the early 1980's, the major sources of animal feed were communal holdings that included communal grasslands and shrub/forest lands. Current grazing strategies in the area consist of maintaining the animals around farm boundaries from March to September and allowing animals to graze freely following crop harvest from October to January. Despite variation in locality, seasonal factors and variation in cover type, a generalized comparison was made of the major livestock methods available in the study area. Hence, as survey results revealed, communal grazing and private grazing ranked as the top livestock grazing method. More particularly, communal grazing is a primary method for those who have large tracts of land. This could be attributed to differences between individuals in terms of preference, access, and ownership of the various plots of land, and individual's preference ranking did show a variation.

However it was pointed out that, among rural households, it was traditionally preferred to have greater number of children and animals for various reasons. To accommodate the latter, they tend to allocate private grazing land from areas of cultivated land, despite the prevalence of a serious shortage of cultivated land. By so doing, they have been managing to strike a balance between crop and livestock production so as to sustain a mixed system that gives relatively better food security than either one of them singly. It is also found that economic returns to land in mixed crop-livestock systems are often higher than for pastoral livestock systems alone (Olson and Maitima, 2006).

Recent shifts in animal grazing strategies could have been efforts to avoid free grazing and the promotion of controlled feeding systems that employ hay collection limiting grazing by locality,

The ranching system restrict mobility of animals, lead to overstocking thus limiting regeneration of pastures/ bushes (Mugerwa et al., 2011). Though ranching could have created an increased shortage of grazing area and feeds forcing the cattle keepers to encroach on the westland seasonally during the July to September and January to March periods depending on the beginning of the rain season. On the other hand, communal grazing is also managed in a shifting manner that allows animals to graze in some parts; However, this is only possible in localities that have alternative sources of grazing land (Kisamba- Mugerwa, 2001).

Woody vegetation cover/ trees areas were considered greater in sites with no grazing while in other areas, shrubs, herbs and grasses supported more livestock than other land uses and became homes to different livestock significantly thus increasing the number of species that can co-exist in grazed sites compared to areas with no grazing in comparisons of percent plant cover of different growth forms in grazed and un-grazed sites.

Plantation of trees around homesteads, as a farm boundary, conservation structures and as a means to stabilize gullies has been tried in study areas; tree planting has shown improvement in rangeland conservation, (Kafeero 2005). However, survival of tree seedlings in some areas is barely possible due to serious soil moisture stress; as Ayana,(2007) noted that barelands are still a problem in agricultural, and settled areas.

The low livestock populations before and shortly after the 1986 bush war meant that the few remaining animals could not effectively graze and browse the entire area and this could have promoted the growth of shrubs and grasslands. However, overgrazing of land has often led into reduced soil fertility and exposure to soil erosion which results into failure of grasses to grow but does not affect the growth of deep rooted shrubs which recruit and suppress grasses (Zziwa et.al 2011).

There was increased animal population in ten years ago and following introduction of ranching, this might have been largely due to the comparative advantage of cross breeds due to its diversified feeding ability, capability to withstand drought (water and feed shortages), An adverse impact on the local environment is being reported due to introduction and growing

population of exotic cattle breeds in Kyeyindula parish; Despite the periodic fluctuations of the various livestock types, the net change over the last three decades appears to be on increase (Zziwa et al.,2011). This trend in livestock population agrees well with general patterns of grassland as revealed by the remote sensing analysis.

5.1.3: Crop Production and land use cover chnage

The expansion of cultivated land as shown on the satellite images in Kakooge was confirmed by interviews with inhabitants that indicated that the land conversion was caused by the high numbers of the youths looking for land because no employment opportunities outside agriculture were available. According to a survey made in Kyambogo parish, 12.8% of the rural households have no access to land (KDP, 2011). Hence, it will be imperative to look for other options of addressing the growing shortage of land and landlessness. For instance, as suggested by one author, access to farmlands can be improved through development of land rental markets (Benin et al., 2002). Consequently, the Subcounty land management office is considering whether other areas owned by churches and schools can be accessed by the landless youngsters.

