ANALYSIS OF FARMERS' ADOPTION OF ZERO GRAZING AND KNOWLEDGE OF CATTLE REPRODUCTIVE PARAMETERS IN WESTERN KENYA

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A dissertation submitted in partial fulfillment of the Degree of Masters of Science in Research Methods of Jomo Kenyatta University of Agriculture and Technology

2013

DECLARATION

This dissertation is my original work and has not been presented for a degree in any other university

Signature é é é é é é é é é ... Dateé é é é é é é é é é é é ..

Justine Nalunkuuma

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

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Dr. Daisy Salifu (ICIPE)

DEDICATION

With love and appreciation, I dedicate this dissertation to my family members (Mum, Teopista Kyotolabye, Brothers, Rev. Fr. Athanasius Mubiru, Deo Kulumba, Sisters, Margret Kyaligamba, and Sylivia Nalujja, my late daddy, brothers, and sister), nieces and nephews.

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ABBREVIATIONS AND ACRONYMS

AEDOs	Agricultural Extension Development Officers
AVOs	Assistant Veterinary Officers
CBS	Central Bureau of Statistics
EPAs	Extension Planning Areas
FAIT	Farmer Artificial Insemination Technician
FAO	Food and Agriculture Organization of the United Nations
ICIPE	International Centre for Insect Physiology and Ecology
ICPM	Integrated Crop and Pest Management
ILRI	International Livestock Research Institute
KARI	Kenya Agricultural Research Institution
Km^2	Kilometers square
MDG	Millennium Development Goal
MoLD	Ministry of Livestock Development, Kenya
NDDP	National Dairy Development Project
NGOs	Non-governmental Organizations
OLS	Ordinary Least Squares
PRA	Participatory Rural Appraisal
TDDP	Tanga Dairy Development Project
VIF	Variance Inflation Factor
WRI	World Resource Institute
2SLS	Two Stage Least Squares

ABSTRACT

Besides soil replenishment through manure application , the zero grazing production system also contributes towards smallholders' standards of living and poverty reduction. Its benefits are many and substantial; in western Kenya, the livestock farmers have adopted it. However, factors influencing its adoption are not known. It is also not certain whether the livestock farmers who practice zero grazing are knowledgeable of the cattle reproductive parameters or not which is key to zero grazing. Inadequate knowledge of the cattle reproductive parameters limits the productivity and profitability of the zero grazing dairy production system. This study determined factors influencing the adoption of zero grazing dairy production system, farmersô knowledge of the cattle reproductive parameters and milk production. It also assessed farmersô knowledge on the cattle reproductive parameters. A cross-sectional study design was used in which a random number of 520 livestock farmers, stratified by type of dairy production system (farmers who practice zero grazing and farmers who do not) were used. The data was collected using a pre-tested structured questionnaire that contained information on personal details of the household head, dairy cattle breeds, animal composition, cattle animal reproductive parameters, animal production systems and milk production records. Data was analysed using descriptive statistics, logistic regression, two-sample t test and ordinary least squares models (OLS). The results obtained by the logistic regression model revealed that adoption of zero grazing was influenced by other factors besides male household heads, herdsize, ownship of one or more means of transport and number of small ruminants. Factors such as age of the household head, years spent in school by the household head, number of school going children, number of exotic cattle, being above the poverty line of Ksh 2,500, dependency ratio and number of cross breed cattle had influence on adoption of zero grazing. The two-sample t- test revealed that farmers who practice zero grazing had significantly higher knowledge of cattle reproductive parameters than the farmers who do not. The OLS regression predicted practicing zero grazing and number of exotic cattle to have been the important factors in influencing farmersô knowledge of the reproductive parameters. The OLS showed farmersô knowledge of the cattle reproductive parameters, number of exotic cattle, number of cross breed cattle, milk production as most important reason for keeping cattle, being above poverty line of Ksh 2,500 and practicing zero grazing as important factors in influencing milk production. It was concluded that the analysis on socio-economic factors was useful in identifying major factors that influence adoption of zero grazing, farmersô knowledge on the cattle reproductive parameters and milk production. Therefore, policy measures, which are directed towards promoting ownership of improved breeds of cattle, poverty line of more Ksh 2,500 and education of farmers will be of considerable importance in promoting zero grazing adoption. Efforts directed towards training of farmers on the reproductive parameters and encouraging farmer to farmer interaction are of importance as these are some of the channels for information dissemination and circulation of technologies among farmers.

Key words: Western Kenya, adoption of zero grazing, reproductive parameters.

CHAPTER 1

1.1 Introduction

Governments, development practitioners, academicians, and Non-governmental organizations (NGOs) around the world are advocating for zero grazing farming of dairy cattle (King *et al*., 2006). It is one of the strategies of eradicating extreme hunger and poverty, according to Millennium Development Goal (MDG) 1 in rural households. This is through increased milk production, soil replenishment through manure application, creation of employment opportunities and generation of income through the sale of animals and animal products. In Kenya, the National Dairy Development Project (NDDP), a project implemented by the Kenya and Dutch governments, introduced zero grazing in 1979. The project, ended in 1999, but the zero grazing practice had spread to most parts of the country covering 25 districts with over 10,000 farmers involved (Mango, 2002). Currently, there are 3.5 million dairy cattle in Kenya (FAO, 2011), many of which are confined under zero grazing units, where water, feed, and minerals are carried to them (Bauer *et al*., 2006).

