LAND USE/LAND COVER DYNAMICS AND THEIR IMPACT ON PASTORALISM: A CASE STUDY OF MELELA WARD, MVOMERO DISTRICT, MOROGORO TANZANIA

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ABSTRACT

Studies which have been conducted so far have focused on the processes of land use/land cover changes in different areas at regional and global levels. Not much has been done to quantify the factors that influence land use/land cover dynamics in Melela ward, Mvomero District, Morogoro, Tanzania. The main objective of the current study was to evaluate land use land cover dynamics and their impacts on pastoralism in Melela. Specifically, the study examined land use/land cover dynamics for the period from 1991 to 2016, to identify socio-economic factors that influence land use/land cover dynamics and to determine the effects of land use/land cover dynamics on pastoral community livelihood and production potential. Remote sensing and GIS techniques were used for data collection and change detection analysis was employed to assess the spatial and temporal land use/land cover change of the study area. Quantitative methods including descriptive statistics was used for analysis of social economic drivers and its impacts on pastoral community livelihood and production potential. The results were the matrices and the categories of land use/land cover changes. The study findings indicate a significant change in LULC as evidenced by an increase in agriculture and a loss of woodland. The period 2000-2016 has shown gains in agriculture and losses of woodland areas. Changes in the crops grown, increased immigration of pastoralists, population growth, charcoal burning, and livestock keeping have contributed to an overuse of the existing land resources, which resulted in significant variations in the spatio - temporal patterns of land use. The assessment of changes in the grazing land in Melela has shown that the current patterns would increase the population of pastoralists in the region, through an increase of immigrants among the pastoralists and grazing pressure. The results of this study quantify dynamics of land use/land cover and its drivers on sustainable use of land. In the face of increasing population size, pastoralism, and charcoal burning, there is need of maintaining a balance for socio- economic drivers and sustainable utilization of land use.

DECLARATION

I, REHEMA KWAYU, do hereby declared to Senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

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DEDICATION

This work is dedicated to Kwayu`s family who laid the foundation of my education. Be blessed.

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LIST OF ABBREVIATIONS AND SYMBOLS

CPRs	Common Pool Resources
ETM+	Enhanced Thematic Mapper plus
FGD	Focus Group Discussion
GIS	Geographic Information System
GPS	Global Positioning System
ha	Hectare
LULC	Land use/Land covers
LULCC	Land use/Land covers Changes
MLC	Maximum likelihood classification
OLI	Operational Land Imager
PCC	Post Classification Comparison
PVLUPs	Participatory Village Land Use Plans
QGIS	Quantum Geographic Information System
SPSS	Statistical Package for Social Sciences
TM	Thematic mapper
URT	United Republic of Tanzania
USGS	United States Geological Survey

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

There is a rapid increase of change in land use/land cover in Sub Saharan Africa (SSA); and this, can have adverse impacts and implications on local land resources (Lambin *et al*., 2003). The land use/land cover pattern of a particular area is an outcome of natural and socio economic factors and their utilization in time and space (Olson, 2004). The driving forces of land use change vary according to specific human and environmental conditions. Moreover, land use changes either modify or change the habitat completely. This trend has implications on the entire ecological systems such as climate, soils, vegetation, water resources, and biodiversity (Turner II *et al.*, 2007; Lambin *et al.*, 2003). A land use change is considered as one of the threats to mobility and flexibility of livestock. For example according to Msoffe *et al*. (2011), agricultural land increased fivefold in Maasai Steppe while human population increased exponentially from 3.3% pa in 1988 to 3.4 % pa in 2002, and this has restricted livestock movements by blocking their migratory routes. Pastoralists in Idodi and Pawaga in Iringa region (Coppolillo, 2004), Kilosa, (Tsoxo, 2006) and Wami Sokoine (Wassena *et al.*, 2013) are reported to have complained that their grazing lands have been encroached by agricultural cultivation, reducing the area available for livestock keeping. This trend has increased stocking pressure in the grazing areas and land use conflicts along the margins. The resultant conflicts over the use of land involved different sectors of the economy (Nzunda *et al.*, 2013).

Pastoralism remains a predominant land use system in most of the arid and semi-arid areas of sub-Saharan Africa. Studies show that there is land use conversion and an increase of exclusion of pastoralists from land with the highest production potential (Campbell *et al.*, 2000), forcing major pastoral communities of Maasai and Barabaig of Tanzania to move

large herds of livestock from traditional grazing areas to low livestock density areas such as Morogoro, the Coast, Mbeya, Iringa, Rukwa and Ruvuma Regions. These livestock migratory trends have brought different ethnic groups into the same ecological areas increasing the potential for environmental degradation and land use conflicts (URT, 1997). A growing number of agro-pastoralists including the Kurya, the Sukuma, the Gogo and the Nyamwezi are changing management systems and adopt extensive livestock production systems. For example, cattle herders have been practicing transhumant systems for a long period (Kisoza, 2007). Thus, interventions for increased food security through the expansion of agriculture can negatively affect pastoralist land use patterns, which would in turn affect food security in ways which are not always noticed by policy makers (Flintan *et al*., 2013).

In Morogoro Region, there have been recurrent conflicts on land resources between farmers and livestock keepers (Kushoka, 2011). For example in Melela Ward, the conversion of native land into settlement and agriculture is on the increase, resulting to a decrease in land size for pasture and water for livestock (Kushoka, 2011). The Government and agricultural stakeholders have made huge efforts in mitigating land conflicts, the problem has however persisted (Tsoxo, 2006). Much of the available literature focus more on the impact of land use / land cover on agriculture. However, the implications of this trend on pastoralism are less evaluated Msoffe *et al.* (2011). The current study therefore, aimed at investigating the dynamics of land use / land cover changes and their implications on livestock keeping. The findings of the current study would be vital in addressing issues with regards to sustainable development and utilization of land resource in general.

1.2 Problem Statement and Justification

Studies have focused on the processes of land use/land cover changes in different areas at regional and global scales. However, the factors that influence land use/land cover dynamics in Melela ward, Mvomero District, in Morogoro, Tanzania remained unknown. It is widely acknowledged that socio-political factors (land policy) have an impact on land use/land cover changes. However, not much has been done to quantify this phenomenon neither has there been a clear explanation as to whether socio-political factors are the only cause of the change. Therefore, the current study aimed at identifying various socio-economic factors that influence land use/land cover dynamics. The study also intends to establish the intensity of such changes.

Previous studies on the land use/cover changes have not done much, if anything, to establish the impacts of expansion of cultivated land, settlement, and clearing of shrub lands and grassland on the livestock production system and pastoral livelihood; especially in relation to availability of pasture resource, water resource, cattle migration, and incidences of diseases among the pastoral community. This exploration is essential for evaluating the status of land use/land cover in understanding pastoral production. Therefore, the current study intended to explore Land use/land cover dynamics and their impacts on pastoralism. The results would be helpful in increasing the ability of policy makers of predicting changes. This in turn would assist them in land use planning and management of Melela ward in addressing the increasing demands for basic human needs and people's welfare.

1.3 Objectives

1.3.1 Overall objective

The overall objective of the study was to evaluate the land use / land cover dynamics and their impacts on pastoralism.

1.3.2 Specific objectives

Specifically the study intended to:

i. Examine land use/land cover dynamics from 1991 to 2016.

ii. Identify socio-economic factors that influence land use/land cover changes.

iii. Determine the effects of land use/land cover change on the livelihood of pastoral community and their production potential.

CHAPTER TWO

2.0 LITERATURE REVIEW

This chapter presents a review of literature for the study, the chapter focuses on definition of key terms and provides good account on land use and land cover change, pastoral production, main drivers to land use/land cover changes, the effects of land use/land Cover changes on pastoral community, Usefulness of Remote Sensing and Geographic Information System (GIS) in Understanding the Intensity of Land Use/Land Cover Change (LULCC).

2.1 Definition of Key Terms and Concepts

Key terms which are defined in this section include land cover and land use as follows.

Land Cover is the observed biological and physical cover on the earth's surface (Di Gregorio and Jansen, 1998). The term ‘land cover’ refers to the attributes of a part of the Earth’s land surface and immediate subsurface, including biota, soil, topography, surface and ground water and human structures.

Land Use is characterized by the arrangements, activities and inputs by people to produce change or maintain a certain land cover type (Di Gregorio and Jansen, 1998). Land use establishes a direct link between land cover and people’s actions to their environment.

A study by Senga *et al.* (2014) shows that land use (both deliberately and inadvertently) alters land cover by converting the land cover, or changing it to a qualitatively different state; modifying it, or quantitatively changing its condition without full conversion; and/or maintaining its condition against natural agents of change. Study revealed that human activities or arrangements (land use) have an effect on land cover.

2.2 Land use/land Cover Change

Land use/land cover changes (LULCC) are a cumulative transformation of land use/land cover (Lambin *et al.,* 2000), which is defined as a quantitative change in areal extent (increase or decrease) of a given type of land use /land cover (Briassoulis, 2000). These changes in global ecosystems are closely linked to issues of sustainability of socio-economic development since they affect the essential parts of natural capital such as climate, soils, vegetation, water resources, and biodiversity (Turner II *et al.,* 2007).

Land use/land cover classes represent the analytical units, which allow the establishment of the first quantitative link between human activities, environmental impacts, and their geographical (spatial) dimensions. Information on land use/land cover change is valuable in integrating the temporal dimension in discovering the underlying causes and consequences.

Land use/land cover changes are grouped into conversion and modification (Stott and Haines-young, 1996). Conversion refers to a change from one cover or use category to another (e.g. from forest to grassland). Modification represents a change within one land use or land cover category (e.g. from rain fed cultivated area to irrigated cultivated area) due to changes in its physical or functional attributes. Land use/land cover information gains a significant value through the analysis, identification and description of the ongoing processes (European Communities, 2001).

2.3 Pastoral Production Potential

In pastoralism, Livestock keeping is the major occupation and the main mode of production. Pastoralism entails a continuous movement of animals in search for pasture and water. It led to medium human population densities and extensive rangelands, which

are usually marginal and unsuitable lands for rain fed crop production Kavana *et al*. (2005). In East Africa and Sub-Saharan Africa, pastoral communities are found in the dry lands, which are referred to as arid and semi-arid areas. In Eastern Africa, pastoral lands stretch as far as from southern Sudan down to Mozambique. Examples of pastoral communities include the Nuer of Sudan, the Somali of Kenya Jie, the Karamojong of Uganda, and the Maasai and Barabaig of Tanzania.

2.4 Main Drivers to land use/land Cover Changes

Study on the causes of land use/cover change has identified three primary factors of change at global level. These changes include population, the level of affluence, and the level of technology. The global land use/land cover change emerged due to the change of the nature of the land surface and the impacts of climate on the ecosystem's goods and services (Lambin *et al.,* 2003). A study by Slayback, (2003) has shown that land use changes in the world's forests, grasslands and woodlands decline and increase the cultivated land in the same magnitude The world is experiencing demographic changes at varying rates of natural increase and net migration.

At the regional level, rural to urban migration, economic growth, changes in lifestyles, and changes in the economic and political arrangements are cited as the main drivers of change (Lambin *et al.,* 2003). Other explanatory factors of change include the role of institutions and the influence of local culture (McCusker, 2004). Land cover conversions processes are complex and are dependent on the scale of the analysis (Campbell *et al.,* 2005), which can be linked to economic, cultural, political, institutional, and demographic factors.

Land use/Land cover changes are driven by interactions of factors at different spatial-temporal scales (Lambin *et al.,* 2003). According to Dale *et al.* (1998), these factors can be

simplified into themes that relate various drivers to particular LULC changes. Msoffe *et al*. (2011) have shown that agricultural expansion occurs at the expense of forests and natural vegetation. The authors concluded that population increase majority of whom are found in rural areas has been the main driving force for change.

2.4.1 Socio Economic Drivers

LULC change is driven by factors such as population growth, migration, economic development, culture, regional and local policies, and environmental conditions. Drivers interact to people's responses and economic opportunities (Ellis, 2012).

2.4.1.1 Population growth

Agricultural expansion, which is associated with population increase, is one of the key drivers to land cover and land use changes within and in the surrounding areas of Pugu and Kazimzumbwi protected forest reserves in Tanzania (Mdemu *et al.*, 2012).

Population increase in the pastoral community is driven mainly by natural growth and immigration of other ethnic communities. Many pastoral communities across the world have experienced population increase as people migrate, settle and open up grazing lands for agricultural activities. For instance, people in Kenya have experienced great changes in land tenure and population growth in the last four decades (Campbell *et al.*, 2005). Population increase has increased in high proportions in places such as Ngong hills, Loitoktok, and Rombo, among others (Campbell *et al.*, 2003). The immigrants who come from overpopulated potential areas in Kenya mainly practice crop cultivation as their key source of livelihood. In Tanzania, the degradation of communal grazing land in pastoral community was found to have been accelerated by a rapid increase of population, which stimulates agricultural expansion to meet the population needs. This has led to more land use conflicts.

