ASSESSMENT OF SOCIO-ECONOMIC AND BIOPHYSICAL ENVIRONMENTAL FACTORS AFFECTING THE ADOPTION OF ZERO GRAZING TECHNOLOGY IN SAMIA SUB-COUNTY KENYA

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DECLARATION AND RECOMMENDATION

DECLARATION

I declare that, this is my original work and that, to the best of my knowledge, it has not been previously published or presented for the award of a degree or diploma in any university.

Signature: …………………….. Date:…………………………..

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RECOMMENDATION

This thesis has been submitted for examination with our approval as university supervisors

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DEDICATION

I dedicate this work to my husband Michael Magero and my son Ethan Mike Samuel for their encouragement and support during my studies, to my mother who worked tirelessly to ensure that I completed my studies and to my sisters and brother for their prayers and financial support throughout my study period.

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ABSTRACT

Adoption of a technology varies from place to place. According to the Rogers Diffusion Theory, most technologies are adopted by farmers if they are perceived to have returns. It is from this view point that this research assessed the role of socioeconomic and environmental factors in the diffusion of the zero grazing (ZG) technology in Samia Sub-County, Kenya. A survey, using a questionnaire and observations was conducted in Lower and Upper Samia. The study employed strata sampling, that is in the Lower Samia and the Upper Samia due to the differences in agro-ecological zones. Additionally, purposive sampling was employed to select households to be surveyed. A sample size of 200 households was selected using the coefficient of variation formula. Descriptive statistics and Regression analysis were used to analyze the data. Statistical significance was assessed at $\alpha=0.05$ levels. Results indicated that, socioeconomic factors had no significant effect on adoption of zero grazing ($P>0.05$).However, environmental factors such as water supply, fodder crops and access to open grazing fields had significant influence on adoption of zero grazing ($P<0.000$). Further, there was significant difference in adoption of the zero-grazing technology among the locations with more adopters in Upper Samia than Lower Samia ($p<0.05$). The study findings indicated that the farmers in the study area were not knowledgeable about the technology with 63.5 % having limited knowledge on zero grazing. In conclusion, the research found that adoption of zero grazing was influenced by level of knowledge, water supply, availability of fodder feeds and open grazing fields. Thus there is need for extension agents in the study area to carry out regular farm visits, field days, trainings and demonstrations, in order to make the farming community aware of the technology and to alleviate the perception farmers have towards the technology. Policies on livestock extension should be reviewed by the government to ensure that farmers receive the necessary services.

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LIST OF ABBREVIATIONS AND ACRONYMS

ANOVA	-	Analysis of variance
DDO	-	District Development Officer
DLPO	-	District Livestock Production Officer
EPD	-	Environmental parasites diseases
ERS	-	Economic Recovery Strategy
FAO	-	Food Agricultural Organization.
FI	-	Family income
FP	-	Farmers perceptions on the zero grazing
FS	-	Farm size
HD	-	Household decision making
HPI	-	Heifer project international
KCC	-	Kenya Co-operative Creameries
LE	-	Level of education
MoLD	-	Ministry of Livestock Development
NDDP	-	National Dairy Development Programme
SSA	-	Sub-Saharan Africa
UNEP	-	United Nations Environment Programme
USEPA	-	United States Environmental Protection Agency
WA	-	Water availability
ZG	-	Zero grazing

CHAPTER ONE

INTRODUCTION

1.1 Background information

High population growth rate in Sub-Saharan Africa has resulted in subdivision of land into small holdings to accommodate an increasing number of farmers (Makokha *et al*., 2007). This is the case in the densely populated areas of western Province, where the area of agricultural land per capita is small and declining and inadequate for the production of arable and cash crops as well as forage for livestock grazing. As a result, more intensive production systems that can ensure food security while conserving the natural resource base have to be adopted.

Zero grazing technology was introduced in Kenya by the colonialists as a means to improve milk production (Bebe *et al*., 2003). This technology is more environmentally friendly than the free range grazing method that is commonly practiced in Samia Sub-County. It brings higher economic growth and overcome the law of diminishing returns from the existing resources, by shifting production upwards (more returns per unit area of land) (Omore, 1999). However, adoption of any agricultural technology is seen to be influenced by: complexity of the technology, the immediate outcome or financial returns of the adoption, costs, farmer's beliefs and opinions towards the technology, farmer's level of motivation, farmer's perception about the relevance of the technology and farmer's perception about risk and change and social cultural issues. Other factors that influence the adoption include: farm size, farmer's education level and prevailing environmental conditions (Mpanya, 1985; Pandey and Lapar, 1985; Cramb, 1998; Guerin and Guerin, 1994; Okoeda and Onemolease, 2009). As farmers adopt new technologies, the element of sustainability has to be considered, since sustainability in livestock production systems centre's on the need to develop technologies and practices that do not have adverse effect on the environment, that are accessible to and effective to farmers (Pretty, 2008). Site specific studies on adoption are necessary because some innovations differ across socio-economic groups, over time and under different environmental conditions (Cramb, 2000). Hence this study focused on factors influencing adoption of zero grazing in Samia Sub-County in Busia County, Kenya.

Zero gazing (ZG) is a livestock production system that involves confining cattle in stalls and developing cut-carry-feed system (Bebe *et al*., 2003). The system has an advantage of being able to replenish soil fertility necessary for crop production by producing manure. In addition, the fodder crops planted on the farm such as *Sesbania sesban*, *Calliandra calothyrsus*, *Acacia* spp, Leucaena *diversifolia*, *Chamaecistus palmensis* and *Gliricidea* spp contribute to environmental conservation by contributing to the tree cover. Zero grazing enables farmers to collect the dung and use it for biogas production or compost it to form manure. The use of biogas eases the burden on fuel wood and thus contributes to environmental conservation as the tree cover is not destroyed. Composting if well done and managed reduces non point sources of organic carbon into the water ways thus controlling water pollution. By composting nutrients are easily absorbed in the soil, enhancing soil structure and prevent soil erosion (Ojiem *et al*., 1998). Another advantage of ZG as a technology is that animals are made to drink from watering troughs, thus minimizing pollution of water sources by direct drinking. This technology can therefore address the constraints of land insufficiency, low productivity of dairy cows, low quality fodder, prevalence of diseases, low income and environmental conservation issues (Makokha, 2007).

Despite being labor-intensive, ZG has been practiced in western Kenya over time. This has been attributed to lack of grazing land, demand for milk, availability of high-yielding fodder varieties, availability of artificial insemination services, and improvements in the supply of foundation stock, veterinary services, market opportunities and new breeding technologies (Amadalo, 2003). However, even with all these facilitative factors, the adoption of Zero grazing technology has not been very successful in Samia Sub-County. Yet, with the population growth rate estimated at 3.2% in Samia sub-county (GoK, 2010; CBS, 2010), people are finding it difficult to manage the critical trade-offs between sustainable resource use and immediate short-term needs. As a result, there is need to adopt more intensive production systems such as ZG that will increase food production with less detrimental impact on the environment. Samia Sub-County is inhabited by some of the poorest people in Kenya with a poverty index of 68% (GOK, 2010; CBS, 2001). The area is faced with low income from the existing farming enterprises and registers low levels of dairy development. This is in spite of indications that there is a potential for dairy development, and that dairy can reduce the level of poverty. Low dairy development in Samia Sub-County is evident on the basis that it is a milk deficit area (GoK, 2010), and that private traders get milk from Nandi and Uganda to sell to people in Samia.

Livestock production sector has a potential for increased employment and income generation if appropriate technologies such as ZG, proper management, improved infrastructure, inputs access and efficient marketing (Mugunieri and Omiti, 2008) are applied since livestock sector play a role in poverty reduction (ERS, 2007; NDP, 2007). The economic recovery strategy, therefore, demands for broad based livestock production programmes to improve welfare of livestock producers.

There are several categories of livestock production systems in western Kenya, which include: free range or tethered, semi-zero grazing (a mixture of free range and some stall-feeding) and stall-feeding (zero-grazing) based on availability of pasture and forage (Waithaka, 2000). In intensive dairy cattle production systems (zero-grazing) involves feeding cattle on Napier grass (*Pennisetum purpureum)* as the main feed resource. While in extensive dairy cattle production systems (free range and semi-zero grazing), animals are mainly grazed on natural pastures (Waithaka *et al.,* 2002). It is from this characterization that this study focused on establishing the factors behind the slow adoption of zero grazing technology in Samia Sub-County.

1.2 Statement of the problem

Although the government has put in place measures to encourage farmers to adopt zero grazing, such as, privatization of Artificial Insemination services, availability of extension and veterinary services, policies on livestock feed formulation, foundation stocks and new breeding technologies, the rate of adoption has remained very low in Samia Sub -County, with less than 100 farmers practicing zero grazing. There is milk deficit in the Sub-County and much of the milk consumed is obtained from Uganda or Nandi County. Furthermore, most farmers still keep large herds of indigenous livestock using the free range method of production. Although the zero grazing technology is economically feasible, it is not understood why farmers in this area are not adopting it. The reasons for the slow adoption of the zero grazing technology by farmers in Samia Sub-County are not well understood and thus the basis for this study.

1.3 Broad objective

The main objective of the study was to assess the socio-economic and physical environmental factors affecting adoption of zero grazing technology in Samia Sub-County with a view of improving food security through increased milk production in the area while enhancing environmental conservation.

1.4 Specific objectives

1. To examine farmers' level of knowledge on Zero grazing in Samia Sub-County
2. To establish the adoption pattern of Zero grazing technology in the study area based on ecological zones.
3. To determine the influence of socio-economic factors on the adoption of Zero grazing technology among farmers in the study area.
4. To establish the effect of physical environmental factors on the adoption of Zero grazing technology among farmers in the study area.

1.5 Research questions

1. What is the farmers' level of knowledge on Zero grazing in Samia Sub-County?
2. Is there a significant difference in the adoption pattern of zero grazing technology in the study area based on ecological zones?
3. What is the influence of socio-economic factors on the adoption of Zero grazing technology by livestock farmers in Samia Sub-County?
4. What is the effect of environmental factors on the adoption of Zero grazing technology by livestock farmers in Samia Sub-County?

1.6 Justification of the study

Farmers in Samia Sub-County practice various livestock production systems ranging from road side grazing; tethering, communal grazing to semi zero grazing. The latter is the least practiced system. The continued high dependence on off farm production systems are unsustainable and negatively affect the environment in terms of rapid surface water runoffs and soil erosion as a result of overgrazing. Management of animal waste is rendered impossible and thus grazing fields become non-point sources of organic carbon from manure and other nutrient loading to water sources such as nitrogen. Furthermore, free grazing animals are allowed to drink directly from rivers and springs leading to pollution of these water sources. Most farmers in the Sub-County keep at least five heads of indigenous cattle per household that are low yielders in terms of milk production, and have negative impact on the environment in terms of overgrazing and waste management. In contrast, zero grazing of dairy animals would improve production per unit area and per animal, and with proper waste management reduce non-point source of pollution. Zero grazing of dairy cattle and goats would also encourage farmers to grow fodder crops that will contribute to improved agro-forestry practices in the study area. The accumulated waste can be used for biogas production and thus reduce deforestation and associated release of greenhouse gases into the atmosphere. It was against this backdrop that this study was conceived to bring out an understanding of the factors that contribute to the low adoption of zero grazing technology in the Sub-County, contributing to the knowledge gap.

1.7 Scope of the study

This study was limited to Samia Sub-County, Busia County, Kenya. The Sub-County has one division, and seven locations. The seven locations of the Sub-County are: Bwiri, Agenga and Nanguba and Nangosia in Lower Samia and Odiado, Namboboto and Nambukua in Upper Samia. The study focused on the socio-economic and physical environmental factors that influence the adoption of zero grazing among the farmers in the Sub-County. The socioeconomic factors included: farm size, family income, and household head, Level of education, farmers perceptions on the ZG, age, and acreage. The physical environmental: factors are: water availability, parasites and diseases, soil fertility and rainfall. The pattern of adoption of ZG technology was determined based on ecological zones.

1.8 Assumptions of the study

The study assumed that:

1. The household heads would be available during the entire period of study to respond to the questions.

2. The respondents would be willing to participate in the study by providing accurate information.

1.9 Limitations of the study

The varying terrain and lack of public transport in some areas was a limiting factor. This limitation was overcome by use of the motor cycle which is a flexible means of transport in all terrains. Lack of climate data especially temperature data limited the analysis on contribution of climatic factors on adoption of Zero grazing.

1.10 Definition of significant terms used in the study

Adoption: The decision to start using something. In this research, it's the decision by farmers to start the practicing zero grazing. It's operationalized by: number of farmers practicing zero grazing, farmers composting manure, number of farmers planting fodder trees, increased income by livestock farmers, and number of farmers with biogas plants and amount of milk being produced in the Sub-County.

Diffusion: Rogers defines diffusion as "the process in which an innovation is communicated thorough certain channels over time among the members of a social system. As expressed in this definition, innovation, communication channels, time, and social system are the four key components of the diffusion of innovations (Rogers, 2003)

Diffusion of technology: The process by which a technology moves from one person to the next in a society. Rogers argues that diffusion is the process by which an innovation is communicated through certain channels over time among the participants in a social system (Rodgers, 1995).

Innovation: An idea, practice, or object that is perceived as new by an individual or other unit of adoption. The process by which an idea or invention is translated into a good or service (Orr, 2003)

Environmental factors: refers to biophysical and climatic factors within the surrounding of an animal that influence its production and well being. These include: temperature, livestock pests and diseases and water availability (FAO, 2014)

Fodder crops: Are crops that are cultivated primarily for animal feed. By extension, natural grasslands and pastures are included whether they are cultivated or not. Fodder crops may be classified as either temporary or permanent crops. (FAO, 2014)

Knowledge: In this research refers to the farmer's awareness of the zero grazing technology and the ability to carry it out. Its Operationalized by: Feeding practices, Housing requirements, disease control, parasite control and Waste management.

Livestock production systems: Different categorizations of livestock production methods adopted by different farmers**.** They are grouped according to the type of land use .in this research zero grazing is a livestock production system.

Socio-economic factors: Refers to education levels of family head, family income, farm size, Land tenure or farm ownership, farming system, number of cattle, traditions relating to cattle ownership, cost of a dairy cow in the area.

Water quality: This is the description of the condition of the water including its chemical, physical and biological characteristics with respect to its suitability to a particular purpose. In this study, it’s the perception respondents had towards the water they use in terms of: clean, dirty, salty, muddy or cloudy.

Zero grazing/stall feeding: Involves growing or acquiring high quality feeds and feeding animals confined in a structure, it is an intensive livestock production system. The technology was introduced in Kenya by the colonialists as a means to improved milk productivity (Muruiki *et al.,* 2003).