Generally, contrasting views are reflected by respondents regarding the state of cultivated land over time. Some of them argued that the net change in cultivated land is negative as the amount of additional land allocated for cultivation is less than the amount of land abandoned due to land degradation and expansion of settlements. On the other hand, the cultivated land has shown an increase due to the encroachment into communally owned lands like grassland, shrub/bush lands, and the close down of fallowing practice triggered by land shortage problem. Furthermore, the analysis of satellite images revealed that cultivated land increased only during the later period followed by a continuous decline in the other land uses, making the net change positive. Agriculture has expanded into forests, savannas, and steppes in all parts of the world to meet the demand for food and fiber (Lambin et al., 2003). Based on data from diverse sources, the Global Forest Resources Assessment 2000 estimated that the world's natural forests decreased by 16.1 million hectares per year on average during the 1990s, which is a loss of 4.2% of the natural forest that existed in 1990 (Lambin et al., 2003).

Cultivation and the associated fencing off of the land to protect destruction not only reduce livestock grazing resources but also restrict animal movements in search for water and forage especially during dry season; Over the past 50 years in East Africa, there has been expansion of agriculture at the expense of grazing land (Olson and Maitima, 2006). This leads to increased overgrazing of the remaining land, thus accelerating degradation of grasslands. Overgrazing also means that animals eat most of the available plant material, both fresh and dry in the struggle to survive. In this situation, the deposition of litter which is a major source of food for the majority of termite species in Kakooge is restricted. The litter feeding termites resort to fresh vegetation, competing with livestock and therefore increasing the pressure on grasslands resulting into unprecedented levels of land degradation and creation of immense patches of bare soil. Termite damage is unequivocal in both grasslands and croplands since they resort to feeding on fresh vegetation due to scarcity of dry materials and are thus regarded as a major threat to forage availability in Kakooge Sub County (Mugerwa et al., 2011). Because crop residues are not utilized in livestock feeding to lift the burden of overgrazing from grasslands during the dry season, the introduction and intensification of crop production in pastoral rangeland communities has no linkage with livestock production and therefore greatly contributed to the presently high levels of land degradation and decrease in livestock grazing areas.

According to Kyagaba (2005), crop yield was high before 1980's but because of drought, that it has been declining from year to year, and the total type of crops grown has decreased from nine to four. In an effort to increase crop productivity, the use of fertilizer was tried but it was not promising, as the crops burned due to the hot temperature condition and lack of water. In the wetland bottoms, a significant proportion of land is lost due to deposition of sand is another problem hampering potential of land for production. Hence, soil moisture stress from unreliable rain fall, land degradation, limited use of organic fertilizers and little success from use of synthetic fertilizers, low crop diversity, decline in size of household level land holding and landlessness appear to be major challenges facing the crop production.

However, due to population growth, expansion of land degradation, soil fertility decline and subsequent production decline, to feed the growing population, communal areas, allocated as a grazing land and covered with vegetation, have been converted to cultivated land and suffer from

severe encroachment. Simplifying natural ecosystems with agricultural uses initiates processes that lead to biomass and species losses and substitutions, affecting abundance of biodiversity (Buyinza, 2004)

Considering the land use patterns, cultivated and settled land cover patterns could be more vulnerable the proportion of land prone to soil erosion increased might have probably due to the transition stage of the degraded woody cover to grasslands. As Getachew (2010) points out that removal of the protective cover exposes the land to impacts of rain drops, this process accelerates detachment and removal of the soil particles. Water erosion resulting from the seasonal burning of grass and bushes as part of land use method of cultivation, or for rejuvenation of pastures, or to facilitate hunting of game. This fires expose land to water erosion in the rainy seasons and to wind erosion during dry periods, which were evidenced by wide gullies along Kyeyindula-Bukabi slopes in Kyeyindula parish; accumulation of smoke contribute to the buildup of atmospheric carbon dioxide and the corresponding regional climate change. While (NDER, 2007; NEMA, 2009), supplement that continued release of smoke makes atmosphere more vulnerable to changes.