2.4.1.2 Market of agricultural products

Market and price fluctuations of agricultural produce are responsible for land use and land cover change. As Duraiappah *et al.* (2000) observe, good prices are an incentive to farmers who decide to acquire large pieces of land for agricultural production. Marketing systems allow households to decide how many agricultural commodities should be produced. According to Noe (2003), before market liberalization in Tanzania, the Government played a major role in controlling market prices through rural co-operative societies. However after trade liberalization in early 1990s, individual farmers had access to free market and market forces influenced commodity prices. Thus, farmers started to compete in producing crops, which have higher returns in terms of income; this means that there was an increase in the demand for land for cultivation.

2.4.1.3 Income levels

The average rural household annual income in Tanzania is far below the expenditure poverty line (URT, 2005). The poor economic environment is likely to increase hardship in the livelihood systems of people; and this is likely to create more pressure on land leading to ultimate loss of land use/land cover. Poor socio-economic base compels poor societies into dependence on biological resources for construction, food, energy, and other related products (Nzunda *et al.,* 2013). This dependence on land resources has affected land cover which has been utilized by humans leading to a change of land use patterns and hence land degradation.

2.4.1.4 Livestock keeping

In many third world countries including Tanzania, social and economic pressure have forced communities to maintain the same land use practices and social values that are no longer suitable in the present land use systems (Lyaruu, 2002; Tiffen, 2003). For example,

ethnic groups such as the Gogo, the Sukuma, and the Maasai, have continued to evaluate their social and economic status in terms of the size of herds owned. This practice encourages poor farming practices of keeping large herds of livestock beyond the carrying capacity of grazing lands (Nzunda *et al.,* 2013). Thus, overgrazing and drought are among the factors that have contributed to land degradation in most areas with high population density, fragile land, and low rainfall. As Kikula (1997) observes, clearing of land for cultivation and lack of proper soil management practices have accelerated loss of land cover.

2.4.1.5 Land tenure system

Land tenure system includes terms and conditions stipulated in land legislations and regulations or implied terms upon which land is acquired, owned, used, and disposed in a given country (Adams *et al.,* 1999). Land acquisition has a great role in determining agricultural systems which finally influence land use and land cover changes. According to Olson *et al.* (2004), land tenure arrangements have been the driving force of land use changes in Tanzania, Uganda, and Kenya. Land tenure dynamics in these countries have led to changes with regard to who is engaged in land management practices, who has the right to use land and the manner in which land should be used. Most of these changes influenced land use patterns in agricultural and pastoral lands.

2.4.1.6 Technology

Improving agricultural technology as well as providing farmers with secures land tenures and better access to credit and markets can potentially encourage more deforestation rather than relieving pressure on the forests (Angelsen and Kaimowitz, 2001). The differing impact of agricultural development on forest conversion depends on how the new technologies affect the labour market and migration, how crops are sold whether locally or

globally, how profitable farming is at the forest frontier, and what is the capital and labour intensities of the new technologies (Angelsen and Kaimowitz, 2001).

2.4.2 Biophysical factors

Land use land cover changes are influenced by the characteristics of biophysical environment that determine, to a considerable extent, land suitability for a range of uses. These include, local climate and weather conditions (temperature, rainfall, snowfall, wind, moisture); local topography (slope, aspect); bedrock type; soil type (and associated physico-chemical characteristics); water resources (surface and groundwater, access to water); and the current quality state of the land (e.g. erosion, contamination).

Study by (Semazzi and Song, 2001) has demonstrated that Land Use / Land Cover Change alter the surface albedo which in turn influences local and regional climate dynamics. LULCC exert important influence on regional climate (Pielke *et al.*, 2007) and the vegetation response to rainfall with positive or negative feedback patterns. Besides greenhouse gases, LULCC is a primary driver of climate change at local and global scales (Feddema *et al.*, 2005). For example, land, which was historically, used for animal grazing in East Africa is being converted to cropland, and with a dramatic expansion of urban areas. These trends are expected to continue in the future (Mundia and Aniya, 2005). Thus, LULCC effects moderate or amplify the greenhouse gas effects on climate change. Anthropogenic effects include LULCC. For instance in agriculture, crop yields are a function of many different biophysical factors (Hay and Porter, 2006), which include temperature, rainfall, length of season, and nutrient availability among others.

2.5 Effects of land use/land Cover changes on Pastoral Community

Much of the grazing land in East Africa particularly Tanzania is treated as unoccupied land and this has led to many problems including lack of documentation for pastoralist systems. As a result, pastoral systems have remained with unrecognized tenures and which have no user rights. The public has been lacking knowledge regarding this land use leading for the need for its protection. Some key features of pastoralism revolve around risk minimization mechanisms and preservation of pastoral traditional knowledge. These include high mobility, herd diversification, herd splitting, and herd maximization. During their long experience and interaction with environmental uncertainty, African pastoralists have developed high flexible social systems and elaborate set of both individual and collective based survival strategies that allow them to effectively utilize harsh and extremely variable environment in order to minimize loss of livelihoods (Herlocker, 1999). A wide variety of pastoralism, which is practiced in eastern Africa, ranges from pure nomadic to a settled mode of pastoralism with communities living in homesteads and villages and engaged in agricultural cultivation (Olson *et al.,* 2004; Kisoza, 2007). This situation is the outcome of many interrelated factors such as population growth, recurrent drought, conversion of rangelands into other uses, weak governance, increased insecurity, political and economic marginalization, poor policies, and program related constraints (Reda, 2012).

2.5.1 Grazing patterns of pastoral communities

The routes followed by pastoralists depend on environmental conditions, availability of resources, and the livestock species which are being managed (Kisoza, 2007). Nomadic pastoralism, which is mainly practiced by the Barbaig and the Maasai ethnic groups, is characterized by absence of cultivation, even for supplementary income. Transhumance pastoralism involves regular seasonal migrations, which may take place between dry and

wet season grazing fields or between highland and lowland pastures. Agro pastoralists, on the other hand, cultivate sufficient areas of land for crop production which can feed their families and enable them to settle in one area, ranching and dairying by land owning associations, villages, corporations or private individuals. Under this system, grazing innovations can be (or have been) successfully introduced (Kidunda *et al.,* 1990).

2.5.2 Extent of Land Use / Land Cover changes in the pastoral community

Study show that woody vegetation cover increased by 9% to 15 % in Ethiopia over 35 years. The cultivated land, bare land, and settlement increased by 2%, 5% and 3%; and by 6%, 7%, and 6%, respectively. On the contrary, the grass land cover decreased by 8% to 34%. This suggests that the expansion of other Land Use/Land cover types were at an expense of grassland cover; the main factor securing animal feed especially for cattle, resulting in negative effects on local ecology and the community. This trend has forced the local communities into expanding land cultivation onto marginal semi-arid lands resulting to the ecological disturbance of the grazing land (Mussa *et al.*, 2017).

2.5.3 Key drivers of LULC change in the pastoral communities

Changes in pastoralist access to grazing land are occurring throughout Tanzania as a result of governmental policies, political boundaries, physical factors, socio economic factors, land tenure, and livelihood diversification.

a) Physical drivers

Physical factors are the fundamental determinants of the extent of change in Land Use/ Land Cover. Climate conditions such as precipitation and temperature, affect the extent of LULC by restricting water supply. This shows that climate warming has major impacts on water resources. Climate warming is mainly attributed to the hydrologic cycle,

precipitation, evaporation patterns, magnitude and timing of runoff, and the intensity and frequency of floods and droughts, thus affecting seasonal availability of water supply among the pastoral communities.

b) Social economic drivers

Socio-economic as well as environmental changes such as population increase and land use land cover (LULC) changes is occurring in Monduli District, (Kiunsi and Meadows, 2006). According to Kiunsi and Meadows (2006), between 1960 and 1999 the increase in agricultural areas, both small scale (subsistence) and large scale (commercial) farms, is the most significant LULC change. This trend is accompanied by a decrease in natural and semi natural vegetation and an increase in bare soil and gullies. Gully erosion is the most dominant erosion process and forms a major threat regarding land degradation. Similarly, Meindertsma and Kessler (1997) observe that overgrazing is a serious cause of land degradation in the Monduli District. Other possible causes of land degradation include the removal of natural vegetation for agricultural purposes, usage of heavy machinery on farms resulting in soil compaction, high erodibility of volcanic soils and population increase (Kiunsi and Meadows, 2006).

2.5.4 Impact of LULC change on pastoral production

Pastoralists' livelihoods are heavily dependent on the availability and access to natural resources. Therefore, a decrease in the availability of quality pastures, restricted access to water resources, land use conflicts, and livestock diseases due to Land use/land cover change impact negatively on pastoral production as follows.

a) Land use conflict (nature, sources and magnitude)

In many parts of Tanzania, pastoralists have evolved through migratory grazing pattern. Livestock migrate to track forage and water availability. Increasing agricultural,

commercial land values and growing human population are the factors that create pressures on community lands. Such pressures result in widespread conflicts including outbreaks of violence between competing groups of people. Similar observations (Mussa *et al.,* 2017) regarding conflicts on rangeland resources due to LULC changes are reported in South east Ethiopia (5.5%).

A study by Mwasha, (2016) in Kilosa District, Tanzania revealed that majority (87%) of the respondents reported that farmer-pastoral conflict was the main type of the conflicts that have occurred in the district. A percent (87%) of farmer-pastoralist conflict was the result of limited land. The land, according to Attito *et al*. (2008), was smaller (483 390 hectares) than its carrying capacity. Thus, it does not have the ability of supporting excessive influx of livestock from different parts of the country in search for pasture and water. According to key informants, land was a major issue which caused farmer-pastoralist conflicts. Moreover, lack of pasture as the result of limited land forces pastoralists to use farmer's crops as animal feed while still in the fields before harvesting. Likewise, pastoralists tended to graze on fallow lands where important perennial crops were grown. Majority reported that conflicts had existed for long period of time, which indicates the extent of the problem within Kilosa District.

Though farmer-pastoralist conflict has existed for decades; the intensity of the conflict has increased with time, thus resulting in uncertainties among local communities. A decrease in pasture has been a common trend as more land is opened for crop cultivation. The trend leads to an escalation of conflicts between various land users. Farmer-pastoralist conflict has been persistent and has led to major problems such as crop damage by pastoralists, encroachment of cattle corridors and grazing lands, and blockage of water points by farmers. Findings from previous study cited a decrease in farmland area to accommodate

both farmers and pastoralist for income generating activities, and excessive influx of livestock keepers from different parts in search for pasture and water for their livestock as the root causes of conflicts.

b) Pastoral resilience

The impacts of closure of grazing pattern routes include a decrease in resilience among pastoral communities against shocks and stresses caused by such things as droughts and erratic rains. Land use pressure in the Northern and central Tanzania, calls for serious attention. Investment on land is pushing pastoral communities into marginal and/or limited land resources. For example, Common Pool Resources (CPRs) study found that land excisions and other restrictions on access to resources lead to a decrease in community resilience and ecosystem stability. Studies found that big tracks of land in the northern highlands of Tanzanian have been given to investors for large-scale commercial cultivation. These farms have been draining water and grazing resources away from pastoral use. This exercise has reduced the grazing area for both livestock and wildlife; it has also led to a significant loss of early, predictable grazing pastures and reserves. Land tenure and conservation policies are the genesis of the current pastoral land use patterns, and the existing household economics and livelihood patterns.

c) Livelihood

The pastoral way of life is gradually shifting from dependence on livestock keeping to crop cultivation in some areas. In Ethiopia, thirty years back, livestock production was practiced by 94% of families and the inhabitants were totally pastoralists (Mussa *et al.*, 2017). In Kenya, the immigrant pastoralists who come from overpopulated high potential areas mainly practiced crop cultivation as their key source of livelihood (Campbell *et al.*, 2003). Additionally in northern and central Tanzania, cultivation has become a common

household activity for pastoralists; the areas that are suitable for cultivation are now limited to pastoralists.

2.6 Usefulness of Remote Sensing and Geographical Information System (GIS) in Understanding the Intensity of Land Use/Cover Change

Remote sensing and GIS have proven to be reliable tools for evaluating spatial and temporal correlation of land use/cover with different factors. Remote sensing can readily show aspects such as arable land, pastures, natural forest, plantations, the pattern of the field and the extent of urban or village use of land.

Studies using remotely sensed data have been carried by various scholars. For example, Mbilinyi *et al*. (2007) used remote sensing to assess land cover dynamics as a result of charcoal production. The findings of a study by Mbilinyi *et al*. (2007) revealed that much of the closed woodland was converted to either open woodland or agricultural farms. In another study**,** Nzunda (2013) used remote sensing to assess the trend of land cover change in Mbozi District, in Mbeya Region, and found that there is an increase of mining areas and bush land and a decrease of forest areas due to charcoal burning. Nzunda *et al*. (2013) also used remote sensing to assess land use and vegetation cover dynamics in and around Kagoma Forest Reserve in Tanzania. The findings in a study by Nzunda *et al*. (2013) revealed that there was a decrease of vegetation cover mainly due to charcoal, timber and firewood harvesting. Similarly, Kashaigili *et al.* (2006) did a study on the dynamics of Usangu Plain wetlands and found that there is a continued decline in wetland covers; and this has the potential of causing irreversible change in wetlands.