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter is divided into two main sections. Section one is a review of literature related to the study from studies conducted by other researchers in the field of diffusion and adoption of agricultural technology as well as factors that affect the same. The second part provides the conceptual framework that shows the linkage between the socio-economic and physical environmental factors and adoption of zero grazing.

2.2 Diffusion of innovations' in the society

Diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system (Rodgers, 1983) or is the process by which an innovation is adopted and gains acceptance by members of a certain community (Rodgers, 1995). While a number of factors interact to influence the diffusion of an innovation, the four major factors are features of the innovation itself, how information about the innovation is communicated, time, and the nature of the social system into which the innovation is being introduced (Rogers, 1995). In any given social system decisions are not authoritative or collective; each member of the social system faces his/her own innovation-decision that assumes the following five steps (Singhal and Dearing, 2006).

1) Knowledge – person becomes aware of an innovation and has some idea of how it functions.

2) Persuasion – person forms a favorable or unfavorable attitude toward the innovation.

3) Decision – person engages in activities that lead to a choice to adopt or reject the innovation.

4) Implementation – person puts an innovation into use.

5) Confirmation – person evaluates the results of an innovation-decision already made.

The most striking feature of diffusion theory is that, for most members of a social system, the innovation-decision depends heavily on the innovation-decisions of the other members of the system. Rogers (1995) avers that adoption of an innovation follows an S-shaped curve that gives a normal distribution over time. There is the first about 10-25 % of members who adopt an innovation, followed by a relatively rapid adoption by the remaining members and then a period in which the laggards finally adopt. The innovation-decision is made through a cost-benefit analysis where the major obstacle is uncertainty. People will adopt an innovation if they believe that it will, all things considered, enhance their utility (Stoneman, 2002). So they must believe that the innovation may yield some relative advantage to the idea it supersedes. If this normal distribution curve is broken into segments, then the individual's innovativeness is categorized as follows: innovators, early adopters, early majority, late majority, laggards. In brief each of these individuals exhibits distinct characteristics (Rodgers, 1995).

Innovators –Innovators are venturesome types that enjoy being on the cutting edge. The innovation's possible benefits make it exciting; the innovators imagine the possibilities and are eager to give it a try. The implementation and confirmation stages of the innovators' innovation-decisions are of particular value to the subsequent decisions of potential adopters

Early adopters –They use the data provided by the innovators' implementation and confirmation of the innovation to make their own adoption decisions. If the opinion leaders observe that the innovation has been effective for the innovators, then they will be encouraged to adopt. This group earns respect for its judicious, well-informed decision-making, and hence this group is where most opinion leaders in a social system reside.

Early majority –This group makes deliberate decisions, they have many informal social contacts and follow the example of opinion leaders

Late majority - They are sceptical of an innovation, traditional in their thinking and also interact with people who are traditional, most members of this group are from lower socio-economic status.

Laggards –can either be very traditional or be isolates in their social system. If they are traditional, they are suspicious of innovations and often interact with others who also have traditional values. If they are isolates, their lack of social interaction decreases their awareness of an innovation's demonstrated benefits. It takes much longer than average for laggards to adopt innovations.

The early innovators form the smallest percent of only 2.5%, but other groups adoption of an innovation depends on the success experienced by the innovators. The laggards are the last people to adopt an innovation mostly because of their economic status or their conservative status. Rodgers (1995) theory has been reviewed and applied in several sectors, for example Wonglimpiyarat (2005), Singhal and Dearing (2006) came up with the importance of communication of an innovation, Wyner (1974) who studied the diffusion of innovations and Surry and Brennan (1998) who looked at diffusion of structural innovations among others.

This research will borrow from innovation theory by Rodgers (1995) to explain the pattern of adoption of zero grazing technology as an innovation in Samia Sub-County and analyze the factors that influence adoption rate of zero grazing technology.

2.3 Zero grazing in Africa

In the year 2025 it is projected that the demand for meat and milk will exceed 19 and 43 million tons (Growing, 2008). This level of production will require a 4% annual rate of increase of livestock production compared with the estimated current rate of 2.5%. These projections show that cattle are expected to provide 60% of meat requirements and almost 100% of milk requirements (Williams, 1999; World Bank, 2005). As increasing population pressure results in progressively smaller agricultural holdings, and traditional grazing areas are taken over for crop growing. The introduction of more productive integrated intensive systems is imperative if total ecological and social collapse as a result of land degradation is to be avoided. These can be achieved by: integrating intensive livestock keeping with crop production and agro forestry. The integration of zero-grazed improved dairy cows and small livestock into smallholder systems results in increased availability of milk, meat and other animal products, improved soil fertility, and reduced soil erosion caused by overgrazing.

Zero grazing as an intensive livestock production system has some disadvantages of being labor intensive and having high initial cost of investment. But the advantages far outweigh the disadvantage, as observed by Otsuka and Yamano (2005), indicating there are some signs of intensification of farming systems in the face of growing population pressure on limited land resources in sub-Saharan Africa. In their study, Otsuka and Yamano (2005) focused on farming of crops using manure produced by dairy cows, and concluded that manure collection can only be easy if dairy cows are being reared under intensive systems such as zero grazing. They used data from Kenya and surveyed 894 households in central province and Western Kenya. 47% of households sampled had at least one dairy cow under semi or zero grazing. These is the case in the study area where there is high population growth rate but intensive production systems have not been adopted thus the basis for this research. Another study carried out in Uganda observed that despite policy and development focus promoting dairy intensification, farmers adopt a range of dairy management practices along the continuum of intensification (Nanyeenya *et al.*, 2007). This study also relates well with Samia Sub-County where the government of Kenya has put in place policies to promote dairy farming but the level of adoption has remained low.

2.4 Zero grazing in Kenya

Zero grazing technology also referred to as stall feeding or "cut-and-carry" (Muriuki *et al.*,, 2003*)*, involves growing or acquiring high quality feeds and feeding animals confined in a structure, it is an intensive livestock production system. The technology was introduced in Kenya by the colonialists as a means to improved milk productivity (Muruiki *et al.,* 2003).

The zero grazing technology intensified through a bilateral cooperation agreement programme between the Dutch and Kenyan Governments, known as the National Dairy Development Programme (NDDP), under the Ministry of Livestock Development, in 25 Districts. Despite all the extension efforts the technology did not receive wide adoption by the livestock farmers and only a small number adopted it (GoK, 2008). In addition, the continued use of the constructed Zero grazing units has remained generally low. Several studies have been done in Kenya, trying to focus on the benefits of zero grazing, and adoption in several parts of the country. For example, Liyamal (2007) indicated that, better utilisation of organic manure from livestock has the potential to ensure sustainable crop-livestock production for poor farmers, especially as they often cannot afford to buy expensive inorganic fertilisers. If effectively applied, crop and livestock activities would not only contribute to income generation but also to higher crop production and better environmental health. Another advantage of zero grazing is the ability to utilise the animal dung for biogas production (Mwakaje, 2007). The above advantages far outweigh the disadvantages but the reason for the slow adoption of zero grazing in the study area has not been well understood thus the basis for this research.

2.5 Adoption of agricultural innovations

The agricultural sector is the backbone of Kenya’s economy. However, several factors have hindered the adoption of agricultural innovations especially in the livestock sector. Adoption of modern technology is urgently required to increase the productivity so as to meet the increasing demand of food (cereals and animal products) for rapidly growing population. The adoption of modern technologies, especially in subsistence farming, would be governed by a complex set of factors such as human capital, information, location, resource endowments and institutional support. Within this frame condition, farmers’ decision depends on their needs, cost incurred and benefit accruing to it would be the major motivating factors for the acceptance or rejection of a particular technology (Karki, 2004).

In addition, researchers have studied and discussed several factors affecting adoption of technologies by farmers. In Australia, for example, Sherchand (2001) argues that constraints to adoption of technologies and innovations by farmers are diverse and can be grouped as: the extent to which the farmer finds the new technology complex and difficult to comprehend; how readily observable the outcomes of an adoption are; its financial cost; the farmer's beliefs and opinions towards the technology; the farmer's level of motivation; the farmer's perception of the relevance of the new technology; and the farmer's attitudes towards risk and change. Similar findings were reported by Chi and Yamada (2002) who also indicated that, farmers’ adoption of a technology depend on factors such as access to technical training, meetings, oral transmission, and trust on technician and believe on technology introduced by scientist. The above findings narrows down to perception, which is a filter through which new observations are interpreted, it’s the process by which we receive information or stimuli from our environment and transform it into psychological awareness (Cruz 1978). On the basis of perception the farmer assesses the expected outcomes and his choice of action depends on his evaluation in terms of his own personal perspective. The perception of farmers towards zero grazing in the study area was not well understood, role of technician (extension workers) was not known and lastly, how the information was introduced and transmitted to the social system.

The decision by a farmer to adopt or reject a new technology also depends on the personal characteristics of the change agent. These include his/her credibility, intelligence, emphaticability, sincerity, ability to communicate with farmers, persuasiveness and development orientation (Services for Rural Development, 2004).The age, education level, income, family size, tenure status, credit use, value system, and beliefs are positively related to adoption (Jungea *et al*., 2009, Cruz 1978).

2.5.1 Social-economic factors affecting adoption of a technology

In deciding whether to develop or adopt a new technology, farmers engage in calculations of expected benefits and expected costs to themselves and if the former is likely to exceed the latter then they adopt the technology (Hategekimana, 2002). This is referred to as cost/benefit analysis. Another socio-economic factor is family income, one’s income and corresponding occupation are factors that can contribute to adoption of a new technology. Zero grazing requires high initial investment, especially if the farmer intends to make a real modern structure. Additionally, farm characteristics such as farm size, family labour involved in the running of the enterprise also determines whether or not a farmer will adopt a new technology (Sheikh *et al*., 2006). Land tenure and time horizon also affect the adoption of technologies. An example is that of technologies that are inherently long term and which require security such as title deed. Many farmers are resource poor and lack the land security thus unable to invest in such technologies (Diederen, 2002). Thus, in these research there was needed to understand how the land acreage, land ownership, family size, family income among others affects adoption of zero grazing technology.

Among socio-economic factors is education. One's level of education can influence how he or she views the world and can contribute to social growth. It can lead to increased earning capacity, which in turn can contribute to quality-of-life issues (Sall, 2000). Education also can contribute to decision-making processes that alter the paths people take in life. Education is an important factor in adoption of innovation and technologies. Chi and Yamada (2005) in their research found out that young educated farmers showed a higher rate of adoption of an innovation than old conservative uneducated farmers. In this research the level of education for those farmers who have adopted ZG will be compared with the non adopters.

2.5.1.1 Religion and gender

Religion plays an important social role in the lives of many and tends to determine the type of technology that a farmer can adopt. The aspect of religion also determines whether or not a farmer will adopt a new technology. Some world religions prohibit their followers from eating dairy products and thus farmers opt not to adopt technologies involving livestock farming. Religion also shapes the value system of a society, these in turn determines how members of the society choose to invest and the aspect of technology adoption comes in.

Women play an important role in adoption and implementation of new technologies. For example, the roles of women in zero-grazing can be summarized by citing the results of a study on the role of women in the National Dairy Development Programme in Kenya, (NDDP, 1990). The study indicated that: women are dominant in 83% of dairy activities and perform 39% of the dairy work compared to men's 26% contribution.

2.5.1.2 Cultural Issues

People’s culture includes their beliefs, rules of behavior, language, rituals, art, and technology, styles of dress, ways of producing and cooking food, religion, and political and economic systems in a social system. Vanclay (2003) defines culture as “shared beliefs, customs, values, language and dialect. Culture and/or ethnicity are socioeconomic factors that can contribute to thoughts and attitudes. Both can have an impact on how people are raised, their core values, and their sense of family and tradition. The history of one's ethnicity, special holidays, and cultural beliefs are all things that can be passed down between generations and shape individual identities. This in turn determines whether or not one can adopt a technology or not. Culture can make one to be so conservative and do things the way they have always been done ‘our way’. Although technology has a direct impact on culture by virtue of its capacity for creating new opportunities; by making possible what was not impossible before. It offers individuals and society new options to choose from.

2.5.2 Environmental factors

2.5.2.1. Zero grazing technology and environmental management

Adoption of ZG technology is more likely to enhance environmental management than the free range/open grazing system (HPI, 2012). One of the advantages of zero grazing is that overgrazing of pasture crops is controlled; this in turn reduces soil erosion that would have resulted in land degradation. Furthermore, the foot trampling effect is also eliminated as animals are confined in structures. The other benefit of ZG to the environment is the fact that collection of waste is made easy. With good management this waste can be properly compost using the pit method or used in biogas production, the benefit here is too fold: manure increases crop yield while biogas when used as fuel wood reduces reliance on trees and thus the tree cover is conserved (NRDC, 2012). The main challenge has been waste management where farmers do not handle the waste properly, for example, direct throwing the waste in the farm without properly composting, which can be overcome by proper farmer training. Furthermore, biogas production can reduce the amount of gases released into the atmosphere (HPI briefs, 2012). In summary, ZG has the following advantages: healthier animals due to less contact with diseases, manure concentrated in one spot can be collected and composted for fertilizer to replenish the soil and enhance crop production, less damage to fragile ecosystems, decreased mortality of offspring due to improved health, the animal saves energy for meat and milk production as movement is limited and protection from predators. Lastly, ZG technology encourages farmers to grow fodder crops such as Napier grass, sweet potatoes, Desmodium, Lucerne, Lupines' and Dolichos which aid in controlling soil erosion in the farm. The fodder trees planted such as *Sesbania* and *Calliandra* improve the tree cover and can also be used as fuel wood (Sherchard, 2001). There is therefore need to understand how manure is handled and utilised in the study area and the type of fodder crops grown since these has never been studied.

2.5.2.2. Physical environmental factors

These are factors that will influence the adoption of a technology. They can either be biological or physical. For example, climatic factors, water quality and quantity, environmental diseases, soil fertility among others. These factors often lead to low productivity or loss of the livestock. The biophysical environment influences adoption of an innovation (Sherchard, 2001). These include: the conditions of the farm location, availability of resources and other facilities such as roads, markets, transportation, pests, rainfall distribution, soil type, water, services, and electricity. This research will assess the farmer's knowledge on the water availability, access to water sources, water quantity and quality, soil fertility, tree cover, and diseases inherent to the environment (Ingold 2002).

ZG technology can limit water pollution as compared to the open grazing systems. In open grazing animal waste is left scattered in the field and thus these fields become non point sources of nutrient loading into water sources. In addition, most farmers practising open grazing prefer to water their livestock directly from rivers and springs, consequently water sources become polluted by dung and trampling. In contrast, ZG of livestock leads to water conservation as animals are watered from troughs; the slurry from grazing units if well managed is used in crop fields and not directed into water sources (Sherchard, 2001).