The adoption of zero grazing stems from the fact that it is regarded as a solution to some of the key challenges faced by small-scale farmers. These challenges include declining grazing land, low productivity of local dairy cattle and challenges of diseases under the free range grazing system (Muma, 1994; Baltenweck *et al*., 1998). Additional challenges include market failure of cash crops, low incomes arising from the sale of local animals and animal products, declining soil fertility (Mango, 2002) and the intergenerational subdivision of farms driven by the rapid population growth C.B.S. (2001). These have prompted the smallholder farmers to engage in intensive farming where small-scale farmers integrate crop with dairy production (Bebe, 2003; Iiyama *et al*., 2007; Murage and Ilatsia, 2010). Under dairy production, farmersô have shifted from free- grazing to semi-zero or zero grazing (Baltenweck *et al*., 1998; Bebe, 2003). They keep 2 to 3 dairy cows on approximately 2.5 to 5 ha, including other livestock and their followers (Gitau *et al*., 1994; Lanyasunya *et al*., 2006). Zero grazing in general has become a common strategy of intensifying dairy production in Kenya (Bebe *et al*., 2003).

To support the adoption of zero grazing at the national level, the Republic of Kenya has put in place policies, which advocate for intensification of agricultural production aimed at increasing output and productivity (Bebe *et al*., 2002). In addition, at the international level, in recent years, developing countries including Kenya have received increased attention on adoption of agricultural technologies (Makokha *et al*., 2007). Adoption of new technologies is viewed as the key to agricultural development (Baltenweck *et al*., 2000).

1.2 Problem statement

Besides soil replenisment through manure application, the zero grazing production system contributes towards smallholders' standards of living and poverty reduction. Its benefits are many and substantial; in western Kenya, the livestock farmers have adopted it. However, factors influencing its adoption are not known. It is also not certain whether the livestock farmers who practice zero grazing are knowledgeable of the cattle reproductive parameters or not. Knowledge on dairy cattle reproductive parameters is a very important factor in improving dairy cattle productivity especially under the zero grazing system. Inadequate knowledge limits the productivity and profitability of the zero grazing production system. In addition, having looked at the various studies carried on livestock production in Kenya; researchers have managed to carry out studies on the estimation of the dairy cattle reproductive parameters. However, none has assessed farmersô knowledge of cattle reproductive parameters and the factors influencing it. This study therefore, seeks to carry out an analysis of the factors influencing farmersô adoption of zero grazing and their knowledge of the cattle reproductive parameters in western Kenya hence contribute to the existing knowledge gap and based on findings recommend measures that would strengthen the zero grazing industry.

1.3 Objectives of the study

The main objective was to determine the factors influencing farmersô adoption of zero grazing and farmersô knowledge of cattle reproductive parameters in western Kenya.

Specific objectives:

i) To determine factors that influence adoption of the zero grazing dairy production system in western Kenya

ii) To assess farmersô knowledge of cattle reproductive parameters and identify factors that influence farmersô knowledge of cattle reproductive parameters in western Kenya.

iii) To investigate the factors that influence cattle milk production in western Kenya

1.4 Justification

Better understanding of factors influencing zero grazing adoption, will avail information that will greatly be used by extension workers, researchers, veterinary scientists and policy makers to further the promotion of zero grazing within the study area and beyond the confines of the study area. The identified parameters will assist proponents of zero grazing to know who to target for zero grazing adoption. Farmersô knowledge of cattle reproductive parameters will facilitate the farmers in maximizing on both milk production and probably animal productivity in terms of calves obtained per year hence increased productivity and profitability of the zero grazing system and help in identifying those parameters that farmers who practice zero grazing have less knowledge on so that means can be sought on how to boost that knowledge. The research will contribute to the body of existing knowledge in livestock production, there is little if any that has been published on factors influencing adoption of zero grazing and farmersô knowledge of cattle reproductive parameters. Other than phenotypic factors influencing milk production, the study will also provide a better understanding of the socio-economic factors influencing milk production.

1.5 Hypotheses

The following hypotheses were tested:

$H_{0:}$ Number of exotic and crossbreed cattle, being above poverty line of Ksh 2,500 and years spent in school by household head positively influence adoption of zero grazing.

$H_{1:}$ Number of exotic and crossbreed cattle, being above poverty line of Ksh 2,500 and years spent in school by household head negatively influence adoption of zero grazing.

H_0: There are no knowledge differences between farmers who practice zero grazing and farmers who do not practice zero grazing regarding their knowledge on the cattle reproductive parameters.

H_1: There are knowledge differences between farmers who practice zero grazing and farmers who do not practice zero grazing regarding their knowledge on the cattle reproductive parameters.

H_0: Practicing zero grazing does not significantly influence farmersô knowledge of cattle reproductive parameters

H_1: Practicing zero grazing does significantly influence farmersô knowledge of cattle reproductive parameters

H_0: Farmersô knowledge of the cattle reproductive parameters has no significant influence on cattle milk production

H_1: Farmersô knowledge of the cattle reproductive parameters has a significant influence on cattle milk production.