Image classification involves assigning pixels to classes to produce land cover information. It also involves image selection, pre-processing and algorithm selection (Lu

et al., 2011, have used different classification approaches such as Supervised and Unsupervised to do image classification. The techniques used in image classification, however, are influenced by users' needs, spatial resolution of satellite images, the complexity of the landscape of the study area, the available image processing and classification algorithms, and time constraints (Lu *et al.,* 2011).

Medium resolution images (e.g. Landsat images) are commonly used in LULC classification even though they have low time frequency, and rarely produce cloud-free images (Henry *et al.,* 2011). Spectral information and parametric classification algorithms such as maximum likelihood are often used. Per pixel classifiers have recurrent difficulties in dealing with mixed pixel problems. As Lu *et al.* (2011) indicate, high resolution images such as QuickBird and IKONOS bring about high spectral variation within land cover class and as a result, per pixel classifiers perform poorly. In such cases, per field or object-oriented algorithms are appropriate (Lu *et al.,* 2011).

In a supervised classification method, pixels categorization is done by specified samples of known cover types to numerical interpretation that distinguishes each class' spectral attribute (Lillesand *et al.,* 2008). This classification may include classifier algorithms such as minimum distance, Gaussian maximum likelihood, and spectral angle mapping. A pixel categorization is done by specified samples of known cover types to numerical interpretation that distinguishes each class's spectral attribute (Lillesand *et al.,* 2008).

Maximum likelihood classification (MLC) algorithm is the common parametric classification that assumes normal or near normal spectral distribution for each feature of interest and an equal prior probability among the classes. MLC algorithm is based on the probability that a pixel belongs to a particular class. It takes the variability of classes into

account by using the covariance matrix. Accuracy assessment involves the use of an error matrix, which calculates the overall accuracy, producer's accuracy, user's accuracy, and kappa coefficient.

The above reviewed studies indicate a thorough feasibility of the methodology for the study of land use and land cover changes and their driving forces making the use of remote sensing and GIS technique methods as most appropriate.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Description of the Study Area

3.1.1 Location

Mvomero is one of seven districts of Morogoro Region covering about 73,325 km^2. Other districts include Kilosa, Ulanga, Gairo, Malinyi, Morogoro Rural, Kilombero, and Morogoro Municipality. Mvomero District was established in 2001. It is found between latitude 06° 42`S - 7° 06`S and longitude 37° 12` - 37° 27`E. Melela is one of the wards in Mvomero District (Fig.1). The ward is located along the Morogoro - Iringa highway.

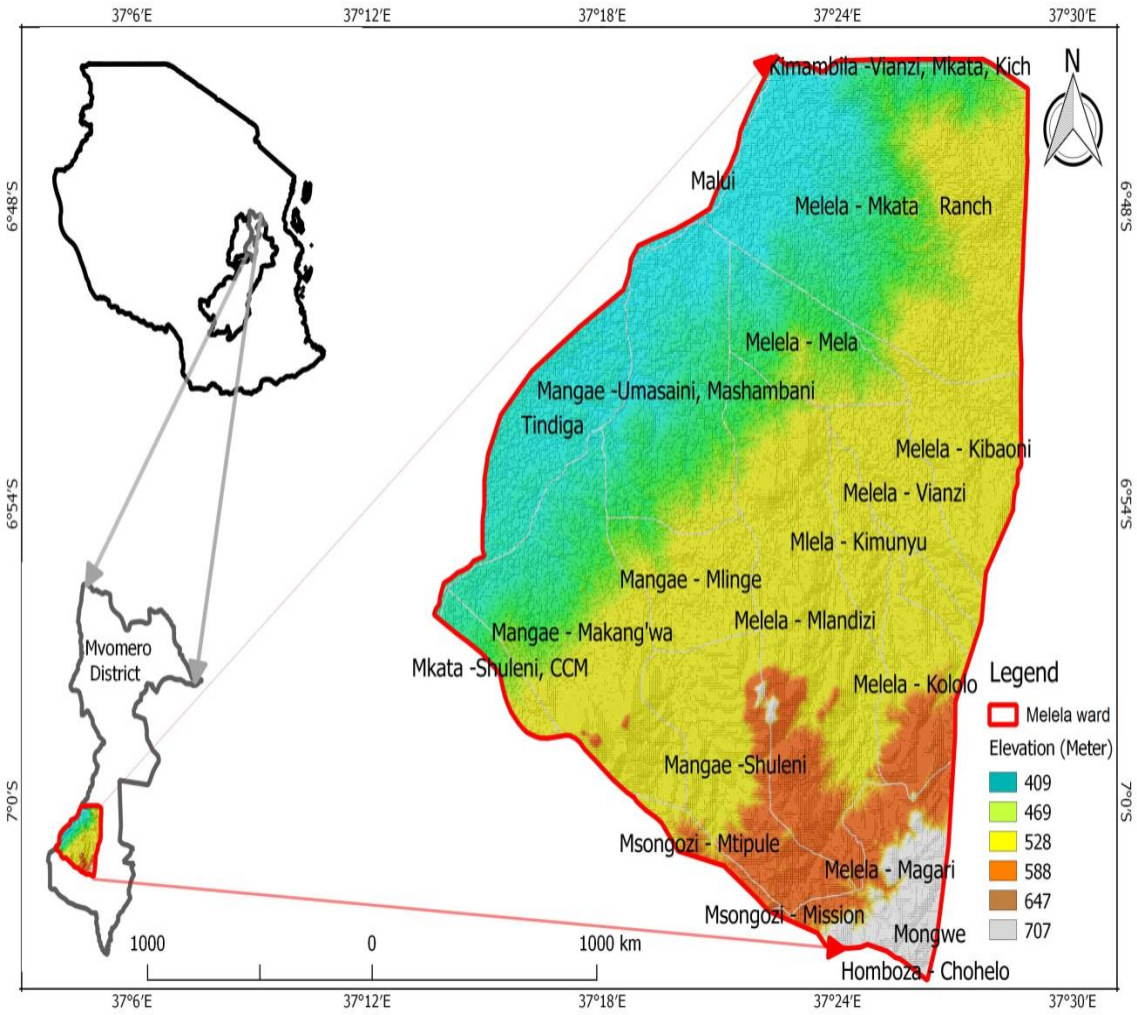

Figure 1: Location of Melela Ward in Mvomero District, Morogoro Tanzania

3.1.2 Historical Background

The name Melela comes from the name of the famous Melela River which runs across Mvomero District. Melela village was established during villagilization programme in 1974. Initially, there were many small neighbouring settlements, which later on were amalgamated into one large settlement called Melela village in 1975. Melela Ward has six villages namely Melela, Kibaoni, Mlandizi, Mangae, Mela, and Magale.

3.1.3 Ethnic groups in Melela Ward

Indigenous people of Melela ward are the Lukungwi, the Zigua and the Luguru. Others are the Makua who migrated from southern Tanzania to Mvomero District for hunting purposes during the colonial period. In the 1980`s, other tribes including the Maasai, the Sukuma and the Mang`ati migrated from North and Central Tanzania to Mvomero District in search for pastures for their livestock. The Pogoro and the Kaguru ethnic groups migrated from Kilosa to Mvomero in search for good fertile farming valleys. The Maasai people do not settle in one area (nomadic in nature), rather they move with their livestock from place to another in search for fresh pastures.

3.1.4 Climate

MelelaWard is characterized with moderate rainfall from March to May (long rains) and from October to December (short rains). The rainfall pattern is predominantly influenced by the eastern trade winds which bring moisture from the Indian Ocean. The annual rainfall is between 600 mm and 750 mm and temperatures range from 18 – 30°C (Mbogoni and Ley, 2008).

3.1.5 Hydrology

The ward is also endowed with both permanent and seasonal rivers as sources of water. Melela River is a perennial river with intermittent rivers such as Lukinge, Mlandizi, Kikundi, Mangae, Maliamka, which provide water during rainy seasons only while permanent rivers provides water throughout the year. Seasonality of the rivers and competing uses of water for both livestock and domestic purposes pose a challenge to the surrounding communities that rely entirely on surface water for domestic purposes.

3.1.6 Geomorphology and soils

Melela District is a peneplain characterized with U shaped valleys and broad ridge summits. The ridge summits are generally over 1 km wide, with almost flat to gently undulating topography, with straight to slightly convex slope form. The slopes between valley and ridge summits are generally gently undulating (slope gradient 2 – 5%) to rolling (slope gradient 10 – 15%) and vary greatly in length. The slope form is generally straight to slightly convex (Mbogoni and Ley, 2008). The lowest part is the Tindiga swamp at an altitude of 400 m and the highest point is the Manamata hill which is situated at an altitude range of from 560 – 720 m. Much of the rain fed cultivation is found at an altitude range of 440 – 520 m (Mbogoni and Ley, 2008). These valleys are characterised with alluvial loam soils which are suitable for agricultural production.

However, soil moisture reserves deplete rapidly during the dry spells due to high evapotranspiration. Much of the soils have low water holding capacity (Mbogoni and Ley, 2008), and crop wilting is probably the common phenomenon in the area.

3.1.7 Land use and land utilization type

Farming system in the area is broadly described as agro-pastoral farming system. The system of production is mainly low density, low rainfall, and utilizing extensive fallow systems. These semi humid farming systems have low population densities and variable rainfall. Major food crops include maize, sorghum, cassava, cowpeas, pigeon peas, lablab, pumpkins, sweet potatoes, and groundnuts. The major cash crops are sunflower, sesame, and cotton. As of now, cotton is no longer grown due to market constraints.

Cropping system mainly mono cropping is practiced. When intercropping is practiced, cereals (particularly maize and sorghum) are mixed with short growing crops such as cowpeas, green gram, and pumpkins. Sunflower is sometimes grown alongside cereals. Sesame is grown in mono cropping. The system of livestock production is basically extensive grazing with cattle, goats, sheep, and chickens as the most important types of livestock.

Natural vegetation consists of wooded bushland of Miombo, Mipingo (*Combretum spp.*,), and bushland of kwambekwambe, kunzu somvugo, *Acacia spp.* Some of the bushlands have been recently cleared and planted with agricultural crops. Bush fallow is also common with a mix of young bushes and grass. In Melela village, natural vegetation consists of open bushland of *Acacia spp.,* and various grasses. The land is used mainly for scattered smallholder rain fed cultivation of sesame, sorghum, and maize.

3.2 Data Collection and Analysis

3.2.1 Analysis of land use and land cover change

Remotely sensed satellite data were used for change detection analysis to assess the spatial and temporal land use/land cover change in the study area. Landsat (OLI, TM and ETM+)

was downloaded from an archive of the USGS Global Visualization Viewer (GloVis) where the time interval for image acquisition year was 1991 – 2000 and 2000 – 2016. Satellite images were processed and analysed to detect changes in the land use/land cover. Change detection analysis technique was employed to evaluate transition in land use/land cover and to estimate changes in the area. Global Positioning System (GPS) receiver was used for the collection of coordinate points for ground truthing and reference points for supervised classification and accuracy assessment.

3.2.1.1 Land use / land cover classification and accuracy assessment

Classification of remotely sensed data was carried out using QGIS version 2.6. The images were classified, and the newly classified categories were calculated for accuracy (error matrix) and Land use/cover change detection.

Image classification

Different methods are available for classification and the choice of the method depends on the resolution of the image and availability of classification software, among many factors (Lu *et al.*, 2011). For this study, a supervised approach and the maximum Likelihood algorithm for the classification of the images were used. Based on visual interpretation of remotely sensed data and the local knowledge of the area, four easily identifiable macro classes were identified.

Accuracy assessment

Accuracy assessments measure how close an image of unknown quality is to the standard image which is assumed to be correct (Campbell, 2007). An error matrix was used to assess such elements as the overall accuracy, omission error, commission error, and kappa

coefficient. In QGIS 2.6, the pixel of classified values for reference data were put in the accuracy assessment and finally the assessment report was generated.

3.2.1.2 Land use and Land cover change detection

The change detection entails finding the type, amount, and the location of land use changes over time. Post Classification Comparison (PCC), as one of the change detection approaches, was used for this study to identify changes in land use/land cover. PCC is frequently employed for comparing data from different sources and dates (Csaplovics and Zewdie, 2015). This approach determines "from-to" changes in order to identify the transformations among the land cover classes. PCC identifies changes by comparing independently classified multi-date imagery on a pixel-by-pixel basis using a change detection matrix. In this study, the change detection assessment was applied to individual image classification outputs in order to identify the respective change: 1991 - 2000, and 2000-2016. The products were the matrices and the categories of land use/land cover changes at the site. The observed change detection matrices were then processed in an intensity analysis program (Pontius *et al*., 2004). The product of the intensity analysis was loss, gain, net change, and swap. The analysis also determined which categories are relatively dormant versus active in a given time interval, as well as the percentage of the area persistence between two periods of time.

Loss, Gain, Net change and Swap of Categories and Intensity graphs

Following Pontius *et al.* (2004) and Aldwaik and Pontius (2012), the subsequent definitions (also Table1 as adopted from Pontius *et al*., 2004) were adopted;

The persistence (C_{ii}) is the area which remained under the same land use/land cover category over time and which, in a transition matrix, is indicated on the diagonal as in Table 1.