2.6 Theoretical frame work

This research was based on the theory of Rodgers (1983) diffusion of innovations. In this theory Rodgers explains that a number of factors interact to influence diffusion of innovations namely: features of the innovation, how information is communicated, time and the nature of the social system. Innovation decision takes five steps, namely: knowledge, persuasion, decision, implementation and confirmation (Rodgers, 1995). The theorist further argues that people will adopt an innovation if they believe it will enhance their utility and grouped individual innovativeness as: innovators, early adopters, early majority, late majority and laggards. This theory has been used in several fields, for example, Singhal and Dearing (2006) came up with the importance of communication of an innovation, Wyner (1974) who studied the diffusion of innovations and Surry and Brennan (1998) who looked at diffusion of structural innovations Daniel and Surry (1997) who looked at diffusion theory and instructional technology among others. Thus, this study borrowed from these theory to try and understand how zero grazing as a technology has diffused and been adopted in Samia Sub-County.

2.7 Conceptual framework

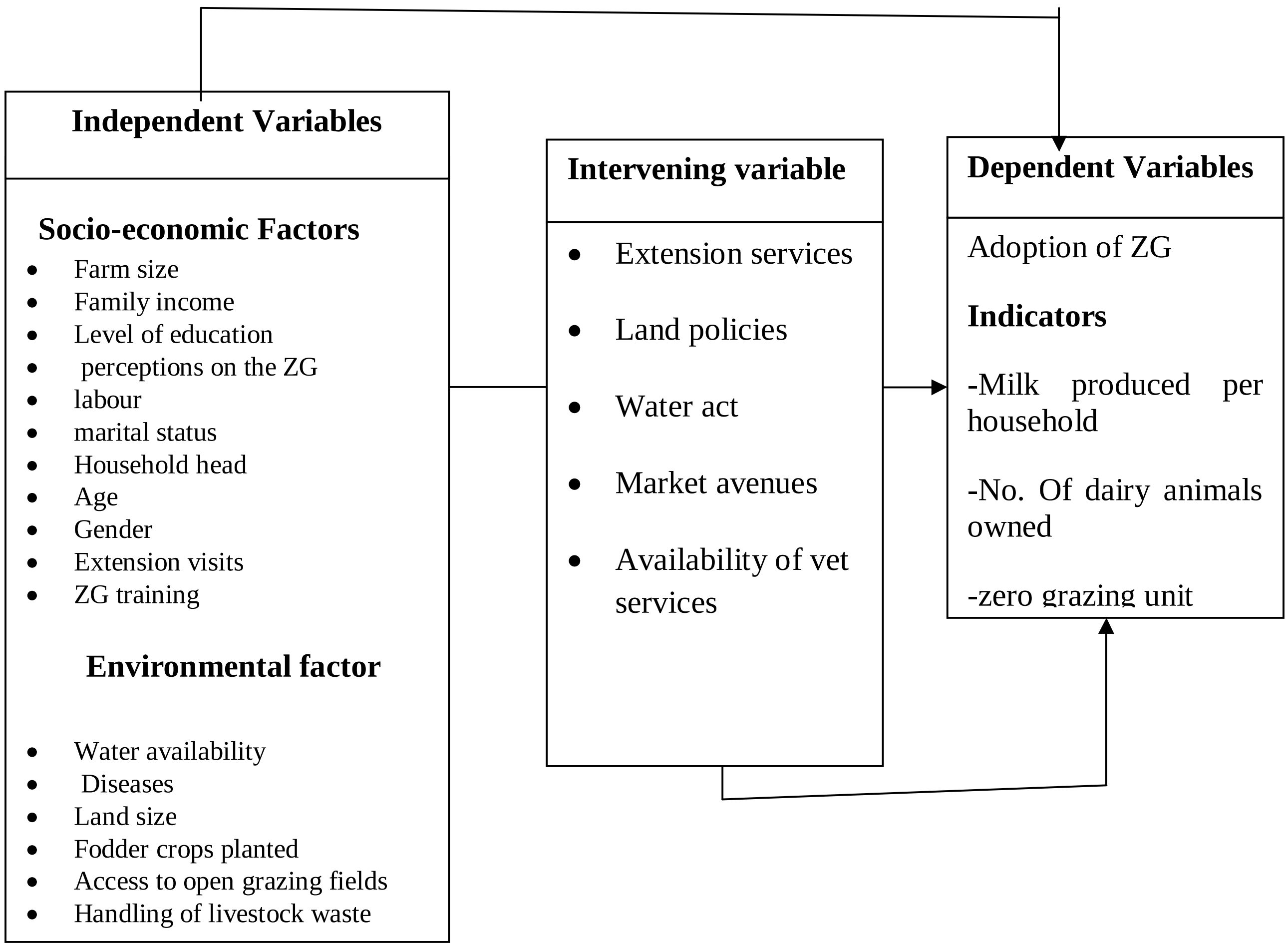

Figure 1: Conceptual Framework of the Study

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter outlines research design, study location, study population and sampling techniques that were used to pick the sample size for the study. The chapter also deals with instrumentation, how the data was collected, analyzed and presented.

3.2 Research design

The study utilized survey research design. A survey involves studying a situation as it is in an attempt to explain why the situation is the way it is. This design allowed for account and adequate descriptions of activities, objects and persons. A Cross-Sectional approach was used to collect both qualitative and quantitative data from the respondents. This approach is relatively faster and inexpensive because it provides self-reported facts about respondents, their inner feelings, attitudes, opinions and habits (Kombo & Tromp, 2007). Survey design enables researchers to make accurate assessment, inferences and relationships of phenomenon, events and issues (Kasomo, 2006).

3.3 Study location

Samia Sub -County is in the County of Busia in Western part of Kenya and covers a total area of 281.2 Km^2 of which 17 Km^2 is under Lake Victoria. Samia borders Butula to the North, Bunyala to the South, Uganda to the West and Siaya County to the East. Samia has one division and seven locations. It is located 0^o16^o'47.52^o'N, 34^o'07^o'05.05^o' E at an elevation of 1273 m above sea level. The population is about 113,364 people (GoK, 2010). Climatic condition favors cultivation of crops like cassava, avocados, oranges, bananas, watermelons among others. The maximum temperatures range from 26^oC to 30^oC while the minimum ranges from 14^oC to 18^oC. Humidity is relatively high because of the proximity of the Sub-County to Lake Victoria. The Sub-County is divided into three agro- ecological zones, LM_2, LM_3 and LM_4. LM_2 is the marginal sugar zone. Lm_3 is the cotton zone while LM_4 is the marginal cotton zone and covers the areas that adjoin Lake Victoria from Sio Port region (GoK 2010). Lower Samia and Upper

Samia fall under different ecological zones. Some parts of the Sub-County have poorly drained soils mainly of clay type due to frequent flooding especially along Lake Victoria, while other parts have well drained soils, deep with moderate water holding capacity. There is still underutilized land that can be used for agricultural production. The Sub-County is largely covered by hills that are commonly referred to as Samia hills (GoK, 2010).The main water masses are Lake Victoria and River Sio (Figure 2).

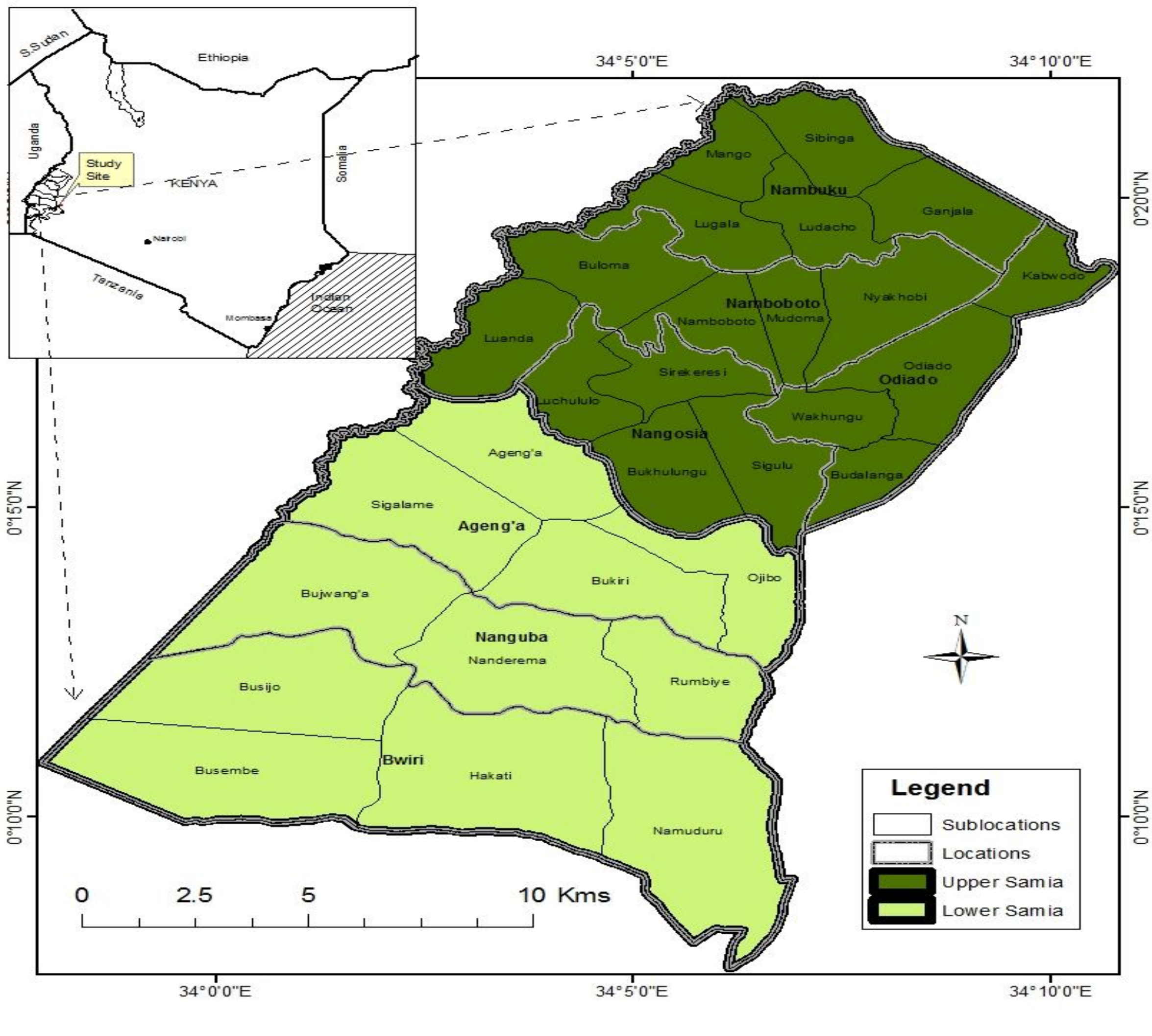

Figure 2: Map of study area

Source: Geoffry Maina (GIS, Environmental Science Department)

3.4 Study population

The population of the study comprised all farm families/households in Samia Sub-County. The unit of investigation was a household, whether the household had adopted zero grazing or not (adopters and non adopters) and the subject of analysis was the household head or spouse of the household head. The Kenya population census of 2009 provides a total listing of 19,395 households in the Sub-County (www.opendata.go.ke 2009). This was used as the sampling frame from which a sample composed of adopters and non adopters of the Zero grazing technology was selected.

3.5 Sample size and sampling procedure

3.5.1 Sample size

A sample is a smaller group obtained from accessible population. It is also a finite part of a statistical population whose properties are studied to gain information about the whole (Mugenda and Mugenda 2003). The sample size for the study was calculated using the coefficient of variation formula by Nassiuma (2000). This is because for most surveys, a coefficient of variation of at most 30 % is usually acceptable. This study took a coefficient of variation of 10 % and a standard error of 0.05. The coefficient of variation should be low so as to obtain reliable results. Thus:

$$n = \frac{NC^2 \ k}{C^2 + (N - 1)\, e^2}$$

Where n = sample, N = population C = covariance

e = standard error

A sample size of 200 hundred households was selected comprising of 150 non adopters and 50 adopters. There are 100 adopters in the study area; from this figure purposive sampling was used to identify the 50 adopters who were included in the study.

3.5.2 Sampling procedure

The study employed strata sampling to obtain two strata based on rainfall amount, that is, the Lower Samia and Upper Samia due to the differences in agro-ecological conditions to capture on spatial variability in adoption of ZG technology. Lower Samia is within eco zone 4; with unreliable rainfall of about 750 mm whereas Upper Samia is more productive and receives higher amounts of rainfall. Purposive sampling was then used to identify adopters and non adopters, from whom simple random sampling was used to select the households that participated in the study. The seven locations of the Sub-County are: Bwiri, Agenga and Nanguba in lower Samia and Odiado, Namboboto, Nambuku and Nangosia in upper Samia. A sample size of 50 adopters and 150 non adopters was selected by applying proportionate to size sample allocation based on the number of households in each location.

3.6 Instrumentation

The study utilized both primary and secondary data. To collect primary data, the researcher developed two sets of instruments for data collection, the household questionnaire and the interview schedule. The household questionnaire was used to collect data from the household heads while the interview schedule was used to collect information from key informants such as knowledgeable farmers and opinion leaders from Samia Sub-county on how farmers view ZG technology. Secondary data was obtained from the ministry of Livestock Development and other published materials to analyze types of diseases that are prevalent in the area, Observation schedule were used for ground truthing.

To examine the level of knowledge on zero grazing, a scoring system was developed to analyze how knowledgeable farmers were. Farmers were asked questions on: definition of zero grazing, feeding, housing, unit construction and management of slurry and answers compared to the department of livestock production guidelines. These questions were given a score from 1-10 thus it was possible to categorize whether a farmer is knowledgeable or not. This method was also adopted by Wambugu (2000) when scoring the knowledge of farmers in dairy production

Table 1: Scores on level of knowledge

Measure	Knowledge Level		
	Knowledgeable	Average	Not knowledgeable
Definition of ZG	≥5	1-4	0
Feeding	≥5	1-4	0
Housing	≥5	1-4	0
Unit	≥5	1-4	0
Slurry management	≥5	1-4	0-

3.6.1 Validity

Validity is the degree to which results obtained from the analysis of data actually represent the phenomenon under study. It is the accuracy, soundness or effectiveness with which an instrument measures what it is intended to measure; the appropriateness of the interpretation of the results of a test or inventory and is specific to the intended use. The instruments were then given to peers and supervisors to review in order to ensure their validity. The panel ensured that the items used to collect data adequately represented concepts that covered all relevant issues under investigation as recommended by Mugenda (2008).

