ASSESSMENTOF THE INFLUENCE OF CLIMATE CHANGE ON SMALLHOLDER DAIRY PRODUCTIVITY IN KOSIRAI, KENYA AND NAMAYUMBA IN UGANDA

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DECLARATION

I hereby declare that this is my original work and has not been presented in part or whole for any degree in this or any University

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Dedication

This thesis is dedicated to my husband Jackson Kirui daughters Maurine Cheruto and Fiona Chepkoech and Son Kelvin Kimutai for their prayers patience and support during course work and field Research

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I also acknowledge the University of Nairobi for giving me an opportunity to pursue the post graduate programme in Climate Change. My mother, sisters and brothers also encouraged and prayed for me during the entire period of my post graduate study.

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Abstract

The influence of climate change in dairy productivity in East Africa is manifested through impacts on fodder production and supply, livestock disease outbreak and water availability for livestock. The overall objective of this study was to assess the influence of climate change on smallholder dairy farming in Kosirai, Nandi district of Kenya and Namayumba in Wakiso district of Uganda, in support of climate smart agricultural practices. Rainfall and temperature variations were the main independent variables of the study. This research was guided by use of cross-sectional survey and Commonwealth Scientific and Industrial Research Organization (CSIRO) Mk3.6 model output. The trend of rainfall and temperature variations was based on both the observed data and CSIRO Mk3.6 model output. A simple random sampling technique was used to select 253 respondents who participated in cross-sectional survey. A validated structured questionnaire with variables on fodder production and availability, milk production, disease outbreak and weather information was used to collect the data. Primary data was analyzed using Statistical Package for Social Sciences (SPSS). Time series climate data was obtained using observed and CSIRO Mk3.6 model output.

The study found out that the mean rainfall in the two study sites had progressively decreased over the last 10 years. Conversely there was a systematic rise in both the minimum and maximum temperature, both in historical and projected period in the two sites. The climate perturbations had positive correlation with fodder production and supply. Likewise milk production that mainly depended on rain fed forages also correlated with supply of feeds. There was increased milk production and supply during the wet season as compared to the dry spells.

Climate change has resulted in the emergence and rise of both the vector born and viral diseases in the two sites. There was significant rise in out breaks of foot and mouth disease and tick borne diseases in Namayumba area. In Kosirai there was an increase in outbreaks of tick borne. The study recommended that dairy farmers be empowered to effectively prepare to climate change through adaptation and mitigation of the effect of extreme climate change. Farmers should also invest in the production and conservation of fodder for their dairy production

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Acronyms

AGCM	Atmospheric General Circulation Model
CSA	Climate smart Agriculture
CSIRO	Commonwealth Scientific and Industrial Research Organization
DIG	Dairy Interest Group
DMG	Dairy Management Group
EADD	East Africa Dairy Development Project
FAO	Food and Agriculture Organization
GHG	Greenhouse Gases
IPCC	Intergovernmental Panel on Climate Change
JGCRI	Global Change Research Institute
OGCM	Ocean General Circulation Model
MDGs	Millennium Development goals
Mm	Millimeters
NMHCs	National Meteorological and Hydrological Centers
RCP	Representative Concentration Pathways
SDP	Smallholder Dairy Project
SRES	Special Report on Emissions Scenarios
Tmax	Maximum temperatures
Tmin	Minimum temperature

Definition of terms

Animal diseases common animal diseases which affect dairy animals in the study area

Catchment Area- In this study catchment area means the area where the study was carried out

Climate smart Agricultural Practices In this study, climate smart agricultural practices refers to the use of environmental friendly production applications to increase dairy productivity

Context- Refers to the environmental and socioeconomic condition of the area

Crop Residue- Refers to on farm crop by products such as maize stoves, beans husk, banana stem peels

CSIRO-Commonwealth Scientific and Industrial Research Organization

Dairy farming-Rearing and management of cows for milk production for home consumption or for sale

Dairy management group- farmer groups formed at the village level for the purpose of improving livelihood through dairy farming and used as focal training unit by EADD.

Drought is prolonged dry spelling longer than expected dry period in the study area

Farmer Organization when farmers come and work together to improve their way of producing milk and marketing

Fodder- Any improved forage grown to be fed to dairy cows

Nganda- Is local breed cow found in Uganda

Knowledge- Refer to sense that people make out of information. In this study farmers knowledge is confined to climate related information and the sources

Mailo Land Tenure System Land tenure system found in Uganda which almost identically to freehold tenure. Registered land can be held in perpetuity and a Mailo owner is entitled to enjoy all the powers of a freehold owner. The only significant difference is that Mailo owners should not use these powers against the interests of customary tenants, bona fide or lawful occupants

Manure is the animal waste and could consist of both urine and dug from cows

Pastures grasses naturally occurring or planted and used to graze of cut and fed to animals

Productivity- In this study productivity is an efficient way of increasing milk yields

Shallow Well: In this study refer to ground water obtained through digging of a well which is mainly dug manually

Secured land with Title deed land is registered and the owner has all the rights with regard to land use

Secured but Family Land the land title deed is available but under the custody of the head of family, farmers under this system access and use land for production but do not have full control on how the land will be used in future especially with regard to crops which take longer period such as trees and perennial grass.

Squatters land tenure system does not own the land and lease the land from legal owner on annual basis there are possibility of being evicted

CHAPTER ONE

1 INTRODUCTION

1.1 Background of Study

Climate change is exerting significant impacts in all sectors of economy in Eastern Africa where farmers rely on rain fed agriculture (IPCC, 2007). The impacts have been largely in terms of food insecurity. Dairy farming is one of the key sectors in agriculture which contributes to improved nutrition and employment in rural areas; it is a sector experiencing 3-4% annual growth (Kenya National Livestock Policy, 2008). The direct impact of climate change to dairy production will be minimal but the indirect impact brought about by change in feed and fodder supply may severely alter the existing livestock production system (FAO, 2004).

In Kenya, key economic sectors of agriculture, forestry and fisheries (Lobell *et al.* 2011) both at global and regional scale will be impacted by climate change. Ugandan milk production is dominated by small holder who own 90% of the total national cattle population (FAO, 2004) 60% of the household keep indigenous animal with very low milk production and mainly kept as source of food, store for wealth and status symbol. However with the increased milk demand which is driving the smallholder dairy farmers to intensify production and increase household income.

There is noticeable change in mean temperatures and rainfall patterns leading to enhanced variability. These impacts have also influenced changes in water availability, enhanced frequency and intensity of drought, floods, sea level rises and salinization and perturbations in the ecosystems (Beddington *et al.* 2012; Thornton *et al.* 2012). However, the extent of these impacts depends on the intensity of the changes and their uncertainty in occurrence.

Climate smart is an agricultural practices (CSA) sustainably increases productivity, resilience, reduces or removes Green House Gas emissions (mitigation), and enhances achievement of national food security (Chaudhury *et al.* 2012) and the Millennium Development Goals (MDGs). FAO (2010) defines CSA as climate change adaptation strategy aimed at helping small rural (subsistence) farmers adapt to climate change by an intensification or diversification of their livelihood strategy, thereby reducing their vulnerability. It involves new agricultural production systems essential at achieving higher productivity together with lower output variability in the face of climate risks, which may be both of an agro-ecological and socio-economic nature. Some of CSA practices include soil and nutrient management, water harvesting and use, pest and disease control or resilient ecosystems.

1.2 Problem Statement

The low dairy herd productivity in East Africa is attributed to limited use of production technologies and inadequate exploitation of the existing environmental influences. Mapiye *et al.* (2006) alluded that the low quantity and quality of feed resources affected productivity of dairy animals in sub-Saharan Africa. East African rainfall is bimodal but is characterized by uncertainty both spatially and temporally where with a high poverty index of 52 percent (World Bank, 2010), Kenya and Uganda whose diary production is predominantly smallholder farmers and whose livelihoods are dependent on rain fed agriculture experience more adverse climate change related impacts. Galvin *et al.* 2003) also alluded that rainfall seasonality affects forage availability, livestock production and ultimately the livelihoods of these people. Therefore, efforts to facilitate adaptation will enhance the resilience of the agricultural sector, ensure food security, and reduce rural poverty.

Milk production in Kenya and Uganda is characterized by high milk production during the rainy season and low milk production during the dry season, the changing climate is expected to make the conditions worse. The purpose of this study is to investigate farmers' perception and knowledge on climate change and their current coping methods, determine the effect of climate change on fodder production, and the baseline, present and future trend of temperature and rainfall. The adoption of climate smart fodder production practices by smallholder dairy farmers will depend on their understanding of the divers of climate change. .

1.3 Conceptual Framework

Good understanding of climate change and dairy production will enhance the capacity of agricultural systems to support food security, incorporating the need for adaptation and the potential for mitigation strategies. To practice climate smart agricultural practices, an understanding of climate related constraints affecting smallholder dairy farming is important.

The same also applies to the knowledge of climate change particularly rainfall and temperature which indirectly influence dairy productivity.

Understanding how farmers are coping with climate change build on the existing local knowledge when developing and disseminating new technologies. Change in rainfall and temperature pattern over time influence fodder production and supply, especially in East Africa where smallholder dairy production is dependent on rain-fed forage production. All the identified influencing factors were in-built in the study as a way of controlling internal validity and their unforeseen potential minimized by having a relatively bigger sample size of 253 respondents randomly selected

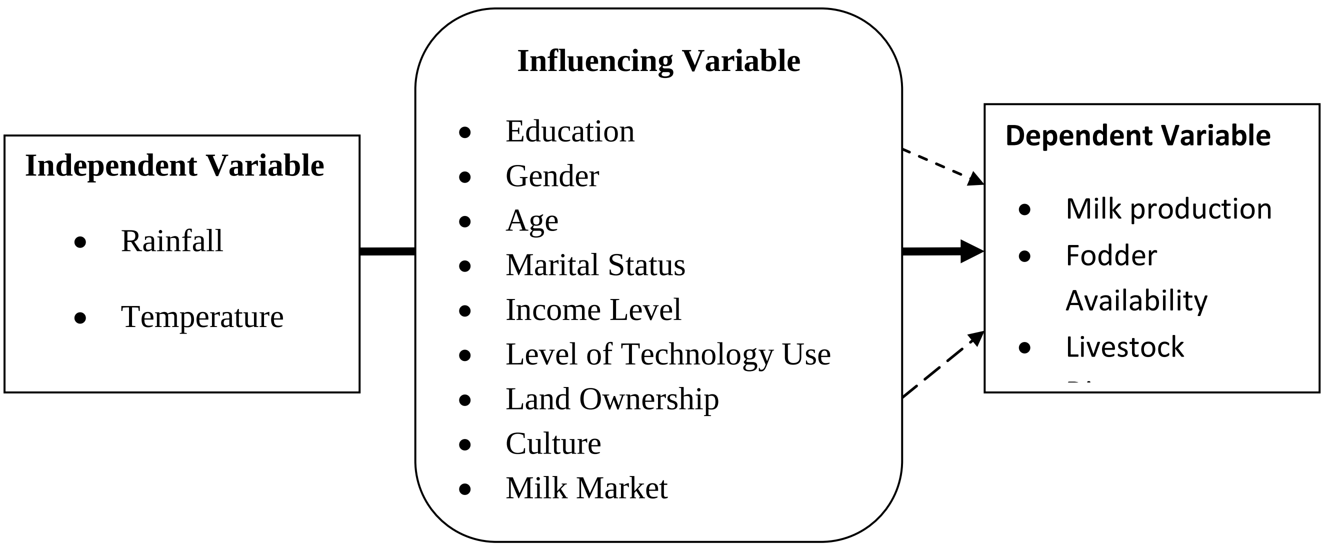

Figure 1-1: Conceptual framework of the study

1.4 Objectives of the Study

The overall objective of this study was to assess the influence of climate change on smallholder dairy farming in Kosirai, Nandi district of Kenya and Namayumba in Wakiso district of Uganda in support of climate smart agricultural practices. The specific objectives were to;

i. Determine the trend of baseline, present and future rainfall and temperature over the study area

ii. Determine the trend of fodder production and temporal availability over the study area

iii. Assess the level of awareness of the smallholder dairy farmers' for climate change impact on dairy production and their coping mechanisms.

iv. Determine the relationship between rainfall and fodder and pasture/ milk production during dry and wet seasons.

1.5 Research Questions

Research questions that guided this study were inferred from the following;

1. Is the trend in present and future variability of rainfall and temperature in Kosirai and Namayumba catchment area been increasing or decreasing
2. How has been the trend of fodder production and availability in Namayumba and Kosirai catchment areas
3. What is the level of farmers' knowledge on climate change, and coping strategies in small holder dairy production in Kosirai and Namayumba
4. How has climate variability affected fodder availability and milk production in Kosirai and Namayumba

1.6 Justification of the Study

Report from the East Africa Dairy Development (EADD) project, currently working with smallholder dairy families in Kenya, Uganda and Rwanda showed that milk production is dependent on rain fed forages production with surplus feed supply during the rainy season and a corresponding rise in milk production. The dry season is characterized by reduction in feed supply and a general deficit in milk production (TechnoServe Kenya, 2008). This is collaborated by work done by Lukuyu *et al* (2011) which found that the rainfall level in Namayumba are generally adequate to support cropping activities; however, rainfall unreliability is increasingly becoming common. Kenya National Climate Change Response strategy (GOK, 2010) indicate that climate variability and change have resulted into frequent droughts and emergency of vector-borne parasites that affect milk production, this is due to increased seasonal variability within the year and also a decline of the long rainy season.

Understanding the past, present and future trends of rainfall and temperature in the study area, the fodder production and availability and farmer's knowledge regarding the effects of climate change will helps in developing and promoting climate smart agricultural practices in fodder and pasture production, fodder conservation and manure management. Extension practitioner with knowledge on expected future rainfall and temperature variability will develop appropriate climate smart agricultural practices to help smallholder dairy farmer cope with the climate change.

Results from this study will assist programs operating in the study site on future trend of rainfall and temperature livestock feed availability and trend and the farmer's knowledge on climate change.

1.7 Area of Study

The study was carried out in Kosirai, Nandi County in Kenya and Namayumba sub-county of Wakiso district in Uganda the two sites are covered by the East Africa Dairy Development (EADD) project. The choice of study site was predetermined by the fact that there is an on-going project on dairy production which intends to in-cooperate climate smart agricultural practices. The two sites mainly rely on rain fed fodder production. Project report indicates that the variation of fodder between the wet and dry seasons lead to fluctuation in available fodder hence milk productions.

1.7.1 Nandi County

Nandi North district is part of the Nandi county and farmers practice mixed farming and the main crops grown being maize, potatoes, millet and sorghum. Coffee, tea and pyrethrum are the main cash crop. Farmers keep cross breed of Ayrshires and Friesian under grazing and stall feeding production system. Dairy farmers in Nandi grow forage crops such as Napier grass (*Pennisetumpurpureum*), Rhodes grass (*Chlorisgayana*), and Nandi setaria (*Setariasphacelata*). About 4000 dairy farmers in Kosirai came together to form a producer organization called Lelchego dairies which assist farmers to bulk and market their milk.

Nandi receives mean rainfall of between 1,200-2,000mm per year. The rainfall is bimodal with dry spells experienced between December and March. The distribution of rainfall is affected by topography and the south-westerly winds from Lake Victoria. About 75% of the district is arable and capable of producing diverse crops such as tree crops, tea, horticulture, pyrethrum, coffee and cereals due to adequate and reliable rainfall.

The population of Nandi North is 374,000 people (2005 projection). The district has a mean population density of 216 persons per km^2 with a population growth rate of 2.9% per annum

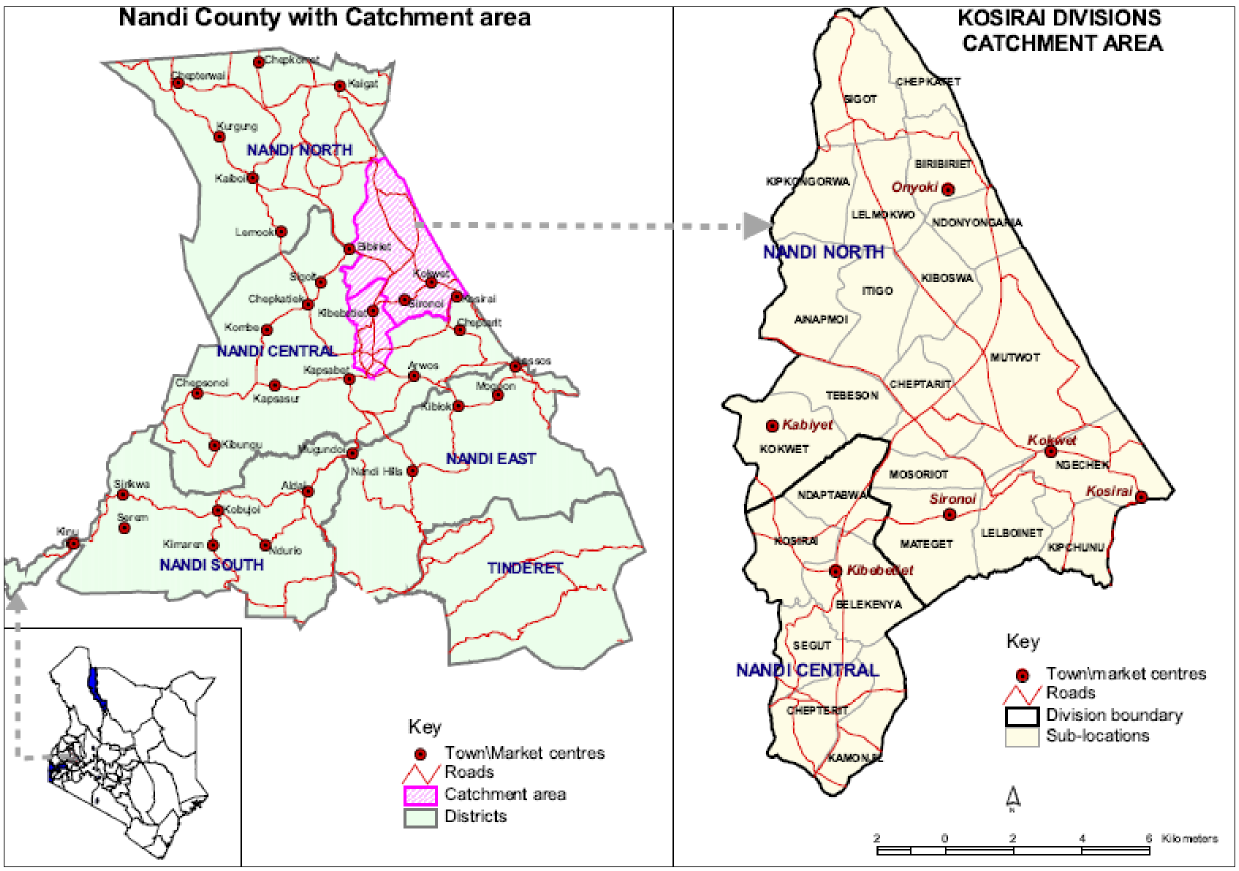

Figure 1-2: Map Kenya showing Kosirai division in Nandi County

1.7.2 Namayumba, Wakiso District of Uganda

The study was carried out in Namayumba in Wakiso District. Wakiso district, strides along the equator. It lies between 1^o north and 0^o 30’ south of the equator. It is in between latitudes 31^o and 33^o east of the meridian. According to the National Housing census, the district has an area of 2,704.6 km^2 and a population of 907,988 people (Twebaze, 2010)