The gross loss of category (GL_i) is the difference between its initial area (C_i, t_1) and the persistence (Equation 1):

$GL_i = C_i,t_1 - C_{ii} \leq 0$……..……..……1

This is given in the last column on the right whereas the last row on the bottom indicates the gross gain of the category. The Gross gain of the category (GGi) is, as shown in equation 2

$GG_i = C_{i,t2} - C_{ii} \geq 0$…….……..….2

While the net quantity change is the absolute difference between the gross gain and the gross loss (Equation 3), and the overall change for each category is given as a sum of the gross gain and gross loss (Equation 4):

Net quantity change = $|GG_i - GL_i|$ 3

Overall change = $GGi - GL_i$ 4

The difference between the overall change and the net quantity which occurs when a land use/land cover category undergoes a simultaneous gain and loss is called Swap (Equation 5).

Swap = Overall change – net quantity change ……...……..5

Table 1: Transition matrix for comparing land use/cover categories of two maps from different points in time

	Time2					
	Category 1	**Category 2**	**Category 3**	**Category 4**	**Total time1**	**Gross Loss**
Time 1						
Category 1	$\mathbf{C_{11}}$	C_{12}	C_{13}	C_{14}	$C_{1,t1}$	$C_{1,t1}$-$\mathbf{C_{11}}$
Category 2	C_{21}	$\mathbf{C_{22}}$	C_{23}	C_{24}	$C_{2,t1}$	$C_{2,t1}$-$\mathbf{C_{22}}$
Category 3	C_{31}	C_{32}	$\mathbf{C_{33}}$	C_{34}	$C_{3,t1}$	$C_{3,t1}$-$\mathbf{C_{33}}$
Category 4	C_{41}	C_{42}	C_{43}	$\mathbf{C_{44}}$	$C_{4,t1}$	$C_{4,t1}$-$\mathbf{C_{44}}$
Total time 2	$C_{1,t2}$	$C_{2,t2}$	$C_{3,t2}$	$C_{4,t2}$	$C_{1,t2}$	
Gross Gain	$C_{1,t2}$-$\mathbf{C_{11}}$	$C_{2,t2}$-$\mathbf{C_{22}}$	$C_{3,t2}$-$\mathbf{C_{33}}$	$C_{4,t2}$-C_{44}	$\sum C_i$	

Sources: Adapted from Pontius *et al*. (2004).

NOTE: The persistence of a category is indicated on the diagonal (bolded) and the change of the main diagonal; the gross gain and the gross loss of a category are given on the last row and column respectively.

The intensity graphs were also generated. This helps to measure how the size and intensity of both gross losses and gains vary across space (Aldawaik and Pontius, 2012). The bars that extend to the right of the vertical axis show the intensity for categories annual gain and loss. The vertical line in dashes is the uniform line for time interval at this category intensity level. If the intensity bar ends on the left of the uniform line, then the change is relatively dormant for that category for that time interval. If an intensity bar extends to the right of the uniform line, then the change is relatively active for that category during that interval. If the changes were distributed uniformly across the total area, then all the bars would end at the uniform line.

3.2.2 Identification of socio-economic factors that influence land use/cover dynamics

3.2.2.1 Research design for socio economic survey

A cross-sectional study design was used, whereby data were collected at one point in a time. Purposive sampling of villages was used whereby three villages in Melela ward were selected based on population of pastoralists and high prevalence of different land uses.

3.2.2.2 Sample size

A systematic random sampling was used to obtain a total of 30 households from each village registry book in the ward. This was a reasonable sample size; according to Nzunda, (2011) and Delice (2010), a sample of at least 30 units at 5% confidence interval is sufficient irrespective of the population size. In order to obtain a sufficient large sample size for satisfactory statistical inferences, a minimum of 30 households were targeted for each study village.

3.2.2.3 Data collection and analysis procedure

Data collection in this research was done in two phases; the first phase was pre-testing which was aimed at testing the validity of the data collection tools. The pre testing phase helped the researcher in modifying tools for actual data collection during household survey.

Primary data source

Scheduled Interview with closed and open-ended questions was conducted to key informants and the selected households to develop a set of hypothesis on socio economic factors that cause changes in land use/land cover. These hypotheses were used to construct a set of questions to ask veteran residents during interviews. The interview was meant to obtain information on the perceptions towards the causes of land use/land cover changes in three periods. The targeted respondents were those who lived in the plain for at least 10 years, and the majority had lived in the valley for 30 or more years. The interview was conducted in each village in a location where landscape could be viewed and discussed. Each respondent was asked to describe major changes in human population growth, income level, market availability, beliefs and attitude, land tenure system, education level, crops grown, and livestock keeping practices. For each major change, participants were asked to explain why the change had occurred and what part of the landscape was affected and this would help to describe the perception of land use/land cover changes (Appendices 2 and 3).

Secondary data source

Secondary data sources were obtained from documentary materials (government reports, research reports, village records and various publications). Socio economic data, as part of secondary data, were obtained from literature.

Focus group discussion

Focus Group Discussion (FGD), which is one among the most widely used methods in collecting qualitative data, was used in this study. FGD method provides the opportunity for small groups of respondents to interact and build on what others in the group have said. A checklist of guiding questions was used in the FGD (Appendix 2).

Key informants

Informal interviews were carried out with government officials, village government leaders, traditional leaders, and extension workers. These respondents were considered as key informants. According to Meteric (1993), key informants are people who are accessible, willing to talk and have great knowledge regarding the issues under discussion.

Data analysis

The analysis was done using quantitative methods including descriptive statistics.

3.2.3 Determination of effects of land use/land cover change on pastoral community and production

Focus group discussion and scheduled interview were used to collect information on how land use/land cover dynamics impacts on pastoral communities and agricultural production. Each participant was asked to indicate livestock ownership, farm size, migration patterns, migratory routes, proximity of farm plots and grazing area, proximity to water sources, and incidences of livestock diseases. Four land use/land cover classes were investigated namely woodland, agriculture, wetland, and grassland / shrub land. These were envisaged to show how land use/cover changes affect livestock production system in terms of grazing resources, water resources, migratory routes, and incidence of livestock diseases.

The analysis of the effect of land use and land cover dynamics on pastoral community and production was done using quantitative methods. The collected data were sorted, coded and entered in the Statistical Package for Social Sciences (SPSS). Descriptive statistical analysis was carried out, this includes frequency distribution. A table of percentages was used to summarize the results from the households' questionnaires.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Land Use/Land Cover Changes (1991-2016)

Variation of different land use/cover changes resulting from human activities and other drivers in Melela Ward were studied. The analysis involved land use/land cover classes for the years 1991, 2000, and 2016. Accordingly, four land use /land cover classes namely woodland, Agriculture, Wetland, grassland/shrub land were identified (Table 2 and Appendix 1). The identified land use/land cover categories revealed the changes in land use/land cover that have taken place during the study period.

Table 2: Land Use Land Cover 1991, 2000, and 2016

	1991		2000		2016	
Land use/Land Cover classes	**ha**	**%**	**ha**	**%**	**ha**	**%**
Woodland	34800	57.0	33900	55.6	16700	27.4
Agriculture	3700	6.1	4400	7.2	20000	32.8
Wetland	5100	8.4	5700	9.3	1400	2.3
Grassland/shrubland	17400	28.5	17000	27.9	22900	37.5
Total	**61000**	**100**	**61000**	**100**	**61000**	**100**

Table 2 and Figure 2 show the total area in hectares and percentage covered by each land use/land cover class in 1991, 2000, and 2016. The results in Tables 3 and 4 show land use/cover classes coverage and a changing trend across the two epochs (1991-2000 and 2000-2016) in terms of land use/land cover classes loss and gain. In 1991, the largest area is shown to be covered by woodland 34800 ha (57%), followed by Grassland/shrubland 17400 ha (28.5%). Agriculture has the least land use cover of 3700 ha (6.1%) followed by Wetland with 5100 ha (8.4%).

A similar trend is recorded in 2000 but with minor variation. In 2016, the largest area is shown to be covered by grassland/shrub land 22900 ha (37.5%), followed by agricultural land 20000 ha (32.8%), woodland 16700 ha (27.4%), and then wetland 1400 ha (2.3%).Woodland appears to have been cleared by the year 2016. The clearance of woodland can be attributed to agricultural expansion, increased number of livestock, and excessive charcoal burning which have been going on from 1991 to 2016 as reported by respondents.

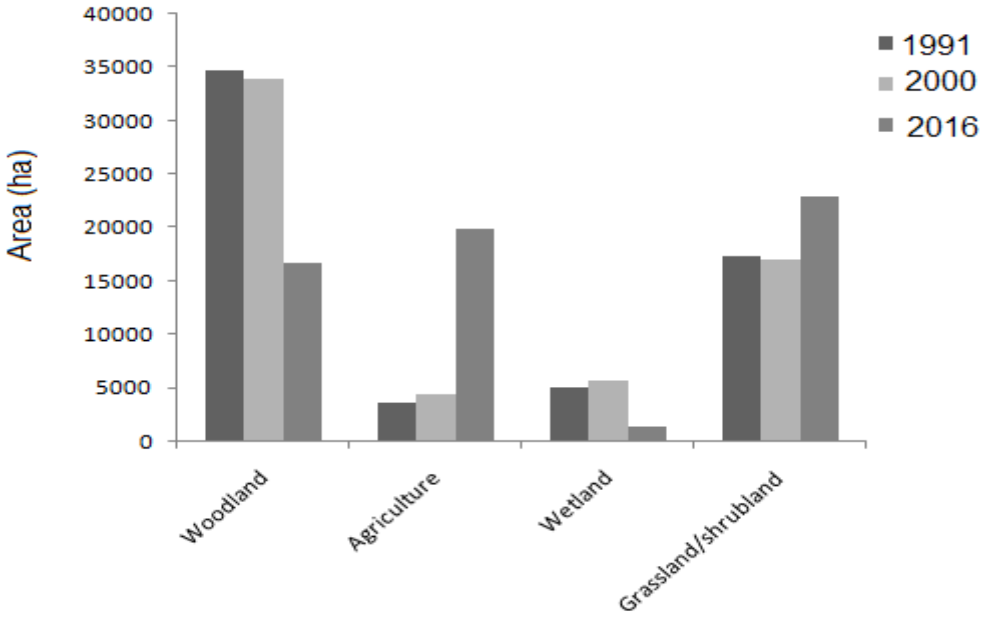

Figure 2: Distribution of land use/land cover for 1991, 2000 and 2016

Table 3: Cross tabulation matrix showing observed persistence (on the main diagonal) and observed Land Use/Land Cover Changes (off the main diagonal) for Melela from 1991 - 2000

		2000					
		Woodland	**Agriculture**	**Wetland**	**Grassland/ Shrubland**	**Total 1991**	**Gross loss**
	Woodland	**20859.93**	2377.98	3387.78	6367.95	32993.64	**12133.71**
	Agriculture	2124.9	**355.14**	461.61	388.62	3330.27	**2975.13**
1991	**Water/Wetland**	3157.74	290.52	**788.13**	563.85	4800.24	**4012.11**
	Grassland/ Shrub land	6728.4	1196.19	710.46	**9441.27**	18076.32	**8635.05**
	Total 2000	32870.97	4219.83	5347.98	16761.69	59200.47	**27756**
	Gross gain	**12011.04**	**3864.69**	**4559.85**	**7320.42**	**27756**	

Table 3 shows that the largest gross loss in 1991 – 2000 was experienced by woodland (12133.71 ha), followed by grassland/shrub land (8635.05 ha), wetland (4012.11 ha) and agriculture (2975.13 ha).

Table 4: Cross tabulation matrix showing observed persistence (on the main diagonal) and observed Land Use/Land Cover Changes (off the main diagonal) for Melela from 2000 - 2016

		2016					
		Woodland	**Agriculture**	**Wetland**	**Grassland/Shrubland**	**Total 2000**	**Gross Loss**
2000	Woodland	**11072.34**	7877.97	795.06	14094.45	33839.82	**22767.48**
	Agriculture	843.66	**2135.43**	76.68	1314.54	4370.31	**2234.88**
	Wetland	1851.75	993.87	**479.16**	2326.41	5651.19	**5172.03**
	Grassland/Shrubland	2949.03	8946.9	38.61	**5132.07**	17066.61	**11934.54**
	Total 2016	16716.78	19954.17	1389.51	22867.47	60927.93	**42108.93**
	Gross Gain	**5644.44**	**17818.74**	**910.35**	**17735.4**	**42108.93**	

Woodland and grassland/shrub land (Table 4) had a net quantity loss of 22767.48 ha and 11934.54 ha respectively. In 2000 – 2016, the largest gross gain was for agriculture (17818.74 ha), followed by grassland/shrub land (17735.4 ha), woodland (5644.44 ha) and wetland (910.35 ha).

Table 5: Quantitative changes for Melela between 1991 and 2000

Years	**LULC classes**	**Gross Gain**	**Gross Loss**	**Sum**	**Net quantity change**	**Swap**
1991 -2000	**woodland**	12011.04	12133.71	24144.75	-122.67	24267.42
	Agriculture	3864.69	2975.13	6839.82	889.56	5950.26
	Wetland	4559.85	4012.11	8571.96	547.74	8024.22
	Grassland/Shrubland	7320.42	8635.05	15955.47	-1314.63	17270.1

The findings in Table 5 indicate that woodland had the greatest gross gain of 12011.04 ha and the greatest gross loss of 12133.71 ha with a net quantitative change of 122.67 ha.