3.6.2 Reliability

The questionnaire was pre-tested in Butula sub-county; this involved trying the questionnaire in the field on a small selected sample that was not part of the actual sample. The number of cases in the pre-test sample was 20. The procedures used during the pre-test were similar to those used during the actual data collection. The subjects were encouraged to make comments and suggestions concerning the instructions, clarity of questions asked and their relevance (Mugenda, 2008).

Data from the pre-test was used to establish the reliability of the items in the instruments using the Cronbach alpha coefficient. Cronbach alpha provides a good measure of reliability because holding other factors constant the more similar the test content and conditions of administration are, the greater the internal consistency, a reliability coefficient of $\alpha = 0.8$ was obtained.

3.7 Methods of data collection

The researcher first obtained approval to proceed with data collection from the Graduate school at Egerton University. Permission to collect data from the households was then secured from the sub -county Officer, Samia. The researcher then obtained the list of households practicing ZG from the District Livestock office after which an exploratory visit was made to the sampled locations to identify the households that have adopted the ZG technology. This was followed by data collection.

3.8 Data analysis

The data collected from the field was coded to transform it into numerical data for ease of analysis. The coded data was then entered into the computer and analyzed with the aid of the Statistical Package for Social Scientists (SPSS) computer programme. Quantitative data was analyzed by use of descriptive statistics and the results presented in frequency distribution tables and percentages. On the other hand, binary regression was used to determine the relationship between socio-economic, environmental factors and adoption of ZG.

Binary regression analysis was used to model and analyze the relationship between the dependent variable (adoption of ZG) and one or more of the independent variables such as age, occupation, and head of household and land size. Significance of the model was assessed at 0.05. The following models were adopted:

First Model: Effect of socio-economic factors on adoption of zero-grazing technology

$$\mathbf{A_{zg} = b_o + b_1 A + b_2 S + b_3 AC + b_4 O + b_5 LE + b_6 HHH + b_7 MS}$$

Where: A_{zg} =Adoption of ZG

A=age

b_o = Constant

$b_1, b_2, b_3 \ldots\ldots\ldots b_7$ coefficients of the independent variables

S =sex

AC =acreage

O =occupation

HHH =head of household

LE =level of education

MS = marital status

Second Model**:** Effect of environmental factors on the adoption f ZG

$$\mathbf{A_{zg} = b_1 ws + b_2 DW + b_3 SW + b_4 WC + b_5 Wq + b_6 S + b_7 F + b_8 OG + b_9 LD}$$

Where:

A_{zg} =Adoption

WS= water source

DW=Distance to water source

SW=supply of water

WC=water cost

Wq=water quality

S=soil

F=fodder trees

OG=open grazing fields

LD=livestock diseases

Table 2: Data Analysis Summary Table

Research question	Parameters	Statistical tool
What is the farmers' level of knowledge on Zero grazing in Samia Sub-County?	Knowledge on: Feeding practices, Housing requirements, Disease and parasite control, Waste management.	Descriptive statistics
Is there a significant difference in the adoption of zero grazing technology in the study area based on ecological zones?	Location(area)	Descriptive statistics Chi square tests
What is the effect of socio-economic factors on the adoption of Zero grazing technology by livestock farmers in Samia Sub-County?	Farm size, Family income, Household decision making, Level of education, Farmers perceptions on the ZG, Extension visits, Training, Age, awareness	Binary regression and frequencies
What is the effect of environmental factors on the adoption of Zero grazing technology by livestock farmers in Samia Sub-County?	Water availability, Diseases Land condition Fodder crops planted Problems with water Access to open grazing field Waste management	Binary Regression and frequencies

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

Studies on adoption of agricultural technologies are site specific and aim at indentifying and understanding the target group and the farming systems. This enhances developing extension strategies that can be used in diffusion of new technologies (Feder, 1985). The agricultural sector is the backbone of Kenya's economy. However several factors such as income levels, age, education and market access among others have hindered the adoption of agricultural innovations especially in the livestock sector (Stoneman, 2002). Adoption of modern technology is urgently required to increase the productivity so as to meet the increasing demand of food for rapidly growing population. The adoption of modern technologies, especially in subsistence farming, would be governed by a complex set of factors such as human capital, information, location, resource endowments and institutional support. Farmers' decision depends on their needs; cost incurred and benefits accruing to it (Karki, 2004). The purpose of this study was to assess the socio-economic and bio physical environmental factors affecting adoption of zero grazing technology in Samia Sub-County. In this chapter, therefore, the results of the study are presented and discussed under sub-headings namely: socio-demographic characteristics of the respondents, farmers' level of knowledge on Zero grazing, adoption pattern of Zero grazing technology in Samia Sub-County, influence of socio-economic factors on the adoption of Zero grazing technology and influence of physical environmental factors on the adoption of Zero grazing technology.

4.2 Socio-demographic characteristics of the respondents

4.2.1 Age of the respondents

Generally, the average age of most respondents in the study area was found to be between 40-50 years for both adopters and non-adopters. Most findings indicate that middle aged people are more likely to adopt an innovation than the very old and young (Cramb, 2000; Chi, 2008; Jungea, 2009).

4.2.2 Sex of the respondents

About 69 % of respondents were male while 31 % were female with 76% reporting their marital status as married. About 84 % of the households surveyed were male headed households. Researchers aver that men are more likely to adopt technologies such as zero grazing than women (Chi, 2008), although this was not the case in the study area.

4.2.3 Education level of the respondents

Education level varied across the study area, 30 % of respondents indicated that they had tertiary education, 28 % had secondary education, 35 % had primary and 7% had no formal education. This indicates that majority of people in Samia Sub- County have basic education, most findings on adoption of innovation show that young educated farmers are more likely to adopt technologies such as zero grazing than uneducated farmers (Okoeda & Onemolease, 2009).

4.2.4 Land tenure systems

Individual land ownership took the highest percentage at 61.5 % while 38.5 % owned land under communal tenure system. Technologies such as zero grazing can only be adopted by farmers who have land rights since they require high costs of investment on the land in terms of unit construction, breeds and planting of forage. Although individual land ownership had the highest percentage, this had no effect on adoption of zero grazing. Respondents who indicated they owned communal land are those who still live on their ancestral land and have not gotten title deeds.

4.2.5 Occupation of the respondents

Nearly 40 % of the respondents were subsistence crop farmers followed by 25 % of livestock farmers. Most of the respondents who indicated farming as their main occupation were observed not to be doing farming as a business but just as a way of life (Figure. 3).

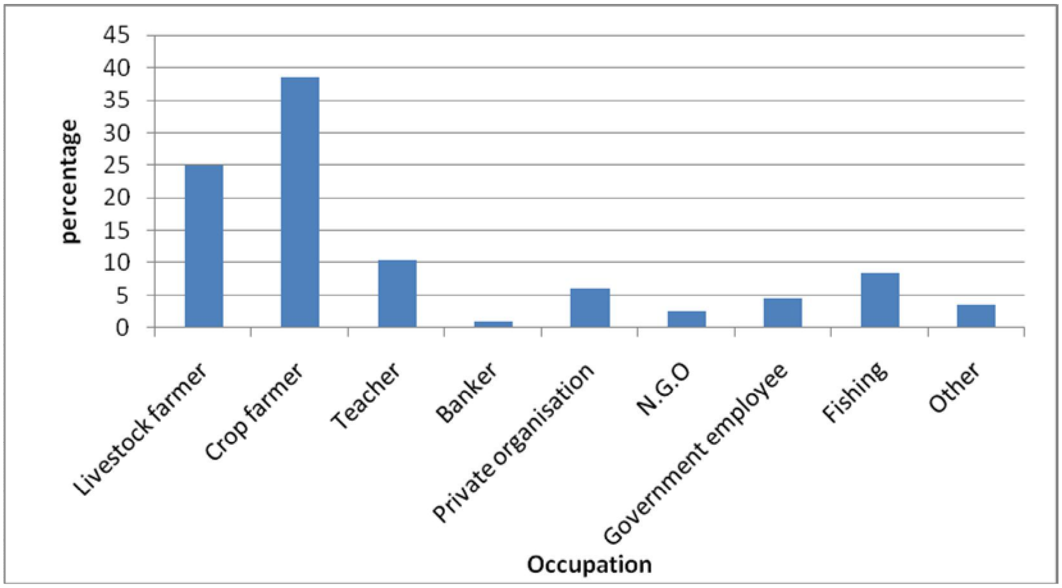

Figure 3: Occupation of the respondents

The occupation of the respondents had no effect on the adoption of zero grazing technology in the study area. In other studies high cost technologies such as zero grazing are adopted by people who are well off and can invest in the technology (Chi and Yamada, 2002).

4.3 Farmers' level of knowledge on zero grazing

The first objective of the study was to examine farmers' level of knowledge on Zero grazing in Samia Sub-County. Under this section, farmers' level of knowledge is presented under sub-sections of level of awareness on zero grazing, perceived benefits of zero grazing, farmers training on zero grazing, visitations by extension workers and a scoring on the level of knowledge.

4.3.1 Farmers' level of awareness on zero grazing technology

In order to assess the level of awareness that farmers in Samia Sub-County have towards Zero grazing technology (ZG), the respondents were asked whether they had heard of ZG technology, from whom, if they had been trained or had been visited by livestock production extension workers.50% of the respondents learned ZG from other farmers (Figure 4)

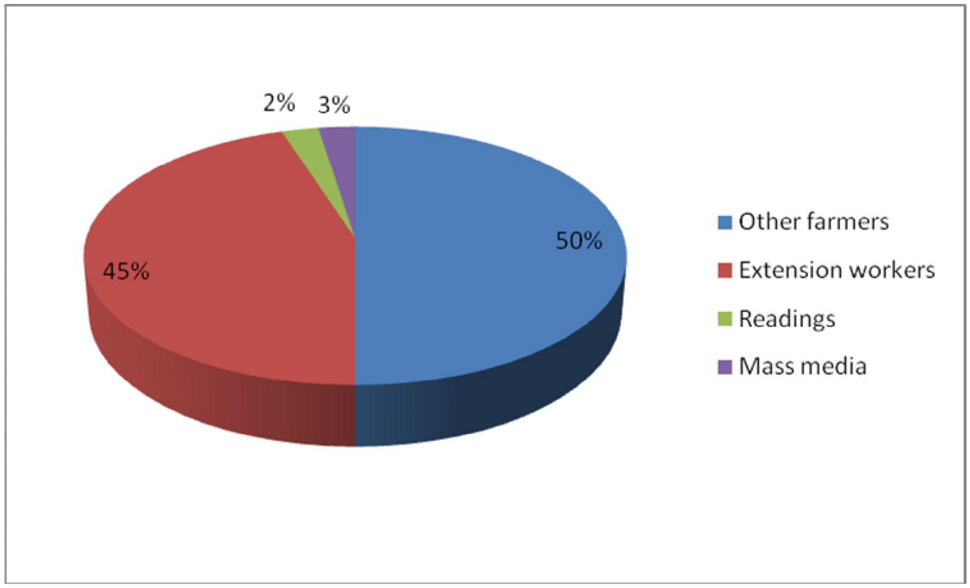

Figure 4: Level of farmers' awareness on ZG.

Adoption of zero grazing technology was seen to be significantly influenced by the level of awareness of the respondents. For those who had adopted the technology, they indicated that they had learnt the technology from other farmers or mass media. Mostly, adopters were retirees who had worked in different parts of the country or people who have visited other areas and thus became aware of the technology. Although there are some adopters in the Sub-County, the farmers to farmer approach of technology transfer do not seem to work in this area. This method of technology dissemination has proved to work in some areas (service-for –rural development, 2004) but there has to be initial awareness by first adopters who can then pass the information correctly to the rest of the farming community. The change agents who are the livestock extension workers have failed in their part of introducing the technology to farmers. In diffusion of any technology in a social system, Rodgers (1995) gives five kinds of individuals namely innovators, early adopters, early majority, late majority, laggards. The innovators cannot adopt a new technology unless they are aware of it, thus they need sufficient information about the technology (Hategekimana and Trant, 2002). The way the initial information is passed to innovators also determines how well they will in turn pass on the information (Geroski, 2000; Sheikh *et al*., 2006). The most striking feature of diffusion theory is that, for most members of a social system, the innovation-decision depends heavily on the innovation-decisions of the other members of the system (Rodgers, 1995). Consequently, since even the innovators in the study area seemed not to be so well informed or aware about Zero grazing, there is general uncertainty by the rest of the farming community about adoption of zero grazing technology. Thus its level of uptake has remained generally low. Extension workers should be at the centre of information flow. They remain the link between research workers and the farmers. If this link is weak then agricultural productivity will not increase (Diederen *et al*., 2003). The link can be strengthened in several ways including improved collaboration between research and extension. Both groups must learn to package information so that it may be readily understood by the farmers they are expected to serve (Karshena and Stoneman, 1995). Awareness among the farmers is a primary tool towards the adoption of any modern technology. Unfortunately, there is dichotomy between research and extension system lacking proper dialogue on technology generation, development and dissemination among farmers. The situation is severe at lower level of extension and research systems keeping the extension agent deprived of proper technical knowledge necessary for dissemination of technologies (Chi and Yamada, 2002).

4.3.2 Perceived benefits of zero grazing

The respondents were asked to state their perceptions of the benefits of ZG. Their responses were organized into key themes, coded and analyzed quantitatively and the findings presented in Figure 5.

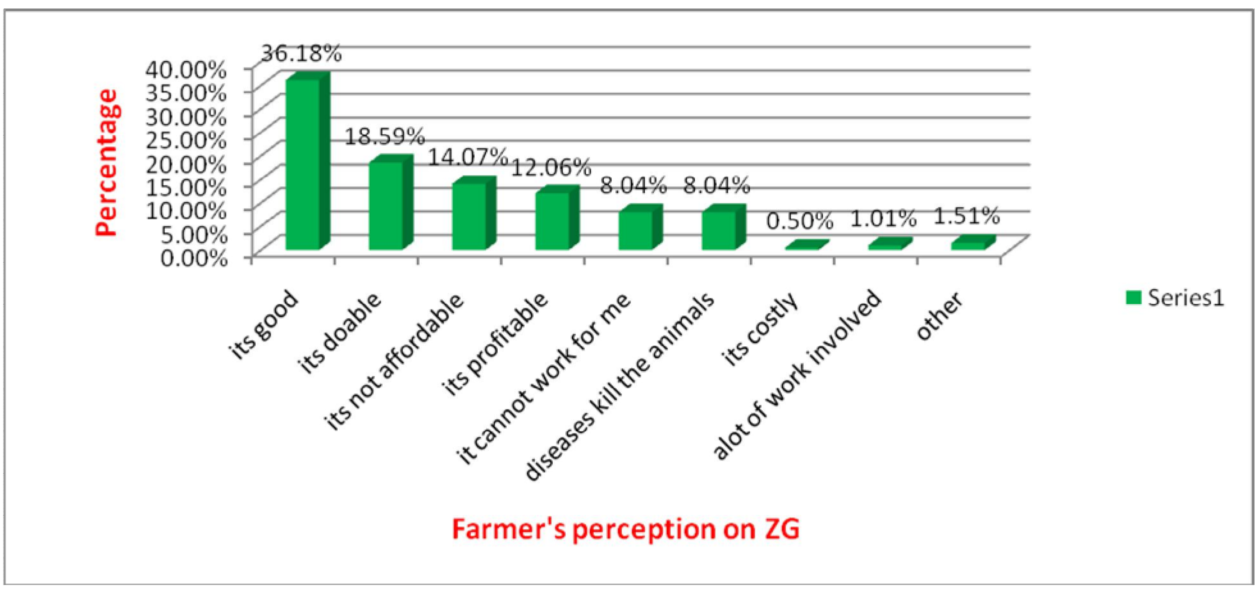

Figure 5: Perception of farmers on zero grazing.