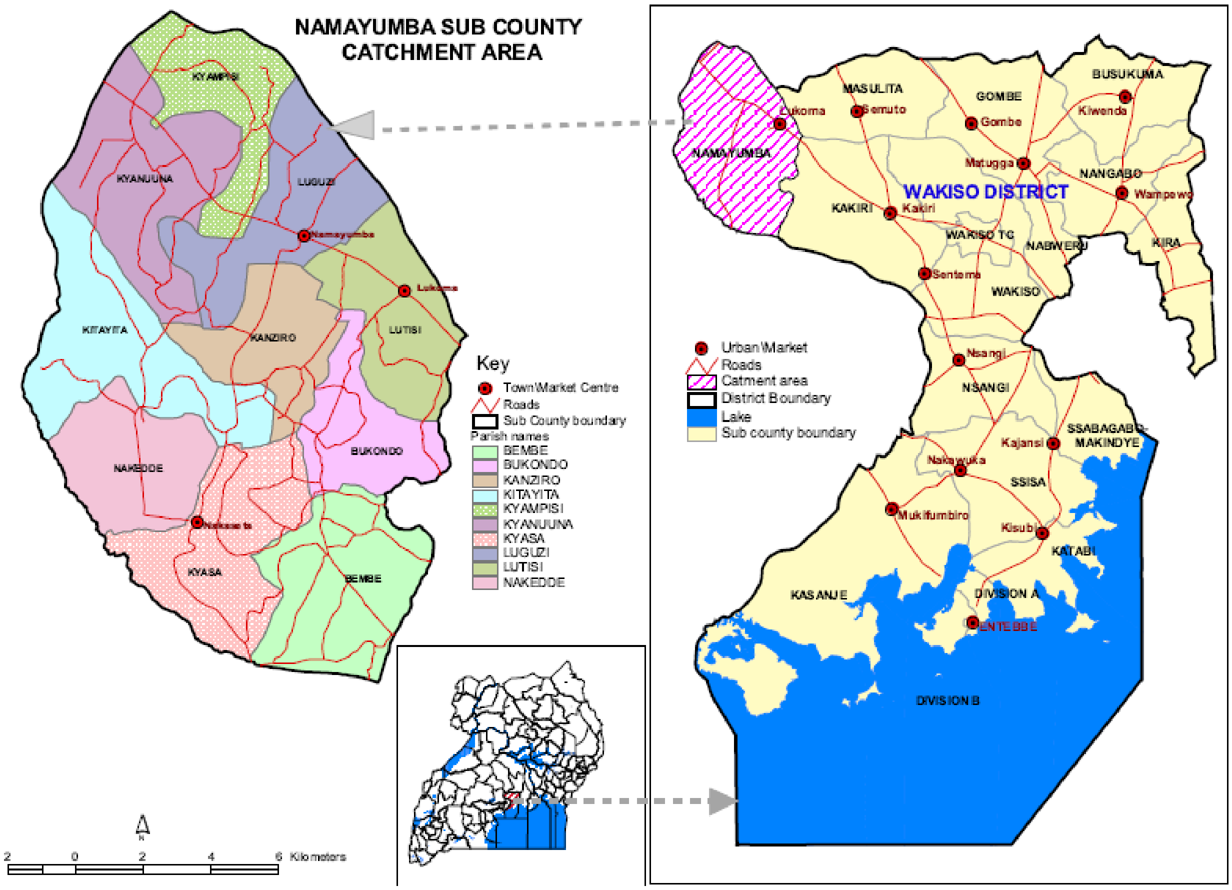

Figure 1-3: Map of Uganda showing Namayumba in Wakiso district

The district population is one of the fastest growing populations according to the district 2008/2009 -2010-2011 Development plan. The population stood at 389,400 people in 1980, 562,209 people in 1991 and projected at 1,158,200 people in 2008. As per 2002 population census, there were 336 people per km^2. Ninety two percent of the populations live in rural areas while as 8% live in urban areas. 51% of the populations are females and 49% are males.

Farmers in this area practice mixed farming with crop and livestock, average land size is 1.5 acres per household crop grown in this area include maize, beans, cassava and banana whiles the fodder crop grown is Napier grass (*Pennisetumpurpureum*), Nandi Setaria (*Setariasphacelata*). and Rhodes grass (*Chlorisgayana*) while a few farmers plant legumes such as Lablab *purpureus*, Mucuna *pruriens* and fodder trees (Lukuyu *et al.* 2011) On average each household has two to three cows, 80% of the household keep Nganda type of cattle though this type of cattle has low milk yield potential . Only 30% keep cross breed of Friesian, Jersey with the local Nganda breed (Lukuyu *et al.* 2011). Farmers practice intensive and semi intensive dairy farming

1.8 Assumption of the Study

This study was designed to create an understanding of the past, present and future trend of temperature and rainfall in the study sites, the fodder production and availability, and the farmers knowledge on climate change with main focus being on dairy farmer organization within the study sites of Kosirai in Nandi county of Kenya and Namayumba in Wakiso district of Uganda.The study was conducted under the following assumptions

i. The farmers interviewed would be able to recall and give correct answers on the fodder they planted, sources of water livestock disease prevalence 10 years ago
ii. The farmers could give honest answers to the questions and that incase a different respondent other than the head of household had a good understanding of the routine management of the farm, their answers would be considered

CHAPTER TWO

2 LITERATURE REVIEW

2.1 Introduction

Climate change and agriculture are inextricably linked. Agriculture still depends fundamentally on the weather. Climate change has already caused a negative impact on agriculture in many parts of the world because of increasingly severe weather patterns (IPCC, 2007). Climate change is expected to continue to cause floods, worsen desertification and disrupt growing seasons. According to the Food and Agriculture Organization, (FAO, 2004) warns that an increase in average global temperatures of just two to four degrees Celsius above pre-industrial levels could reduce crop yields by 15-35 percent in Africa and western Asia, and by 25-35 percent in the Middle East. Agricultural practices also exacerbate climate change (IPCC, 2007).

Climate change and food security is related because climate change can directly affect a country’s ability to feed its people. However, IPCC (2007) shows that climate change will not equally affect all countries, and will likely have the biggest impact in equatorial regions such as sub-Saharan Africa. This means that countries already struggling with food security are likely to find themselves struggling harder in the future. According to the IPCC report (IPCC, 2007), climate change projections indicate that yields from rain-fed farming in some African countries could be reduced by up to 50 percent by 2020. Dairy industry is one of key subsector in agriculture with the highest degree of protection due to the economically vulnerable position of smallholder milk producers.

Predictability of the impacts of climate change on agriculture requires appropriate and dependable data, tools and models at spatial scale and in the actual production areas Lobell *et al.* 2011). Parry (2007) observed that while a few areas, especially in the temperate latitudes, experience some improved conditions for production, globally, climate change reduced cereal production by 1% to 7%. This observation corroborated with that of Nelson *et al.* 2010) that climate change resulted into substantial variations in productivity of both irrigated and rain-fed crops. It is estimated that at least 22% of the cultivated area under the world’s most important crops will experience negative impacts from climate change by 2050, with 56% of the land area being from sub-Saharan Africa (Campbell *et al.* 2011). Easterling *et al.* (2007) postulated that the impacts of climate change will be progressively worse and more so in the second half of the century. This change will likely widen the gap between developed and developing countries with the vulnerable latter experiencing more severe impacts exacerbated by their lower technical and economic capacity to respond to the ensuing threats (Padgham, 2009).

Milk production grew steadily in East Africa in the 1980s and 1990s. The pace of growth has since accelerated following recent high rates of income growth and urbanization, though exact figures are not easy to verify (Place *et al.* 2009). Ngigi (2004) reports that milk production increased during the 1990s at an annual rate of 4.1% in Kenya and 2.6% in Uganda due to high rates of domestic consumption among other reasons. Evidence is less precise for other countries, but there are at least several hundred thousand smallholder dairy farmers in the neighboring countries of Ethiopia, Rwanda, Tanzania and Uganda. The smallholder farming systems in Kaptumo, Kenya are characterized by low land and livestock productivity due to unreliable and inadequate rainfall, infertile soils, poor agronomic practices, undeveloped marketing channels and lack of agricultural inputs (Wambugu and Franzel, 2012). Farmers experience frequent droughts, excessive rains in the wet season and subsequent crop failures and decline in livestock productivity which increases their vulnerability to food insecurity and poverty (Zagst, 2011).

Small holder dairy farmers in East Africa face challenges of uneven milk production mainly because they rely on rain fed forage production. Kenya`s Policy document, the Strategy for Revitalization of Agriculture (SRA), showed that despite the heavy investment in research, extension and other donor supported dairy development initiatives, productivity still remains low and positively correlated to seasonal patterns(Poulton and Kanyinga, 2013). The resultant higher temperatures and changes in rainfall patterns, has enhanced the emergence and spread of vector –borne diseases (Thornton *et al.* 2008).

2.2 Climate Change Impact on Dairy Productivity

Dairy farming is vulnerable to climate change through increased temperatures and changes in rainfall patterns (Kasulo *et al.* 2009) and thus affect feed and water availability, animal health and breeds, and in turn milk production. Further, warmer and drier conditions increase the likelihood of heat stress in cattle. There is normally a decrease in milk production for cows under heat stress. Changes in rainfall patterns affects pasture growth patterns thereby affecting the quality and quantity of both feed grains and fodder produced outside dairy areas. Droughts lead to water shortage which in turn leads to a decrease in milk production (Siemes, 2008).

Bruckner (2008) indicated that climate change has an impact on the increase or decrease in animal disease risk. Examples of diseases which were related to climate change included avian influenza which spread over 4 continents since the beginning of the new millennium; bluetongue which spread across Europe; and the Rift Valley fever which spread in Africa as a result of severe floods.

2.3 Contribution of Livestock Farming to Climate Change

Although agricultural production is affected by climate change it is also evident that current agricultural practices contribute to the continued change in climate, globally livestock contribute directly or indirectly 18% (7.1 billion tons equivalent) of global greenhouse gases through the emission of methane, nitrous oxide and carbon dioxide (FAO, 2006) gases. Livestock Greenhouse gas(GHG) emission throughout the commodity value chain emit 9% of the total Anthropogenic carbon dioxide, 37% of Methane and 65% of nitrous oxide(FAO, 2006) there are possible mitigation options to reduce emission through restoration of organic carbon, manure management and sequestration of carbon through agro-forestry, proper animal diet, nutrient management and use of biogas.

Methane emissions mostly occur as part of the natural digestive process of animals (enteric fermentation) and manure management in livestock operations while carbon dioxide results from fodder production activities which require opening of new land, use of fertilizer use of fossil fuel and other factors of fodder production changes (deforestation to open pastures and cropland for feed production). These activities accounts for 32% of emissions associated with livestock; nitrous oxide (N_2O) from manure and slurry management, which accounts for 31% and methane (CH_4) production from ruminants, which accounts for 25% of emissions (Herrero and Thornton, 2009). Livestock's "hoofprint" is particulary high in developing countries with emissions in Europe and North America. It ranges between 1-2 kg CO_2-eq. per kg fat-and-protein corrected milk at the farm gate, this number is estimated to range from an average of 5.7 kg CO_2-eq. in Kenya, 8.9 kg in Uganda, and 17.1 kg in Tanzania (Opio *et al.* 2013).

2.4 Climate Smart Agriculture

Climate smart agriculture (CSA) is an agricultural practice that sustainably increases productivity, resilience, reduces or removes Green House Gas emissions (mitigation), and enhances achievement of national food security (Chaudhury *et al.* 2012) and the Millennium Development Goals (MDGs). (FAO 2010) defines CSA as climate change adaptation strategy aimed at helping small scale rural (subsistence) farmers adapt to climate change by an intensification or diversification of their livelihood strategy, thereby reducing their vulnerability. It involves new agricultural production systems essential at achieving higher productivity together with lower output variability in the face of climate risks, which may be both of an agro-ecological and socio-economic nature. Other CSA practices include soil and nutrient management, water harvesting, conservation and use, pest and disease control or resilient ecosystems (Sullivan *et al*. 2013)

CSA will: (i) sustainably intensify production systems to achieve productivity increases thereby supporting the achievement of national food security and development goals; (ii) increase the resilience of production systems and rural livelihoods (adaptation); and (iii) reduce agriculture's GHG emissions (including through increased production efficiency) and increase carbon sequestration (mitigation). There is no blueprint for CSA and the specific contexts of countries and communities would need to shape how it is ultimately implemented.

Investing in CSA is a new strategy to meet the need for the growing global demand for food in a climate smart manner (Hobbs *et al.* 2007). At the same time, the strategy is aimed to reduce the socio-economic vulnerability of rural communities in developing countries and thus safeguarding the MDGs. CSA practices such as increasing soil organic matter in cropping systems, mixed-species forestry or agro-forestry can improve the soil quality, reduce the impacts of droughts or floods and thus lowers the vulnerability of communities (Hobbs *et al.* 2007).

More efficient management of water, a resource threatened by climate change, is also critical for reaching the adaptation and livelihood goals of CSA. Best practices for irrigation, water-harvesting technology, and terrace or contour farming systems can contribute to improved water-use efficiency and conservation (Milder *et al.* 2011). Incorporating the shifts in hydrologic regimes and water availability due to climate change into the design and management of water systems will enhance adaptation (Falloon and Betts, 2010). Employing integrated nutrient management principles, such as green manures, planting nitrogen-fixing crops, and incorporating livestock manures into the soil, decreases the amount of nitrogen lost to runoff and emissions of nitrous oxide (Scherr, 2012). Applying these management principles can serve adaptation needs by improving soil quality, while also decreasing farmers' costs and dependence on outside inputs. Organic farming and use of non-synthetic inputs can increase the amount of carbon and nitrogen retained in the soil by 15% to 28% and 8% to 15% respectively, simultaneously reducing the costs of inputs for farmers (Milder *et al.* 2011).

Agroforestry, the use of live fences or intermingled crops and trees, is another strategy to achieve climate-smart objectives. Agroforestry and tree crops increase resilience of local communities by providing a diversity of fruits, nuts, medicines, fuel, timber, nitrogen-fixation services, fodder, and habitat. Furthermore, these economically useful trees and shrubs can reduce soil erosion and maintain higher levels of biomass than annually tilled crops (through extended growth periods and root systems), also storing more carbon (Milder *et al.* 2011).

Faidherbiaalbida is a tree commonly found in agro-forestry systems in sub-Saharan Africa (FAO, 2010). This tree, which is widespread throughout the continent, thrives on a range of soils and occurs in ecosystems from, deserts to wet tropical climates. It fixes nitrogen and has the special feature of 'reversed leaf phenology' meaning it is dormant and sheds its leaves during the early rainy season and leafs out when the dry season begins. This feature makes it compatible with food crop production, because it does not compete for light, nutrients and water (FAO, 2010). Farmers have frequently reported significant crop yield increases for maize, sorghum, millet, cotton and groundnut when grown in proximity to Faidherbia.

Yield increases from 6 percent to more than 100 percent yield increases have been reported in the literature (FAO, 2010). Like many other agro-forestry species, Faidherbia tends to increase carbon stocks both above-ground and in the soil and improves soil water retention and nutrient status. Faidherbia trees are currently found on less than 2 percent of Africa's maize area and less than 13 percent of the area grown with sorghum and millet. With maize being the most widely cropped staple in Africa, the potential for adopting this agro-forestry system is tremendous. Further research is needed to better explore the potential benefits Faidherbia can provide, including for crop productivity in different agro-ecosystems; wood and non-wood products for household use or sale on the market; and possibilities for engaging with carbon markets (FAO, 2010)

2.5 Climate Change Scenarios

A scenario is a coherent, internally consistent and plausible description of a possible future state of the world (IPCC, 2007). It is an alternative image of how the future can unfold and not a forecast. A projection may serve as the raw material for a scenario, but scenarios often require additional information (e.g., about baseline conditions). A set of scenarios is often adopted to reflect the range of uncertainty in projections (IPCC, 2007). Climate scenarios are plausible representations of the future with our understanding of the effect of increased atmospheric concentrations of green house gases (GHG) on global climate. Unlike weather forecasts, climate scenarios are not predictions. They are consistent with assumptions about future emissions of GHG and other pollutants. A range of scenarios can be used to identify the sensitivity of an exposure unit to climate change. This in turn helps policy makers decide on appropriate policy responses to the change (IPCC, 2007)..

In 2000, the IPCC published a set of emissions scenarios for use in climate change studies (Special Report on Emissions Scenarios – SRES). The SRES scenarios were aimed at exploring future developments in the global environment with special reference to the production of greenhouse gases and aerosol precursor emissions. Four narrative storylines were defined by SRES and named A1, A2, B1 and B2. These scenarios describe the relationships between the forces driving greenhouse gas and aerosol emissions and their evolution during the 21st century for large world regions and globally

In contrast to the SRES scenarios, Representative Concentration Pathways (RCPs) represent pathways of radiative forcing, not detailed socio-economic narratives or scenarios. Central to the process is the concept that any single radiative forcing pathway can result from a diverse range of socio-economic and technological development scenarios. There are four RCP scenarios: RCP2.6, RCP4.5, RCP6.0 and RCP8.5 with radiative forcing of 2.6W/m^2, 4.5 W/m^2, 6.0 W/m^2 and 8.5 W/m^2 respectively. These scenarios are formulated such that they represent the full range of stabilization, mitigation and baseline emission scenarios available in the literature (Hibbard *et* *al.* 2011). The naming convention reflects socioeconomic pathways that reach a specific radiative forcing by the year 2100

The RCP 2.6 is developed by the IMAGE modeling team of the Netherlands Environmental Assessment Agency. The emission pathway is representative for scenarios in the literature leading to very low greenhouse gas concentration levels. It is a so-called "peak" scenario: its radiative forcing level first reaches a value around 3.1 W/m2 mid –century, returning to 2.6 W/m2 by 2100. In order to reach such radiative forcing levels, greenhouse gas emissions (and indirectly emissions of air pollutants) are reduced substantially over time. The RCP 4.5 is developed by the MiniCAM modeling team at the Pacific Northwest National Laboratory's Joint Global Change Research Institute (JGCRI). It is a stabilization scenario where total radiative forcing is stabilized before 2100 by employment of a range of technologies and strategies for reducing greenhouse gas emissions. The scenario drivers and technology options are detailed in Clarke *et al.* (2007). Additional detail on the simulation of land use and terrestrial carbon emissions is given by Wise *et al* (2009).

The RCP 6.0 is developed by the AIM modeling team at the National Institute for Environmental Studies (NIES), Japan. It is a stabilization scenario where total radiative forcing is stabilized after 2100 without overshoot by employment of a range of technologies and strategies for reducing greenhouse gas emissions. The details of the scenario are described in Fujino *et al.* (2006) and Hijioka *et al.* (2008). The RCP 8.5 is developed by the MESSAGE modeling team and the IIASA Integrated Assessment Framework at the International Institute for Applies Systems Analysis (IIASA), Austria. The RCP 8.5 is characterized by increasing greenhouse gas emissions over time representative for scenarios in the literature leading to high greenhouse gas concentration levels. The underlying scenario drivers and resulting development path are based on the A2r scenario detailed in Riahi *et al.* (2007).