This is followed by Grassland/Shrub land which shows the greatest gross gain of 7320.42 ha and the greatest gross loss of 8635.05 ha with a net quantitative change of 1314.63 ha. Agriculture had the least gross gain of 3864.69 ha and the least gross loss of 2975.13 ha with a net quantitative change of 889.56 ha. This is followed by wetland which showed the gross gain of 4559.85 ha and the gross loss of 4012.11 ha with a net quantitative change of 547.74 ha.

Table 6: Quantitative change for Melela between 2000 and 2016

Years	LULC classes	Gross gain	Gross loss	Sum	Net quantity change	Swap
2000-2016	**Woodland**	5644.44	22767.48	28411.92	-17123.04	45534.96
	Agriculture	17818.74	2234.88	20053.62	15583.86	4469.76
	Wetland	910.35	5172.03	6082.38	-4261.68	10344.06
	Grassland/Shrubland	17735.4	11934.54	29669.94	5800.86	23869.08

The findings in Table 6 indicate that agriculture had the greatest gross gain of 17818.74 ha and the gross loss of 2234.88 ha with a net quantitative change of 15583.86 ha. This is followed by Grassland/Shrub land which shows the greatest gross gain of 17735.4 ha and the gross loss of 11934.54 ha with a net quantitative change of 5800.86 ha. Woodland had the least gross gain of 5644.44 ha and the greatest gross loss of 22767.48 ha with a net quantitative change of 17123.04 ha. This is followed by wetland which showed the gross gain of 910.35 ha and the gross loss of 5172.03 ha with a net quantitative change of 4261.68 ha.

The category level intensity analysis compares the intensity of gain and loss for a particular class in a given time interval (Figs. 3 - 4). The analysis provides a graphical approach of intensity analysis at category (class) level whereby the dotted line indicates a uniform rate of change. The rate of change on the left of the uniform line (i.e. rate of

change less than uniform) indicates a dormant class change and on the right of the line (i.e. rate of change greater than uniform) indicates an active class change. Similarly, category analysis shows whether or not the pattern of category is stable across time intervals in terms of gains and losses. If the intensity of a category's gain/loss is greater (changing at a rate faster) or less (changing at a rate slower) than the uniform line for both time intervals, that particular category is said to be stationary, otherwise it is dynamic.

The results of intensity analysis at category level for 1991 – 2000 and 2000 – 2016 respectively are given in Figures 3 and 4. During 1991 – 2000, the classes showed significant activeness in both gains and losses. Woodland was most active in gaining, followed by grassland/shrub land. Wetland and agricultural land were more active in losing. During the period 2000 – 2016 (Fig. 4), agricultural land and grassland/shrub land were dormant in losing and active in gaining especially the agricultural land. A similar observation was made by Zewdie and Csaplovies (2015) who noted that in North West Ethiopia the crop land expanded further to reach 22.56% of the total area during the period from 1984 to 2000. And from 2000 to 2010, cropland areas stretched further to 55.23% of the total area. Woodland was the major loser to the newly emerged cropland. These significant increases in croplands coupled with rapid population growth and recurrent drought contributed to major deforestation and woodland degradation (Lemenih *et al.*, 2012). Different studies also showed gains in agricultural areas and losses in the woodland areas. As Kisoza, (2007) reports, the cultivation area has undergone a slight loss of – 416 ha, which is equivalent to – (0.2) percentage. The loss is probably due to the reason that the area of cultivation reverted into bush and fallow land.

This could be a result of increased population growth, increased pastoral activities, increased catchment degradation, expanded market and increased conflicts over resources. Interviews with farmers and ground truth exercise ascertained this finding, and most

woodland and bushland areas were found to be cleared for agricultural purposes. Also, tree felling for economic charcoal production was found to be a dominant activity in the villages close to woodland.

According to Lyoba (2009), land degradation in the refugees' settlement in Ulyankulu for the period of 1978, 1984, 1994 and 2006 has led to an increase in the cultivated land and grassland, and a decrease of woodland and forest lands. An increase in population was reported to be a major driver of land use changes in these areas.

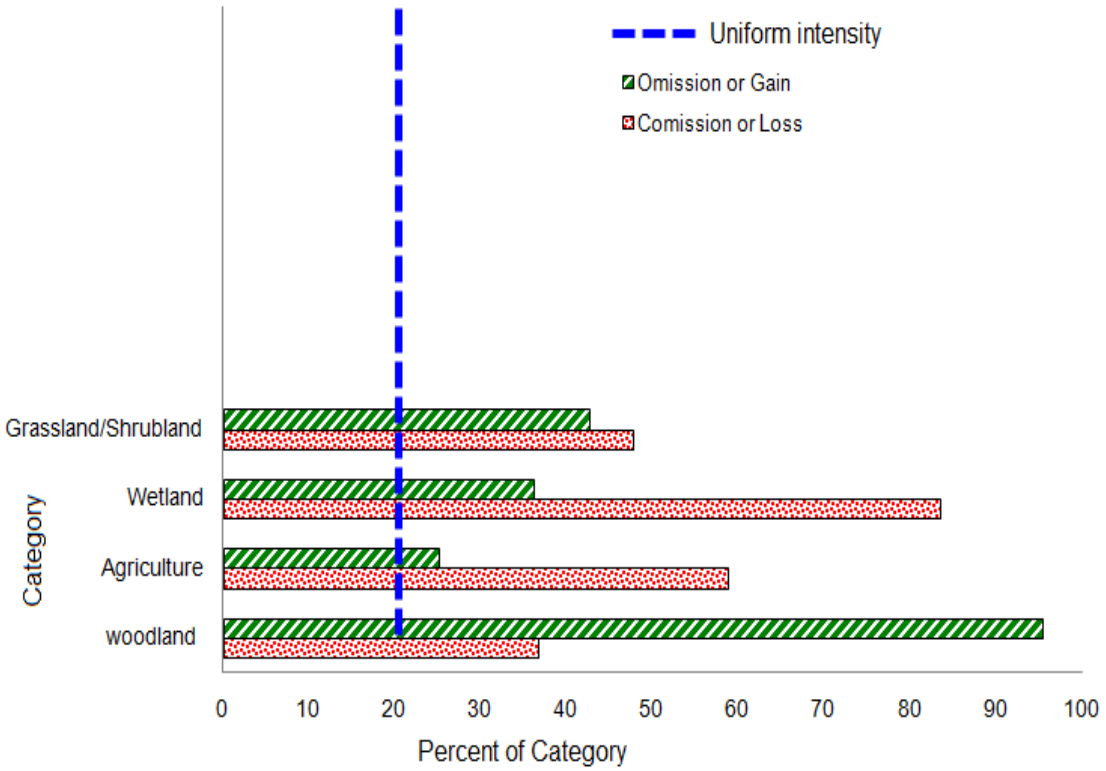

Figure 3: Category intensity analysis for Melela 1991 – 2000

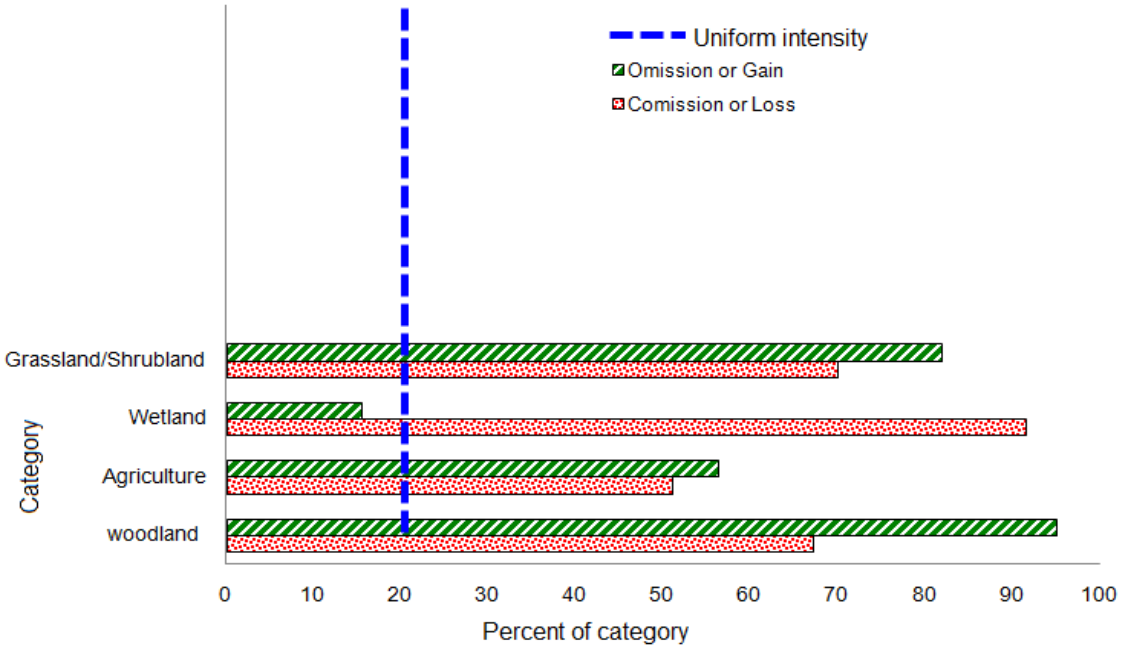

Figure 4: Category intensity analysis for Melela 2000 – 2016

4.2 Socio-economic Factors Influencing Land Use/Land Cover Changes

LULC change was driven by various socio-economic factors such as Level of Education, influx of immigrants of other ethnic group, land tenure and land acquisition as shown below.

Table 7: Summarized Age of the respondents

	Age of the respondent	
	Frequency	**Percent**
18 – 30	12	13.3
31 – 45	39	43.3
46 – 60	21	23.3
Over 60	18	20.0
Total	**90**	**100.0**

The findings in Table 7 reveal that the majority (about 43.3%) of the respondents in Melela ward belonged to an age group ranging from 31 to 45 years old, and about 13.3% were relatively young with less than 30 years of age. However, all these age distributions

indicate the experience level of the respondents in different fields of land use dynamics and pastoral production potential and community livelihood.

Table 8: Level of Education of the People in Melela ward

	Frequency	Percent
No formal education	32	36
Adult education	9	10
Primary education	44	49
Secondary education	4	4
College	1	1
Total	**90**	**100.0**

The findings in Table 8 indicate that about 49% of the respondents completed primary education while 36% had no formal education. The percentage of respondents with education above Secondary School level is only 1%. An increase in the level of education of the community reduces the possibility of land degradation. An educated person is more knowledgeable on the wise use of land resources. Majority of the respondents required a work force to assist in seasonal movement of the herds and in cultivation of the land. Thus, the social system preferred employment at young age rather than pursuing higher education.

In this respect, loses of woodland is driven by economic or income related factors which included charcoal burning. Thus, education tends to improve the economy of the society and thus reducing dependence on land resources. As Nzunda *et al*. (2013) observe, education tends to create awareness, positive attitudes, social values, and motivation which stimulate self-reliance. Educated rural households are more productive and are more likely to use off farm income earning opportunities than none educated households.

Reporting on the disadvantages of low education on resources use, a study by Nzunda *et al*. (2013) in Zambia reveals that, people with low education could not recognize the impact of clearing forests for cultivation while the educated people were capable of seeing the relationship. This implies that education level has a crucial impact on the management of local natural land resources among rural households thus reducing pressure on land resources.

Table 9: Responses on influx of immigrants of other ethnic group

	Frequency	**Percent**
Yes	81	90
No	9	10
Total	**90**	**100**

Population growth in certain places is normally facilitated by several factors including the availability of land, which provides room for migrants to establish settlements. It was observed that the community in Melela ward was experiencing an influx of immigrants, and 90% of whom were pastoralists. According to the respondents, the major driver of immigration was availability of unrestricted land for grazing and free access to water. This observation concurs with the findings in a study by Lesslie *et al*. (2011); and that by Hamza and Iyela (2012) who reported that high population growth rates coupled with relatively unrestricted access to land have led to significant land use/land cover changes on native vegetation covers such as grasslands resulting from an increase of demands for food. An increase in population pressures, mainly through migration, is associated with an increase in human dominated cover types, resulting in a decrease of the native grazing lands in some parts of the world (Olson *et al*., 2008). As population increases, pressure on resource availability including productive land also increases (Lesslie *et al*., 2011). This

trend leads to a shift of agricultural production to including native grazing to higher value production such as intensive crop production or modified pastures (Brink and Eva, 2009). However, the impact of increasing population pressures has in some instances led to losses of grassland/shrub land and gain in agriculture with crop residues being used as pasture for livestock. A similar finding is reported by Makokha *et al*. (2013) who reveal that the impact of increasing population pressures has led to loss of natural and managed herbaceous pasture crops. Logging of trees for timber extraction was reported to have led to gains in natural pastures (Lambin *et al.,* 2003). Other pressures associated with population changes include loss of grazing land to give way to built-up areas leading to the expansion of urban and rural residential areas (Lesslie *et al*., 2011; Olson *et al*., 2008; Fuchs *et al*., 2015).