Massive encroachment on wetlands for; crop production, and dairy farming extensions could have resulted into loss of bio diversity, reduced water quality, occasional floods. Many farmers were also found practicing cultivation on marginal lands and fragile ecosystems (wetlands). wetlands had been reclaimed for agriculture leading to the alteration of their physical and chemical properties due to prolonged exposure resulting into acidification, in other areas soils seem to be too toxic to most plants thereby making the area barren. While this may be true as Nature Uganda (2004), reports that aremarkable dependence of local communities on wetland resources led to their persistence decline.

Land degradation in the form of gully erosion is reported to be a problem in the study area at greater magnitude in Kyeyindula parish, which brought significant increase in area of cultivated land out of production. Unsustainable and improper land use and land cover changes are the major causes of land degradation (Bossio et al. 2007).

Besides the general trends in land use cover changes, there has been great implications on the existing climatic conditions. According to respondents, following transformation in land use and land cover over the study areas, the climatic condition has changed significantly. They reported a trend towards a shorter rainy season that starts later and finishes earlier with a relatively less predictable pattern as compared to the old times. Particularly, respondents remarked that there was a more regular and predictable rainfall pattern three decades back with a positive influence on the various farming activities.

It is of interest to note that the community has evolved towards other mechanisms to predict possible outcomes of their farming practices using various components of climate variables as a proxy. For instance, the communities have acquired a traditional experience that if there is sufficient rainfall in the period from March to May and September to November. There is a high likelihood of getting a good crop harvest provided that other factors are kept constant. With regard to this, there is a local belief that if it rains, one should put extra effort to save resources available at home as there are strong indicators that the harvest will be good.

Land use cover change has partly result into advance of drought conditions in the area, drought conditions are being manifested by an unreliability in rainfall, reduction in the amount received, reduced rainfall effectiveness and increased evaporation at $AI = 0.43$ in table 17. The rainy seasons were reported to have changed greatly and of present farmers hardly tell the planting and harvesting seasons for crops, they have adopted several practices including crop watering, because of insufficient rainfall to increase on the output from the crops and harmonise the changes in the farming seasons. According to Chidumayo et al., (2003), where there are trees there is life, implying that, the reduction in the woodlands directly affects the survival of different organisms including man since through rainfall formation, they can even support agriculture, thus their conservation is very important.

General increase in atmospheric carbon dioxide concentration above the upper safety limit (350 ppm) in 1988 is believed to have had a significant contribution on the increased woody encroachment in the savanna ecosystems in Nakasongola. Since farmers started noticing woody encroachment in 1990 and consequently becoming a rangeland management problem from 1994

(NEMA, 1996), the elevated CO₂ levels might have led to the increased dominance of woody species into grasslands of Nakasongola rangelands as earlier observed in other regions which accelerate charcoal burning.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1: Study Conclusions

This research work demonstrates the ability to interpret remotely sensed data like satellite images which were found useful in analysing land use and land cover changes in the present study.

Implications of the land use approaches in Kakooge Sub-county showed the existence of appreciable land use cover changes over time. In the analysis the identified land use and cover systems included; built up area, pine establishment, bushlands, grasslands, wetlands, woodlands, commercial farmlands and subsistence farmlands.

Kakooge Sub-county has faced a significant decrease in woodland, forest plantations, wetlands and bushlands since 1987 associated with significant increase in other recognised land use cover systems like built up, grass lands and others.

Changes in land use cover overtime showed a greater influence of the socio-economic, policy and ecological aspects on the existing rangeland ecosystems. They varied from population growth, poverty, restoration of peace, termites activity to infrastructure development. Therefore Cultivation, pine establishment, ranching, bush and woody encroachment are pointed out as the most pervasive land use and cover changes in the Sub County.