CHAPTER 2

LITERATURE REVIEW

2.1 Cattle production in Kenya

Cattle production plays a major role in the lives of many Kenyans those living in rural and urban areas. Approximately Kenya has 17 million heads of cattle of which about 13.5 million heads of cattle kept are for beef whist the remaining 3.5 million heads of cattle are for dairy production (MoLD, 2007). Kenyaøs dairy sector is the most developed in Eastern Africa with its cattle breeds ranging from local breeds, their crosses with the pure breeds to pure breeds (Friesian, Ayrshire, Jersey and Guernsey breeds). Exotic dairy breeds (Holstein-Friesian, Aryshire, Jersey, and Guernsey) or their crosses with Bos indicus Zebu breeds (Boran, Sahiwal, and small East African Zebu) dominate most farms in Kenya (Bebe *et al*., 2003; Muasya *et al*., 2004 and Lanyasunya *et al*., 2006). High producing exotic dairy breeds are prefered under zero grazing systems whereas crosss breeds dominate free grazing herds (Lanyasunya *et al*., 2006). The cattle breeds are kept for numerous reasons; milk production, meat production, manure production and income generation. Other reasons are; animal traction, reproduction, symbol of wealth, security, dowry payment, employment, prestige, and as a shield against inflation (Udo and Cornelissen, 1998; Staal *et al*., 2003; Mwacharo and Drucker, 2005; Mahabile *et al*., 2005 and Murage and Ilatsia *et al*., 2011) among others.

2.2 Livestock Production systems

In Kenya, different authors have categorized the livestock production systems differently. According to Lanyasunya *et al*. (2006), these have been grouped with regard to the increasing levels of intensification. They are; free grazing, semi-zero and zero grazing. Under the free- grazing systems, farmers graze their cattle on private or public owned pastures during the day and keep them within the homestead at night. Zero grazing is a cut and carry, stall-feeding system where napier grass and crop residues are the main feeds. Concentrate supplementation is generally restricted to milk cows. Semi-zero grazing, is a combination of the two (free- grazing and zero grazing), however, the combination depends on the seasonal availability of labour and feeds (Bebe *et al*., 2003).

On the other hand, Kenyan cattle production systems are categorized as small - scale dairy and meat ; small- scale dairy ; and large-scale dairy and meat (KARI, 1996). This classification depends on species kept, climate, scale of production and type of output from the systems. These production systems have similar structure and function (Dixon *et al*., 2001). However, the herd sizes kept differ within small-scale dairy production system, this range from two to four cows , three to ten cows in small-scale dairy and meat, and lastly 56 to 177 cows under the large-scale dairy and meat system (Bebe *et al*., 2003; Duguma, 2011).

2.3 Cattle reproductive parameters

2.3.1 Calving to conception interval

Calving to conception interval is the period from calving to conception in dairy cattle. Muhuyi *et al*. (1999) reported calving to conception interval for Sahiwal local breed in Kenya to be 151 ± 90.6 days. In crossbreeds cows calving to conception interval ranges from 3 to 9 months in Eithpoia(Duguma *et al*., 2012). Banda *et al.*, (2012) reported calving to conception interval to range from 60 to 270 days for dairy cows in smallholder farms of Malawi.

2.3.2 Age at first heat in heifers

This is the age at which a heifer or cow goes on heat for the first time. Age at first heat in Holstein-Friesian cattle is reported to range from 14 months to 18 months, 356 to 1077 days and 373 to 1065 days (Ojango and Pollott, 2001; Scatter *et al*., 2005; Irshad *et al*., 2011).

Age at first heat in crossbreeds ranges from 24 months 6 days to 27 months 3 days, 24 and 36 months and 18 to 36 months (Murenda and Mukuriaw, 2007; Mapekula *et al*., 2009; Dinka, 2012) respectively.

Age at first heat in indigenous cattle ranges from 24 to 35 months and 21 to 48 months (Mukasa Mugerwa, 1989; Msanga *et al*., 2012) respectively. Age at first heat in Boran and Sahiwal cattle ranges from 18 months to 24 months (MoLD, 2008).

2.3.3 Duration from calving to first heat

This is the length of time from calving to first heat in cows. Gietema (2005) observed that first heat occurs around 10 days to around 60 days after calving. If a cow is not seen on heat around that time there are reasons to explain the scenario. The cow has not been on heat, there has been poor heat detection, the cow is not normal and cow being poorly fed.Calving to first heat ranges from 80 to 100 days for crossbreeds in Tanzania (Chenyambuga and Mseleko, 2009). Calving to first heat for local breeds ranges from 60 to 90 days (Falvery and Chantalakhana, 1999) in a study smallholder dairying in the Tropics. According to MoLD (2008), calving to first heat for exotics ranges from around 30 to 60 days in Kenya.

2.3.4 Signs of pregnancy in dairy cattle

There is little information on signs used by farmers to detect pregnancy in cows. Farmers consider cows that show any of these signs to be pregnant; non- return to oestrus, quiteness, increase in belly size, swollen udder, movement of the foetus and physical appearance (Wattiaux, 1998; Gietema, 2005; Bayemi *et al*., 2007; Singh and Nanda, 2007; Tanjoy *et al*., 2007; Shamsuddin *et al*., 2007; Garcia *et al*., 2011; Banda *et al*., 2012).

2.3.5 Heat signs in heifers and cows

Cows or heifers on heat portray the following signs; being mounted while standing, mounting others, nervousness, mucus discharge and swollen vulva (Mukasa-Mugerwa, 1989; Dijkhuizen and van Eerdenburg, 1997; De Moi, 2000; At-Taras and Spahr, 2001; Garwe, 2001; Mathew, 2002 and Lopez *et al*., 2004). In addition, cows coming on heat tend to herd together in groups of three to five, have dirty manure on flanks, have depressed milk yield and appetite and lick other cows (Mukasa-Mugerwa, 1989; Wattiaux, 1998; Dijkhuizen and van Eerdenburg, 1997; Swai *et al*., 2007; Dobson *et al*., 2008 and Garcia *et al*., 2011). Other than bunting, sniffing the vulva or urine of other cows, urinating frequently, being followed by other cows, resting chin on other animal and mounted but not standing (Mukasa-Mugerwa, 1989; Dijkhuizen and van Eerdenburg, 1997; Law *et al*., 2009; Garcia *et al*., 2011 and Sveberg *et al*., 2011) cows portray increased activity and standing behaviour. Other than having rubbed tail head, and separating itself from the rest of the herd, others heat signs were noted cow on heat walk along fences to seek for a bull (Wattiaux, 1998; At-Taras and Spahr, 2001; Mathew, 2002; Van Eerdenburg *et al*., 2002; Lopez *et al*., 2004; Gietema, 2005; Dobson *et al*., 2008; Gilmore *et al*., 2011 and Sveberg *et al*., 2011).