Table 10: Respondents' perceptions on Land uses that help Melela community make choices on livelihood options

	Frequency	**Percent**
Fire wood and charcoal making	14	15
Selling livestock and livestock product	47	52
Selling harvested crops	26	29
Farming horticultural crops	6	7
Total	**93**	**103**

*Respondent has more than one option.

The results in Table 10 indicate that there was a quick option in making life through market availability and good prices for the products. This means that 52% of the respondents depend on the sales of livestock and livestock products. Seven percent opted for farming horticultural crops with other options. This implies that an increase of cash in one of the land use/land cover changes motivates the respondent to increase the use of land in order to sell and harvest more in the following season or years. The results show further that, market pressure plays a significant role in land use/land cover changes. For

example, it was observed that the price of cash crop, which is cotton, was one of the factors that had a positive influence on the expansion of agricultural land because it attracted more farmers into expanding areas of cultivation. Similarly due to an increase of immigration by pastoralists, some of the respondents shifted to charcoal making instead of farming. As Lesslie *et al*. (2011) report, market pressures also play a significant role in land use/land cover changes. According to Lambin *et al*. 2001), grazing lands are more prone to being developed as a consequence of conversion and intensification processes in response to triggers such as opportunities created by markets. For instance, changing opportunities with the development of national markets for crop commodities creates a pull factor towards crop production leading to land use/land cover changes (Hu *et al*., 2008). As highlighted by Reid *et al.* (2004), people residing in grazing areas, as elsewhere, respond to opportunities with the development of external markets such as those dealing with crop farming leading to grazing habitat conversion, modification, and fragmentation. New economic pressures with the development of market economies have also been observed to bring changes in land tenures and subsequently land uses in pastoral systems (Sternberg, 2008). The evolving of new pastoral land tenure systems towards private possession of land have has been reported elsewhere to have resulted in increased conversion, modification, and fragmentation of grazing lands with significant environmental implications Adams *et al.* (1999).

Susceptibility of grazing land to dynamic changes is a result of market inefficiencies in the form of distorted market prices for land and livestock outputs, among others (Makokha *et al.*, 2013). For instance, with the increasing demand for crops, high prices of crops are reported to lead to an increase of profits from crops (Johansson and Azar, 2007). This trend has, in turn resulted in the expansion of not only cropland but also grazing land despite the fact that the costs for cultivation in grazing lands are higher than those on

croplands. Furthermore, low benefits from livestock production are reported to compel livestock producers into adopting alternative means of sustaining livelihood.

Table 11: Respondents' perception on land tenure

Land ownership	Frequency	Percent
Yes	88	98
No	2	2
Total	**90**	**100**

Table 12: Respondents' responses of on land acquisition

Land acquisition	Frequency	Percent
Bought	21	23
Rented	2	2
Inherited	26	29
Allocated by government	29	32
Bush clearing	12	13
Total	**90**	**100**

The findings in Table 11 indicate that 98% of the respondents own land. Security of land tenure over land occupied by household significantly leads to gains and losses of intensity on land uses such as unplanned farms or unrestricted grazing land. Usually, insecure pieces of land in Melela ward were occupied without title deeds or certificate of occupancy. Land is inherited and belongs to certain clans. Lands which are demarcated by customary leaders are normally not respected by the occupier, who may abandon it as fallow land, build settlement or cultivate small pieces of land for demarcation. This situation might have been the cause of poor land use practices such as free access to grazing land and expansion of agricultural farms, clearing of woodland through charcoal burning, and other unnecessarily land uses which were observed during the field survey in the area. The findings in Table 12 indicate that only 32% of the respondents who are mainly nomadic pastoralists and live communally in Mela village obtained land through

Government allocation. This land allocation was aimed at reducing land use conflicts between pastoralists and farmers. The findings show further that 29% of the respondents obtained land through inheritance, when family grew in size they slash the bushes and cut down trees to establish new settlements and farms. Other factors such as policy, land tenure, and land potential were reported to affect land-use change as well (Homewood *et al.*, 2001, Campbell *et al.*, 2005). As reported by Msoffe (2011), changes in land tenure, which are driven by governmental policies since the colonial era, have played a significant role in land use change across the Maasai Steppe particularly in the Tarangire ecosystem. In the pre-colonial period, when the land was communally owned and resources were abundant, pastoralists were few and ranged freely, which allowed sustainable use of rangeland resources. After independence, government policies continued to encourage agriculture at the expense of pastoralism (Shivji, 1998). The Villagization Policy of 1974, which forced people to live in nucleus villages, enhanced the sedentarization of nomadic pastoralists.

The Land Acts of 1999, which gave villagers more autonomy over land use (Tenga *et al.*, 2008) accelerated the sedentarization of the pastoral communities. These changes in land tenure led to rapid population growth, as a result of autochthonous growth and immigration of people from other regions seeking for arable land (Mwalyosi, 1991, Campbell, 1999) with young people being attracted by mining activities (Igoe, 2000).

Table 13: Respondents' perception on factors that lead to Land use / cover change

	Frequency	**Percent**
Level of illiteracy	16	18
Poor agricultural technology	26	29
Economic factor (market and level of income)	33	37
Social and health factor	19	21
Soil degradation	36	40

Findings in Table 13 indicate that soil degradation, which accounts for 40%, and the level of illiteracy which accounts for only 18% are likely to influence land use /land cover change in Melela. Soil degradation is mainly caused by an increased in livestock keeping and immigrants of pastoralists searching for pasture and water and for pests and disease free areas.

The perceived degradation of grazing land increases the likelihood of having a village communal grazing land degraded. Most of the pastoralists consider the village communal grazing lands as being in good condition; they are also committed to sustaining productivity of their land. But in Melela ward, communal grazing land continues to be degraded due to overgrazing. This could be one of the reasons which forced pastoralists in Melela plains to engage into seasonal movement of their herds to alternative grazing lands in the neighbouring farmers' villages and to open access land. The move also aimed at easing pressure on grazing land in their villages. Some of the pastoralists are proposing to limit the number of livestock, which can be grazed on village communal grazing land per household but the increase in the number of livestock owning households is likely to increase overgrazing on the village communal grazing lands. Similar findings are reported by Kisoza (2007) on pastoralists in Mkata plain who manage village communal grazing land.

4.3 Impact of LULC Change on Pastoral Community Livelihood and Production Potential.

The perceptions of the respondents on the impact of LULC dynamics on feeding system, availability of pasture, distance covered to grazing land, availability of grazing area, access to water sources and incidence of diseases are as shown in Tables below.

Table 14: Respondents' responses on feeding system

	1991		2000		2015	
Feeding system	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**
private pastures	4	4.4	0	0	2	2.2
Communal	75	83.3	83	92.2	81	90.0
Mixed	11	12.2	7	7.8	7	7.8
Total	**90**	**100**	**90**	**100**	**90**	**100**

Table 14 shows feeding systems among livestock keeping communities. The findings indicate that about 90% of the pastoralists depend on communal land for grazing. The impact of LULC dynamic on pastoral production has been observed using satellite imagery and these confirmed the dynamics of pastoral production in Melela Ward. As for gains in agricultural and grassland/shrubland, the respondents reported to have been feeding their livestock more on communal land (Table 14) reported by 83.3% in years 1991 - 2000 (and by 90% in the year 2000 - 2015 while private pastures were used to feed livestock reported by 4.4% in the years 1991 - 2000 and by 2.2% in the years 2000 – 2015. Impacts of LULC dynamics on availability of pasture are as shown in table Table 15.

Table 16: Respondents' responses of on availability of pasture

	1991		2000		2015	
Availability of pasture	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**
Adequate	70	77.8	22	24.4	14	15.6
Inadequate	20	22.2	68	75.6	76	84.4
Total	**90**	**100**	**90**	**100**	**90**	**100**

Table 17: Respondents' responses on distance covered to grazing land

	1991		2000		2015	
Distance covered to grazing land	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**
Less than 1km	25	27.8	0	0	0	0
2-5 km	50	55.6	23	25.6	6	6.7
6 – above	15	16.7	67	74.4	84	93.3
Total	**90**	**100**	**90**	**100**	**90**	**100**

Table 18: Respondents' responses on grazing area

	1991		2000		2015	
Grazing area	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**
reduced thus increase stoking pressure	64	71.1	68	75.6	68	75.6
increased thus decreased grazing pressure	2	2.2	4	4.4	2	2.2
remain the same	24	26.7	18	20.0	20	22.2
Total	**90**	**100**	**90**	**100**	**90**	**100**

Table 19: Respondents' responses on water source

	1991		2000		2015	
Water source	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**
Permanent river	22	24.4	8	8.9	4	4.4
Seasonal river	18	20.0	21	23.3	10	11.1
Dam/ponds	2	2.2	18	20.0	31	34.4
Mixed	48	53.3	43	47.8	45	50.0
Total	**90**	**100**	**90**	**100**	**90**	**100**

Findings in Table 15, 16, 17 and 18 respectively, in response to pasture availability, distance covered, grazing area and water source indicates that, availability of pasture was adequate in 1991 - 2000 (77.8%) but reduced in 2000 - 2015 (84.4%). Distance covered by herders looking for pasture was 6 km and above in the year 2000 - 2015 (93.3%) and was less than 1 km in 1991 - 2000 (27.8%). Grazing area in 2015 (75.6%) was reduced thus increased stoking pressure. Water sources in 1991, about 53.3% of the pastoralists used available water from permanent rivers, seasonal rivers, and dam/ ponds.

These changes have occurred due to the increase of immigrant pastoralists and agriculture practice. This findings in assessing spatial changes in livestock distance covered, response to water, pasture availability and grazing area is in line with study by Ernest *et al.,* (2017) who reported that water and pasture availability on livestock routes under a changing climate Ilemela and Magu Districts. The study revealed that approximately 5% of stock

routes have been lost, 3% have been narrowed, and 92% are now used as village roads. Changes have occurred due to the increase of settlements and cultivated area. These anthropogenic activities have resulted to a general decline of grazing land, water sources, woodland and land use conflicts between pastoralists and farmers.

Table 20: Respondents' responses on access to water sources

Access to water source	1991		2000		2015	
	Frequency	%	Frequency	%	Frequency	%
limited supply	28	31.1	65	72.2	72	80.0
unlimited supply	62	68.9	25	27.8	18	20.0
Total	**90**	**100**	**90**	**100**	**90**	**100**

However, access to available water source (Table 19) became limited in 2015 (80%) due to blocking of the migratory routes to water sources. Land degradation was another reported limiting factor to accessing water sources due to overgrazing and encroachment of agriculture in wetlands.

The findings showed further that dry season wetland areas had a reduction of vegetation and the water dried completely due to overgrazing and agricultural expansion. The respondents reported of the emerging expansion of farming areas adjacent to the rivers. It was also reported that immigrant pastoralists from different places are coming to the area searching for water and pasture. Immigrants began to migrate after the village and government plans for land use came into effect. Mela village was designated for pastoralists and pastoral production. As reported by Sulieman and Ahmed (2013), the areas along the rivers suffer from overgrazing due to overstaying of pastoralists in the same areas. Overstocking around permanent water supplies is another serious problem causing loss and or degradation of the grazing value of the areas.

Table 21: Respondents' responses on incidence of diseases

Incidence of diseases	1991		2000		2015	
	Frequency	**%**	**Frequency**	**%**	**Frequency**	**%**
less severe	46	51.1	12	13.3	10	11.1
Severe	28	31.1	25	27.8	23	25.6
more severe	16	17.8	53	58.9	57	63.3
Total	**90**	**100**	**90**	**100**	**90**	**100**

The results in Table 20 indicate that incidences of diseases were less severe in 1991 (51.1%) but were more severe in 2015 (63.3%). The dynamics of using grazing land for agriculture and other uses reduce the prevention potential against infectious diseases in livestock. According to the respondents, when mobility is increasingly restricted, traditional strategies such as grazing cattle in a disease free zone become more difficult to practice. This has resulted in the losses of grazing lands because livestock is forced to share pasture and water in a confined land and this increases the risk of the spread of livestock diseases such as Lumpy skin disease, African swine fever, bluetongue and theileria parva infection Karstad *et al*. (1981). Similar findings are reported in a study by Lankester and Davis (2016). The authors worked on the uses of grazing land near Lake Naivasha in Kenya, and found out that as grazing options become increasingly limited, herds were forced to share pastures, which increases the risk of transmissible and vector-borne diseases.

Overgrazing, expansion of rain fed agriculture, and charcoal burning have exposed the soil surface to accelerated water erosion in areas along the Melela River. This reduces vegetation cover and expose of soil surfaces to erosion leading to more land degradation. Similar observation was made by Wezel and Haigis (2000) who report that a decrease or

disappearance of certain plant species reduces vegetation cover and increases the exposure of soil surfaces to wind and water erosion, leading to more land degradation.