The significant changes in land use cover might have generally resulted in the deterioration of the ecosystem through increasing the area prone to erosion, water scarcity, destruction of the original bush lands, wetlands and the desirable vegetation species types (trees, shrubs, etc) which might have directly decreased the productivity and carrying capacity of the area. As a result local

people have shifted to a change in land use patterns (eg. Expansion of commercial farm land, agro forestry), seeking for more income generating activities like sell of fire wood and charcoal to urban centres. The latter activities could further drive ecological disturbances to irreversible conditions unless proper interventions are made from time to time.

There is disruption of some ecological functions through the pressure created on regeneration and dynamics of scattered shrubs and trees in farmlands, near homesteads and in unprotected communal areas. One farmer even remarked that "all the shrub, bush and tree species currently found scattered in the farmlands are those that finished their seedling/sapling stage and grew up to be a tree prior to the arrival of charcoal burning in the area". This means that succession is seriously undermined and the regeneration ability of some species that are well adapted in Kakooge is being affected. Similarly, due to the fact that most shrub/bush lands are open access for human and animals and consequent pressure created due to fuel wood collection and grazing, regenerative capacity, distribution and status of some tree/shrub species is hampered.

6.2: Study Recommendations

The changes in land use cover have had negative implications in the area. It is therefore suggested that encouragement should be given to people to carry out agroforestry with local tree species like Albizia, Acacia, and re-forestation towards the outskirts of the wetland and deforested lands through the provision of incentives like tree seedlings and massive tree planting strategies that are available at the national level will help in improving rural family welfare and environment protection.

In the face of the growing household level land shortage and growing number of landless youths, it will be imperative to create and strengthen non-farm /off-farm income generating activities due to limited capacity of land to accommodate additional population.

Forest resources development, protection and use strategies need to be devised to counteract the deteriorating shrub/bushes and avoid further extinction of important shrub/tree species and migration of associated wild animals.

As revealed by the socio-economic survey, land provided for investors in the sub county is done without consent of the community and this led to tension and lack of trust. According to Sub county leaders, effort is underway to provide additional area to provide for new investors. Therefore, participation of the community and getting their approval is highly required prior to providing land for investors and making similar decisions in order to avoid conflicts.

Designating interventions/activities that can be synchronized with joint management is very important, as an effort to improve the livelihood of the community and to increase economic importance of such areas as community participation is lacking in protection of communally owned vegetated areas. Hence, rehabilitation, closure and distribution of degraded hills or other conservation practices has to be launched to minimize land degradation.

Redd+ project, encompassing forest management, research and extension activities, has brought several positive benefits. However, negative impacts are also reported few years after termination of the project due to some of the interventions. Hence, further study is required to better understand current challenges and evaluate overall impacts so as to make immediate corrections and draw important lessons to further scale up the experience to other areas.

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APPENDIX 1

STUDY QUESTIONNAIRE FOR COMMUNITY MEMBERS.

Research Topic: The Effects of Land Use Cover Dynamics on Rangeland Ecosystem in Uganda Between 1987 and 2005. A Case Study of Kakooge Sub-County Nakasongola District

Part one

Questionnaire for Local Population in the Study Area

Data Management

Interviewer code:Date:Time of interview:

AREA DESCRIPTION

1. Village/Local Council 1..... 2 . Parish/ Local Council II

A: HOUSEHOLD BIO DATA

1. Gender of respondent: 1. male 2female

2. Gender of HH head 1. Male 2.female

3. Highest level of education of HH head and spouse(s)

Primary Secondary

College/Unvty Vocational None

4. Household size (number) 1-5 6-10 >10

5. Do you own land 1<11 dec 2>11 dec

6. Household Proximity to the wetland and forests; 1 within the wetland , 2 living near the wetland, 3 None

7. How long have you lived in this area? Tick (✓)

1-6 Years 7-12 Years >13 Years

8. What major activity do you carry out in the rangelands? Tick (✓)

Home gardening	
Animal grazing	

Brick making	
Charcoal burning	
Water collection	
Others (specify)	

9. What are the benefits of wetland, grasslands and woodland conversion to other land-uses mentioned above?

.....