2.6 Global Climate Change Models: CSIRO MK 3.6

The CSIRO MK3 climate system model was developed by the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Australia at the CSIRO Australian Numerical Meteorology Research Centre. The Mk3 version of the CSIRO model contains a comprehensive representation of the four major components of the climate system: atmosphere, land surface, oceans and sea-ice. The atmospheric model dynamical core has been developed entirely in-house. The same applies to the land-surface (vegetation canopy) model and sea-ice model. The cloud scheme has been coupled to an atmospheric convection scheme in a way that is derived from that used in the Hadley Centre model. The oceanic model is based upon the Geophysical Fluid Dynamics Laboratory (GFDL) Ocean General Circulation Model, the MOM2 code. These 27 components can be used independently, provided that the appropriate boundary forcing fields are provided. Before the Mk3 coupled model was assembled, the separate Atmospheric General Circulation Model (AGCM) and Oceanic General Circulation Model (OGCM) modules undergo extensive development and testing.

The Commonwealth Scientific and Industrial Research Organization (CSIRO) model resolution is 1.8°~ 200km. The coupled model is in fact assembled from two major modules that are developed independently. These are denoted as the AGCM (the Atmospheric General Circulation Model), which contains the atmospheric, land surface, and sea-ice components, and the OGCM (the Ocean General Circulation Model). The ocean component for the Mk3 model is based on the GFDL MOM2.2 ocean model (Gordon *et al.* 2010). It was configured with the specific aim of forming the coupled model with non-overlapping grid boxes when using T63 atmospheric resolution. However, the ocean model resolution is enhanced (relative to the AGCM) in the meridional direction in order that a more adequate representation of highly important El Niño features is obtained.

The meridional resolution of the OGCM has thus been set at double that of the AGCM. The resolution is 1.875°EW x (approx.) 0.9375°NS (sometimes referred to as "T63_2" resolution). This means that, horizontally, there are two ocean grid boxes to each atmospheric grid box in a coupled configuration. There are 31 vertical levels in the ocean model. The Mk3 AGCM is a spectral model developed specifically to use horizontal spectral resolution T63 [1.875°EW x (approx.) 1.875°NS] with 18 vertical levels which is also an AGCMresolution for the coupled Mk3 model (Gordon et.al, 2010). The spectral model contains a Semi-Lagrangian Transport (SLT) method for the moisture components and atmospheric tracers such as aerosols. The number of grid boxes in the horizontal for the AGCM (T63) is 192 (EW) x 96 (NS) = 18,432. The vertical coordinate of the AGCM (18 levels) is a hybrid (p:σ) vertical coordinate, where spp/=σ, with being the vertical pressure and the surface pressure.

CHAPTER THREE

3 DATA AND METHODOLOGY

3.1 Introduction

This chapter outlines the data and methods that were used to achieve the objective of the study. It gives a detailed description of the sample size, instrument of study and assessment of reliability and validity of the study tool. It also describes how data was collected, quality controlled and analyzed.

3.2 Data Type and Sources

The data used in this study included climate data for rainfall and temperature while dairy production data included fodder and milk production.

3.2.1 Climate Data

Climate data used included both observed and model output data for rainfall and temperature. Observed data covered the period between 1963 and 2009 for Eldoret and Kampala Synoptic meteorological stations. The observed data were sought from Kenya and Uganda National Meteorological and Hydrological Centers (NMHCs) respectively. CSIRO Mk3.6 model output included historical and projected data based on historical and $2.6Wm^2$, $4.5Wm^2$ $6.0Wm^2$ and $8.5Wm^2$ scenarios. The baseline and projected model data was obtained from the European Climate Assessment Data and KNMI Climate Explorer (KNMI) for ensemble mean of CSIRO MK 3.6 a Coupled Model Inter-comparison Project phase 5 (CMIP5) multi-model dataset (Mitchell *et al.* 1989) available at http://climexp.knmi.nl/get_index.cgi. The rainfall, maximum and minimum temperatures data records were from 1950-2005, and future climate variable were from 2006 to 2100.

3.2.2 Household Data

Data on the trend of fodder production and availability, level of smallholder dairy farmer's awareness to climate change impact on dairy production and their coping mechanisms were collected through a household survey

3.3 Methodology

This section gives a description of the research design that guided the study. It also describes the sampling techniques used in selecting respondents and the sample size that was applied. It further explains the instrument that was used in data collection, its validity and reliability. Finally the section indicates how data was processed and analyzed.

3.3.1 Trend Analysis

Trend analysis can be described as the general movement of a time series over an extended period of time or it is the long term change in the dependent variable over time. Rainfall and temperature data are collected over time.

The most convenient and popular way of describing data is using graphical method. This method is easier to understand and interpret data when they are presented graphically than using other statistical methods such as frequency table. This method is easy and it allows a pair of value such as rainfall and crop yield data to be depicted by a single point placed suitably on a piece of graphic paper. The usefulness of graphical presentation arises partly from the quantity, information that can be displayed. However, graphical method is quite subjective.

In this study line graphs and bar graphs were used to determine the trend of rainfall, temperature, fodder production and milk production.

3.3.2 Cross-Sectional Survey

A household survey was conducted to assess the level of awareness of the smallholder dairy farmers for climate change impact on dairy production and their coping mechanisms

3.3.3 Research Design

This study was guided by a cross-sectional survey research design. This design is ideal for such a study where sampling from a specific population is done at one point in time (Wiersma (1986). The design allows collection of data to be done under natural setting, and is relatively quicker and cheaper to undertake and the results can easily be inferred to the larger population. It's application allows for collection of both qualitative and quantitative data from dairy farmers whose productivity is affected by climate change/ variability.

In order to reduce potential biases, sampling of the target farmers was randomized, a relatively higher sample size was taken, and the study done in two separate distinct sites. All other identified confounding variables was built in the study

3.3.4 Sampling Technique

A purposeful simple random sampling technique was used to select the farmers from Kosirai and Namayumba sites. The two sites were selected because these are the areas where a project promoting climate smart agricultural practices in dairy production is being implemented. The smallholder dairy farmers participating in this project were targeted for this study.

3.3.5 Sample Size

Kathuri and Pals (1993) observed that a sample of 100 respondents is ideal for a study of this kind. In order to appropriately control the influences of the potential extraneous variables and respondents who may decline to answer questions, this study sampled a total of 253 farmers of which a random sample of 129 farmers were from Kosirai site in Kenya while 124 farmers were randomly selected from Namayumba in Uganda.

3.3.6 Instrument of the Study

Structured questionnaire was used as an instrument to collect data from the respondent to get trend of fodder production and availability and farmer's knowledge and awareness on climate change and the coping mechanisms based on the objective of the study, research questions, conceptual framework and various study variables. Other confounding variables that could have influenced the result of the main independent variables were identified and inbuilt in the study.

3.3.7 Validity of the Questionnaire

The questionnaire was subjected to a critique by school members, departmental lecturers and peers and positive comments were incorporated to improve on questionnaire. According to Mugenda and Mugenda (1999), incorporation of positive comments makes the questionnaire to capture appropriate, useful and dependable data whose finding and inferences can be a true reflection of the study population

3.3.8 Reliability of the Instrument of the Study

To ascertain reliability, the study instrument was pretested in one identified site which has smallholder dairy farmers experiencing similar socio –economic and physiographic characteristics. In this study pretesting was done in Molo District of Kenya. Molo is predominantly occupied by smallholder dairy farmers who have similar socioeconomic and climatic characteristic to the two study sites. Pretesting was done with 15 smallholder dairy farmers and responses and analysis used to review the data capture tool. Pretesting enable the summary and focused questions which improve clarity and ambiguity.

3.3.9 Administration of the Questionnaire

The field work for data collection started with introductory meeting at the East Africa Dairy Development Project country office in Eldoret, to introduce and explain the purpose of the study and selected study site. Through the country office, six enumerators were identified and half day training and pretesting of questionnaire carried out to ensure all the enumerators had the same understanding. This was then followed with four days of data collection in Kosirai area. Each evening, a meeting was held to review progress and identify challenges encountered by each enumerator, a total of 129 respondents were interviewed.

A similar exercise was carried out in Uganda Namayumba area with six enumerators and 124 respondents were interviewed. One major challenge met during the data collection in Kosirai area was too much rainfall especially during the afternoons and the interviews had to be scheduled in the morning. In Uganda the challenge faced was language barrier and the interpretation of the questionnaire was done by the enumerators.

3.3.10 Data Management and Analysis

The collected data were organized and prepared for analysis. The data was cross-checked and corrected during the data cleaning process. Then it was exported for analysis by Statistical Package for Social Sciences (SPSS) version 21.0 software. Descriptive analysis such as proportions, percentages, frequency distributions and measures of central tendency mean and median were then used. Data summary and classification were done and presented using tables and graphs.

3.3.11 Relationship between Climate Change and Dairy Productivity

Investigation of the effects of climate change on milk and fodder production was based on observed rainfall and farmer's awareness. Based on monthly rainfall totals, major wet and dry seasons within the study period (1973–2010) were identified as extreme rainfall values and computed based on moving average method. The moving average method implemented by a macro program identified three highest values (extremes) in the first block where each block had a length of three years. It also computes the relative frequency of the highest values in the first block to the whole data set. It then shifts by one step and repeats the whole procedure. As it moves, it checks how the extreme values in each block relate to other values in the whole dataset series. The resulting time series of perturbations of monthly rainfall totals were then compared to identify how extremes were changing and then compared to fodder and milk production data from the household survey using bar graphs

CHAPTER FOUR

4 RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents key results and discussion arising from the objectives of this study.

4.2 Time Series Analysis of Rainfall and Temperature in Kosirai and Namayumba

The trend of rainfall and temperature based on observed data and CSIRO Mk3.6 model output are presented in subsequent sections.

4.2.1 Descriptive Statistics of Rainfall and Temperature

The table 4-1 shows a summary of descriptive statistics based on observed and model outputused in the study.

Table 4-1: Descriptive statistics of annual rainfall and temperature in Kosirai and Namayumba

	Scenario	Period	Descriptive Statistic	Kosirai			Namayumba		
				Rainfall (mm)	Tmax ^oC	Tmin ^oC	Rainfall (mm)	Tmax ^oC	Tmin ^oC
Gauge rainfall	Observed data	1973 - 2009	Mean	1062.8	28.5	15.5	1172.5	26.5	16.3
		1973 - 2009	STDEV	213.5	0.3	0.5	182.5	0.2	0.5
CSIRO Mk3.6	Historical	1950 - 2005	Mean	675.9	27.6	16.8	1063.0	28.1	17.6
			STDEV	236.3	0.6	0.3	167.6	0.5	0.4
	RCP2.6	2006-2100	Mean	648.2	29.3	18.3	930.4	29.9	19.3
			STDEV	254.5	0.8	0.6	184.9	0.8	0.7
	RCP4.5	2006-2100	Mean	735.6	29.5	18.9	1013.5	30.3	19.9
			STDEV	236.6	0.9	1.0	162.1	1.1	1.1
	RCP6.0	2006-2100	Mean	743.6	29.4	18.7	1028.5	30.1	19.7
			STDEV	287.5	0.8	0.9	171.2	1.0	1.0
	RCP8.5	2006-2100	Mean	823.2	30.0	19.6	1038.8	30.9	20.7
			STDEV	292.3	1.4	1.7	173.3	1.7	1.9

The table 4-1 shows that observed mean annual rainfall at Kosirai and Namayumba were 1062.8mm and 1165.2mm while average observed maximum temperature was 28.5^{o}C and 26.5^{o}C respectively. Based on all the scenarios considered in the CSIRO model, the mean annual rainfall ranged between 648.2mm and 823.2mm in Kosirai and between 930.4mm and

1063.0mm in Namayumba, an indication that Namayumba in Wakiso district of Uganda received higher amounts of annual rainfall compared to Kosirai in Nandi North district of Kenya. Maximum temperature ranged between 27°C and 31°C while minimum temperatures ranged between 16°C and 21°C in with RCP of 8.5Wm^2 showing the highest standard deviation of between and 1°C and 2°C.

4.2.2 Trend of Baseline Rainfall in Kosirai and Namayumba

The results of the trend of past rainfall and temperature are presented based on observed data and CSIRO Mk3.6 model outputs are presented in figures 4-1 and 4-2.

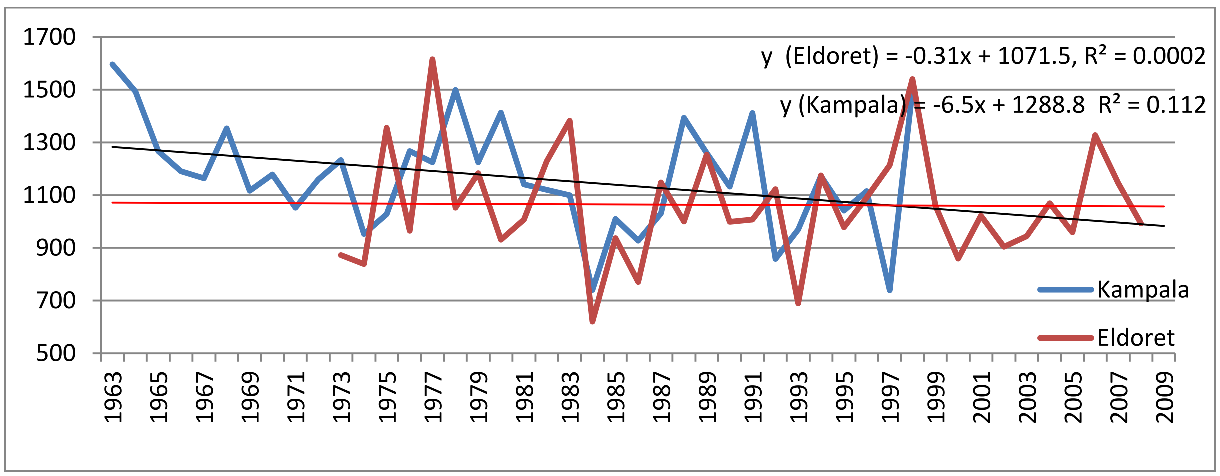

Figure 4-1: Trend of observed rainfall for Eldoret and Kampala synoptic meteorological stations

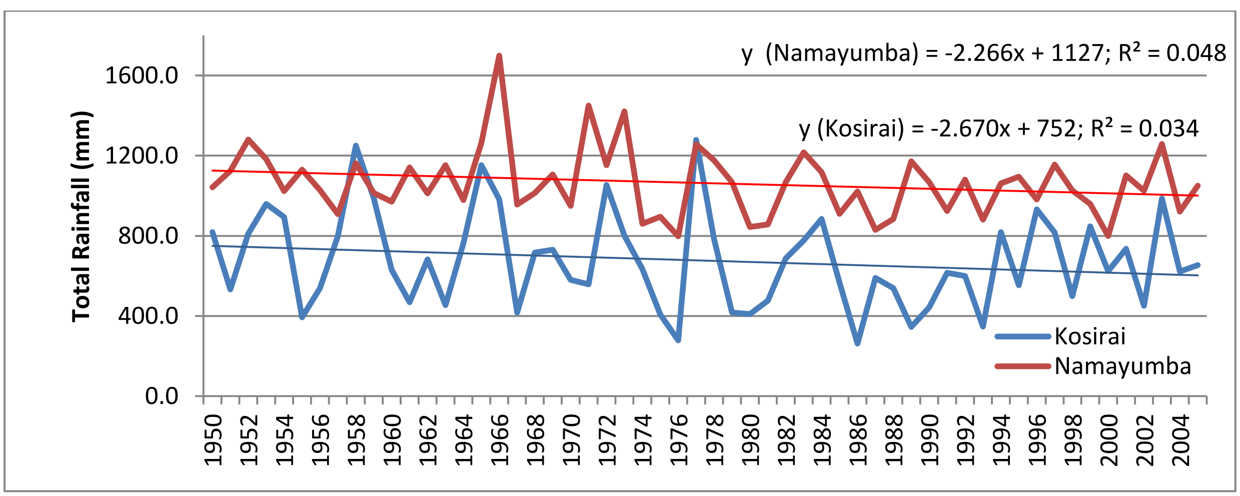

Figure 4-2: Trend of Rainfall based on historical CSIRO model output over Kosirai and Namayumba

In the Figures 4-1 and 4-2, the study shows that observed rainfall decreased between the period 1963 and 2010 while CSIRO baseline rainfall data showed a decreasing trend over Kosirai and Namayumba. However, these trends could only be explained by 4.8% (R^2 ~ 0.048) and 3.4% (R^2 ~ 0.034) of data that fitted in the linear regression line for Namayumba and Kosirai respectively

4.2.3 Trend of Baseline Maximum Temperature in Kosirai and Namayumba

The results of the temperature trendusing both observed data and, CSIRO Mk3.6 model output are presented in figure 4-3

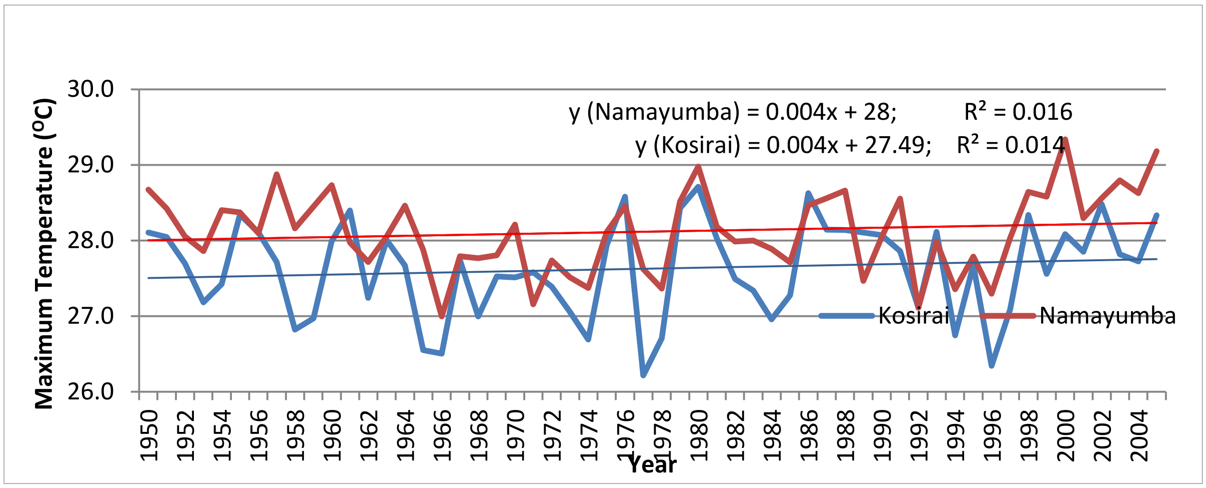

Figure 4-3: Trend of Maximum temperature based on historical CSIRO Mk3.6 model output over Kosirai and Namayumba

The figure 4.3 shows that maximum temperature generally increased during the historical period over Kosirai and Namayumba. However, this increasing trend of maximum temperature could only be explained by less than 2% of data that fitted into the linear regression as noted by values of the coefficient of determination which were all less than 0.02.

4.2.4 Trend of Baseline Minimum Temperature in Kosirai and Namayumba

The results of the trend of past rainfall and temperature are presented based on observed data, CSIRO Mk3.6 output are presented in figures 4-4.