2.3.6 Length of gestation

Gestation length is the period from conception to normal delivery of a calf. Length of gestation for Holstein-Friesian is reported to range from 260 to 300 days and 275 to 280 days Satter *et al*. (2005) and Gietema (2005) respectively.

Mukasa-Mugerwa (1989) reported the range from 270 days to 292 days for *Bos indicus* cattle (Zebu, Sahiwal, and Boran) in Kenya. Muhuyi *et al*. (1999) reported the mean length of gestation Sahiwal cattle in Kenya to be 287 ± 5.1 days. The length of gestation in days was 280 for Ankole cattle in Uganda (Mulindwa *et al*., 2009).While Miazi *et al*. (2007) reported the average length of gestation of indigenous cows was 289.88 ± 1.44 months under rural conditions in Comilla, Bangladesh.

Dutta *et al*. (1989) reported the length of gestation for crossbreedsôranges from 271 to 301 days. Islam *et al*. (2004) found the mean length of gestation for crossbreed to be 277.61 ± 0.58 days in Bangladesh. The length of gestation in days was 280 for Ankole-Friesians in Uganda (Mulindwa *et al*., 2009). Miazi *et al*. (2007) reported the average length of gestation of crossbred cows was 283.98 ± 1.24 under rural conditions in Comilla, Bangladesh.

2.4 Farmers' knowledge on cattle reproductive parameters

In a study on the index for measuring knowledge and adopting scientific methods in treatment of reproductive problems of dairy animals, findings indicate that overall knowledge of livestock farmers on reproductive traits was 59.54%, which was quite satisfactory. Farmersô knowledge on age of maturity of crossbreed cattle was 65.33%, 53.79% on age of maturity of indigenous cattle. Farmersô had substantial knowledge (67.00%) regarding heat symptoms of dairy animals. Farmers had sound knowledge about gestation period (75.29%). The knowledge about calving to first heat interval was 56.11 percent (Meena *et al*., 2012). In a similar study, majority of the respondents (60-62%) knew about the symptoms of bellowing and mounting. In the same study, respondents knew that when the cows come on heat they become restless, urinate frequently, and discharge mucus from the Vulva (Solanki *et al*., 2011).

A study conducted by Swai *et al*. (2007) on the reproductive performance of crossbred dairy cows raised on smallholder farms in eastern Usambara Mountains, Tanzania, revealed loss of appetite, mounting other cow, drop in milk yield, discharge of white mucus, bellowing and restlessness as the heat signs portrayed by crossbreed cows. Ninety percent of the participants could recognize at least one of the key heat signs (mucus discharge) while 50 % could recognize other signs like restlessness, bellowing and mounting other cows. Whereas Shamsuddin *et al*.,(2006) in his study on radioimmunoassay of milk progesterone as a tool for fertility control in smallholder dairy farms, Bangladesh argued that, in intensive farming having one cow, oestrus cannot be detected by primary signs such as standing to be mounted as the cows are always tied up. However, the main weakness affecting the accuracy of oestrus detection is that farmers are missing, misinterpreting, or are unaware of secondary signs of oestrus such as mucus discharge and swollen vulva.

Chinogaramombe *et al*. (2008) carried out a study to identify constraints and opportunities faced by the smallholder dairy farmers in semi-arid areas of Zimbabwe. Results revealed that milk production was the most significant livestock enterprise in the surveyed areas and that sixty percent of the farmers observed the cows for exhibition of oestrus. Alternatively Banda *et al*. (2011) in a baseline study conducted in Kasungu, Mzimba, Lilongwe and Thyolo District to characterize the livestock production system and document existing challenges and opportunities for integrating smallholder dairying was conducted. In his findings, general extension workers (AEDOs) had knowledge score in most of the recommended diary husbandry practices though they did not achieve a score close to 90% as an expected satisfactory score in the study. The Assistant Veterinary Officers (AVOs) had appreciable knowledge in animal husbandry as their average score was 70%. It was observed that neither the AVOs scored 90% showing that their level of knowledge is not satisfactory. The farmer AI technician (FAIT) had relatively higher knowledge in Artificial Insemination (AI) and pregnancy diagnosis than the AVOs from Kaluluma Extension Planning Area (EPA) in Kasungu District. They scored above 75% in several aspects including animal housing, disease control and milk management.

While Lyimo (2004) carried out a study in Urban and peri urban areas of Tanga municipality in Tanzania and found out that farmers had satisfactory knowledge and perception of dairy cow reproductive performance. Fifty percent of the farmers were able to confidently detect their cows in oestrus since majority of them had received training in aspects of animal management and record keeping.