The gain in agriculture, which has been detected in LULC dynamics analysis, was in agreement with the respondents' observation when responding to the challenges facing the routes. The respondents admitted to have been buying the route from farmers so as to access water from the river during the cropping season. However during the dry season, pastoralists access the routes by force thus leading to conflicts with farmers. This is because farmers try to cultivate some parts of the available land and leave other parts as fallow land. Thus, pastoralists use fallow lands to graze their animals. Therefore, conflicts between farmers and pastoralists mainly occur in the rain and post-rainy seasons because pastoralists' would graze their animals near farming plots. As Sulieman and Elagib (2012) observe, livestock mobility is increasingly becoming challenging. According to the authors, land degradation and blocking of animal routes are one of the main factors that lead to pastoralist sedentarization, urbanization and the breakdown of traditional pastoralist livelihood systems. In addition to loss of grazing land, agricultural expansion has also blocked livestock migratory routes between dry and wet season pastures, and between the herds and their daily watering points. The authors reveal further that the situation is more or less similar with situation that exists in other countries in Africa where commercial agriculture is reported to threaten the existence of livestock migration routes (Flintan, 2011).

Grassland/shrubland is the prevailing LULC in the Melela area, field visits and interviews with herders clearly showed that qualitative degradation in terms of composition is evident. Domination of inedible species has been observed in many villages in the area. This trend could be attributed to communal grazing system which has been used by

pastoralists since the establishment of these villages. According to the herders, species of higher nutritive value have almost completely disappeared. Villagers depend only on edible species which are found in Mkata ranch and Mikumi National park, which are not freely accessible. Sometimes, villagers illegally get to Mikumi National park in search for edible species but end up getting caught by game reserve officers who submit these villagers to paying fines. The respondents considered open access and uncontrolled grazing as the principal causes of overgrazing and land degradation. Communal grazing lands require individual users to come together and decide on the optimal number of livestock to be allowed in the village and then distribute grazing rights among all users so that the total number of livestock does not exceed the carrying capacity of the land. However, experience has shown that in the absence of strong institutional controls over individual stocking decisions, it is difficult to enforce this kind of agreement (Kisoza, 2007).

Shrubland and woodland cover are decreasing in Melela and edible woody species are disappearing due to heavy browsing especially in the vicinity of settlements and where water sources are available. It is clear that selective grazing in Melela has led to severe vegetation transformation. Woody vegetation is currently predominant in the depressions and hills consisting mainly of inedible species. As reported by Suleiman and Ahmed (2013), the disorganized use of grazing lands by ethnic groups has led to a rapid spread of desertification which is further aggravated by droughts.

According to herders, the amount and timing of precipitation were the most important determinants of change in vegetation. The authors consider factors such as changes in rainfall pattern as playing a significant role in LULC Change. For example, late and erratic rainfall is not favourable for the growth of edible vegetation, while it is suitable for the

growth of inedible vegetation to livestock. An erratic rainfall pattern makes it more difficult to predict grazing land productivity and changes where water and pasture resources are available, making pastoral production more uncertain than ever before. This trend coupled with conflict and other socio economic disadvantages make pastoralists less able to cope with the changes.

Table 22: Perception of respondents on access to crop residue on the fields belonging to farmers in Melela

Access to crop residue on the field belongs to farmers	Frequency	Percent
Freely available	16	17.8
Purchase	48	53.3
Negotiate with farmers	26	28.9
Total	**90**	**100**

The findings in Table 21 show that crop residues from agricultural land represent the supplementary forage sources for the livestock. These observations are consistent with the findings in a study by Kisoza, (2007) who revealed that crop residues formed a significant portion of the livestock diets in Mkata plain. Therefore to some extent, pastoralists have secondary access rights to crop residues in the farming villages after the harvest of the crop.

Table 23: Respondents' responses on availability of grazing land

Reasons for inadequate of available grazing land	Frequency	Percent
Too many animals	30	33.3
encroachment by farmers	12	13.3
all of the above	26	28.9
None	22	24.4
Total	**90**	**100**

The increase of agricultural land in Melela is the main factor for natural vegetation losses in the ward, and bridges the gap in forage supply for pastoralist livestock that results from

agriculture. But this matter needs careful examination as it causes seriously conflicts with farmers. Although the supply of natural grazing land and forage in Melela area has been depleted due to recent changes in land use, these resources are now supplemented by livestock feed sources which are provided by arable farms. Crop residues, fallow fields, and failed crops now provide grazing and forage sources for the entire area.

Table 24: Responses on shortage of pasture

Experience shortage of pasture for livestock	Frequency	Percent
Dry season	65	72.2
Rainy season	11	12.2
All year around	14	15.6
Total	**90**	**100**

Initially, the pastoralists were free to enter the cultivated area after harvest and graze their livestock. In recent years however, pastoralists have been required to pay for gaining access to crop residue in agricultural lands. Similar findings are reported in a study by Kisoza, (2007) who reveals that access to crop residues in Mkata plain are available for sale.

Table 25: Adoption strategies used by pastoralist to ensure pastoral livelihood

Adoption strategies	Frequency	%
Vaccinate	58	64
Migrate to other sites	78	87
Purchase migratory routes	58	64
Maximize stocks	58	64

* Respondents have more than one adoption strategies

Results in Table 24 indicate that majority of the respondents adopt more than one strategies so as to continue pastoral livelihood. Table 24 indicates further that respondents migrate to other areas searching for pasture land and water. Majority of the respondents

usually move their livestock to dry grazing area during dry season with the aim of taking maximum advantage of crop harvesting season in Kilosa and coastal areas. During wet season they return back to their respective settlements. In another study, Kisoza (2007) reports of the prevalence of livestock mobility practices in terms of access to various grazing areas in Mkata plains and Ngorongoro area. The majority (94.8%) of the respondents in Mkata plains reported to have usually been moving their livestock to dry season grazing areas. A grazing cycle starts at the beginning of short rains towards the end of January, when the animals return to the permanent villages and continue to graze on village land throughout the rain season. As the dry season sets in in mid-May, the animals would be moved progressively towards pasture reserves along river banks. As the dry season advances towards the end of June, most of the herders would cross into farming villages to feed their animals on crop residues or have them graze on wetland patches found on river valleys.

Mobile livestock grazing is a traditional mechanism, which is practised by herders for coping with the changes induced by climate variability which affects availability of water and fodder at different places and times. In recent years however, pastoralists have shortened their pattern of mobility, to enable them make more frequent movements, especially during the dry season. According to the pastoralists, they have shortened their pattern of mobility so as to search for enough fodder and water for their herds. Therefore, some pastoralists have adopted partial sedentarization by leaving children, wives, and the elderly people in settled locations practicing agro pastoralism in order to make these movements practical and easier. These pastoralist groups benefit from having permanent settlements; this is evident in in Mela, Kibaoni and Mangae Villages where they (pastoralists) can access services such as health, markets, and education more easily. By so doing however, pastoralists do not intend to abandon their traditional ways of keeping

animals. Many have developed and advanced form of transhumance, as can be seen among the Maasai ethnic group in Melela ward. The movements of Maasai who practice agro pastoralism are no longer limited with lack of water in places where grazing is available for their animals. They (the Maasai) have developed a system of using local tankers, MODECO Dam, water ponds along seasonal rivers to supply water to the animals where they can have enough grass for grazing. During this period, some members of the families are settled in places where they can have access to the necessary services.

Destocking and splitting of herds into groups are the strategies adopted by many pastoralists in order to cope with climate variability and to provide money for purchasing crop residues. This finding is consistent with the findings of previous studies, such as Sulieman and Elagib (2012), on the Lahaween in eastern Sudan who revealed that natural resources have been considerably impoverished due to the decline of their pastoral resources. According to some of the respondents, in order to get pasture for their livestock, herders need to cross to Kilosa, Mikumi National park and the coastal areas during certain seasons. Before deciding to cross the border, they need to get permission from local tribal leaders on the Maasai side. However, transboundary conflicts between the Maasai and farmers are recurrent and have a long and complex history (Kisoza, 2007).

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The current study evaluated land use land cover dynamics and their impacts on pastoralism in Melela. Specifically, the study examined land use/land cover dynamics for the period from 1991 to 2016, identified socio-economic factors that influence land use/land cover dynamics and determined the effects of land use/land cover dynamics on pastoral community livelihood and production potential to provide current and historical profile of events at Melela Ward. Remote sensing and GIS techniques were used for data collection and change detection analysis was employed to assess the spatial and temporal land use/land cover change of the study area. Change detection analysis was used to detect changes in spectral signature of the image.

The study findings indicate that there is a significant change in LULC in Melela ward as evidenced by an increase in agriculture and a loss of woodland. The period 2000-2016 has shown gains of agricultural and losses of woodland areas. Changes in the crops grown, an increase immigration of pastoralists, population growth, charcoal burning and livestock keeping have all contributed to an overuse of the existing land resources, which resulted in significant variations in the spatio temporal patterns of land use changes with respect to specific socio economic drivers. The assessment of changes in the grazing land in Melela has shown that the current patterns would increase the population of pastoralists in the region, through an increase of immigrants among the pastoralists and grazing pressure. The results of this study quantify dynamics of land use/cover and its drivers on sustainable use of land. In the face of increasing population size, pastoralism, and charcoal burning,

there is a need for maintaining a balance on socio economic drivers and sustainable utilization of land use.

Study concludes that pastoral grazing patterns are threatened because of limited land. Land tenure systems have evolved overtime without embarking CPRs like grazing land and watering points under communal or private ownership. Physical and social political drivers have led to a decrease in flexibility among pastoralists in Melela ward. Thus, the study perceived land use/land cover change being among the factors that contribute to increased conflicts between pastoralists and farmers in Melela ward.

It is also concluded that participatory village land use plans (PVLUPs) in some villages is another aspect that needs to be considered in mitigating the impacts of land use/land cover changes on grazing patterns and formalization of land regimes under pastoral communities. This aspect can enhance resilience among pastoralists taking into account administrative boundaries, ecological as well as socio-economic aspects. Formalization of land ownership may reduce negative externalities. However, policies and legislations should realize that pastoral and agro communities share common interests. These communities are further dependent on each other ecologically and socioeconomically, especially through the exchange of goods and services. Therefore, any move to separate the two by means of policies and legislation may not provide an answer. Rather, we should come up with well-drawn participatory land use plans that take into account the interest of all land users.

This study has used LULC dynamic analysis using satellite imagery, in combination with local knowledge from pastoralists to quantitatively and qualitatively analyse the spatial-temporal changes from 1991 to 2016 on grazing resources in Melela ward. The

information generated from the LULC pattern of the study area is expected to be helpful in formulating policies and programmes that are required for development and Land use planning in the pastoral sector.

The assessment of changes in grazing land in Melela has shown that the current patterns would increase the existence of pastoralists in the region. Farmers see immigrants among the pastoralists and grazing pressure in their farms in Melela ward as some of the major problems that they face in the area.

Furthermore, pastoralists are denied access to water resources for their animals and are compelled to compete with settled villagers for access to land and water, which often leads to conflicts. Some Pastoralists have to make difficult choices of splitting their livestock into groups, and shift them to other regions, pay fines in case they are caught feeding the animals on raw crops or have their livestock graze in Mikumi National park. Pastoralists have to destock in order to buy crop residues and fetch water for their herds, so as to continue with their pastoral system of livelihood. Those who cannot afford such choices may risk losing their herds over time. However, even this choice is becoming partly difficult to achieve since some of the nomadic pastoralists have started to invest in agriculture and use their crop residues to feed their own livestock. One more choice that pastoralists make is the use of Government owned Mkata Ranch, which is currently free to access and has plenty of grazing land.

5.2 Recommendations

Pastoralists, unlike the settled population in the region are marginalized. They have limited access to market, water and health; they need to move to the settled population to have a stable life. Despite these limitations, they are still doing their best to adapt to the

changing situations and need to continue discussions with the government to bring basic socio economic services close to them.

From the findings and discussion the following recommendations can be made:

(a) Land use planning in the villages is essential in reducing human pressure on the land resources, and enhancing enforcement of laws that govern land management and land use.

(b) Land owned by individuals and groups should be surveyed and/or issued with title deeds, this would provide security of land tenure for Melela community.

(c) Policy makers should aim at improving and sustaining productivity of pastoral systems by establishing secure land tenures of common grazing areas to specific groups of users. This measure would limit the nomadic movements of pastoralists, improve grazing land, and set rules for accessing and limiting the number of animals that can be grazed in their area.

(d) Further research studies should be carried out in order to establish sustainable livestock carrying capacities and to determine the sustainable grazing system in Melela.

(e) Landsat images which were used in this study were of low spatial resolution (30 m by 30 m); future studies should use high resolution images to achieve better results.