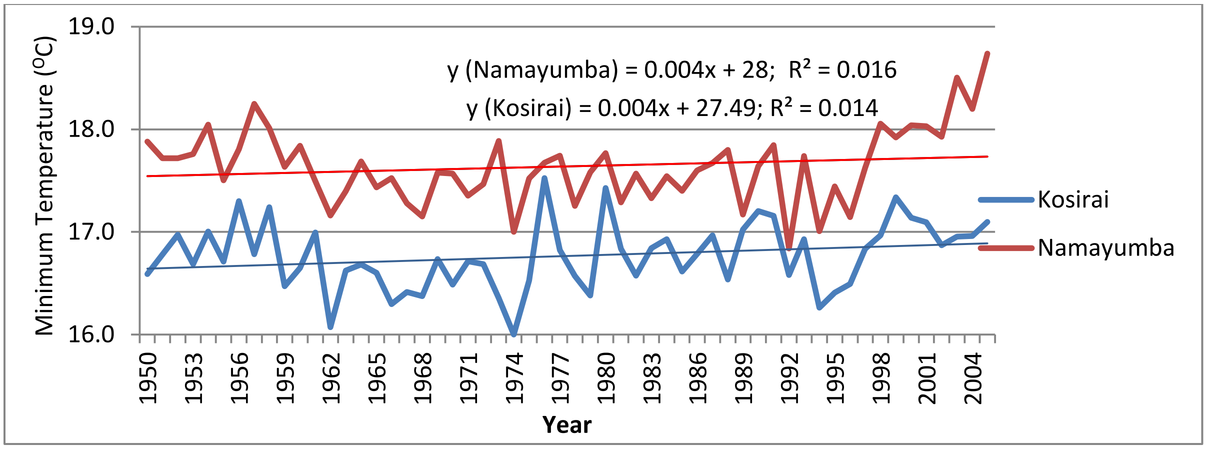

Figure 4-4: Trend of minimum temperature based on historical CSIRO model output over Kosirai and Namayumba.

Based on CSIRO model output (Figure 4.4), the trend of minimum temperature for the baseline period was noted to increasing at both Namayumba and Kosirai site. However, this increasing trend could only be explained by 1.6% (R^2 ~ 0.016) and 1.4% (R^2 ~ 0.014) of data sets which along the line of best fit.

4.2.5 Trend of Projected Rainfall in Kosirai and Namayumba

The results of rainfall Maximum and Minimum temperature variability were based on CSIRO Mk3.6 model output (RCP 2-6, 4-5. RCP 6-0 and 8-5) and presented in figures 4-5 to 4-8.

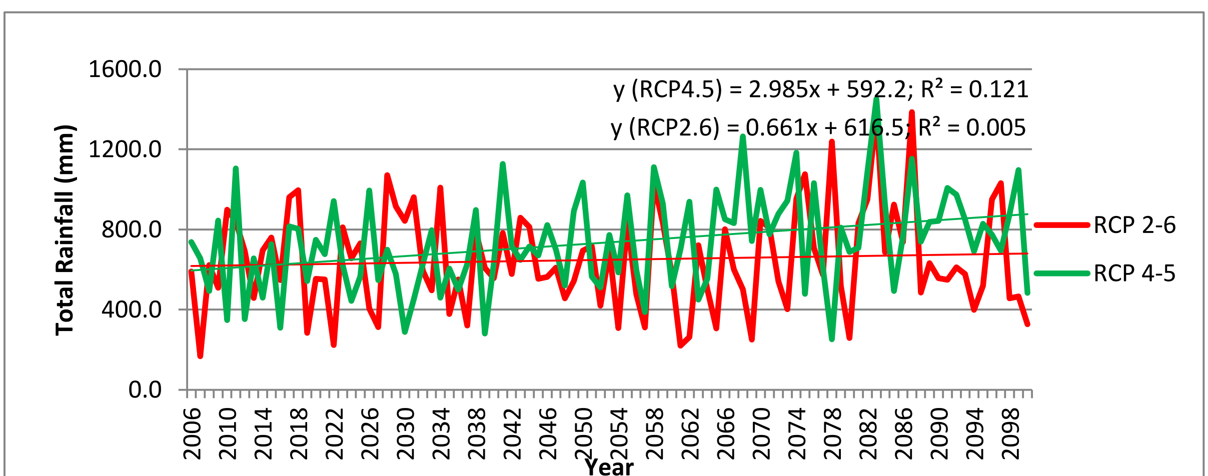

Figure 4-5: Trend of Rainfall based on 2.6 Wm^2 and 4.5Wm^2Scenarios fromCSIRO model over Kosirai

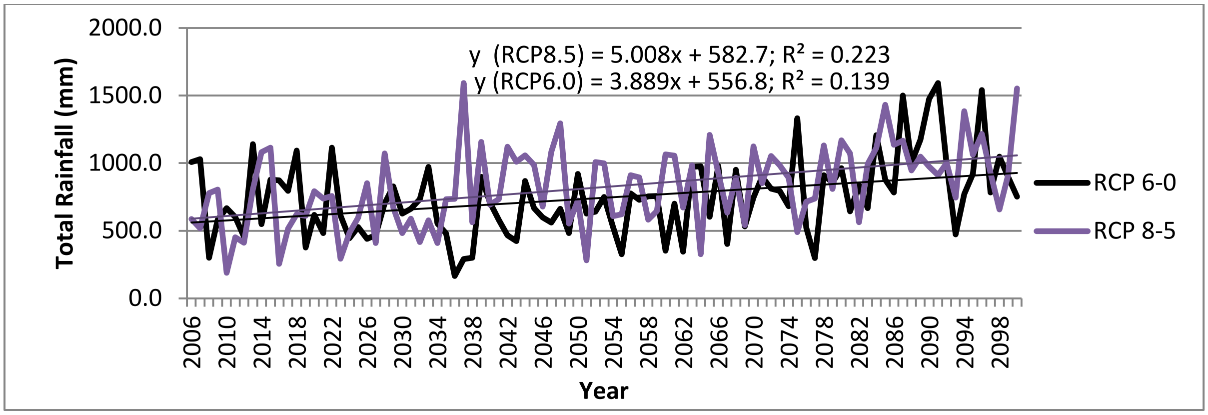

Figure 4-6: Trend of rainfall based on 6.0 Wm^2 and 8.5 Wm^2 Scenarios from CSIRO model over Kosirai

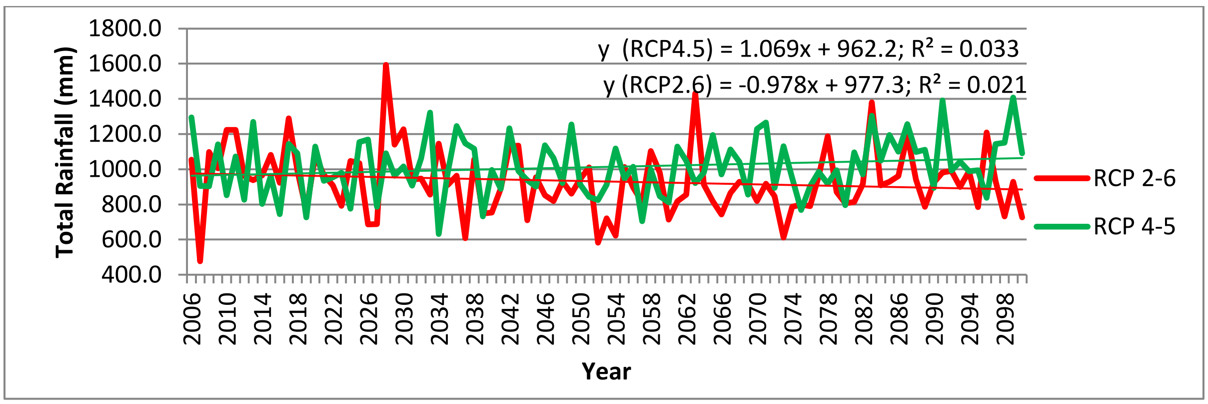

Figure 4-7: Trend of rainfall based on $2.6Wm^2$ and $4.5Wm^2$ Scenarios from CSIRO model over Namayumba

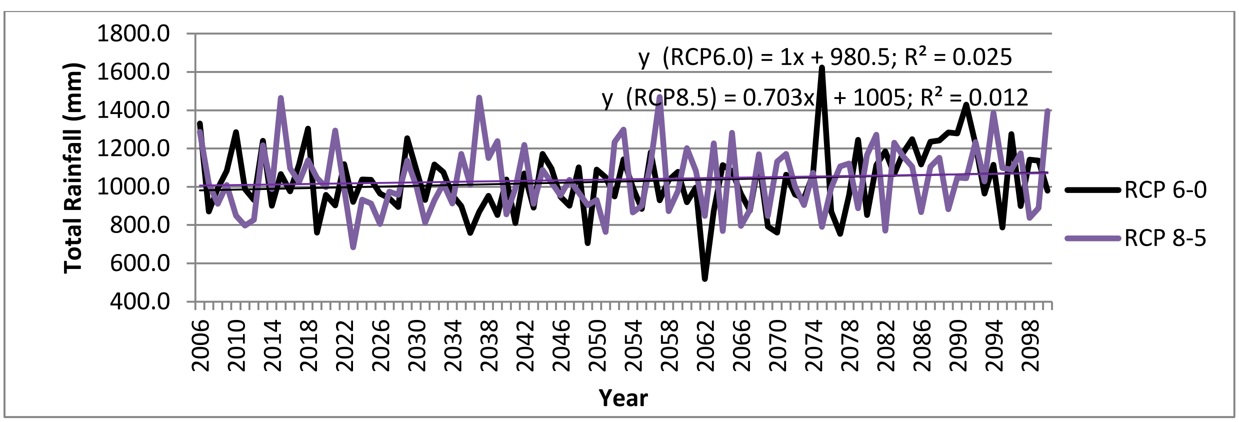

Figure 4-8: Trend of rainfall for $6.0Wm^2$ and 8.5 Wm^2 Scenarios from CSIRO model over Namayumba

In the figure 4-5 and 4-8, annual precipitation under the different representative concentration Pathway had increasing trend with only RCP 2.6 scenario in Namayumba showing a decreasing trend in annual precipitation. Kosirai had highest increased observed under the RCP 8.5 scenario Therefore, these results implied that annual precipitation was expected to increase in most scenarios with the RCP 8.5 expected to show a higher increase compared to other RCP scenarios. These changes in rainfall pattern over time is expected to influence fodder production and supply, especially in East Africa where smallholder dairy production is dependent on rain-fed forage production

4.2.6 Trend of Projected Maximum and minimum Temperature in Kosirai and Namayumba

The results of rainfall Maximum temperature variability were based on CSIRO Mk3.6 model output and presented in figures 4-9 to 4-16.

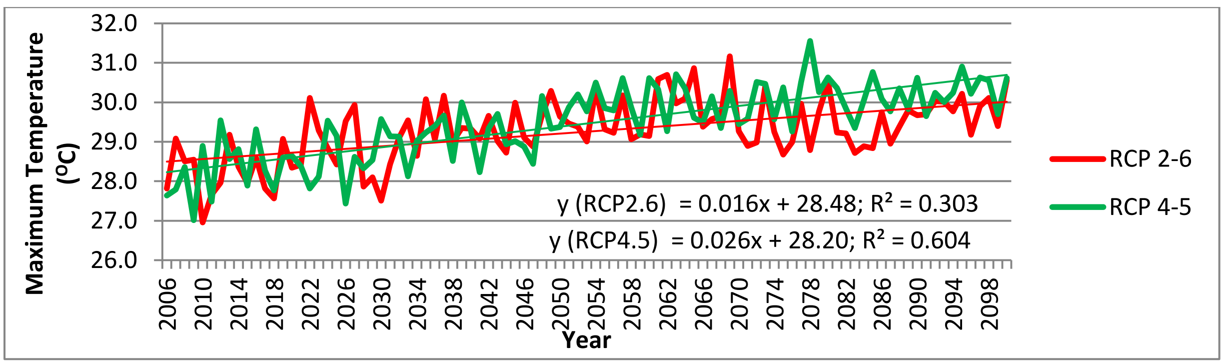

Figure 4-9: Trend of minimum temperature based on 2.6 Wm^2 and 4.5Wm^2Scenarios from CSIRO model over Kosirai

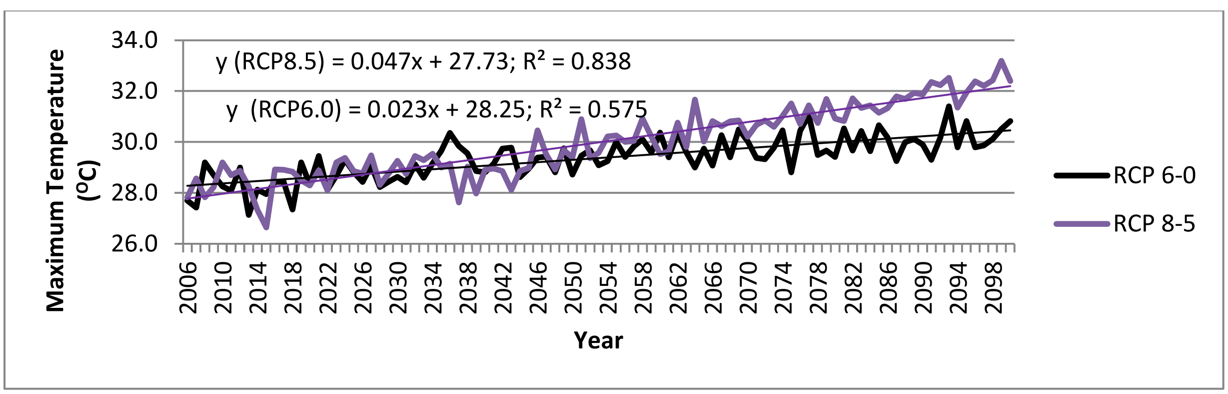

Figure 4-10: Trend of minimum temperature based on 6.0 Wm^2 and 8.5Wm^2 Scenarios from CSIRO model over Kosirai

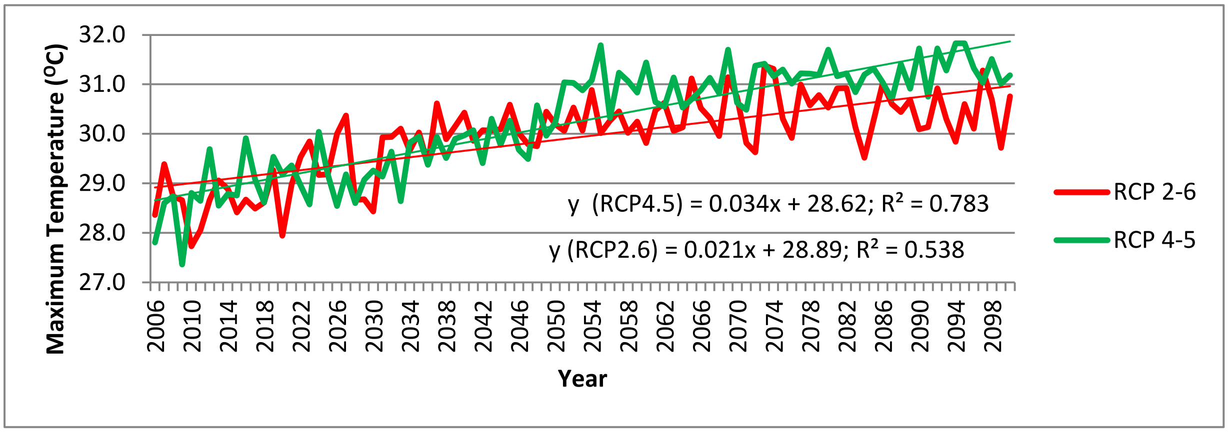

Figure 4-11: Trend of minimum temperature based on 2.6 Wm^2 and 4.5Wm^2Scenarios from CSIRO model over Namayumba

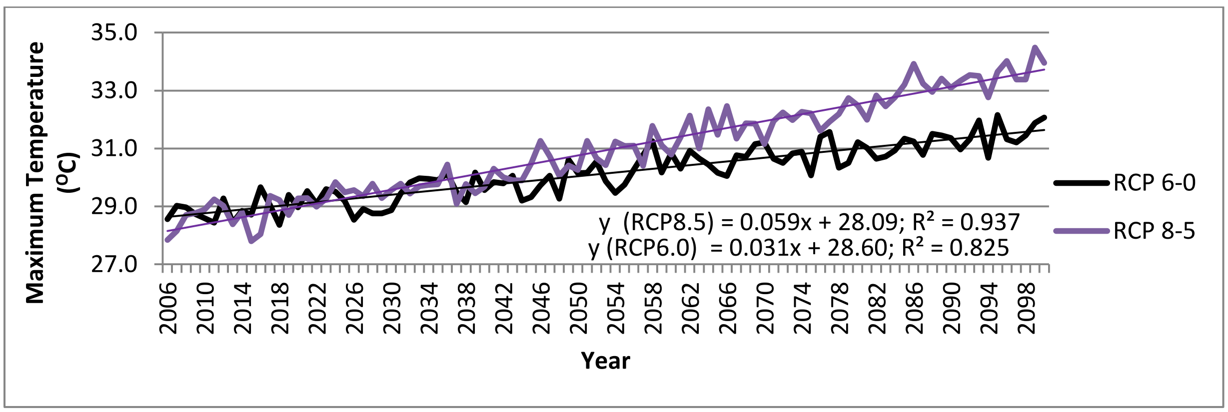

Figure 4-12: Trend of minimum temperature based on 2.6 Wm^2 and 4.5Wm^2Scenarios from CSIRO model over Namayumba

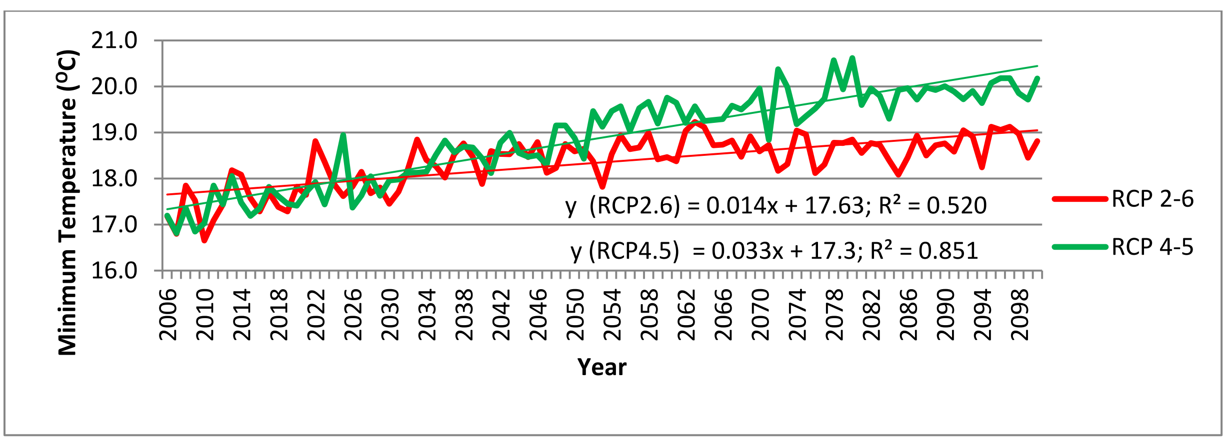

Figure 4-13: Variability of Minimum Temperature for 2.6 Wm^2 and 4.5Wm2 Scenarios from CSIRO model over Kosirai