2.5 Factors influencing adoption of livestock technologies

Among the socio-economic characteristics influencing adoption of technologies are age, education, sources of incomes, animal holding, information, and information sources. Other factors are access to credit, extension contacts, experience, training on dairy farming, utilization behavior, family labour, lack of knowledge regarding improved dairy husbandry practices and family size (Chagunda *et al*., 2006; Espinoza-Ortega *et al*., 2007; Musaba, 2010 and Fit *et al*., 2012). Farm characteristics include land size, herd size, farm size, management levels, farm productivity and technological levels (Espinoza--Ortega *et al*., 2007) and farmersô wealth (Lapar and Ehui, 2004). Other factors noted in the literature are extension programmes, location and importance of technologies to farmers (Adegbola and Gardebroek, 2007; Mekonnne *et al*., 2009 and Garcia *et al*., 2012).

2.6 Adoption studies carried out under livestock production

Musaba (2010) in a study to examine the socio-economic determinants of adoption of improved livestock management practices among communal livestock farmers in northern Namibia employed a questionnaire to obtain responses from 468 communal livestock farmers. Descriptive statistics and a linear regression model were used to analyze the data.

The results revealed that castration and vaccination were the most adopted technologies whilst dehorning, feeding cut crop residue and livestock marketing were the least adopted. Regression analysis showed that the adoption of livestock technologies increased with education, off-farm income, farmer training in animal health and farmer residing in Oshana and Ohangwena regions. Adoption of livestock technologies decreased with distance from the extension office and for a farmer residing in Omusati region.

Mekonnne *et al*. (2009) examined factors influencing dairy technology adoption and impact on milk yield on 240 smallholder farms in Dejen district, Ethiopia. A cross-sectional questionnaire survey, farm visits and Participatory Rural Appraisal (PRA) methods were used to gather responses. The survey focused on demographic characteristics of smallholders, livestock herd size, land use patterns, husbandry practices, dairy technologies adoption and constraints. A sample checklist served as a guide for the PRA interviews. Data was analysed using computer software programs; Microsoft Excel, 2003 and Statistical Package for Social Sciences (SPSS Ver. 15, 2006). Results were analysed using descriptive statistics, and General Linear Model procedures. Results revealed that the level of technology adoption by the smallholder farmers was still unsatisfactory and was highly dependent on gender, family size and level of education of smallholder farmers and location of farms.

Chagunda *et al*. (2006) in a study whose objectives were to study farmer perceptions on record keeping and factors affecting its adoption randomly interviewed 86 smallholder farmers from six dairy cooperative schemes of Lilongwe. Logistic regression approach was used to analyze the adoption decision. The results revealed that the following variables individual assigned the recording task, milk recording using simple calibrated containers and herd size had a positive relationship with participation in dairy recording. Negative relationships were observed between recording participation and recording using calibrated scales, sale of milk at the informal markets as opposed to the formal market and use of natural services as opposed to artificial insemination for breeding. Farmer education level, cattle genotype, and daily milk yield had no significant influence on the adoption of milk recording.

Garcia *et al*. (2012) conducted a study whose objectives, among others was to identify the factors influencing adoption of technologies promoted by government to small- scale dairy farmers in the highlands of central Mexico. A field survey was conducted which comprised of 115 farmers. These were grouped using cluster analysis and divided into three-wealth status categories (high, medium, and low) using wealth ranking. Chi-square was used to examine the association of wealth status with technology adoption. Results indicated that wealth status had a significant association with adoption. Other factors included importance of technology to farmers, usefulness and productive benefits of innovations and farmersô knowledge were important.

Fita *et al*. (2012) conducted a study to ascertain the extent of adoption of improved dairy husbandry practices and its relationship with the socio-economic characteristics of the dairy farmers in Adaâa district of Oromia State, Ethiopia. The study was taken in 8 purposively selected peasant associations/kebeles of the district in which 30 dairy farmers were purposively selected. The relevant information was collected using a pre-tested structured questionnaire. A teacher made test was used to measure the extent of knowledge of the dairy farmers regarding improved dairy husbandry practices. A simple adoption index was used to measure the extent of adoption of the improved dairy husbandry practices. While a correlation coefficient, (r) values of the selected socio-economic characteristics of the respondents were computed to establish the relationship between socio-economic characteristics and adoption of improved dairy husbandry practices. The study revealed that 50.44% was the overall extent of adoption of improved dairy husbandry practices in the study area.

Factors that had positive and highly significant relationship with the adoption of improved dairy husbandry practices were mass media exposure, knowledge of the dairy farmers on dairy husbandry practices and training on dairy farming. Experiences of the dairy farmers on dairy farming, education status and participation of the dairy farmers in various dairy farming related organizations also had positive and significant relationship with adoption of the improved dairy husbandry practices (Fita *et al*., 2012).

2.7 Factors affecting milk production

It is estimated that dairy cattle contribute about 60% of the national milk production while the other indigenous breeds contribute the rest 40% (Karanja, 2003). Milk production is affected by a number of factors as studied by authors such as (Bajwa *et al*., 2004 and Rhone *et al*., 2007). Among the factors are the breed of cow, parity, season, calving, geographical location, and management factors (feeding, health, and veterinary services). In this study, it was in the interest of the researcher, to investigate how the socio-economic factors influence milk production.

CHAPTER 3

STUDY METHODOLOGY

3.1 Description of the study area

3.1.1 Western Kenya

The study was carried out in western Kenya, a region that occupies an area of 20,719 km^2. This region borders the republic of Uganda to the west and Tanzania to the south. It comprises formally Nyanza and Western administrative provinces. It lies between latitude 1^0 8ʹN and 1^0 24ʹS and between longitude 34^0 and 35^0 20ʹE (Amadalo *et al*., 2003 and WRI, 2011). The region receives an annual rainfall that ranges between 1000 mm to 2000 mm. This relatively high rainfall occurs in two rainfall seasons; the long and short rain seasons. The long rain season lasts for four months. It starts in March and ends in June, while the short rain season lasts for only three months, from September to November. The temperatures are mostly warm; with the average minimum and maximum temperatures of 15^0 and 29^0 C respectively (Amadalo *et al*., 2003).