In this study, 40 % of respondents perceived the technology to be economically viable, doable and good in terms of control and waste management (Figure 5). But their fear of adoption of the technology was majorly based on the fact that diseases normally kill the animals. The aspect of the technology being labor intensive was also highlighted by some farmers. Perception of zero grazing technology had no influence on adoption because in as much as the respondents agreed that the technology was good; the rate of adoption has remained low.

Most findings indicate that perception significantly affects the rate of adoption of any agricultral innovation. For example, Makokha (1999) concluded in his findings that farmers perception had an influence on adoption of soil management technologies in western Kenya. In the study area although most farmers perceived the technology to be good they were not adopting because they had fear of diseases killing the animals. Adoption of dairy technologies has always been seen to be influenced by the perception farmers have towards the technnology, if they perceive it to be economically feasible and has utility then they readily adopt it (Makokha, 2004).

4.3.3 Farmers' training on zero grazing

Half of the adopters reported that they learned the technology from other farmers while 45 % learnt from extension workers. Majority (68 %) of respondents indicated that they had never been visited by livestock extension officers (Table 3). About 74% of respondents had never received any form of training concerning ZG technology whereas only 24 % had received training (Table 3).

Table 3: Visitation by extension officers

Visited	Frequency	Percentage
Yes	64	32.0
No	135	68
Total	**199**	**100**

.

Table 4: Training of farmers on zero grazing

Trained	Frequency	Percentage
Yes	52	26
No	147	74
Total	**199**	**100**

The policies governing livestock extension services in the country currently states that farmers should demand for the services, these coupled with the low facilitation of officers is the most likely reason why farmers are complaining of not being visited (Jaetzold, 2007). On scoring the level of knowledge on zero grazing the following results were obtained:

Table 5: Farmers' level of knowledge on ZG

Knowledge	Frequency	percentage	Valid Percent
0: not knowledgeable	90	45	45
1-4: below average knowledge	35	17.5	17.5
5-11: Knowledgeable	75	37.5	37.5
Total	200	100.0	100.0

From the table on level of knowledge, 45 % of respondents had no basic knowledge on zero grazing, 17.5 % had slight knowledge and the rest had basic knowledge. The findings of this study indicate that majority of respondents lacked basic knowledge about zero grazing technology (Table 5). They were not well informed about aspects such as housing, feeding, disease control and waste management. This was the case for both adopters and non adopters. The low level of knowledge is the most likely reason why adoption of ZG has remained generally low in the study area. This means that majority of the population in the study area had no knowledge and thus the low level of adoption.

Most researchers indicate that knowledge positively affects the rate of adoption of any agricultural technology. For example, Chi *et al.*, (2002) argued that factors affecting diffusion of technology use include; access to technical training, meeting, oral transmission, trust on technician and believe on technology introduced by scientist. Lack of technical training on zero grazing in the study area might have contributed to the low level of adoption. Lack of collaboration between the researchers and change agents (extension officers) makes flow of information to farmers ineffective. Chi (2008) also argues that lack of capacity by extension workers to reach the farming community and carry out trainings and demonstrations results into low adoption of new agricultural technologies.

4.4 Adoption pattern of zero grazing in Samia Sub-County

The second objective of the study was to establish the adoption pattern of Zero grazing technology in the study area based on ecological zones. To assess the adoption pattern of ZG in Samia Sub-County, the numbers of adopters from each location were assessed. Upper and lower Samia locations were based on the differences in eco zones. The adoption pattern was as shown in Figure 6.

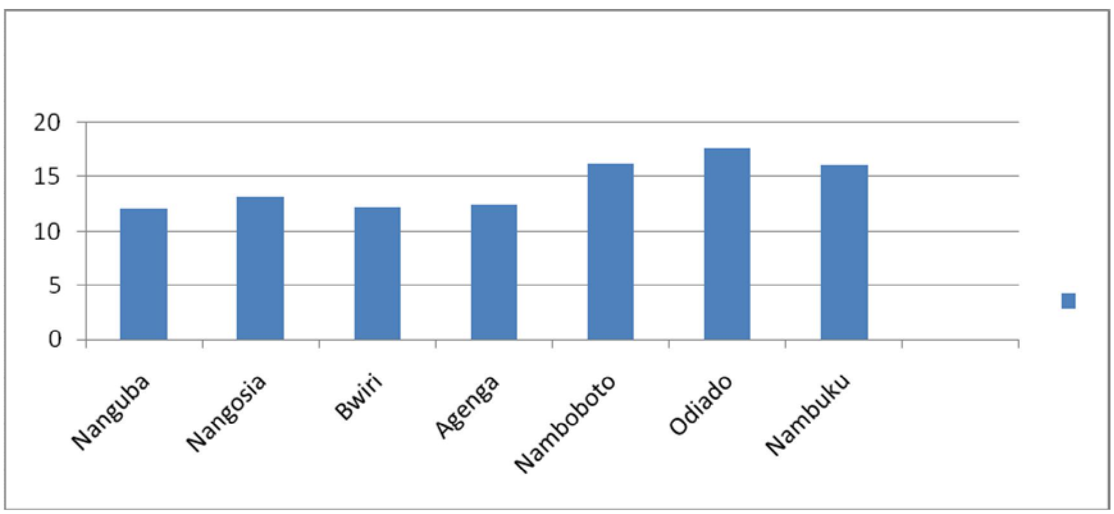

Figure 6. adoption of zero grazing per location

As shown in Figure 6, the upper locations of Nambuku, Namboboto, and Odiado had more adopters than the lower locations of Nanguba, Nangosia, Bwiri and Agenga. Thus adoption of zero grazing in the study area was seen to be influenced by location. Odiado had the highest number of adopters followed by Namboboto and then Nambuku. There were more respondents who had ever practiced Zero grazing in upper Samia locations than in Lower Samia with the exception of Bwiri location which registers a higher number of respondents.

The above results were confirmed by a Pearson chi square test at 6 degrees of freedom giving $x^2=14.592$ and a $p<0.040$. This indicated that there is a significant difference in the adoption of zero grazing technology in lower and upper Samia locations.

This can be explained by the fact that upper Samia receives higher amounts of rainfall and this translates to higher amount of forage and fodder production for livestock than the lower Samia locations. High temperatures in Lower Samia were likely to be impacting negatively on dairy animals and thus the low levels of adoption. Adoption of any agricultural technology has been seen to be influenced by the location of the farm (Sheikh *et al*, 2006). Location in turn affects access to market and access to information and services. Other biophysical environmental factors of distance to water sources, rainfall pattern and distribution, temperatures and soils affect the ability of animals to survive in an area (Sherchand, 2001). Lower Samia has been indicated to register very high temperatures and receive unreliable rainfall of about 750 mm per year. The soils are not well developed due to lack of sufficient moisture for plant and microbial action and thus fodder production is limited. Adoption of any technology is influenced by the costs incurred and benefits accrued and, farmers would adopt a technology that they perceive to be economically rewarding to them and that has low risks (Sunding and Zilbernan, 2001). In Lower Samia farmers find fish business to be more lucrative than dairy farming and this can be the reason why adoption of zero grazing has remained low in Lower Samia. Another aspect is accesses to veterinary services and extension services; due to distance from the headquarters farmers in Lower Samia may not be well covered.

4.5 Effect of Socio-economic factors on adoption of zero grazing technology in Samia Sub-County

The third objective of the study was to determine the effect of socio-economic factors on the adoption of zero grazing technology in Samia Sub-County. The following regression equation was therefore used to model the socioeconomic factors affecting adoption of ZG technology in Samia Sub-County.

$A_{zg} = b_o + b_1A + b_2S + b_3i + b_4AC + b_5O + b_6\, le + b_7HHH + b_8MS$

Where: A_{zg} =Adoption of ZG

A=age

S =sex

AC =acreage

O =occupation

HHH =head of household

LE =level of education

MS = marital status

Predictors = Age, Farm size, Sex, Occupation, Head of HH, Marital status and Level of education. Using binary regression to assess the predictor variable: all the variables were found not to be significant in the equation. Generally, adoption of zero grazing technology in Samia Sub-County is not significantly influenced by socio economic factors (Table 6).

Table 6: Relationships between socio economic factors and adoption of ZG

Variable	**B**	**S.E**	**df**	**Sig.**
Age	-1.656E+01	3.767	1	.999
Marital status	1.714	1.665	1	.743
Head_HHH	-5.536E-01	1.589	1	.815
Education	21.159	2.632	1	.995
Occupation	41.013	10877.	1	.997
Acreage	-1.526E-01	10956.695	1	.603

Factors such as age of respondents, sex, marital status, and head of household did not significantly affect adoption of zero grazing in the study area with $P>0.05$ (Table 6). This is to say irrespective of the age of the farmers, the level of education among others, farmers do not adopt ZG. Most researchers on adoption aver that education level has a significant effect on adoption, that young educated farmers adopt new technologies faster than old uneducated farmers, this was not the case in the study area where P>0.05. in other adoption studies male headed households were found to adopt technologies such as ZG more than female headed households (Diederen *et al.*,2003) this also was not the case in the study area where head of household had P>0.05. People who were earning non farm income i.e. those in other occupations other than farming were seen to adopt new technologies (Karki, 2004) this is because income from other sources could be used to invest in the technologies such as ZG which need high initial capital (Wanyoike,2003)

4.6 Environmental factors and adoption of zero grazing technology

The fourth and final objective of the study was to establish the effect of environmental factors on the adoption of zero grazing technology in Samia Sub-County. Under this section, descriptive findings are first presented on sources of water and its availability, parasites and diseases, soil fertility and rainfall. In the later sub-section, findings are presented on the effect of these factors on adoption of zero grazing.

4.6.1 Sources and availability of water

Majority (50 %) of respondents depended on borehole water that was either individually owned or communal (Figure 7)

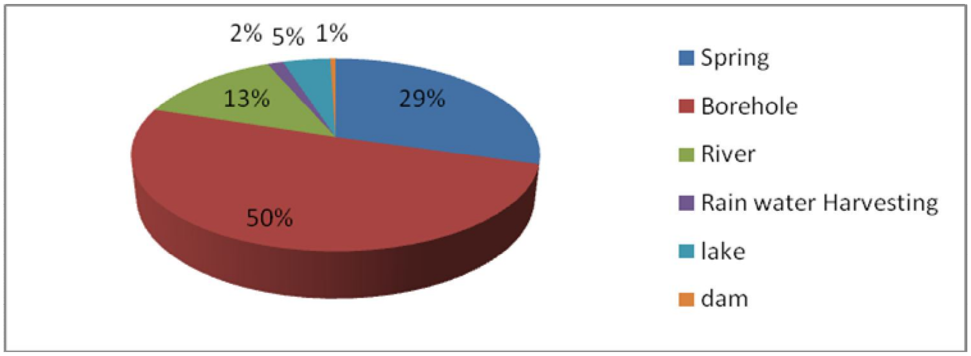

Figure 7: Water sources in the study area

With regard to water quality, the respondents reported that water quality was good. The average cost of water was between Ksh.50 and-100 per month, a fee mainly charged for maintenance of the bore holes. About 91% of the respondents indicated that the supply was adequate for their needs. About 76% indicated that they watered their livestock from watering troughs, while 23.5% watered directly from the springs, rivers and lakes. About 55% of the respondents indicated that they had no water problems, 17.5 % complained of distance to water sources, 12 % complained of water insufficiency, 3.5% said the water was dirty, 9.5 % said it was salty and 2 % said it was colored.

4.6.2 Soil fertility

The respondents were asked to indicate their general view of soil fertility of their land. About 45.0 % reported that soil fertility was good, 36.5 % considered the fertility to be fair while 18.0 % said the soils were poor. Nearly, 59 % of respondents have not planted fodder crops even though they indicated that the soil fertility is good. From observation, it was noticed that most land in Samia Sub-County was not cultivated but had been left fallow with bushes hence soil in most parts was still virgin. Although respondents indicated that the soil fertility was good results from the department of agriculture on soil sampling showed that most parts of the Sub-County have acidic soils (GoK, 2014). The acidity was attributed to the parent rock and the use of fertilizers when cotton and coffee used to be grown in the area. From observation the soil is not well formed in most parts and the bed rock is at 30 cm depths in some parts. Soil fertility affects the types of crops grown in an area and consequently the adoption of agricultural innovations (Makinde, 2007).

4.6.3 Parasites and disease prevalence

There is a prevalence of trypanosomiasis (59.5%) and East Coast Fever (17.5%) in the study area (Figure 8). The two diseases have in the past wiped out large herds of cattle in the study area; this has made people to fear keeping dairy animals because they are most susceptible to the above diseases. The strong entrenched fear in the farmers was likely to have hindered adoption of ZG.