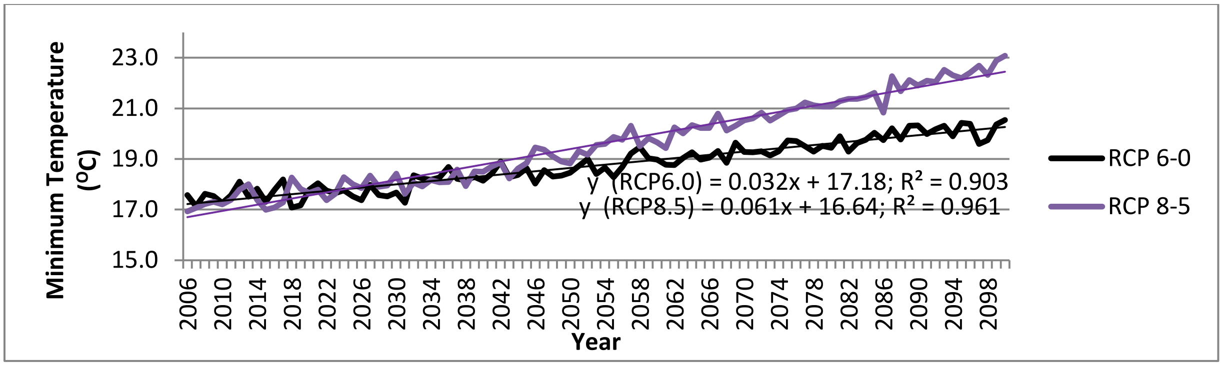

Figure 4-14: Variability of Minimum Temperature for 6.0 Wm^2 and 8.5 Wm^2 Scenarios from CSIRO model over Kosirai

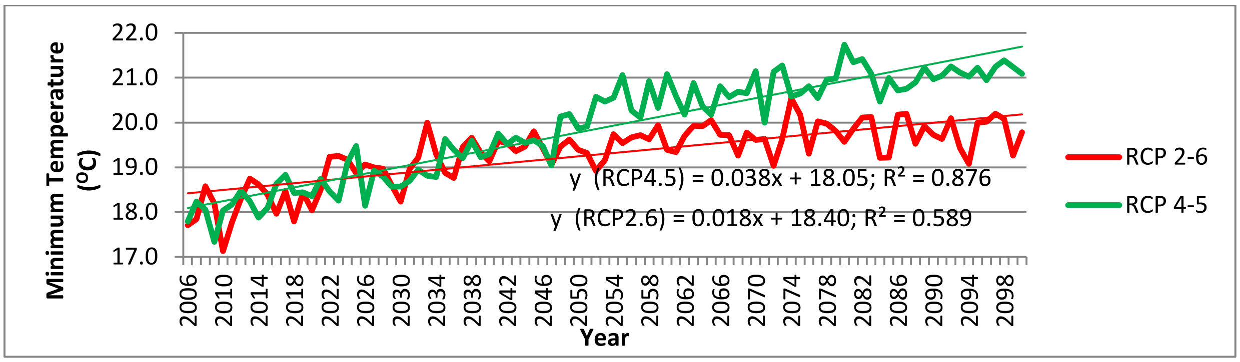

Figure 4-15: Variability of Minimum Temperature for 2.6 Wm^2 and 4.5Wm^2 Scenarios from CSIRO model over Kosirai

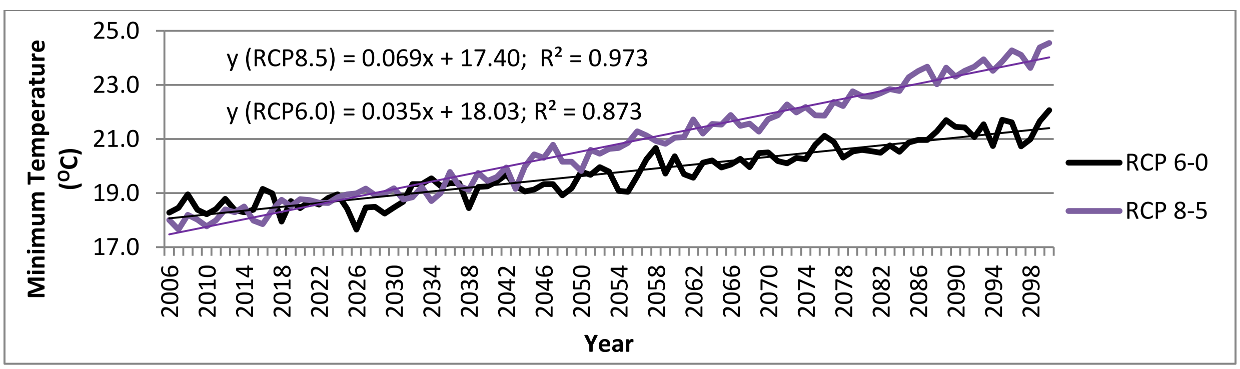

Figure 4-16: Variability of Maximum Temperature for 6.0 Wm^2 and 8.5 Wm^2 Scenarios from CSIRO model over Kosirai

From the figures 4-9 to 4-16, the study showed that both maximum and minimum temperature was increasing for in Namayumba and Kosirai areas. Increasing trend in maximum and minimum temperature for RCP 4.5, RCP 6.0 and RCP 8.5 could be explained by R^2 values of more than 0.5 (50%) . These meant that projected temperature would most likely increase over study and region. According to Food and Agriculture Organization (FAO, 2004) an increase in average global temperatures of just two to four degrees Celsius above pre-industrial levels could reduce crop yields by upto15-35 percent in Africa

4.3 Trend of Fodder Production and Availability over Kosirai, Kenya and Namayumba, Uganda

4.3.1 Household Respondent and Type

The sex of respondent, their relationship to the household head and the type of household in Kosirai, Nandi North District of Kenya and Namayumba, Wakiso District of Uganda are presented in Figures 4-17 to 4-19.

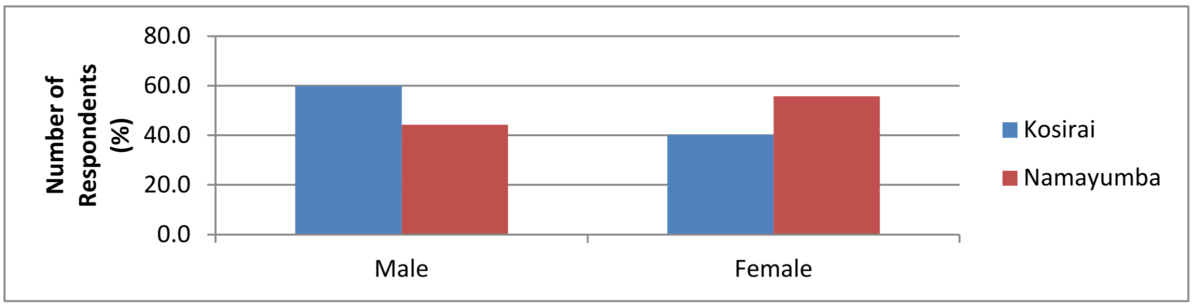

Figure 4-17: The sex of respondent in Kosirai, Kenya and Namayumba, Uganda

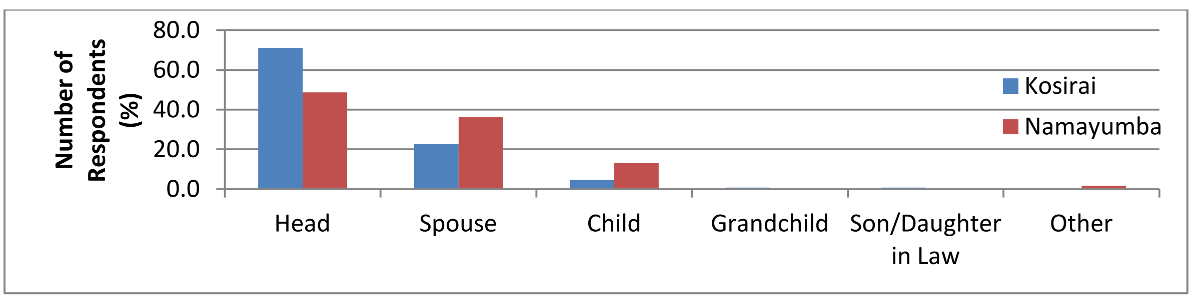

Figure 4-18: Relationship of the respondent to the household head

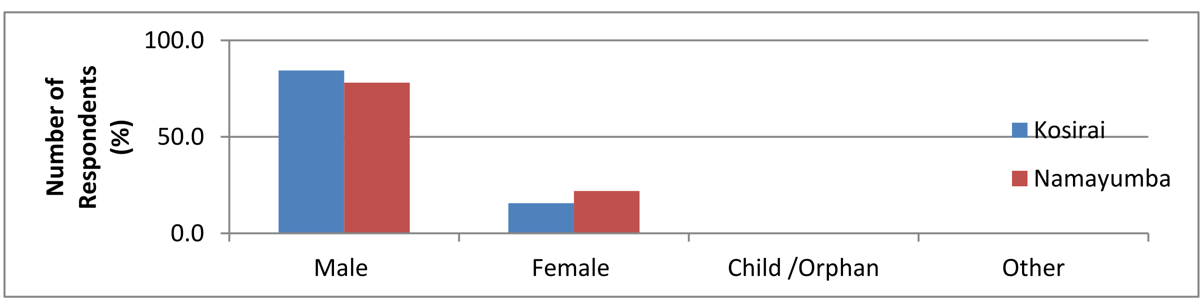

Figure 4-19: The type of Respondent in Kosirai, Kenya and Namayumba, Uganda

In figure 4-17, the study notes that men were more than women in Kosirai, Nandi North district of Kenya as indicated by the their 59.8% male respondents compared to 40.2% women. However, Female respondents from Namayumba, Wakiso district of Uganda were noted to be higher at 55.7%. Furthermore, more than 71.1% and 48.8% of the respondents were observed to be the household heads in Kosirai and Namayumba locations respectively followed by the household spouse as shown in Figure 4-18. Generally, the study noted that most men (84.4% in kosirai and 78.0% in Namayumba) as shown in Figure 4-19.

4.3.2 Characteristics of Respondents

The characteristics of respondents in the household were analyzed based on their number, age group, level of education, occupation and source of income. The results are presented in Figures 4-20 to 4-24.

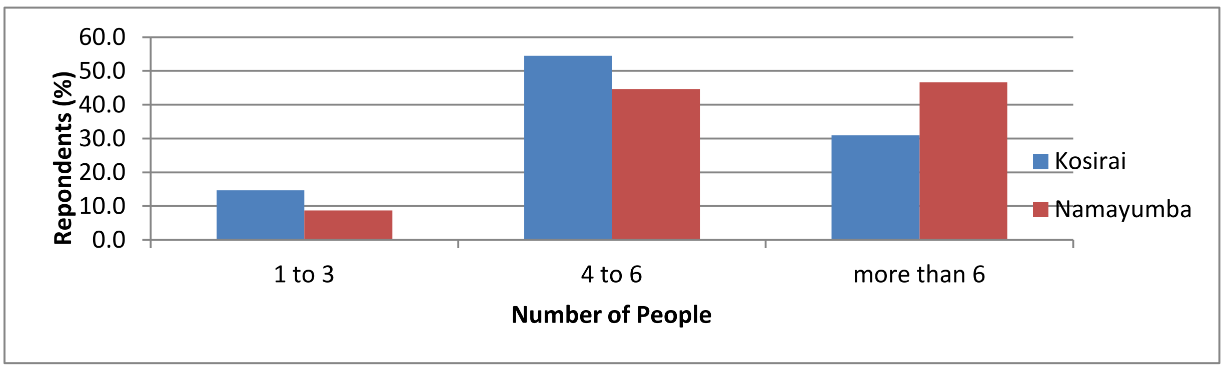

Figure 4-20: Number of People in the households

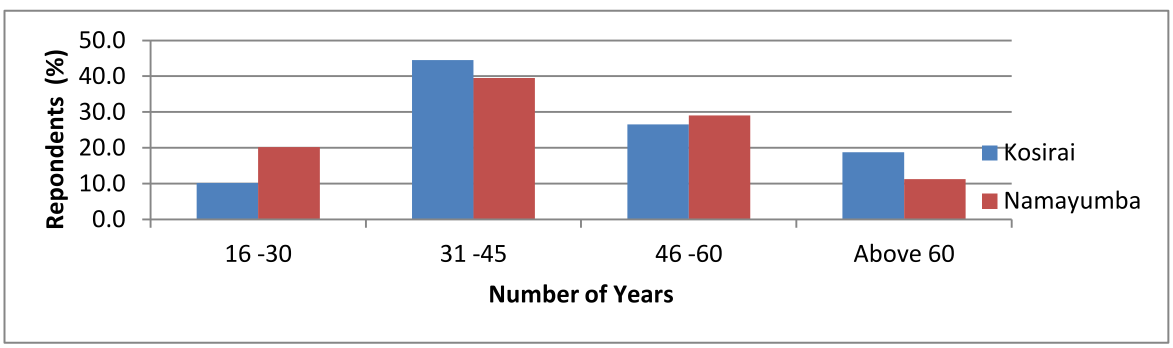

Figure 4-21: The Age group of People in Kosirai, Kenya and Namayumba, Uganda

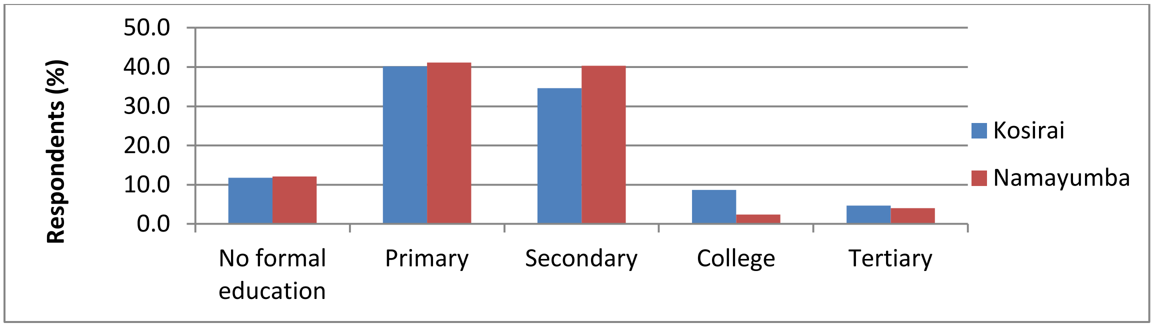

Figure 4-22: The Highest Level of Education

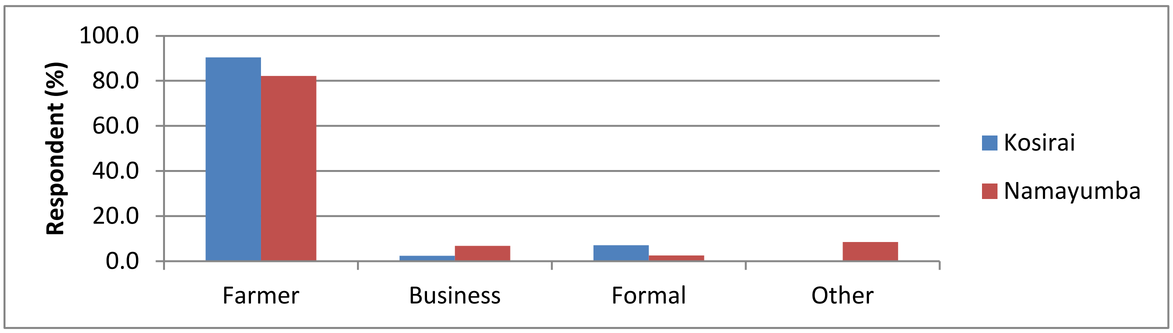

Figure 4-23: The main occupation of Respondents in Kosirai and Namayumba

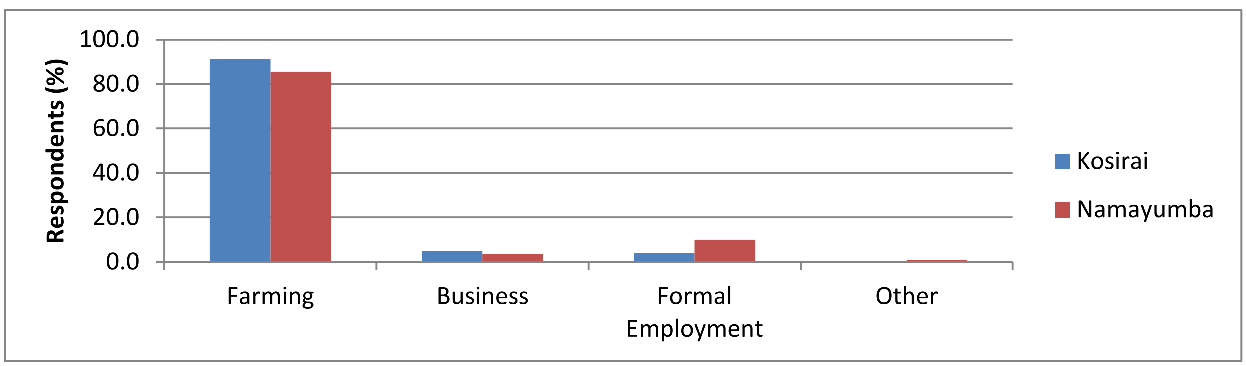

Figure 4-24: The Main Source of income in Kosirai, Kenya and Namayumba, Ugunda

The figure 4-20 shows that most Households in Kosirai, Kenya (54.5%) had between four to six people while most households in Namayumba, Uganda (46.7%) had more than six people in the household. Generally, most respondents in both Kosirai and Namayumba catchment area were between the ages of 31 and 45 years comprising of 44.5% and 39.5% of the total respondents respectively followed by 46 to 60 years age group as shown in Figure 3-21. Moreover, primary education was noted as the highest level of education with 40.2% and 41.1% respondents in both Kosirai and Namayumba locations followed by Secondary education. In Figure 4-23, most of these respondents (80%) were noted to be farmers while business, Formal and other occupations accounted for less than 20% of the total respondents and thus farming was observed as the main source of income.

4.3.3 Wealth Indicators

The study assessed the wealth indicator of Kosirai and Namayumba areas based on Total land holding and size allocated to dairy farming, land tenure system and the type of items owned. The results are presented in Figures 4-25 to 4-27.

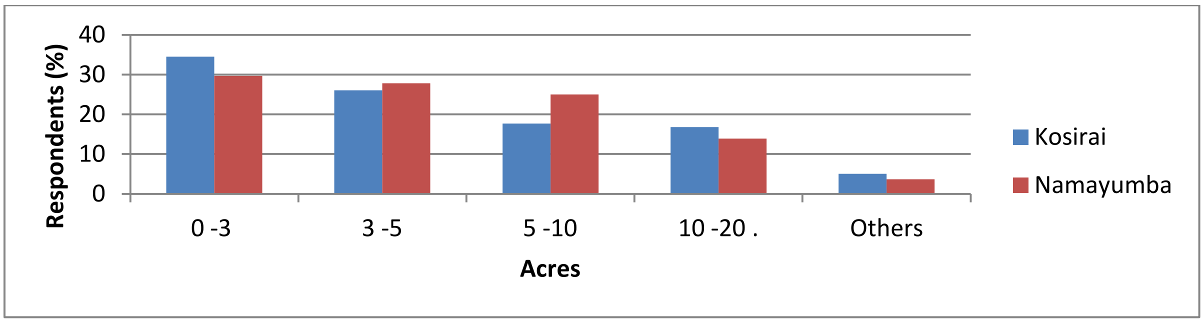

Figure 4-25: Total Land Holding in Kosirai and Namayumba Areas.