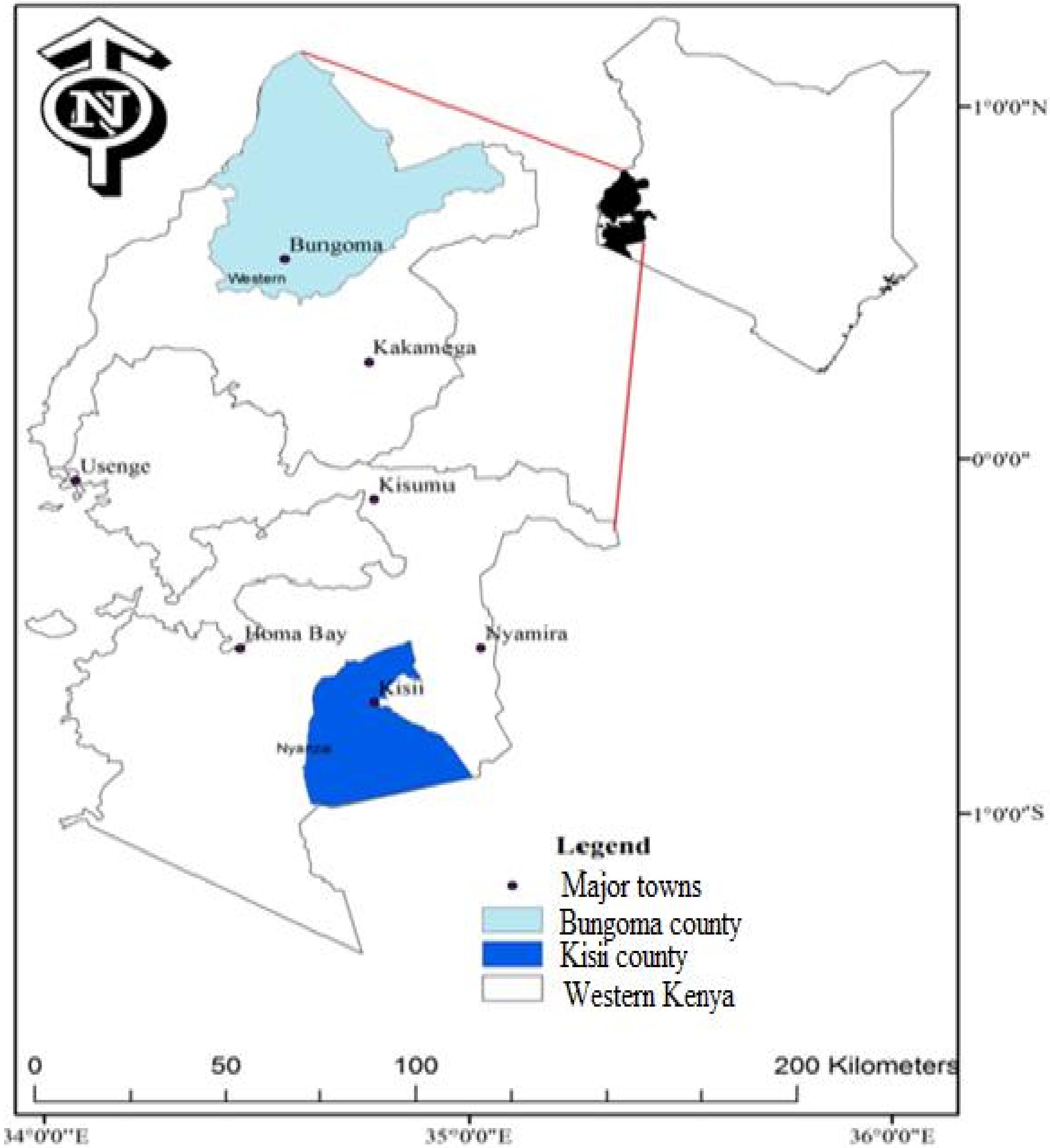

Figure 3.1: A Map of Western Kenya

Source: World Resources Institute, (2011) and International Livestock Research Institute (ILRI), (2010).

Western Kenya is home to a total of 9,776,993 people; with 5,442,711 from Nyanza province and 4,334, 282 from Western province (Kenya population census, 2009). The mean household size is 7 people. It is also one of Kenyaõs most densely populated regions. Its population densities range from 500 to 1200 people per km^2. Livestock rearing is one of the principal economic activities practiced in the region. Farmers keep chicken, goats, local zebu cattle, improved breeds of cattle, and sheep. Grazing systems predominant in the region are free grazing, controlled grazing using tethering, and zero grazing (Amadalo *et al*., 2003). The Western province consists of 219,904 exotic breeds of cattle and 843,608 indigenous cattle breeds. Within Western Kenya (Nyanza and Western provinces), the study was conducted in Kisii and Bungoma counties (Kenya population census, 2009).

3.1.1.1 Kisii County

Kisii County is a county in the Western Province of Kenya. It lies between latitudes 0^0 30 and 0^0 58qSouth and longitudes 34^0 36qand 35^0 05qEast The county is located to the south east of Lake Victoria and is bordered by six counties with Narok to the south, Migori to the west, Homa Bay to the north west, Kisumu to the north, Bomet to the south east and Nyamira to the east. It covers a total land area of about 1,317.4 Km^2. It has 7 constituencies and these are; Bobasi, Bonchari, Bomachoge, Kitutu Chache, Nyaribari Chache, Nyaribari Masaba, and South Mugirango. The county experiences two rainfall seasons. The short season runs from September to November while the long season is from February to June of every year (http://softkenya.com/kisii-county/ accessed on 7th/ 4/2013).