10. What are the costs of conversion to other land-use mentioned above?

.....

11. What would you do if you were told to stop using these resources? (How to cope and meet needs currently provided by the resources)

B. Rangeland Ecosystem Services & Products

12. What were the past (12 years ago) ecosystem services & products provided by Wetlands/woodlands and other land covers to you and or community?

Types of Services	Services & Products (1990 -2011)	Has there been (Change) increase or decrease in Wetland/woodlands Services & Products (Yes/No)
Fuel wood		
Food		
Income		
Cultural Services		
If others Specify		

C. Rangelands Cover Changes (Drivers & Synergies)

13. What could be behind the changes of the ecosystem services provided by the rangelands mentioned above Tick (✓)

- i. human cultivation
- ii. commercial plantations and use of agro-chemicals;
- iii. Brick making
- iv. introduction of new plants or species;
- v. government policy

vi. other forms of land use

14. What changes have occurred to wetland/woodlands (please emphasize changes in area,

.....

15. How have the changes in ecosystem services named No. (14), above affected human well-being (food security, income and health and other factors in your household?

.....

.....

D. Rangeland Management

16. What are the current efforts that are being done to conserve these rangelands?

(i) Individual.....

ii) Government/LCs.....

iii) Community.....

iv) NGOs/ CBOs.....

b). In your opinion, do you think the efforts mentioned above are effective? If NO, Why?

.....

c) What might accelerate the degradation of this wetland, woodlands and grasslands?.....

17. In your opinion, what could be the best strategy that can be applied to conserve wetland, woodland / grasslands?.....

Thank you,

Mbaziira James

Part two

Questionnaire for Government Institutions Involved in the rangeland monitoring and management (NEMA, and Wetland Inspection Division)

Kakooge rangeland resources Assessment Questionnaire

Dear interviewee, I am carrying out an Assessment of rangeland vulnerability to land use practices. I am trying to establish the past and current ecosystem services provided by the rangelands, costs and benefits to the Kakooge rangelands resource conversion to other uses and assessment of drivers behind their change.

Data Management

Interviewer code: Date:

Name of the Interview.....

Designation.....

Name of Institution.....

A: PERSONAL BIODATA

Gender of respondent: 1. Male 2. Female

SECTION B ROLE OF THE ORGANIZATIONS:

1. What is the mandate of this institution (NEMA or others) in proper management of Kakooge -Nakasongola rangelands
2. How has the rangelands ecosystem services changed overtime (that is since the establishment of NEMA 1995)?.....
3. What are the major drivers of its change.....
4. In your own opinion, what are the benefits that have been accrued from the conversion of rangelands to other uses.....
5. In your own opinion, what are the costs that have been accrued from the conversion of rangelands to other uses.....

6. What are management strategies that are being put in place to ensure sustainable use of rangelands.....

Thank you

Mbaziira James

APPENDIX 2

DATAFORM FOR LAND USE COVER AND SAMPLE INFORMATION

Data form and sample information								
Sheet no.		Locality name:			Vegetation cover type		Quadrat no.	
Observer:				Mapping unit Code:		Sample code:		
Date:		Plot size:			Coordinates	X:	Y:	
Altitude (m):		Soil Texture:			Slope (%):			
Distance to a drainage line:				Drainage description:				
Vegetation structure				Species Composition				
Layer and % cover	Layer code	% Layer cover	Height (m)	No. of species	Local name	Scientific name	Height (m/cm)	% cover
TREE LAYER	T1							
	T2							
SHRUB LAYER	S1							
	S2							

	S3							
GRASS LAYER	G1							
	G2							
SWAMP/WETLANDS	F1							
	F2							
Other Environmental Observations /Comment								
Land use/Cover								
Grazing								
Fires								
Signs of flooding								
Comments on cover class								
Damage on trees and shrubs								
Phenology (Flowering, fruiting etc)								