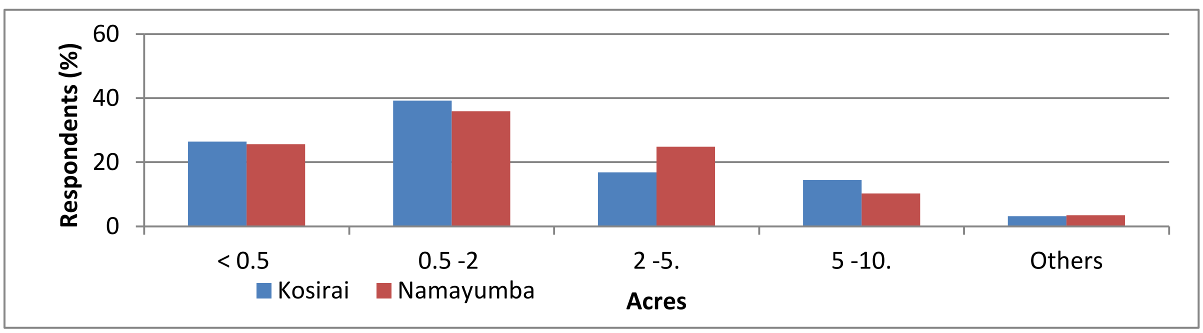

Figure 4-26: Total Land allocated to dairy Farming

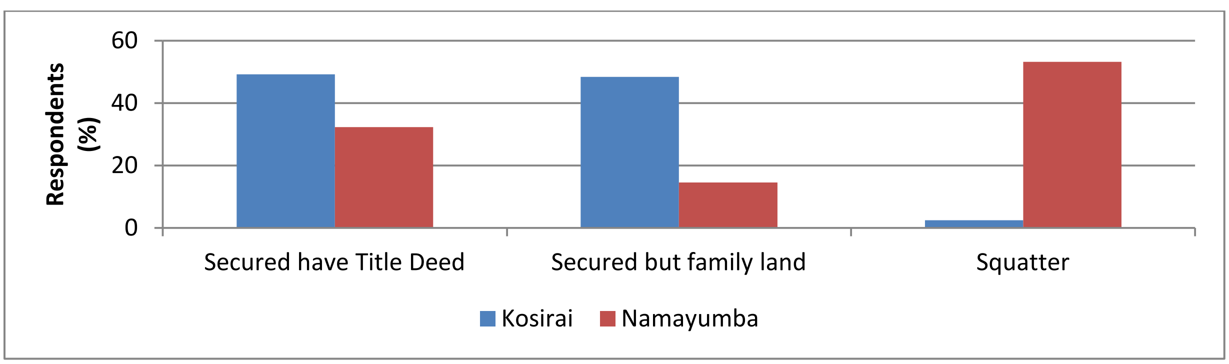

Figure 4-27: Land Tenure System in Kosirai and Namayumba Areas

The figure 4-25 indicated that most respondents had a total land holding of less than 3 acres and accounted for 34.5% and 29.6% in Kosirai and Namayumba respectively. The study also noted that the average land allocated to dairy farming (Figure 4-26) was 39.2% and 35.9% in Kosirai and Namayumba areas. Generally, the study observed that most of respondents in Kosirai land tenure system were either secured and had title deed (49.1%) or categorized as family land (48.4%) whereas the land tenure system for most respondents in Namayumba were categorized squatters (figure 4-27). This type of land tenure system is a subset of the mailo land tenure system where the land belongs to Kabaka and it is leased at a small fee.

4.3.4 Fodder and Pasture Production Trend

Trend of fodder and pasture was determined based on the type and changes over the ten year period and results presented in figure 4-28 to 4-30 and tale 4-2 and 4-3.

Table 4-2: Type of fodders and Pastures planted now in Kosirai and Namayumba

5 Station	**6** Pasture							
	Response	Natural (%)	Improved pasture (%)	Napier (%)	Rhodes (%)	Fodder trees (%)	Mucuna/ Lab (%)	Others (%)
Kosirai	yes	82.8	3.3	53.3	40.5	2.5	0.0	4.9
	No	17.2	96.7	46.7	59.5	97.5	100.0	95.1
Namayumba	yes	52.1	4.9	68.9	2.5	41.0	12.3	10.7
	No	47.9	95.1	31.1	97.5	59.0	87.7	89.3

Table 4-3: Type of fodders and Pastures planted Ten Years ago in Kosirai and Namayumba

7 Station	**8** Pasture							
	Response	Natural (%)	Improved pasture (%)	Napier (%)	Rhodes (%)	Fodder (%)	Mucuna/ Lab (%)	Others (%)
Kosirai	yes	73.0	3.3	35.2	20.7	1.7	0.8	0.8
	No	27.0	96.7	64.8	79.3	98.3	99.2	99.2
Namayumba	yes	50.0	5.7	52.5	0.8	18.0	10.7	4.1
	No	50.0	94.3	47.5	99.2	82.0	89.3	95.9

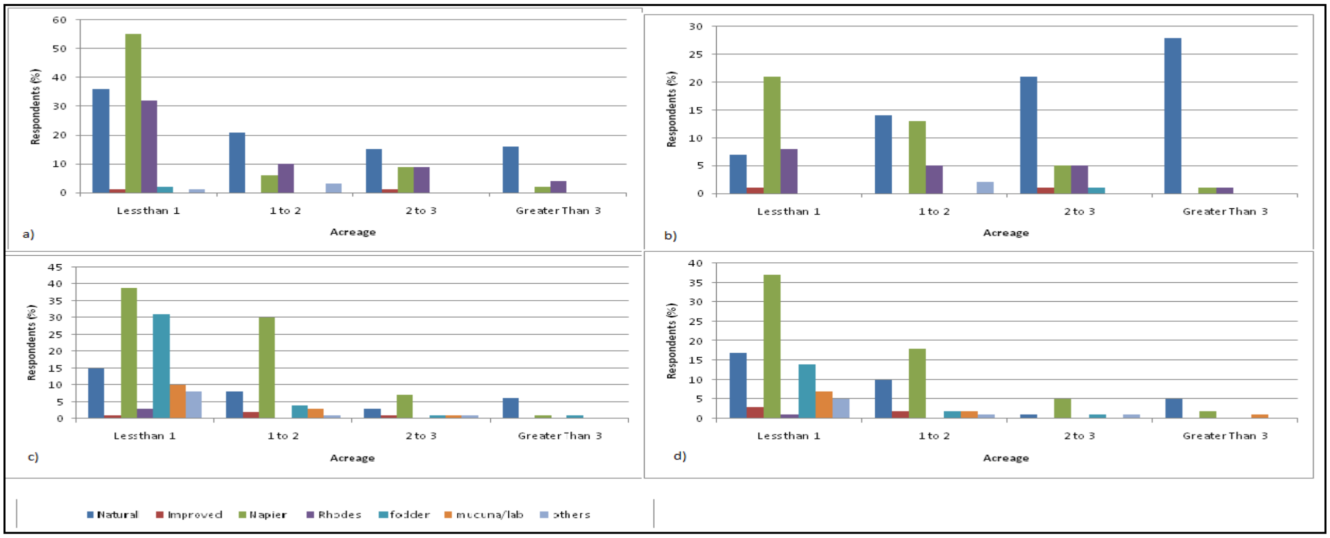

Figure 4-28: The acreage of pasture/Fodder Planted in a) Kosirai now, b) Kosirai 10 years ago c) Namayumba now and d) Namayumba 10 years ago

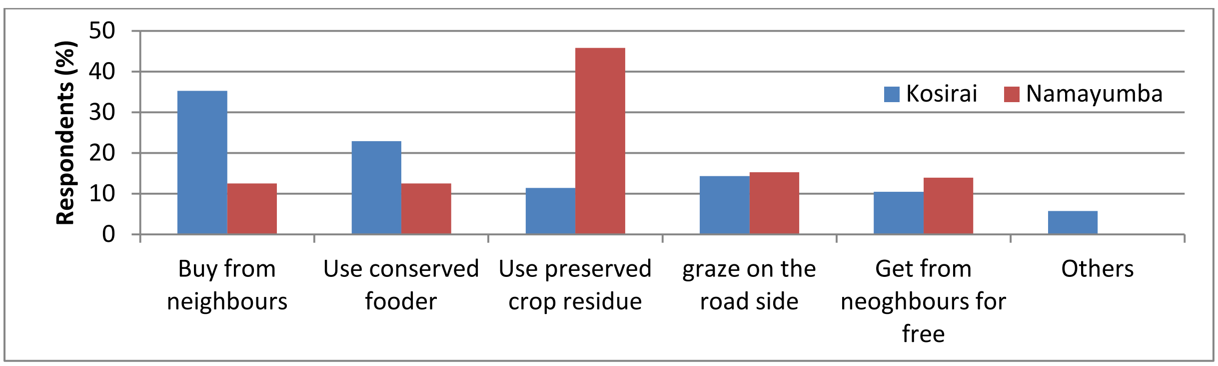

Figure 4-29: The way farmers cope with fodder/ Pasture shortage

From the table 4-2, the study showed that most respondents in Kosirai and Namayumaba mainly have Natural pasture (82.8%) and Napier (68.9%) respectively. However farmers in Kosirai, were noted to plant Napier (53.3%) and Rhodes (40.5%) while those in Namayumba are also planting Natural pasture (52.1%) and Fodder trees (41.0%). A comparison between pastures grown ten years ago (Table 4-2) and those presently planted (table 4-3) indicates similar trends.

The figure 4-28 shows an increase of 36% and 30% in the number of farmers with less than 1 acre of land currently planting Napier and Natural pasture in the last ten year period. Moreover, Natural pasture grown in more than 1 acre land was observed to decline over the same period. In Namayumba, an increase of 14% in the number of farmers growing fodder was noted with declining trend of Natural pasture of the same period.

In case of shortage in fodder/pasture, farmers (35.2%) in Kosirai bought them from neighbors while those in Namayumba (45.8%) used preserved crop residue as shown in Figure 4-29.

8.1.1 Dairy Animals

Information on dairy animals aimed to establish the number of dairy animals owned by farmers compared to ten years ago, changes and their average milk production. The results are presented in Figures 4-30 to 4-34.

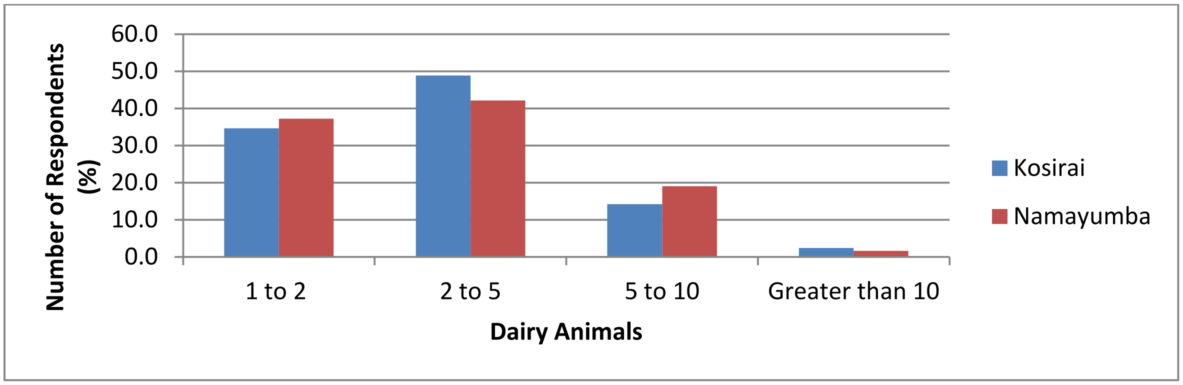

Figure 4-30: The Number of dairy animals owned by farmers at the present.

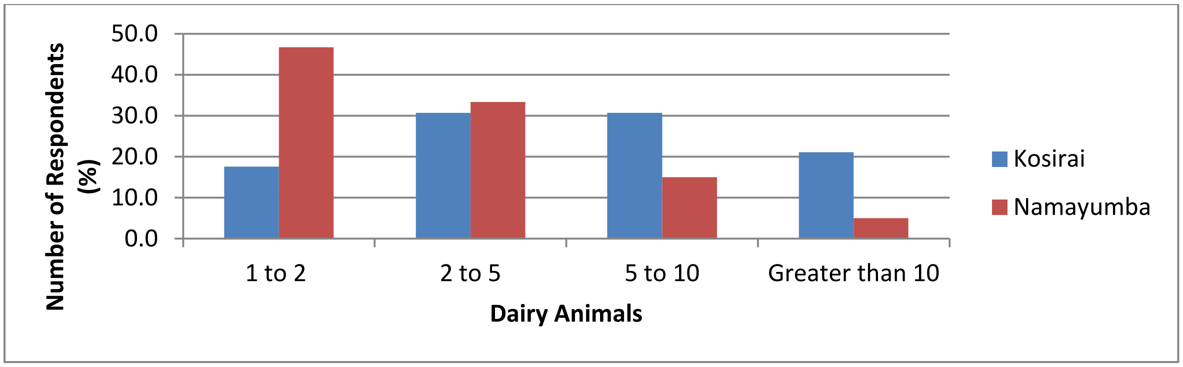

Figure4-31: The number of dairy animals owned by farmers ten years ago.

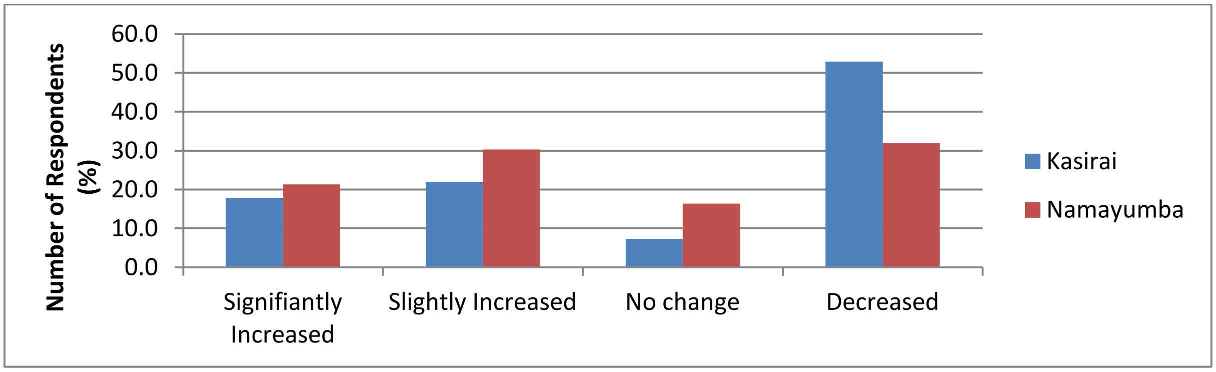

Figure 4-32: Changes in the number of dairy animals over the ten year period (2003 to 2013)

From the Figure 4-30, the study notes that most respondents presently owned less than five dairy animals and accounted for more than 79% of total dairy animals owned by farmers at present in both Kosirai and Namayumba areas. Compared to ten years ago (Figure 4-31) where most of the dairy farmers (46.7%) owned less than two dairy animals in Namayumba and 30.7% owned between two to five animals in Kosirai. The number of dairy animals in the ten year period had decreased as evidenced by a 52.8% and 32.0% of the respondents in Kosirai and Namayumba areas (Figure 4-32).

8.1.2 Animal Diseases

The common animal diseases such as Foot and Mouth, Tick born (East Cost Fever), Rift valley fever, Lumpy skin decease and Pneumonia were investigated and the results presented in Figures 4-33 and 4-34

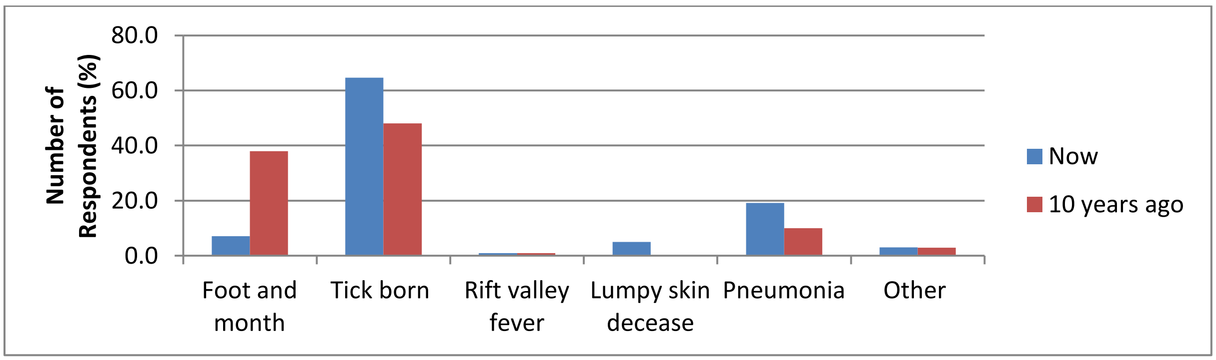

Figure 4-33: Trend of Animal diseases during the ten year period over Kosirai

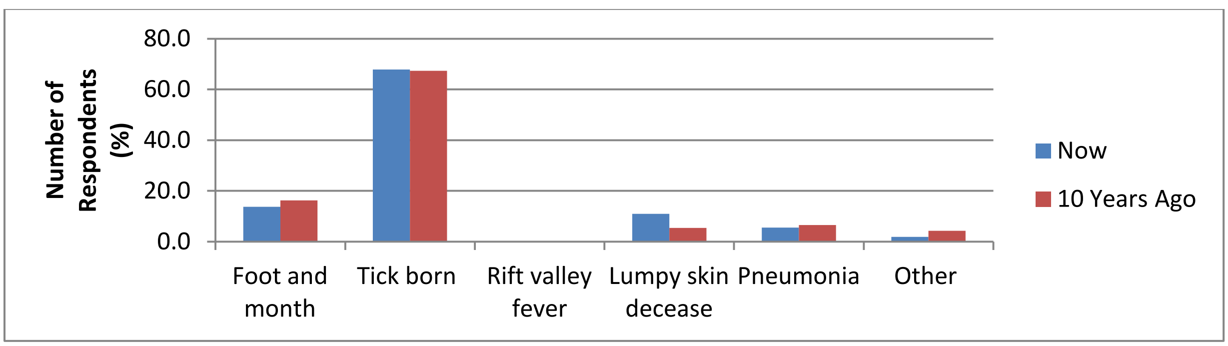

Figure 4-34: Trend of Animal diseases during the ten year period over Namayumba

The figure 4-33 showed that the tick born and pneumonia diseases increased by 16.6% while the foot and mouth disease decreased by 30.9% in the last ten years in Kosirai area while slight changes were noted in Namyumba area with the tick born disease accounting for the most cases of animal disease as observed by more than 67% of the respondents. Generally, the tick born disease was noted as the most dominant animal disease as noted in figure 4-34.