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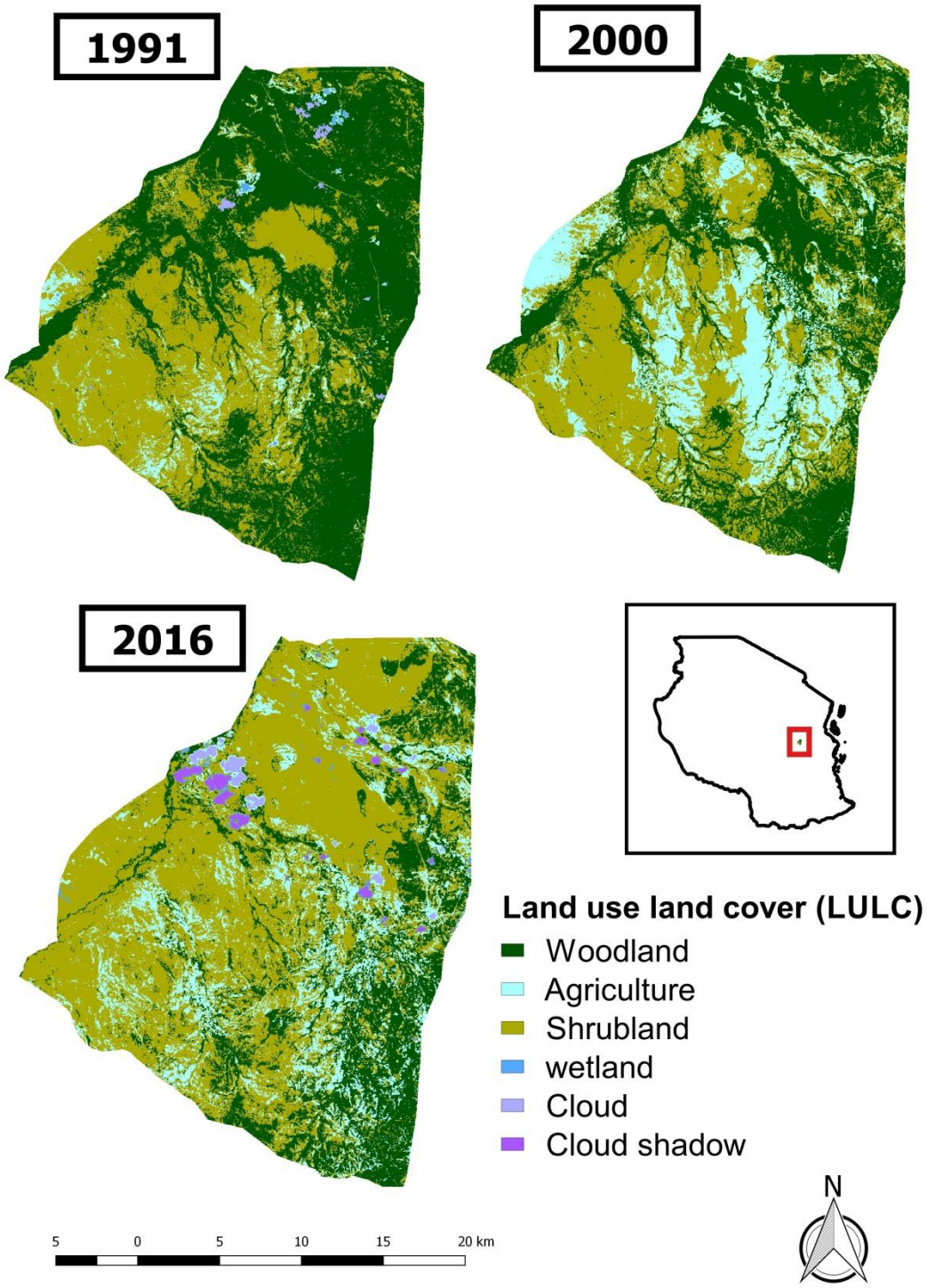
APPENDICES

Appendix 1: Land use land cover (LULC)



Appendix 2: Household structured questionnaire

Village……..…… Ward……...

INTRODUCTION

You are required to provide information on the following questions. All information will be treated confidentially.

1.0 Household background information

1.1 Age of respondent……..... (Years)

a) 18 – 30 c) 46 - 60

b) 31 – 45 d) Over 60

1. 2. Who is the head of the household?

(1) Male (2) Female

1.3. What is your level of education……

1. No formal education

2. Adult education

3. Primary education

4. Secondary education

5. College

Other (specify)…… …….

2.0 Household socio economic status

2.1. Do you have family member staying outside your household 1. Yes. 2. No.

2.2. If Yes in Qn 2.1. Give reasons for family members staying outside your household

1. Employment in public service

3. Transhumant movement

4. Operating business

5. New farming area

6. Schooling ( )

7. Others……

2.3. Does your household experience any labor shortage for herd management and agriculture? (1) Yes (2) No

2.4 Is your village experiencing an influx of immigrants of other ethnic groups? (1) Yes (2) No

2.5 What is the domicile area of your ethnic group…….?

2.6 Have you ever migrated? 1) Yes 2) No

2.7. If yes in 2.6. What are the main reasons for migration?

1. Searching for grazing lands

2. Searching for water

3. Searching for agriculture lands

4. Avoiding livestock disease
5. Easy access to marketing facility ( )
6. Others (specify)……..

3.0 Land tenure system

3.1. Do you own any land in this village? 1) Yes 2) No

3.2 If yes in Qn 3.1. How did you acquire the land you own?

1. Bought 2. Rented 3. Inherited ( ) 4. Allocated by government

5. Bush clearing 6. Other (specify) ……

3.3. What property rights do you have over your farm holdings?

1. Have title deed
2. Have customary rights
3. Village protection
4. No rights ( )
5. I don't know

3.4. Who decides on general grazing matters in this village?

1. Village government leaders
2. Customary leaders
3. Grazing management groups
4. Farmer groups ( )
5. Others (specify)

4.0 Trend of land uses /cover over the 1990`s, 2000`s and 2015`s?

4.1 What was the situation of the land type from time you acquire /inherited?

1.) Cultivated 2.) Bushland 3.) Forest 4.) Grazing land 5.) Settlement 6. Others (specify)……..

4.2 Did you change acquired land to others uses? Yes / No.

Status of change from - to

1. From cultivated to grazing land
2. Cultivated to settlement
3. Bushland to cultivated
4. No changes since acquired
5. Others (specify)…….

4.3 What is the average size of your land plot?

4.4 What could be the reason of land use changes?

1. Population increase
2. Introduction of commercial and food crops

3. Individual behaviori.e when family grew in size
4. Extension from agriculture officers
5. Economic hardship
6. Immigrants from other ethinic group
7. Others (specify)…….

4.5What are the main land use types in your village 1990`s, 2000`s and 2015`s??

Priorities	1990`s	2000`s	2015`s
1			
2			
3			

4.6 What are the major food crops grown in 1990`s, 2000`s and 2015`s?

Priorities	1990`s	2000`s	2015`s
1			
2			
3			

4.8 What are the major cash crops grown in 1990`s, 2000`s and 2015`s?

Priorities	1990`s	2000`s	2015`s
1			
2			
3			

5.0 Trend in ease availability of land uses over the 1990`s, 2000`s and 2015`s

5.1Which type of land ownership do you have?

1.) Private registered
2.) Customery land ownership
3.) Communial land
4.) Others (specify)……..

5.2 What are the uses of land?

1) Cultivation with scattered bushland 2.) Mining 3.) Grazing 4.bushland 5. Tree plantation 6.) Others (specify)…….

5.3 What is the situation of land uses at present (acres)?

1.) All land in use
2.) ¾ land in use
3.) Half of land in use
4.) Quarter /less in use

5.4 Is there decline of soil fertility? Yes / No

5.5 If yes how did you improve soil fertility?

1. Use of inorganic fertilizers
2. Use of organic manure
3. Adoption of irrigation
4. Practice fallowing
5. Others (specify)……

6.0 Factors influencing land uses and livelihood diversification

6.1 What are the constraints that occurred and contributed to changes in land use pattern?

1.) Level of illiteracy
2.) Poor agriculture technology
3.) Economic factors (market, level of income)
4.) Social and health factors
5.) Soil degradation
6.) Others (specify)…….

6.2 How much did you harvest per acre?

6.3 Does the yield increases or decreases? Why?

6.4 When you increase acreage under food crops does the yield increases? Yes / No Why?

6.5 Do you have sufficient food balance throughout the year? Yes / No

6.6 Which of the following land uses make easy and quick option to make living in the community?

1. Firewood and charcoal making
2. Selling livestock and livestock products
3. Selling harvested crops
4. Farming horticultural crops
5. Others (specify)…….

6.7 How much did you earn from those land use type?

6.8 How do you sustain your daily household basic needs like school fees, food, clothes, and medication?

1. Selling livestock and dairy products 2. Selling harvested crops 3. Firewood and charcoal making 4. Mining 5. Other (specify)……..

7.0 Food and livestock production in the 10 year interval (1991- 2015)

Production	**1. Increase 2. Decrease 3. No changes**	**Reason for the reported changes**
Cash crop farming/ horticultural crops		
Food crop farming		
Pattern of crop yield		
Pattern of livestock yield		
Adequacy of food grown		
Incidence of food shortage		
Livestock keeping		
Adequacy of land for livestock keeping		

7.2 If your main economic activity is livestock keeping, which category of pastoral system are you?

1. Nomadic 2. Agropastoral 3.Transhumance

7.3What are the main reasons for your engaging in?

1. Nomadic ……..
2. Agropastoral…….
3. Transhumance…….

7.4 What categories of livestock you own?

Type of animal	Feeding system 1.Zero grazing 2.Private pasture 3. Communal pastures 4.Others(specify)	Purpose for keeping the animal category
Cattle		
Goats		
Sheep		
Donkeys		
Total		

8.0 Effects of land use land cover changes on pastoral production

8.1. Where is the location of your farm plots in the landscape?

1. beside the stream/river
2. around homestead
3. Near the grazing lands ( )
4. Other (Specify) ……

8.2 Is the available grazing land adequate (1) Yes (2) No

8.3 If no in 9.2, what is the main reason?

1. Too many animals
2. Land planned for grazing is small compared to agriculture
3. Encroachment by farmers
4. Others (specify)…….

8.4 At what time of the year do you experience shortage of pastures for your livestock?

1. Dry season (specify month)
2. Rain season (months)
3. All year round ( )
4. Other (specify) ……

8.5 Do you have access to crop residues on fields belonging to farmers? (1) Yes (2) No

8.6 If yes in Qn 6.5, under which terms do you access to the crop residues?

1. Freely available
2. Purchase
3. Exchange with livestock manure
4. Negotiate with farmers ( )
5. Other (specify) ……

8.7 What are the main livestock production constraints you are facing? ……

8.8 Are there any restrictions on stocking rates in this village? (1) Yes (2) No

9. History of LULCC (expansion of cultivated land, settlement, clearing of grassland, shrub land) on pastoral production.

9.1	Pasture		1991	2000	2015	Reason
	9.1.1.Feeding system	a.zero grazing b.private pasture c.communal d. Others specify……				
	9.1.2 distance covered to grazing land	a. less than 1km b. 2-5 km c. 6 - above				
	9.1.3 Availability of pasture	a. Adequate b.Inadequate				
	9.1.4 Grazing area	a. Reduced, thus increase stoking pressure b.increased, thus decreased stoking pressure c. remain the same				
9.2	Water					
	9.2.1 water source	a. permanent river streams b. seasonal river streams c. Dam/ponds d. others (specify)…..				
	9.2.2 Access to water source	a. Limited supply b. Unlimited supply				
9.3	9.3.1Incedence of Diseases	a. Severe b.Less severe c.more severe				
9.4	9.4.1 Adoption strategies	c.perception				

A Checklist

1. Administrative Issues: Village ……..Ward ……..

Village registration number …… Date ……

What is the ethnic composition …….……

What is the migration trend? ……..……..

2. **Economic Activities**

- What are the main land use activities?
- How many households practicing pastoralism?
- How may pastoral households practicing farming?
- What is the trend in herd size/ livestock ownship?
- Do the pastoralists practice transhumant or nomadic, movement?

3. Land Tenure

- Which land is owned communally?
- How land is acquired?

What is the current health of the communal land?

- What are the current changes in land use and land tenure ship?

4. Land use land covers changes in three time periods 1985 to 2015 (10 years interval)

- What are the changing trends of land uses?
- What could be the reason for changes?
- Which land uses is increasing?
- Which land uses is reducing?
- What is a trend in human population (in 1991, 2000, and 2015)?
- What is a trend in livestock populations ((in 1991, 2000, and 2015)?
- What is land area for cultivated, grazing, mining, bush land (in, 1991, 2000, and 2015)?
- Which part of the landscape was / is affected (in 1991, 2000, and 2015)?
- What are the incidences of livestock diseases in (1991, 2000, and 2015)?
- What are the trends in pastoralist `s migration patterns (1991, 2000, and 2015)?
- What is the proximity of farm plots and grazing land (1991, 2000, and 2015)?
- What is proximity to the water sources (1991, 2000, and 2015)?
- What is the condition of wetlands/ valley/ rivers?
- Do you have food shortage in your village?
- Which month of the year starts experiencing food shortage? What could be the reason for the shortage?
- Which month of the year starts experiencing pasture shortage? What could be the reason for the shortage?
- Which month of the year starts experiencing immigrants' pastoralist from other sites? What could be the reason?
- What are the constraints that occurred and contributed to changes in land use pattern?
- What is the trend in food and livestock production in the 10 year interval (1991- 2015)
- Are there any effects which occur due to LULCC to the pastoral community and pastoral production?