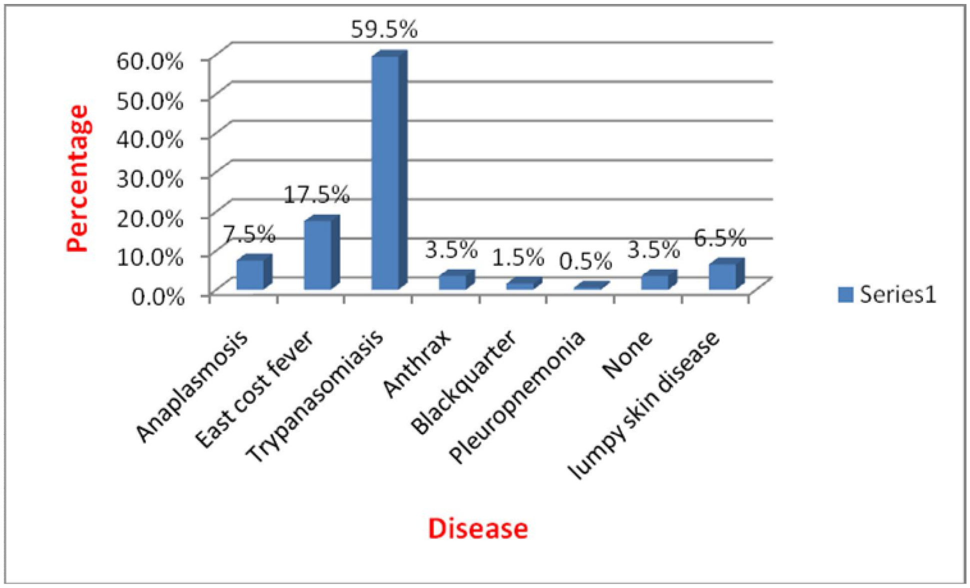

Figure 8. Types of disease in the study area

It was evident from the study that Trypanosomiasis was the most prevalent disease followed by East Coast Fever and anaplasmosis. Trypanosomiasis is a disease that thrives in a bushy environment. Samia Sub-county has bushy thickets comprising of a variety of shrub species but mostly *Lantana camara*. From observation most residents do not clear bushes around their homes, this makes tsetse to find a suitable habitat thus spread the disease (PATTEC, 2008). There are 8 tsetse species in Kenya and an estimated 13 % of cattle are at risk (PATTEC, 2008). From the data in the veterinary department increased deteriorations in livestock production has been caused by Trypanasomiasis followed by tick borne diseases (GoK, 2012). It was also observed that all dips constructed by the government were not functioning due to mismanagement by the local community. Farmers lamented that they were losing most of their animals due to Trypanasomiasis and East Cost Fever. The poverty prevalence in the tsetse infested area of the country is above 56 % (PATTEC, 2011). The aspect of disease prevalence has forced farmers to keep large herds of indigenous cattle that are well adapted to the local environment (GoK, 2012) in as much as the zebu cows are not productive; farmers feel it's better to have them than to risk high mortality by keeping up dairy cows.

4.6.3 Effect of environmental factors on adoption of zero grazing technology

Binary regression model was used to assess the effect of environmental factors on adoption of zero razing technology in Samia Sub-County. Only water supply, fodder feeds and access to open field are significant predictors of adoption with $p<0.041$. Other factors such as water source ($p>0.0678$), distance to water source ($p>0.0495$) were found to be insignificant predictors (Table). Most respondents in the study area indicated that they depended on bore hole water and from observation most of this bore holes are communally owned and thus the supply of water may not be adequate for all households and dairy cattle (Figure 4). ZG of dairy animals is an intensive system of production and requires adequate supply of water for watering the animals and for cleaning the unit daily. Thus inadequacy of water supply would automatically be significant on adoption.

Fodder feeds $p<0.000$ was significant in adoption; lack of fodder crops means farmers cannot practice intensive livestock production systems. Most adopters have established fodder crops especially Napier grass on their farms and only buy to supplement (Figure 10). Lack of access to open grazing fields means that the land resources has declined and farmers are forced to adopt more intensive systems of production such as ZG. Open grazing fields had a significant effect on adoption of ZG with $p<0.000$. As population growth increases farmers are forced to confine their animals in homesteads and some from observation graze along the roads and paths.

Model summary

$$\mathbf{A_{zg} = b_1 ws + b_2 DW + b_3 SW + b_4 WC + b_5 WP + b_6 S + b_7 F + b_8 OG + b_9 LD}$$

Where:

A_{zg} =AdoptionWS= water source

DW=Distance to water source

SW=supply of water

WC=water cost

WP=water problems

S=soil

F=fodder trees

OG=open grazing fields

LD=livestock diseases

Table 7: Relationships between environmental factors and adoption of ZG

Variable	B	S.E.	df	Sig.
water source	17.642	40193.108	1	1.000
Water Distance	.933	1.368	1	.495
Water supply	3.110	1.520	1	.041
Water Problems	.655	3.374	1	.846
soil fertility	16.102	.934	3	.411
Fodder feed	7.572	1.418	1	.000
Open fields	-3.271	.846	1	.000

Effect of rainfall distribution on adoption

Samia Sub-County receives erratic, localised and unreliable rainfall. Upper Samia receives higher amounts of rainfall than lower Samia (Table 8). The rainfall figures were obtained in upper Samia. However, there is no rainfall recording station in lower Samia which is semi-arid land with very low and erratic rainfall patterns. It was observed that more farmers in Upper Samia adopted zero grazing compared to Lower Samia

Table 8: Rainfall amount in Upper Samia

Year	Jan	Feb	Marc	Apri	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Rain days
2006	51.5	177	58.4	341.3	104.4	86.6	28.8	m	m	m	m	m	
2007	34.8	85.3	100.1	99.5	137.1	43.3	82.2	m	m	m	m	m	
2008	45.6	64.3	177.7	114.8	156.7	35.2	69.8	22.3	26.7	168	107.6	5.7	127
2009	47.9	8.9	77.8	204	205	71.3	21.8	100.5	151.7	131.2	76.1	116	123
2010	36.5	103	178	98.7	153.4	54.6	51.5	78.8	126	72.2	79	24	105
2011	0	20	147.8	190.5	162.5	60	67.2	126	137.2	155.5	207.5	9	228
2012	0.6	0	46.2	347.4	360.2	45.6	29.3	72.3	81.1	259.2	141.3	118	114
2013	57.9	19.8	176.8	271.1	116.2	m	m	m	m	m	m	m	

m-no record of rainfall

Source of data: Wakhugu Forest station in the Upper Samia.

Approximately 100 households practice zero grazing in Samia Sub-County, out of which 80 come from upper Samia which receives higher rainfall as indicated in the table above. Most farmers interviewed perceived the environmental conditions to be so hostile for adoption of technologies such as Zero grazing. For example, the low and erratic rainfall in lower Samia has severely affected adoption. Because, lack of rainfall means there are no enough fodder crops to sustain intensive livestock production systems. In addition, lack of rainfall affects water supply and this further hinders adoption. Due to rainfall distribution in the study area, there are more adopters in upper Samia than lower Samia that receives very low rainfalls. Rainfall distribution also affects the type of vegetation in an area (Pratt and Gwyne, 2000). Bushy vegetation is dominant in the study area which is a good habitat for tsetse flies that transmit trypanasomiasis. This disease has made farmers very fearful to adopt zero grazing especially of dairy animals as they argue that they cannot survive.

4.7 Livestock waste management

Majority of the respondents at 40.5 % stated that they compost above the ground, only 14.5 % of the respondents indicated that they compost in a pit (Figure 9). This was confirmed by the findings of observations made which revealed that most farmers in the study area heap livestock wastes in open places and leave the wastes to decompose until the time they use the decomposed manure on the farms. Waste management is poorly done and thus acts as non point sources of nutrients into water bodies (Alberta Agriculture, 2007). Respondents who practiced open grazing left the waste to decompose in the fields. Since open grazing and tethering are the most common livestock production methods, the amount of nutrient loading into water sources is very high although no research has been done on the same.

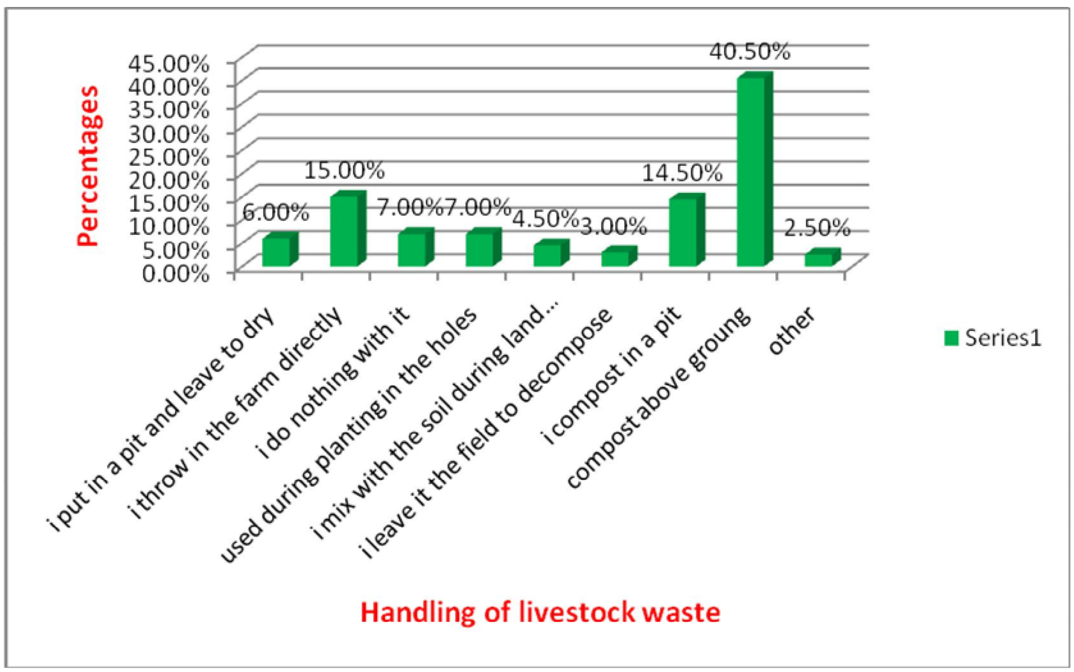

Figure. 9: Livestock waste managemnt techniques

It's evident that livestock farming can adversely affect the environment due the vast amounts of manure they produce (NRDC, 2012). For example, California officials indentify livestock farming as the major source of nitrates in more than 1000,000 square miles of ground polluted water (NRDC, 2012). High levels of nitrates in drinking water increases the chances of blue baby disease. Animal waste also contains disease causing organisms such as *Salmonella typhus* which are harmful to humans (Sherchard, 2001). The effect of nutrient loading from livestock enterprises also affects the aquatic ecosystem, as phosphorus and nitrates get into the water ways, eutrophication occurs. Most rivers in the study area drain into Lake Victoria. It's evident that Lake Victoria has been undergoing eutrophication due to the heavy presence of water hyacinth. Eutrophication is the phenomenon of aquatic ecosystem enrichment due to increased nutrient loading. Eutrophication is often caused by human activities such as livestock farming and additional input of fertilizers from agricultural farming (Thornton and Rast, 1999). Consequently, eutrophication causes the deterioration of the aquatic environment and typically leads to the formation of harmful algal (*Phytoplankton*) blooms which may subsequently induce fish kill, further ecosystem damage and, at times, are directly or indirectly associated with human health problems (Reardon, 2009). Eutrophication has been viewed as a factor that degrades the water quality by accelerating organic matter growth and decomposition as well as decreasing the light availability in the waters, leading to low dissolved oxygen (Reardon, 2009). Another factor leading to low DO are Nutrients, Nitrates and phosphates which limit plant nutrients and can cause plant life and algae to grow in abundance (bloom) (Radwan *et al.,* 2003. In aquatic ecosystems, when algal blooms collapse they contribute to organic carbon in the water, which is then decomposed by bacteria (Radwan *et al.,* 2003) resulting into high Biological Oxygen Demand (BOD) in aquatic ecosystems. High BOD levels result in a decrease in dissolved (DO) levels because the oxygen that is available in the water is being consumed by the bacteria during respiration (Diaz & Solow, 1999). Since less dissolved oxygen is available in the water, fish and other aquatic organisms may not survive.

Thus it's important to properly manage livestock waste so as to avoid damage both to the terrestrial and aquatic ecosystems. Zero grazing technology if well managed can reduce these effects as the waste is easily collected and decomposed (Bationo, 2004). Results indicated that in the study area composting of waste is not properly done, 40.5 % of respondents compose above ground that is, and they just heap the waste in a place and leave it for some time. This acts as a source of nutrients into water ways especially during the rainy season (Figure 9). Proper composting of manure by use of the four pit method reduces the amount of nutrients getting into water ways. Also, proper application of manure by using it during planting in a hole or ploughing it in the soil the same day it's applied. Soil erosion control measures would also reduce nutrient loading into water ways (Alberta agriculture, 2007). It is not well understood why majority of farmers choose to compost above ground and why some do not even bother to use the manure but just leave it to dry. From observation, there was no farmer in the area with a standard method of waste management.

4.8 Contribution of livestock to pollution

The results (Table 9) show that 77 % of the respondents indicated that they were aware of the pollution caused by livestock wastes, whereas 23 % indicated they were not aware. None of the respondents seemed to know that waste and acaricides were harmful to the environment.

Table 9: farmer's awareness that livestock can pollute the environment

Awareness	**Frequency**	**%**	**Valid %**	**Cumulative**
Yes	154	77.0	77.0	77.0
No	46	23.0	23.0	100.0
Total	**200**	**100.0**	**100.0**	

Most respondents explained that, livestock can destroy the environment by overgrazing and thus exposing the soil to erosion and by trampling. This is an area that needs a lot of training to the farmers in the study area**.**

The contribution of livestock to environmental pollution is an aspect of concern and needs to be dealt with adequately**.** From observation most farmers heap manure in an open place and leave it to decompose, this results to the release of methane gas into the atmosphere. Methane is one of the gases causing ozone layer depletion and thus global warming.

Most of the methane gases getting into the atmosphere are said to be originating from intensive livestock production systems (Shrchand, 2001). These can be controlled by proper waste handling and use of the dung to produce biogas for home use.

The fact that free grazing animals are not controlled means overgrazing is eminent. As the land is overgrazed soil erosion occurs on a large scale and consequently there is land degradation and loss of productivity in the long run. It was observed that most farmers in the study area graze along the roads, on grazing systems the following results were obtained, majority of the farmers practice open grazing at (36 %), followed by tethering at 27 % and ZG 8.0 %. This is despite the fact that 41 % of farmers said they had access to open grazing fields while 59 % indicated that they had no access. Thus, land degradation due to overgrazing and foot trampling are likely to occur in the study area.

4.9 Zero grazing and Fodder tree establishment

About 59 % of respondents indicated that they did not feed their livestock on fodder. Meaning they graze animals on open pasture (Table 10).

Table 10: Fodder feed

	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	82	41.0	41.0	41.0
No	118	59.0	59.0	100.0
Total	**200**	**100.0**	**100.0**	

For those who fed livestock on fodder 38 % indicated they had planted the fodder crop. The most popular fodder crop planted is Napier grass at 32 % followed by *Sesbania* at 7 %. From observations made, most farmers in the study area were not aware of fodder trees to be planted (Figure 10). Consequently, they had not planted fodder trees and as a result the contribution of fodder trees to the tree cover in the study area had not been realized. The findings on the types of fodder crops planted on the farm were as shown in Figure 10.