8.1.3 Water Source

Availability of the water and its sources was investigated and the results presented in figure 4-35 to 4-37. The table 4-4 specifies farmer's livestock water sources on the basis of dry and wet season over the past ten years while table 4-5 shows the distance of the farm from the source of water

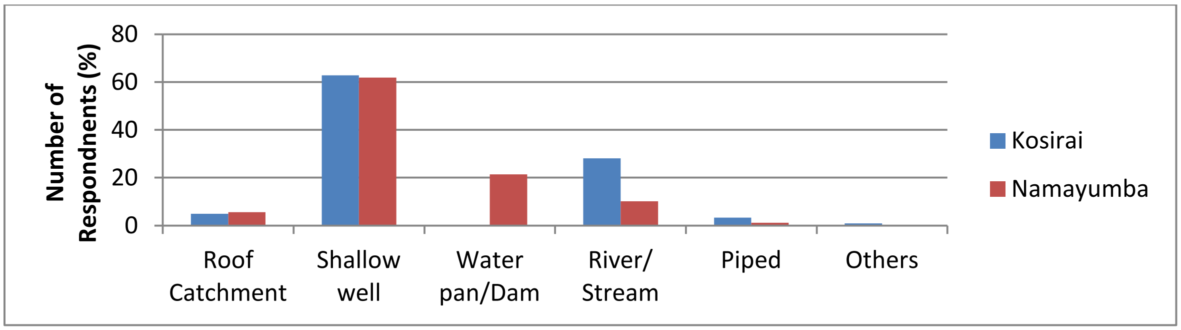

Figure 4-35: Source of water for dairy animals

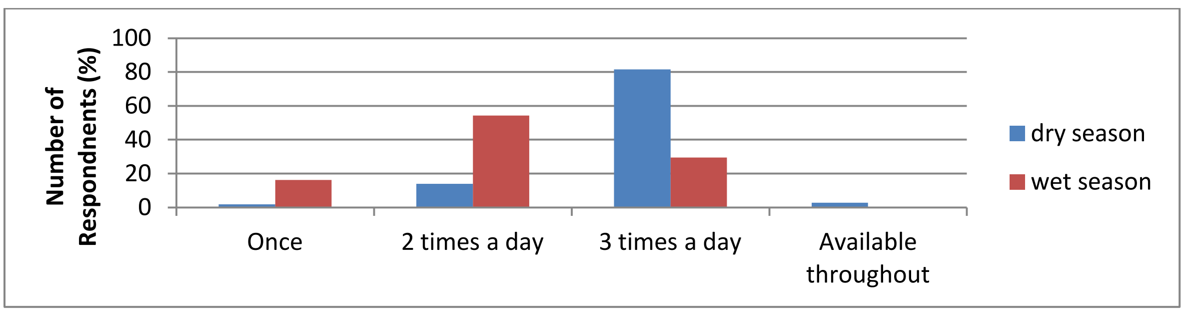

Figure 4-36: Frequency of watering animals during dry and wet season in Kosirai

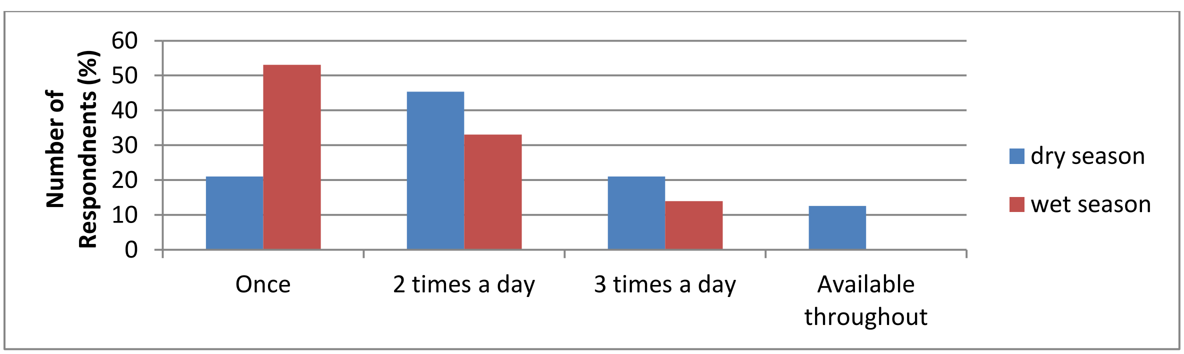

Figure 4-37: Frequency of watering animals during dry and wet season in Namayumba

Table 4-4: Livestock Water sources on the basis of dry and wet season

Variable	Kosirai				Namayumba			
Season	Wet 10 yrs ago (%)	Wet now (%)	Dry 10 yrs ago (%)	Dry now (%)	Wet 10yrs ago (%)	Wet now (%)	Dry 10 years ago (%)	Dry now (%)
Roof Catchment	3.3	0.8	0.0	0.8	33.0	35.8	0.8	2.6
Borehole/Shallow well	66.4	58.5	50.9	55.9	38.5	42.2	62.5	56.9
Water pan/Dam	1.6	0.8	4.3	5.1	15.6	15.6	18.3	18.1
River/Stream	26.2	37.4	43.1	34.7	12.8	6.4	17.5	22.4
Piped Water	1.6	1.6	0.0	0.8	0.0	0.0	0.8	0.0
Others	0.8	0.8	1.7	2.5	0.0	0.0	0.0	0.0

Table 4-5: Distance of the farm from the water source for livestock

Distance	Kosirai		Namayumba (%)	
	10 years ago (%)	Now (%)	10 years ago (%)	Now (%)
Less than 200m	59.0	74.5	35.5	46.2
200 -500 m	20.5	20.2	19.8	44.5
501 to 1000m	15.4	3.2	29.8	9.2
2 to 3 km	4.3	2.1	14.9	0.0
Other	0.9	0.0	0.0	0.0

The study notes that most people in both Kosirai and Namayumba areas use boreholes or Shallow wells as their main source of water for their dairy animals as indicated by more than 60% in both areas (Figure 4-35). In Kosirai (Figure 4-36), it was noted that 81.4% and 54.3% offarmers watered their animals 3 times a day during dry season and twice daily during wet season respectively while 45.3% and 53.4% of farmers in Namayumba area (Figure 4-37) watered their animals twice daily during dry season and once a day during wet season

The table 4-4 showed that during both wet and dry season, the main source of water was from shallow well in Kosirai and Namayumba areas. However, in Kosirai, the dependence of these Shallow wells decreased from 66.4% 10 year ago to 58.5% now during wet season while increased from 50.9% to 55.9% during dry season. In Namayumba, the dependence on shallow well increased from 38.5% to 42.2% during wet season and decreased from 62.5% to 56.9%

during dry season. Furthermore, the study noted (Table 4-5) that most of the water sources were located less than 200m from the farm in both Kosirai and Namayumba areas. The distances of these water sources were noted to decrease and thus meant more access to water sources.

8.1.4 Manure Management

This subsection assessed farmers manure management in Kosirai and Namayumba area and is presented in table 4-6 and Figures 4-38to 4-40.

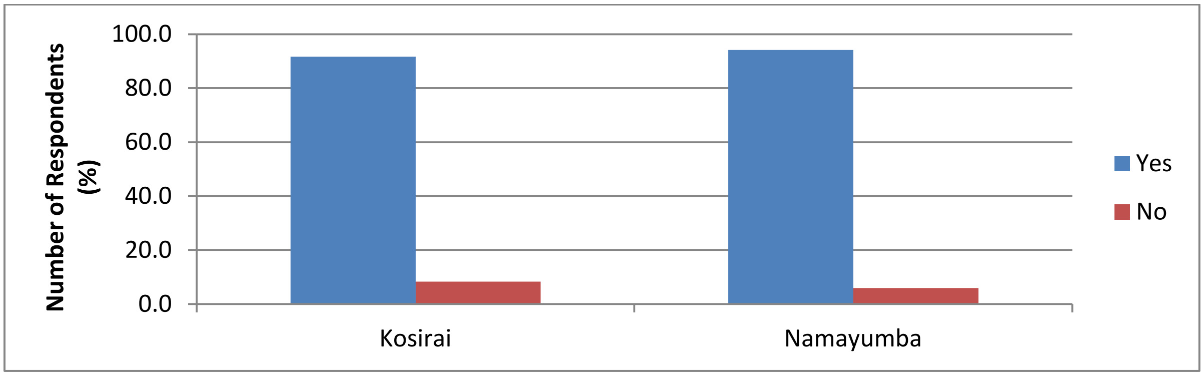

Figure 4-38: Use of Manure from Dairy animals

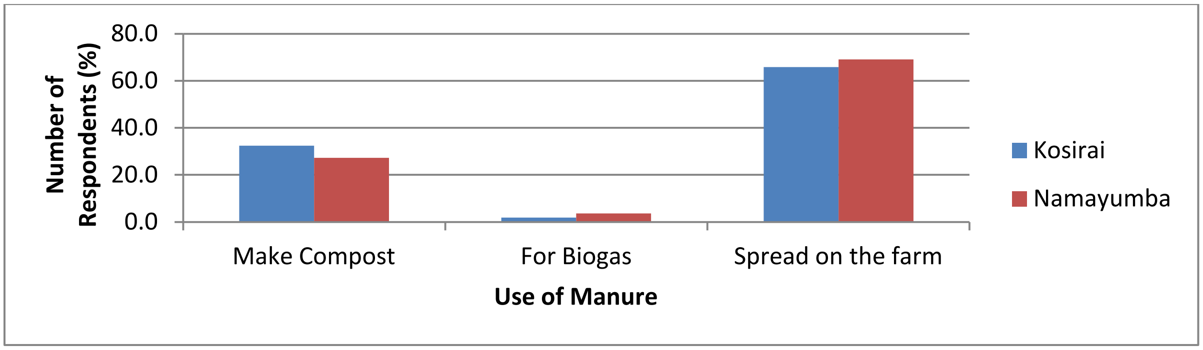

Figure 4-39: Use of Manure in Kosirai and Namayumba areas

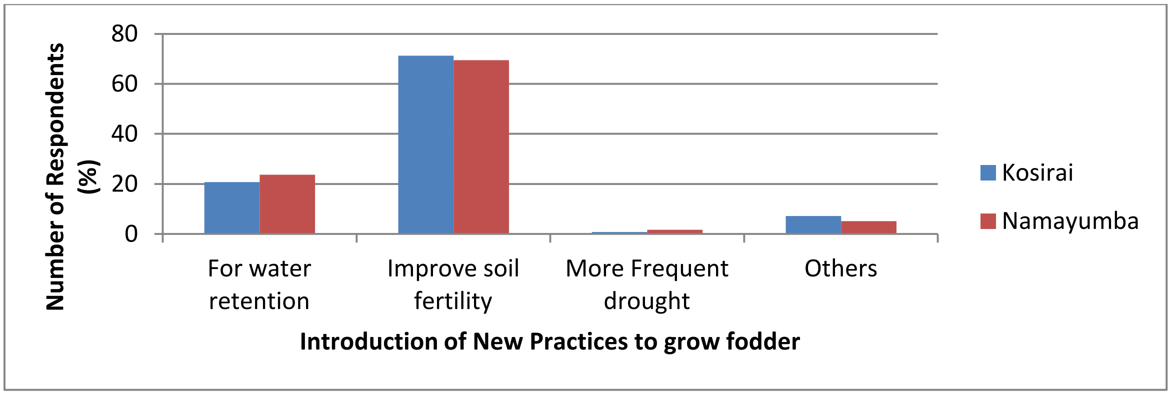

Figure 4-40: Introduction of New Practices to grow fodder

Table 4-6: Introduction of the following practices in growing fodder

Station	Practices in Growing fodder			
	Double digging (%)	Introduced Intercropping (%)	Stopped burning (%)	Others (%)
Kosirai	24.7	33.8	35.7	5.8
Namayumba	20.6	48.5	19.1	11.8

Most of respondent in the study sites used manure, though direct spreading of manure on the farm was preferred as opposed to compost making(figure 4-38) .The study notes that 33.8% and 48.5% of respondents inKosrai and Namayumba introducedintercropping while 24.7% and 20.6% in Kosirai and Namayumba practiced double digging (Table 4-6) for water retention and to improve soil fertility. The study further noted that 35.7% and 19.1% of respondents in Kosirai and Namayumba had stopped burning of crop residue.

8.2 Farmers Awareness of Climate Change Issues in Kosiraiand Namayumba

Farmer's awareness on climate change in Kosirai and Namayumba areas was aimed at assessing weather information they received and their knowledge of climate risks. The results are presented in figures 4-41 to 4-44.

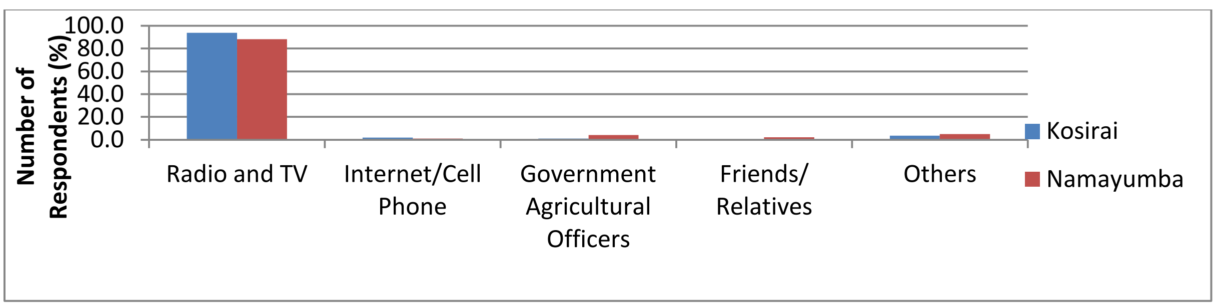

Figure 4-41: Source of Weather Information

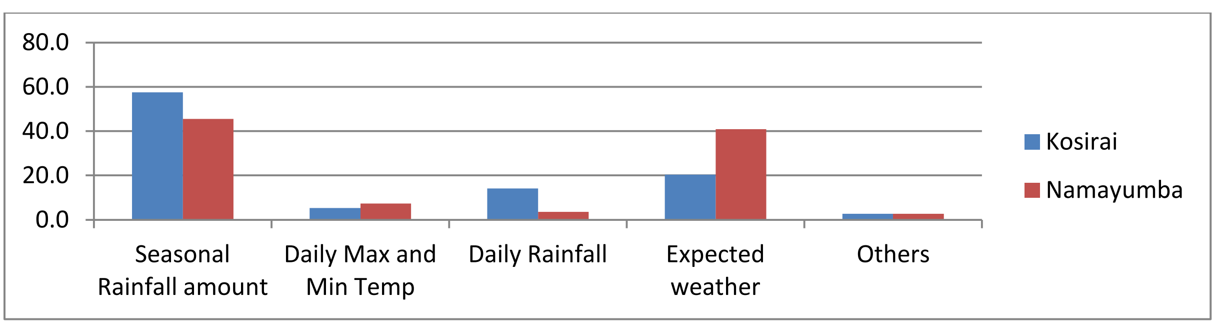

Figure 4-42: The weather information farmers want to receive

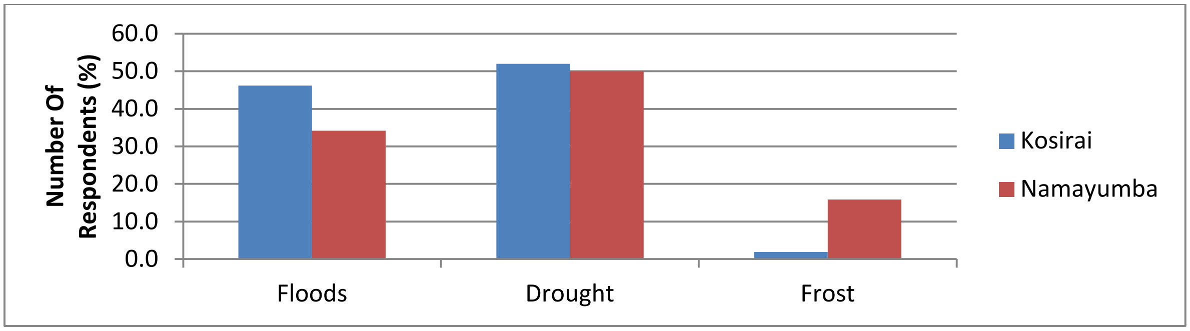

Figure 4-43: Climate Risk in Kosirai and Namayumba

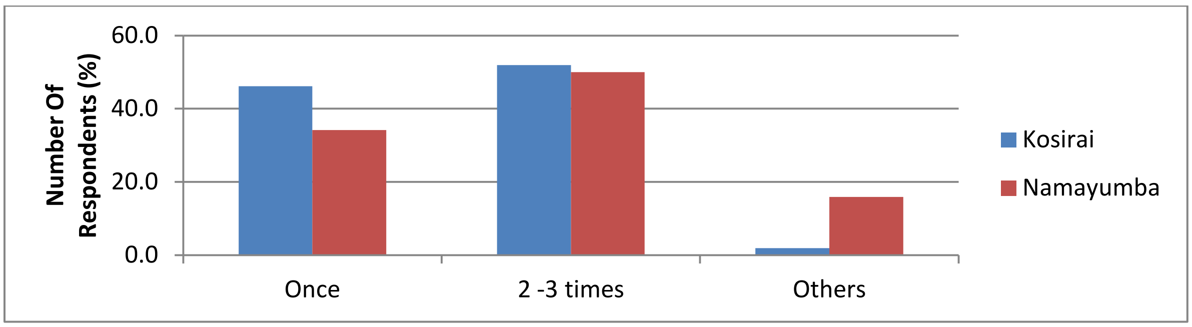

Figure 4-44: Occurrence of Climate Risk in the last 10 years

The study shows that radio is the main source of weather information to over 80% of the respondents in Kosirai and Namayumba (figure 4-41). It was further noted that 57.5% and 45.5% of farmers would be interested in the information on the seasonal rainfall amount while 20.4%/40.9% preferred to receive the expected weather conditions in Kosirai and Namayumba areas respectively (Figure 4-42). Drought was observed as the main Climatic risk condition by 51.9% and 50.0% of respondents in Kosirai and Namayumba in the last 10yrs while 46.2% of respondents in Kosirai noted that floods as the main climate risk compared to 34.1% in Namayumba (Figure 4-43). Figure 4-44 shows the occurrence of climatic risks with 51.9% and 50.0% of respondents reported that climate risk in Kosirai and Namayumba had occurred two to three times in the last 10 years.

8.3 Relationship between Rainfall and Milk/FodderProduction

This subsection sought to assess the effects of climate (rainfall) on milk/fodder production in the study area and presented in Figures 4-45 to 4-48.