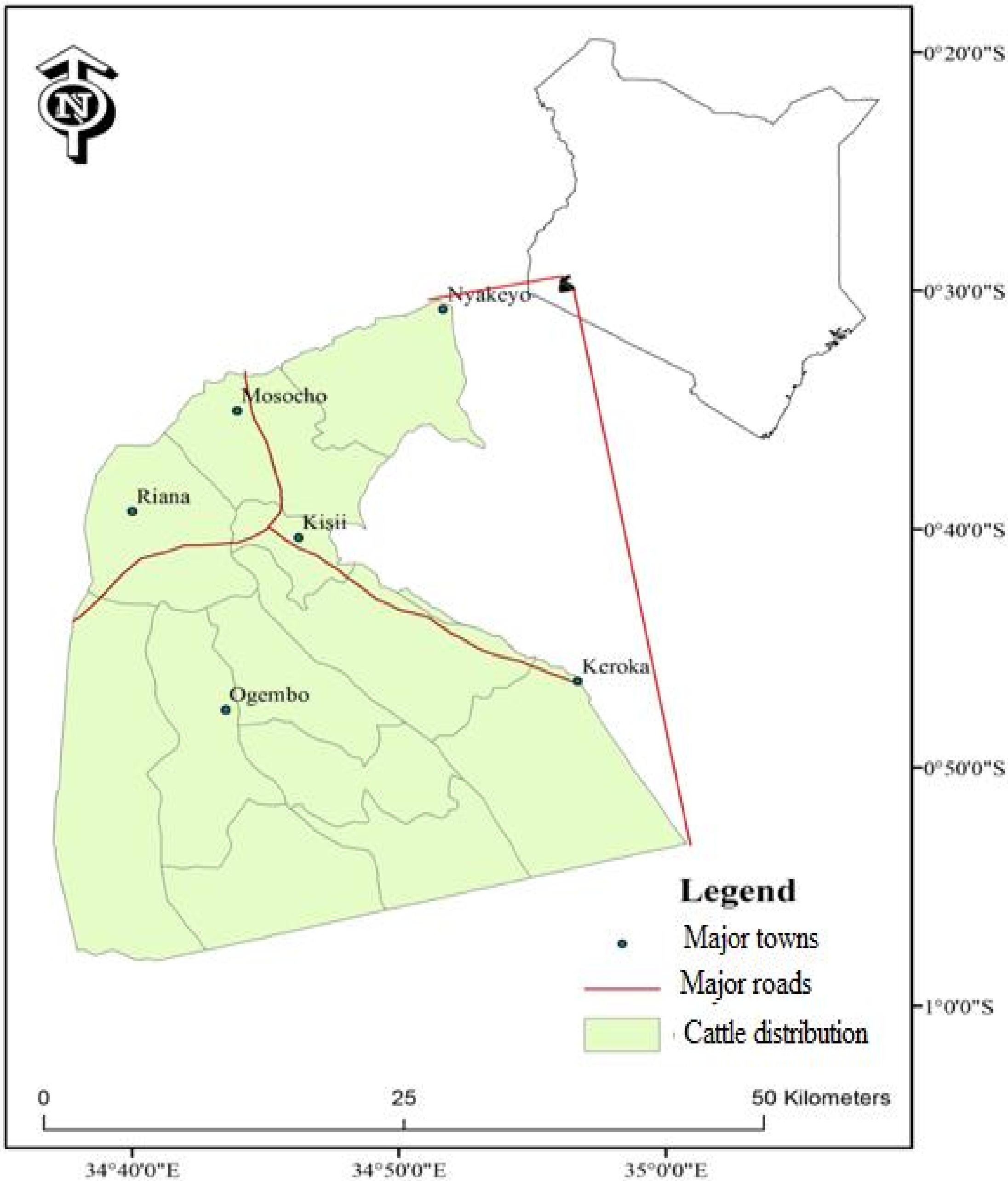

Figure 3.2: A map of Kisii County

Source: World Resources Institute, (2011) and International Livestock Research Institute (ILRI), (2010).

It receives 1,350 mm to 2,100 mm of annual rainfall and its temperature range from 10°C to 30°C (minimum and maximum, respectively) (GOK, 1997b). In Kisii County, agriculture is the main economic activity. Over 70% of farmers in the district are cattle keepers. The main breeds kept include exotics, cross breeds and indigenous breeds. Semi-intensive and zero grazing dairy farming system are largely practiced (Ouma *et al*., 2003). The Kisii area is one of the most densely populated in Kenya (C.B.S., 2001). It has a total population of 1,152,282 with 245,029 households and has a population density 874.7 people per sq. km and 51% of the population lives below the poverty line with an age dependence ratio of 100:94 (Kenya population census, 2009).

3.1.1.2 Bungoma County

The county borders Uganda to the West; Trans-Nzoia to the north, Kakamega to the East, Mumias Butere to the south and borders Busia and Teso districts to the southwest. The county occupies a total land area of 2,068.5 km^2. It lies between latitude 0^0 25.3ɋand $1^0$8ɋ north and longitude 34^0 21.4ɋand 35^0 04ɋEast (Jaetzold *et al*., 2005). The population census (2009) indicated Bungoma County as one of the most densely populated counties. It has a total population of 1,630,934 of which 795,595 are males and 835,339 are females. The county experiences a bimodal rainfall season. The average annual rainfall ranges from 1200 mm to 1800 mm (Republic of Kenya, 1997). Within the county, temperatures range from 26 to 30^0 C during the year (Jaetzold *et al*., 2005).