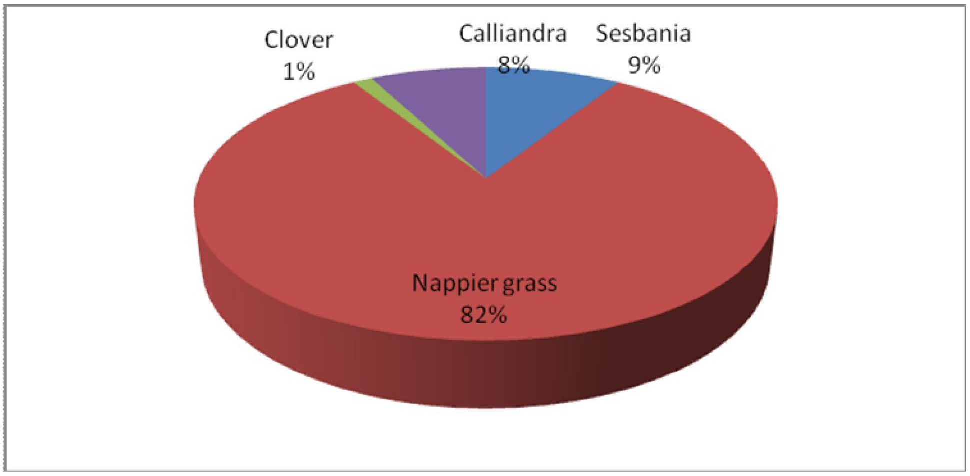

Figure 10: Types of fodder crops grown in the study area.

Growing of fodder crops in the study area would have contributed to the tree cover, currently the tree cover in Samia Sub-County is below the government recommendation of 10 % tree cover per farm. From observation, fodder species such as *Sesbnia Sesban* are doing well and even grow naturally on the road sides but most farmers have not incorporated them in the cropping system. Results indicated that only 9 % of respondents had grown *Sesbania* in the whole Sub-County. Some farmers did not even know that it can be fed to livestock. *Calliandra* species were mostly planted by farmers who kept bees and also had livestock; this fodder tree had been promoted in the study area as forage for bees. Thus, planted near the apiary and only utilized as feeds when they have overgrown. Clover was also found in the area at 1 % and had been integrated into the main crops. Fodder trees have been well adopted in other parts of the country such as Embu (Wanyoike, 2002) through initiatives by the government and other stakeholders promoting them.

Although most famers who fed Napier to their livestock had planted the fodder, they observed that Napier stunting disease had been a problem in the area. The disease has not been controlled and thus most of the Napier grass is affected. Another area of concern was the planting methods and the management of the Napier grass. Most farmers did not seem to know the required spacing and even the need to manure the crop or use fertilizer. Growing of Napier grass on terraces can act as a soil erosion control measure a concept that is not being practiced in the study area.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Introduction

In this chapter, the summary of the study's findings are presented and conclusions drawn from the findings highlighted. Recommendations are also made based on the findings as well as the conclusions of the research study.

5.2 Summary of the findings

Most respondents in the study area had an average age of 40-50 years, about 69 % were male and 76 % were married. Education level was seen to vary with 30 % indicating they had tertiary education. Majority of the respondents were crop farmers at 38.5 % followed by livestock farmers at 25.0 %. Fishing was seen to thrive along the lake region at 8.5 % although occupation did not have a significant effect on adoption of zero grazing.

The major water source in the study area was borehole at 50 %, followed by springs at 29 %, about 13 % river. The lakes contribution to water source was 5 % despite it being a large mass of water. The soil fertility in the study area was perceived to be good by respondents, nearly 45 % considered the soils to be fertile, the next 36 % considered the soils to have fair fertility while 18 % indicated the soils were poor. The most prevalent disease in the study area was seen to be trypanasomiasis at 59.5 % followed by 17.5 % of east cost fever. This is manageable diseases. Other diseases such as anthrax, black quarter, and lumpy skin disease are in the study area but not on a large scale.

Farmers in the area indicated that they had learnt the technology from other farmers or the mass media. This brings in the aspect of awareness, it was evident that respondents were not aware of the technology and thus could not confidently adopt.

Respondents perceived the technology to be economically feasible at 36.18 %, doable at 18.6% but some felt that if they kept the animal's diseases would kill them while a few felt the technology was costly at 0.5 %.

The level of knowledge was seen to be very low in the study area with 45 % of respondents not being knowledgeable followed by 17.5 % who had below average knowledge. Only 37.5 % had adequate knowledge about zero grazing technology. This was confirmed by the fact that most respondents had never been visited by livestock extension works at 68 % and had never been trained on the technology at 74 %.

The adoption of zero grazing was seen to vary by location in the study area with $x2=12.592$ and a $p<0.040$. The upper Samia locations had more adopters than the lower Samia locations.

The socio economic factors had no significant effect on adoption of zero grazing technology with a $p>0.05$.

Environmental factors of water supply ($p<0.000$(, fodder feeds ($p<0.041$) and open grazing fields $p<0.000$) had significant effect on adoption of zero grazing.

5.3 Conclusions

Most farmers in the study area are in their most productive age group in terms of adoption of agricultural innovations. There are more crop farmers in the study area than livestock farmers, respondents in other occupations such as teachers, bankers, were not many.

Water supply was not adequate in the study area. Thus depending entirely on borehole water to water livestock in the Sub-County may not be sufficient. Most of the boreholes are communally owned and farmers walk long distances to the water source.

Diseases such as trypanasomiasis and east cost fever are common in the study area but they are management diseases and should not be the reason for not adopting the technology.

Farmers in the study area have got no knowledge about zero grazing technology because they have not been trained, they are not visited by extension workers and do not understand where they can get the information on the technology. The government policies on extension have not promoted the technology.

The prevailing environmental conditions in lower Samia have greatly contributed to low adoption levels of the technology. Secondly, lower Samia people prefer to practice fishing and have not been exposed to Agricultural innovations.

Waste management in the study area is not well done; farmers seem not to know how to compost the manure and even how to apply it in the field. They may not be aware of the advantages of using the manure in crop farming or for biogas production.

5.4 Recommendations

There is need for extension agents in the study area to carry out regular farm visits, field days, trainings and demonstrations, in order to make the farming community aware of the technology and to alleviate the deep rooted fear that farmers have towards the technology. This will increase the level of knowledge of the technology among farmers. Although diseases such as trypanasomiasis and east coast fever are now manageable, farmers do not seem to know this fact and still fear keeping dairy animals, thus the importance of equipping the farmers with knowledge. This can only be achieved if the current livestock extension policies are reviewed and tailored to meet the needs of farmers. The demand driven approach seem not to be working well in the study area.

The department of livestock production and veterinary services should train farmers on production and help them acquire breeds that can survive in the prevailing environmental conditions of lower Samia, thus, enhancing the level of adoption of zero grazing in all locations of Samia Sub-County.

More boreholes should be constructed at closer distances and farmers especially in lower Samia trained on rain water harvesting. The government should come up with more water projects and even harness the Lake Victoria water for watering livestock since the results indicated water supply affected adoption of zero grazing.

More emphasis should be put in controlling the environmental factors, bushes should be cleared and farmers advised to plant trees, fodder trees should be encouraged in agroforestry. Additionally, farmers should be capacity build on waste management practices to ensure that they manage agricultural waters in the right manner. The government should come up with measures to eradicate tsetse flies using low concentrations of insecticide to enhance dairy livestock production and minimize environmental pollution. This would reinforce the efforts being made by PATTEC.

5.5 Suggestions for further research

Further research should be done in the study area to understand the amount of nutrients being produced by livestock and loaded to the major water body which is Lake Victoria. Other models such probit should be used to assess the effect of socioeconomic factors on adoption of Zero grazing technology.

REFERENCES

Alberta Agriculture (2007), .*Nutrient management planning guide*. Agriculture and rural development, Alberta government press

Amadalo, B., Jama, B., Niang, A., Noordin, Q., Nyasimi, M., Place, F., Franzel. S., Beniest, J. (2003). *Improved fallows for western Kenya: an extension guideline.* Nairobi: World Agro forestry Centre (ICRAF).

Bationo, A., Nandwa, S. M., Kimetu, J.M., Kinyangi, J.M., Bado, B.V., Lompo, F., Kimani, S., Kihanda, F., Koala, S. (2004). Sustainable Interaction of Crop-Livestock Systems through Manure Management in Eastern and Western Africa: Lessons Learned and Emerging Research Opportunities', in Williams (eds.), Sustainable Crop-Livestock Production for Improved Livelihoods and Natural Resource Management in West Africa. Nairobi: International Livestock Research Institute. pp. 173-198.Benin S, Smal

Bebe, B. O. (2003**).** *Herd dynamics of smallholder dairy in Kenya highlands*. PhD Thesis, Wageningen University, the Netherlands, 155 pp

Brett, C. (2004). Farm level adoption decisions of soil water management technologies in Semi-Arid Eastern Kenya. In: Contributed Paper Presented at the 48th Annual Conference of the Australian Agricultural and Resource Economics Society, 11–13th February, 2004, Melbourne, Victoria.

CBS. (2010). The 2010 population and housing census: counting our people for Development. Volume 2. 2011. Ministry of Planning and national development. Central Bureau of Statistics, Nairobi, Kenya.

CBS. (2001).The 1999 Population and Housing Census: Counting Our People for Development. Volume 1, 2001. Ministry of Planning and National Development, Central Bureau of Statistics, Nairobi, Kenya, Pp 1-5.

Chi, T. N. (2008) .Factors affecting technology adoption among rice farmers in the Mekong delta through the lens of the local authorial managers: an analysis of qualitative data. *Journal of Omonrice. Pp* **16**: 107-112

Chi, T.T., and Yamada, R. (2002) Factors affecting farmers' adoption of technologies in farming system: A case study in OMon district, Can Tho province, Mekong Delta. *Omonrice* **10**: pp 94-100.

Cramb, R.A and Nelson, R.A. (1998). Investigating constraints to the adoption of recommended soil conservation technology in the Philippines. In: Penning de Vries,

Cramb, R.A. (2000) processes influencing the successful adoption of new technologies by small holders-University of Queensland, Australia

Cruz, FA. (1978). *Adoption and diffusion of agricultural extensions*. In An introduction to extension delivery systems by Valera, J. B., Martinez, V.A and RF Plopino eds. 1987.Island Publishing House, Manila. P. 97-127.

Daniel, W., Surry, E.D. (1997) Diffusion Theory and Instructional Technology. *Journal of Instructional Science and Technology* 2 (1), 11-20.

Diaz, R. J., and Solow. (1999). Ecological and Economic Consequences of Hypoxia: Topic 2 Report for the Integrated Assessment on Hypoxia in the Gulf of Mexico. NOAA Coastal Ocean Program Decision Analysis Series No. 16. NOAA Coastal Ocean Program, Silver Spring, MD. 45 pp.

Diederen, P.J.M., van Meijl .J.C.M. and Wolters A.M. (2003). Modernization In agriculture: what makes a farmer adopt an innovation? *International Journal of Technology Management*, 23(6) pp 67.

Diederen, P.J.M., van Meijl. H.C.M and Wolters A.M. (2002). Innovation and farm performance: the case of Dutch agriculture, *in: Innovation and Firm Performance: Econometric Explorations of Survey Data*, London, Palgrave MacMillan.

Diederen, P., Meijl. H., Wolters, A., Bijak. (2003). *Innovation Adoption in Agriculture*: Innovators, Early Adopters and Laggards. Cahiers d'économie et sociologie rurales, n° 67.

ERS. (2007).The Kenya Economic Recovery strategy. www.siteresource.worldbank.org/kenya. Retrieved on 9th October 2014.

FAO. (2014). Définitions and classification of commodités (Draft). fodder crops and products, United Nations.

Feder, G., Just, R.E., And Zilberman, D. (1985). Adoption of agricultural innovations in developing countries: a survey, *Economic Development and Cultural Change*, 33(2), pp.255-298.

Government of Kenya. (2014). Sub-County Crops Report. Annual report Samia Sub-County

Government of Kenya. (2008). Sub-County livestock Production Report. Annual report Samia Sub-County.

Government of Kenya. (2010). Sub-County livestock Production Report. Annual report Samia Sub-County

Government of Kenya. (2012). Sub-County livestock Production Report. Annual report Samia

Geroski, P.A. (2000). Models of technology diffusion, *Research Policy,* vol. 29, pp. 603-625.

Growing, J.W., Palmer, M. (2008). Sustainable agricultural development in sub-Saharan Africa: the case for paradigm shift in land husband. *Journal of Soil Use Mgt*. **24** (1) pp 92–99.Haggblade, S.

Guerin, L.J and Guerin T.F. (1994).Constraints to adoption of innovations in Agricultural research and environmental management: A review. *Australian journal of experimental agriculture*. **34** (4) pp 549-571.

Hategekimana, B., Trant, M. (2002). Adoption and diffusion of new technology in agriculture: genetically modified corn and soybeans, *Canadian Journal of Agricultural Economics,* vol. 50, pp. 357-371.

HPI (2012) Heifer project international briefs Livestock Manure and biogas Production.

Iiyamal, M., Maitima. J. and Kariuki. P. (2007). Crop-livestock diversification patterns in relation to income and manure use: A case study from a Rift Valley Community, Kenya. *African Journal of Agricultural Research* **2**(3), pp. 058-066.

Ingold, T. (2002). *The Perception of the Environment, Essays in livelihood, dwelling and skill* Published by Routledge Taylor & Francis Group, London and New York. p. 294-322.

Jaetzold, R., Hornetz, B., Shisanya, C. (2007). Farm management Hand book of Kenya 2nd Edition. Vol. 2, Ministry of Agriculture, Government printer.

Jungea, B. O., Dejib, R., Abaidooa, D., Chikoyea, K. (2009). Farmers' Adoption of Soil Conservation Technologies: A Case Study from Osun State, Nigeria. *The Journal of Agricultural Education and Extension*, **15(**3) pp 257 — 274

Karki, L. B. (2004). Impact of project intervention on rural households in Nepal: Assessment of socio-economic and environmental implications. A PhD thesis submitted to the University of Giessen, Institute of Project and Regional Planning, Giessen, Germany.

Karshenas M., Stoneman, P. (1995). Technological diffusion, *in: Handbook of the Economics of Innovation and Technological Change*, Stoneman P. (ed.), Oxford, Blackwell.

Kasomo, D. (2006). *Research methods in humanities and education: Statistic*, measurement and evaluation testing. Egerton University Press, 245p

Kenya Open Data (2011). Population-Households. https://opendata.go.ke/Population/ Census-Volume-1-Question-1-Population-Households-a/wd27-eki2 (Retrieved on 9th October 2012).

Kombo, D.K, Tromp, D.L.A. (2009). *Proposal and Thesis Writing*: An Introduction. Paulines Publications Africa, Don Bosco Printing Press, Nairobi Kenya.