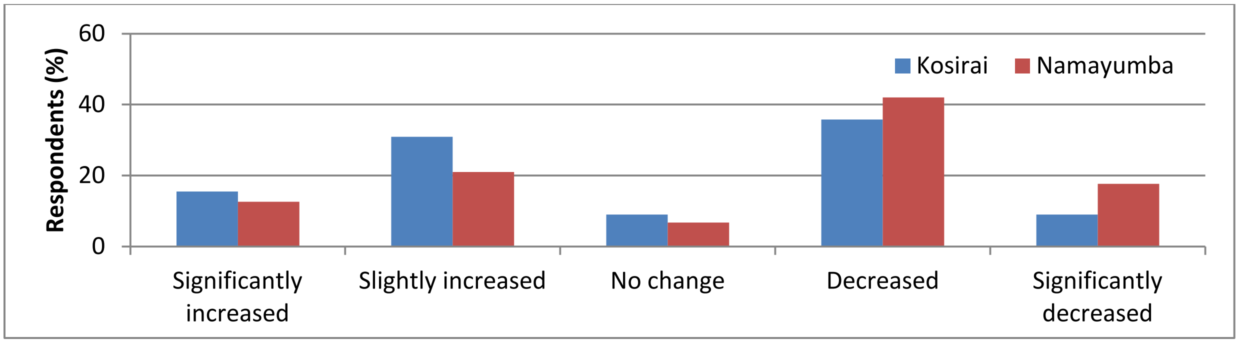

Figure 4-45: Changes in fodders and Pastures production over the last ten years (2000 to 2010)

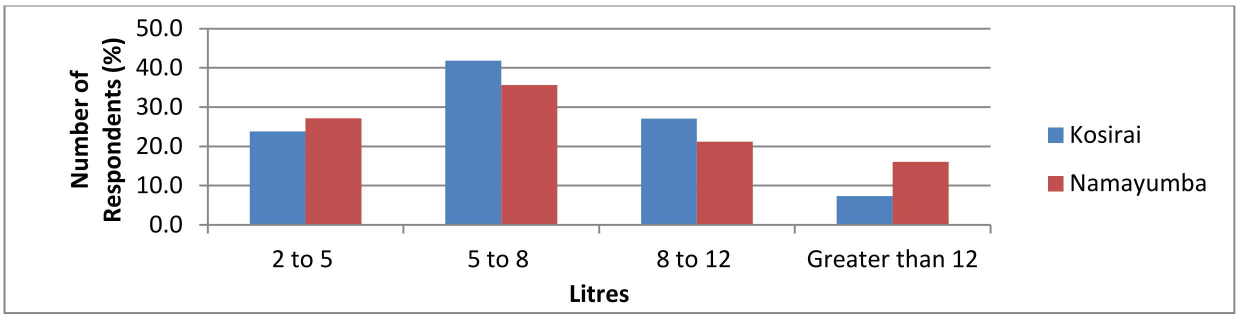

Figure 4-46: Average milk production per cow during the wet season

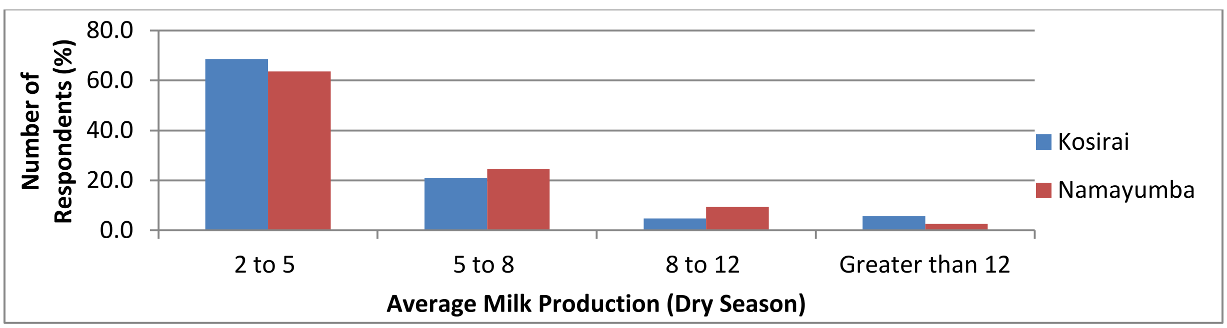

Figure 4-47: Average milk production per cow during the dry season

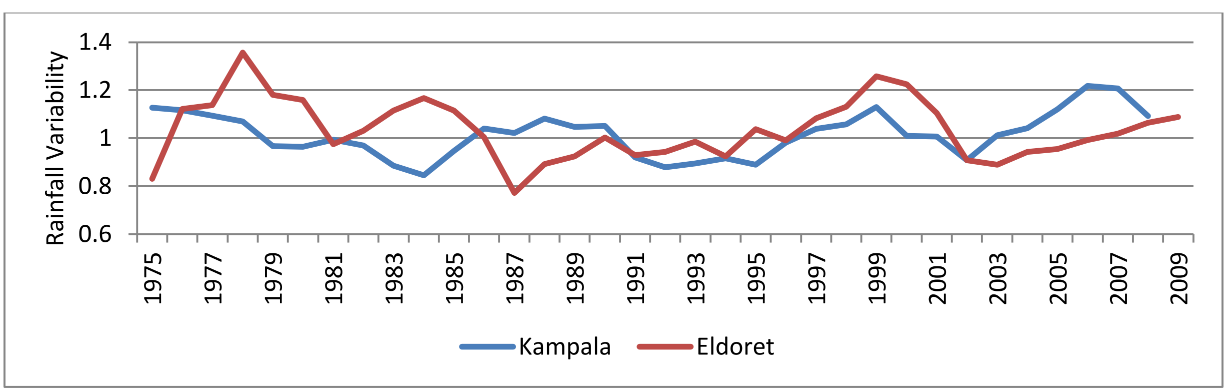

Figure 4-48: Variability of observed extreme values based on monthly rainfall in Eldoret (Kosirai) and Kampala (Namayumba)

The study showed that in both sites, dairy production was dependent on rain fed forages. There was increasing fodder optionlike Napier grass, Rhodes grass and fodder trees in the two study sites. Development of improved fodders especially Napier grass and fodder trees were however more significant in Namayumba than Kosirai. The size of Land allocated to fodder development was however decreasing both in Kosirai and Namayumba.

Respondents in Kosirai and respondents in Namayumba estimated the decreased changes in production of fodders and improved pasture over the last ten years (Figure 4-45) to be 43.9% and 59.6% respectively. Moreover, the study noted that during the wet season, the average milk production per cow ranged between 5-8litres (Figure 4-46) which was comparatively higher than the average production per cow, 2-5 litres during the dry season (Figure 4-47).The changes in milk and fodder production positively correlated with changes in rainfall amounts in both sites, these changes could be attributed to the increasing trend of extreme periods as shown in Figure 4-48 especially between the year 2002 and 2010.

CHAPTER FIVE

9 Summary, Conclusions and Recommendations

This chapter presents a summary of the study, conclusion drawn and recommendations given on the key findings.

9.1 Summary

Limited dairy herd productivity in Kenya and Uganda is attributed to inadequate feeds and feeding and over reliance of rain fed forages. This study therefore investigated the influence of climate on fodder availability and milk production in Kosirai, Kenya and Namayumba, Uganda. The study was guided by a cross-sectional survey design and CSIRO output model. Secondary data obtained from meteorological stations, livestock development offices, research institutes and other development partners was also used. A randomized sampling technique was used to select 129 respondents from Kosirai and another 124 from Namayumba giving us a total sample size of 253 respondents. Other than the observed and simulated data on climate, primary data was gathered from the respondents using a structured questionnaire. Both descriptive and inferential statistics was used to analyze primary data using SPSS software.

Based on the observed and CSIRO Mk3.6 model output findings, there were changes in both rainfall and temperature in the two sites. The amount of rainfall in Kosirai and Namayumba decreased between 1963 and 2010. The decrease in rainfall was however slightly higher in Namayumba(4.8%) than Kosirai (3.4%). Similarly further results of the model output concur with that of the observed rainfall data. The observed mean annual rainfall at Kosirai and Namayumba was 1062.8mm and 1165.2mm while average observed maximum temperature was 28.5^{o}C and 26.5^{o}C respectively. For all scenarios considered in the CSIRO Mk3.6 model, the mean annual rainfall ranged between 648.2mm and 823.2mm in Kosirai and between 930.4mm and 1063.0mm in Namayumba, an indication that Namayumba in Wakiso district of Uganda received higher amounts of annual rainfall compared to Kosirai in Nandi North district of Kenya. Maximum temperature ranged between 27^{o}C and 31^{o}C while minimum temperatures ranged between 16^{o}C and 21^{o}C with RCP of 8.5Wm^{2} showing highest standard deviation of between and 1^{o}C and 2^{o}C. Observed and CSIRO results showed a decreasing trend in rainfall patterns during the historical period in both areas. However, results indicated increased trend in of both maximum and minimum temperature during the historical period.

Under different representative concentration Pathways, projected annual precipitation showed highest increasing trend in Kosirai under RCP 8.5 scenario. This implied that under increased radiative forcing of $8.5Wm^2$, annual precipitation will increase at a higher rate than the other RCP scenarios. In Namayumba, all the RCP scenarios except RCP 2.6 showed an increasing trend in annual precipitation. For maximum temperatures, the increasing trend was noted to be significant for the RCP 4.5, RCP 6.0 and RCP 8.5 scenarios while minimum temperatures were noted to be significant for all scenarios

The finding indicates that there was increased livestock feed choices available although the acreage under fodder and pasture production had decreased.

Farmers in Kosirai and Namayumba owned less than 5 dairy cows that produced a daily average of 5-8 litres per cow during the wet season as compared to a mean of 2-5litres during the dry season. During the dry season, farmers used preserved feed, crop residues or feed spurchased from neighbours. While the tick borne diseases and pneumonia incidences had increased in Kosirai, foot and mouth disease had decreased during the past ten years. Results of data analysis in Namayumba area, showed increased incidences of lumpy skin disease and tick borne diseases. Extreme weather changes especially dry spell was associated with increased incidences of tick borne and Foot and Mouth diseases, shortage of feed resources and reduced milk production in the two study sites

Shallow wells were the main sources of water in the wet and dry season. Animals were watered twice and three times a day during the wet and dry season in Kosirai while in Namayumba, they were watered once and twice in wet and dry season respectively.

Farmers in the two sites used manure from dairy cow on their farms. There was limited compost making and insignificant use of biogas technology in both sites.

Radio and Television were the main sources of information on weather. Farmers preferred to get information on the seasonal rainfall amount and expected weather condition.

Approximately half of the respondents in both sites had experienced drought risks 2-3 times during the last 10 years. Nearly a similar number of respondents had witnessed food risks over the last 10 years.

9.2 Conclusions

1. Over the last 10 years, the two study sites had experienced changes in climate. Historical data on observed rainfall and model output indicated a declining trend in the amount of rainfall experienced in both study sites. Similarly there was progressive increase in both the minimum and maximum temperatures within the two sites.
2. Changes in climatic patterns especially the increasing dry spell contributed to increased livestock diseases incidences, shortage of feed resources and overall reduction of milk production in the Kosirai and Namayumba
3. There existed a relationship between the changing climatic patterns and dairy herd productivity in the two study sites. Further, projected changes based on CSIRO Mk3.6 model output RCPs scenarios and observed variables indicated an increasing trend in both minimum and maximum temperature in Kosirai and Nyamayumba. These changes are expected to have adverse impacts on livestock productivity

9.3 Recommendations

1. As a response to the effects of climate variability and change, dairy farmers should invest in fodder development and conservation in order to sustain their dairy herd productivity
2. Adequate mechanisms should be put in place to minimize losses and damages of the dairy herd and dairy herd productivity occasioned by increased frequency of extreme rainfall over the two sites
3. Dairy farmers should be empowered to adapt and mitigate against the effects of drought and emergence of new vectors and livestock diseases occasioned by extreme weather variability.

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APPENDICES

Questionnaire to Capture the Influence of Climate change on Dairy Farming in Kosirai, Kenya and Namayumba , Uganda

Section I: - Household Information

1. Name of Household Head ---
2. Name of Respondent Sex of Respondent [1] Male [2] Female --------------------
3. Relationships of Respondent to household head ---

00 = Head 01=Spouse 02=Child, 03=Grandchild 04=Son/daughter-in-law 05=Other unrelated (specify)-------------------

4. Type of household

00=Male headed, 01=Female headed,

07=Child headed (age 16 or under)/Orphan

08=other, (specify) ----------------------------------

Section 2: -Respondent's Information

5. How many people are in your household? ------------------
6. Age group of the respondent in years**------------**

   00=16-30 01=31-45 02=46-60 03=Above 60

7. Respondent's Highest level of education---------

00=No formal education 01=Primary 02=Secondary

03=collage education 04=Tertiary

8. What is your main occupation ----------------

00= Farmer 01=Business 02=Formal employment 04= other Specify---------------

9. What is your main source of income-------------------

00=Farming 01 =Formal employment 02=Business 03=other Specify

Section 3 Wealth Status

10. Total land holding (acres)

00=0-3acres, 01= 3-5Acres, 02=5-10acres 03= 10-20acres 04 others specify

11. Total land size allocated to dairy farming in acres

00=<0.5 acres, 01=0.5-2acres, 02=2-5acres 03=5-10acres 04=others specify---

12. Land tenure system

00=Secured have title deed, 01=Secured but family land, 02 =squatter

13. Which of the following items does your household own at the present time?

00= Radio, TV 01=Cellphone 02=Solar Panel 03 =Vehicle, Tractor

Section 4 Fodders and Pastures

14. What types of fodders and Pastures have you planted?

00= Natural pasture 01=Improved pasture 02= Napier Grass 03=Rhodes grass

04 =Fodder trees 05=Mucuna/Lablab 06=Others (Specify) ----------------------------

15. What types of fodders and Pastures did you plant 10 years ago? tick appropriately

00= Natural pasture 01=Improved pasture 02= Napier Grass 03=Rhodes grass

04 =Fodder trees 05=Mucuna/Lablab 06=Others (Specify)---------------

16. Since the last 10 years how has been the trend in fodders and pastures yield per acre in your farm

01=significantly increased 02=slightly increased 03=No change

04=Decreased 05 significantly decreased

17. What do you attribute the changes in question 16?

00= Poor soil fertility 01=unreliable rainfall 02= low knowledge on fodder management

03=improved knowledge on fodder/pasture production

04=Others Specify-----------

18. Specify the acreage of each pasture or fodders that you have planted

Type of pasture/fodder	Now 00=<1, 01=1-2, 02=2-5 03=>5	10 years ago 00=<1, 01=1-2, 02=2-5 03=>5

19 b, For fodder tree give the number of trees 00=1-50trees 01=50-100

02=100-500 03=over 500

19. What other feeds did you use in feeding your dairy cows?

Type of Feed	now	10 years ago
00=Maize Stover 01=Hay/Silage 02=Other Crop residues		

20. What are the reasons for choosing the planted fodder/Pastures on your farm.

Fodder/Pastures type planted 10yrs ago	Reason for choice 01= Easy to plant and manage 02= planting material available 03=High yielding 04= drought resistant 05= technology available	Fodder/Pasture type Planted now	Reason for choice 01= Easy to plant and manage 02 =planting material available 03=High yielding 04=Drought resistant 05= technology available

21. What is your position on fodder/pasture supply in wet and dry seasons

Status	now		10 years ago	
	Wet Season	Dry season	Wet season	Dry season
01=Surplus				
02=Adequate				
03=Shortage				
04=No Change				

22. In case you have surplus fodder what do you do to manage the excess pasture/fodder 00=Yes 01=No if yes what do you do with surplus

---

00=Give it away to neighbours for free 01= sell to neighbor

02= Conserve into hay/Silage 03=Just leave it on the farm

04=others(Specify)-----------------------

23. Do experience fodder shortage? 01=Yes----- 02=No-----

---

a. If the answer to the above is yes how many months in the year

   00=1-2months 01=2-3 months 02=>3months

24. How do you cope with fodder/pasture shortage?

00=buy from neigbours

01= use conserved fodder and pasture 02= Use preserved crop residue 03=graze on the road side 04=get from neigbours for free

05=Others (specify)---

SECTION 5 DAIRY ANIMALS

25. How many dairy animals do you own 00=1-2 01=2-5 02=5-10 0=>10

26. How many dairy animal did you have 10 years ago

    00=1-2 01=2-5 02=5-10 0=>10

27. How has the number of dairy animal changed on your farm over the last 10 years

    00= significantly increased 01=slightly increased 02=no change

    03= decreased

28. What is the average milk production, yield per cow per day

    i. During the wet season 00=2-5lts 01=5-8Lts 02=8-12lts 03>12lts

    ii. During the dry season 00=2-5lts 01=5-8Lts 02=8-12lts 03>12lts

Section 6 Animal Disease

common animal diseases	Now	10years ago
00=Foot& month 01=Tick born (East Cost Fever(ECF) 02=Rift valley fever 03=Lumpy skin decease 04= Pneumonia 05 other Specify		

SECTION 7 Water source

29. What is your main source of water for livestock use

00= roof catchment 01=Shallow well 02= Water pan/Dam

03=River/Stream 04=Piped water 05=Others (specify)-----------------

30. How many times do you water your animals

i. During the dry season 00-once 01 =2 times a day 02= 3 times a day 04=Water available throughout

ii. If once a day why?

00= Water source is far 01= once is enough 02=available water is little

iii. During the wet season00-once 01 =2 times a day 02= 3 times a day

iv. If once a day why?

00= Water source is far 01= once is enough 02=available water is little

31. Specify your Livestock water sources on the basis of dry and wet season 10 years ago and now(Record appropriate)

Water source by season	Wet season 10yrs ago	Wet season now	Dry season 10 years ago	Dry season now
00= roof catchment				
01=Shallow well				
02= Water pan/Dam				
03=River/Stream				
04=Piped water				
05=Others (specify)				

32. How far from your farm is the water source for your Livestock

    i. 10 year ago 00=<200m 01=200-500m 02=501 -1km 03=2-3km 04=other specify-------

    ii. Now 00=<200m 01=200-1km 02=2-3km 03=other specify-------

33. Do you have irrigation system for fodder/pasture production 00=Yes 01=No
34. If yes which fodders are irrigated-------------------------------------
35. What is the source of water for irrigation 00=Borehole, 01=River 02= other specify--------------------

SECTION 8 Manure management

36. Do you use manure from your dairy **cows** 00 Yes 01=NO
37. If yes How do you use it 00=make compost 01=for biogas, 02=spread on the farm
38. Have introduced one of the following practices in growing your fodder

00= double digging (tubukiza) 01=Introduced intercropping

02=Stopped burning 03=others (Specify)-----

39. Why have you introduced the above changes(Practices)

00=For water retention 01=improve soil fertility 03=more frequent drought

04=Others Specify

Section 9 Climate and Weather Information

40. Do you receive information on weather? 00=No--- 01=Yes---

41. If Yes from whom do you receive information

00=Radio, Television 01=Internet /Cell phone   02-Government agricultural officers

04=Friends and relatives   06=Others (specify)---------------------------

42. What kind of weather information would you like to you receive

00=Seasonal rainfall amount 01=Daily maximum and min temperature

02=Daily rainfall 03= Expected weather (sunshine cloudy or temperature)

04= others (Specify)--------------------

43. Did the information on weather come with advice on farming?
    00=Yes 01=No----
44. Were you able to use the advice 00=Yes 01=No
45. What kind of dairy farming did you change as a result of this information   01=early planting of fodder 02=Stored feeds 03=control of diseases/pest   04=Water harvesting   05=other Specify)---------------------------
46. Have you had any weather crisis00 =Yes 01=No
47. If yes Which crisis00=floods , 01= drought 02=frost
48. How many times has it occurred in the last 10 years

    00=once 01=2-3 times   02=other specify