Makinde, E.A., Saka, J.O., Makinde, J.O. (2007). Economic Evaluation of Soil Fertility Management Options on Cassava-Based Cropping Systems in the Rain Forest Ecological Zone of South Western Nigeria. *African Journal of Agricultural Recourses*. **2(**1) pp 007-013.

Makokha, M. H. O., Maritim, H.K., Okalebo, J.R. and Iruria D. M. (1999). Farmers’ perceptions and adoption of soil management technologies in western Kenya. *African Crop Science*, 7 (4), pp. 549-558.

Makokha, S., Karugia, J., Staal, S. and Kosura, O. (2004). Kenya. Paper presented at the 9th KARI Biennial Scientific Conference/Kenya Agricultural Research Forum, 8-12 November 2004, Nairobi, Kenya.

Makokha, S.N., Karugia J., Staal S. and Oluoch, K. (2007). Analysis of factors influencing adoption of Dairy Technologies in western Kenya. AAAE conference proceedings (2007) pp 209-213.

Mpanya, M. (1985). The decision to adopt or reject new technologies: A case study of Agricultural development projects in Zaire. Working paper 51.

Mugunieri, G. L., and Omiti M. J. (2008). *Strategies of improving the contribution of livestock sector to food security and increased incomes*: The case of red meat. Published on the Kenya knowledge network.

Muriuki, H., Omore. A., Hooton. N., Waithaka, M. M., Ouma, M., Staal, S. J., Odhiambo, P. (2003). The policy environment in the Kenya dairy sub-sector: A review. SDP Research and Development Report No. 2, Smallholder Dairy Research and Development (R and D) Project, Nairobi, Kenya, Pp 21.

Mugenda O, Mugenda. A. (2003). *Research methods quantitative and qualitative Approaches*. Nairobi Acts press.

Mugenda, A. (2008*) Social Research: Conception, Methodology and Analysis.* Kenya applied research and training services, 350.

Mwakaje, A., G. (2008). Dairy farming and biogas use in Rungwe district, South-west Tanzania: A study of opportunities and constraints. Renewable and Sustainable Energy Reviews 12 pp 2240–2252

Nanyeenya, W.N., Staal, S.J., Mugish, J., Baltenwe, K. I., Romney, D., Halberg. N. *(* 2007).Determinants Of Dairy Intensification In Uganda - An Integrated Analysis Of Farm Resources, Location And Gis - Derived Factors Determinants Of Dairy Intensification In Uganda. *An African journal of extension* vol **5** pp14-20.

Nassiuma, D.K., (2000) *Survey sampling theory and methods*: Nairobi University press.

National development project (1990) Dairy report. Naivasha Kenya.

NRDC. (2012). Natural Resource Defense council. Facts about pollution from livestock farms environmental issues.

Ojiem, J.O., Ransom, J.K., Odongo, M. and Okwuoso, E.A. (1998). Agronomic and chemical characterization of potential green manure species in western Kenya. In Adoption of maize production technologies in northern Tanzania. Paper presented in the sixth Eastern and Southern Africa Regional Maize Conference, 21-25th, September, 1998. pp 210-217.

Okoedo-Okojie, D. and Onemolease, E. A. (2009). Factors Affecting the Adoption of Yam Storage Technologies in the Northern Ecological Zone of Edo State, Nigeria. *Journal of human Ecology*, **27** (2): pp 155-160

Omore, A. (1999). The Kenyan Dairy Sub-sector: A rapid Appraisal. MoARD/KARI/ILRI.

Otsuka, K. and Yamano, T. J. (2005). The possibility of green revolution in sub Saharan Africa Evidence from Kenya. *Journal of agricultural and development economie*s, **2** (1) pp 7-19

PATTEC (2008). Briefs on tsetse fly prevalence in Kenya. Ongoing activities.

PATTEC (2011). Briefs on tsetse fly prevalence in Kenya. Ongoing activities.

Pandey, S. and Lapar, M.A.L. (1998). A microeconomic analysis of adoption of contour hedgerows in the Philippine uplands. In: Penning de Vries, F.W.T., Agus, F. and Kerr, J. ed. Soil Erosion at Multiple Scales: Principles and Methods for Assessing Causes and Impacts, *journal of Agricultural Economics vol.**21***, pp 241–256.

Pratt, D.J., and Gwynne, M.D. (2000). *Rangeland Management and Ecology in East Africa*. Holder and Stoughton publisher, 310 pages.

Pretty, J. (2008). Agricultural sustainability: concepts, principles and evidence. *Journal of biological sciences,* 363 (1491), pp 447-465.

Republic of Kenya (2003-2007) Economic recovery strategy. Government printers. Nairobi Kenya.

Radwan, M., Willems, P., El-Sadek, A., and Berlamont, J. (2003). Modelling of dissolved oxygen and biochemical oxygen demand in river water using a detailed and a simplified model. *Journal of river Basin Management.* Issue, *2(1):* 97-103.

Reardon E.E and ChapmanL. (2009) Hypoxia and life-history traits in a eurytopic African Cichlid. *Journal of fish biology, 75(7)* pp 795-815

NDP. (2007).*National Development Plan: Effective management for sustainable economic growth and poverty reduction*. Govt. Printer, Nairobi.

Rogers, E.M. (1983). *Diffusion of innovations* (3rd edition).The Free Press. A Division of Macmillan Publishing Co., Inc. New York. Collier Macmillan Publishers, London. Publishing House, Manila. P. 51-61.

Rogers, E. (1995). *Diffusion of Innovations.* Reviewed by Greg Orr March 18, 2003.

Rodgers, M. (2003). Diffusion of innovation (5^{th} edition). The Free Press. A Division of Macmillan Publishing Co., Inc. New York. Collier Macmillan Publishers, London. Publishing House, Manila.

Sall, S., Norman, D., Featherstone, A. M. (2000). Quantitative assessment of improved rice variety adoption: the farmer’s perspective. *Journal of Agricultural Systems*, 66 (2) pp, 129–144.

Sheikh, A.D., Mahmood, M.A., Bashir, A., and Kashif, M., (2006). Adoption of rice technological package by the farmers of irrigated Punjab. *Journal of Agricultural Resources,* **44** (4) pp341-344.

Sherchand, L. (2001). Livestock and its relation to environment. Agriculture and Environment. Communication Issue. His Majesty's Government, Ministry of Agriculture and Cooperatives, Singh Durbar, Kathmandu, Nepal.

Singhal, A., and Dearing, J. W. (Eds.). (2006). *Communication of innovations: A journey with EV Rogers*. New Delhi: Sage.

Stoneman, P. (2002). *The Economics of Technological Diffusion*, Malden (Massachusetts), Backwell Publishers.

Sunding, D., Zilberman D. (2001). The agricultural innovation process: research and technology adoption in a changing agricultural sector, *in: Handbook of Agricultural Economics*, Gardner B.L., Rausser G.C. (eds), vol. 1, Amsterdam, and Elsevier Science.

Surry, D. W. and Brennan, J. P. (1998).*Diffusion of instructional innovations*: Five important, unexplored questions. (ED 422 892).

Thornton, J. A. & Rast, w (1999). Assessment and control of non point source pollution of aquatic ecosystems .A practical approach. *Man and the biosphere series,* Vol.**23**

Vanclay, F. (2003). The potential application of social impact assessment in integrated coastal zone management. *Journal of Elsevier* **Vol.** 68 pg 149-156

Waithaka, M., Wokabi. A., Nyaganga, J., Ouma, E., de Wolf .T., Biwott. J., Staal, S. J., Ojowi, M., Ogidi, R., Njarro, I. and Mudavadi, P. (2002).Characterization of dairy systems in the western Kenya region. The Smallholder Dairy (R&D) Project Washington D.C.:IFPRI , Nairobi: ILRI. pp. 132-151.

Waithaka, M.M., Wokabi, A, Nyangaga, J., Ouma, E, de Wolff, T., Biwott, J., Staal, S., Ojowi, M., Ogidi, R., Njarro, I. and Mudavadi, P. (2000). *A participatory rapid appraisal of farming systems in western Kenya*. Smallholder Dairy (R&D) Project Report of Dairy and Crop Characterization Activities in Western Kenya.

Wambugu, M. N. (2000). Extension and its effect on dairy cattle nutrition and productivity in small holder dairy enterprises in Kiambu District. MSC. Thesis University of Nairobi department of Animal science, Kenya.

Wanyoike, F. G. (2003). Dissemination and adoption of improved fodder tree: the case of Callindra Calothyrus in Embu District Kenya. Msc Thesis University of Nairobi department of Agricultural economics, Kenya.

Williams, T.O., Hiernaux, P., Fernández-Rivera, S. (1999).*Crop-Livestock Systems in Sub-Saharan Africa:* Determinants and Intensification Pathways', in McCarthy, N., Swallow B., Kirk, M., and Hazell, P. (eds.), Property Rights, Risk and Livestock Development in Africa.

Wonglimpiyarat, J. and Yuberk, N. (2005). In support of innovation management and Roger's Innovation Diffusion theory .Government Information Quarterly, **22** (3), pp 411-422.

World Bank (2005) http://www.worldbank.org.

Wyner, N. B., (1974). A study of diffusion of innovation: Measuring perceived attributes of an innovation that determine the rate of adoption. Dissertation Abstracts International, (University Microfilms No. 74-26)

APPENDICES

Appendix 1: Research Questionnaire

Hello my name is-------------------------------- I am a researcher/student from Egerton University. I am conducting a research on socio-economic and physical environmental factors affecting adoption of zero grazing technology in Samia Sub-County. The interview will take 20 minutes and you will be asked questions about your home environment, your economics status, whether or not you keep dairy animals, systems of livestock production that you use among other questions. Your participation is voluntary and will be highly appreciated, thanks in advance as I look forward for your cooperation in answering the questions.

Signing this consent form indicates you are willing to participate in this survey.

Respondent name and signature ____

Interviewer ____

Date place of interview ________________________________

Time of interview ____

PART A: DEMOGRAPHIC DATA

NO		code
1	Household No:	
2	Sub-Location____________________location________________ Division_____________________village______________________	
3	Age of respondent	
4	Sex : Male (1) Female(2)	
5	Marital status Single(1) Divorced (3) Married (2) widowed (4)	
6	Head of household: Male (1) female (2)	
7	Total number of people living in the household	
8	Total number of children in the family	
9	Total number of dependants in the household	
10	Level of education Non formal education(1) Lower primary (2) Upper primary (3) Secondary (4) Tertiary (5)	
11	What is the acreage of your farm?	
12	Do you individually own your land? (1) yes (2) NO	
13	If no in question 12, what kind of land ownership do you have? (1) communal ownership (2) Ancestral land 3) hired 4) Leasehold	
14	What is your main occupation Dairy farmer (1) Crop farmer (2) Teacher (3) Banker(4) Private organizations (5) NGO worker (6) Government employee (7) Business (8) other (9)	
15	On average how much do you earn per month 5000 and below (1) 20001-30000 (5) 5000-10,000 (2) 30000-40000 (6) 10,000-15000 (3) above 50000 (8) 15000-20000 (4)	
	PART B: ENVIRONMENTAL FACTORS	
16	What is the source of your domestic water?	

	Spring (1) Borehole (2) River (3) Water pan (4) Rain water harvesting (5) Any other (specify)_________________________________	
17	What is the estimated distance from your home to the nearest water source (1)0-5 km (2)5-10km (3)10-20km	
18	Which of the following best describes your perception on the quality of water you use? Very good (1) Good (2) Fair (3) Bad (4) very bad (5)	
19	What is the total cost of water used in your household per month?	
20	Is the water supply adequate for your needs? Yes (1) No (2)	
21	How many liters of water does livestock consume in your household per day?	
22	How do you water your livestock? From a watering trough(1) directly from the river(2) other_____________	
23	List the problems you experience with regard to water supply in this area ____ ____ ____	
24	What is your general view of soil fertility in your farm? Very good (1) Good (2) fair (3) bad (4)	
25	Do you feed your livestock on fodder? Yes(1) No(2) If yes:	
26	If yes in 25 above what is the source of fodder on your farm Planted(1) Bought(2) any other(specify)_________________	
27	Which one of the following fodder crops have you planted on your farm? Sesbania (1) Napier grass (2) alfalfa (3)clover (4)calliandra(5) leucania(6)Glaricidia	
28	Do you have access to open grazing fields? (1) yes (2)NO	
29	Are you aware of any livestock disease in your area that you attribute to environmental conditions? Name them. 1. _________________ 2. _________________ 3. _________________ 4. _________________	
30	How do you handle livestock waste?____ ____ ____	
31	Are you aware that livestock farming can pollute the environment? YES (1)NO (2)	

	PART C :TECHNOLOGICAL ISSUES	
32	Name any livestock production methods that you know ____ ____________________________________	
33	Do you keep any livestock? Yes(1) No(2)	
34	If yes, Name them 1.____________________ 2.____________________ 3.___________________ 4.____________________	
35	How long have you been keeping cattle?	
36	Do you own any dairy cattle Yes(1) No(2)	
37	What system of livestock production do you practice? (1)Zero grazing (2) semi-zero grazing(3) open grazing(4) tethering(5) paddocking (6) communal grazing	
38	How do you handle livestock waste? Compost (1) use to make biogas(2) throw in the farm directly(3) any other, specify	
39	Have you ever practiced zero grazing? Yes(1) No(2)	
40	If yes where did you learn it from? Other farmers(1) extension workers(2) Reading(3) mass media (4)	
41	In your opinion is zero grazing a viable system of production? Yes(1) No(2)	
42	If NO give the reasons ____	
43	If YES how has Zero grazing benefited you? ____ ____	
44	Where do you get the milk you use in your household: produce (1)Buy (2)	
45	If you produce? How much milk do you produce per cow per day (1) 1-4 litre (2) 5-10 litres (3) 10-20 litres	
46	Do you get surplus milk for sale?(1) yes (2)NO	
47	How much is a liter of milk in this area?	
48	What is the cost of a dairy cow in this area?	
49	Are you aware of the advantages/ disadvantages of Zero grazing? 1) yes 2) NO	
50	If yes in question 49 above how do you perceive the technology ____ ____	
51	Have you ever been visited by livestock production extension officers? 1) Yes 2) NO	
52	If yes in question 49 above, have you ever been trained on Zero grazing? 1) yes 2) NO	
53	Where do you seek help when your livestock present with disease symptoms? (1)Veterinary office (2)Agro vets	

	(3)Village doctors	
54	Who takes care of your livestock? (1)self(mother or father) (2)Children (3)Hired (4)Other(specify)	
55	In your own opinion, do you think zero grazing of dairy animals can increase your farm income?_explain____ ____	
56	Have you ever adopted the zero grazing technology 1) YES 2) NO	
57	If YES in question 56 above how is the enterprise fairing? Explain____ ____	