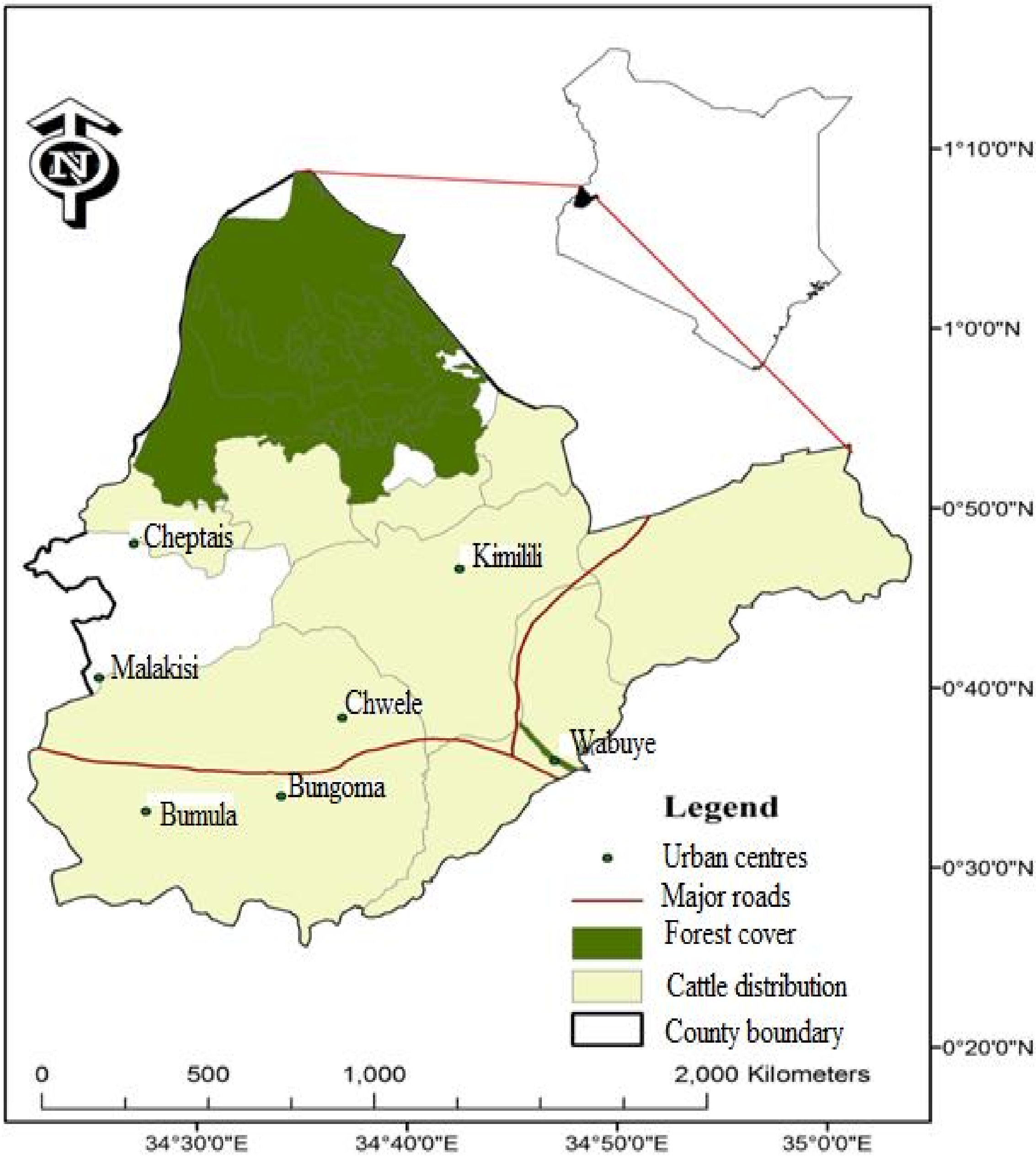

Figure 3.3: A map of Bungoma County

Source: World Resource Institute, (2011) and International Livestock Research Institute (ILRI), (2010).

In Bungoma, agriculture is the principal economic activity. Farmers in the county grow crops and keep livestock. The livestock kept include cattle, poultry, sheep, and goat. Cattle are the most important livestock with the local zebus being most common (Jaetzold *et al*., 2005).

3.2 Study Design

This study used a cross-sectional study design, which involved conducting field surveys. The first survey took place in December 2011 and the second one was from February 2012 to March 2012. The first survey concentrated mainly on obtaining data from farmers who practice zero grazing whilst the second survey both groups of farmers, farmers who practice zero grazing and farmers who do not were visited.

3.2.1 Target population

The target population was dichotomous in nature, as such it comprised of the farmers who practice zero grazing and farmers who do not. The list containing the list of farmers who practice zero grazing and those who do not was obtained from the International centre for Insect Physiology and Ecology. This formed the sampling frame. It consisted of 977 livestock farmers.

3.2.2 Sample size determination

The sample size was determined by a simplified formula provided by Yamane (1967). In computing the sample size, a 95% confidence level and level of precision of 3% were assumed. The level of precision is also known as sampling error. This is the range in which the true value of the population is assumed to be (Yamane, 1967). In this paper this is the range in which farmers who practice zero grazing within the study area were assumed to fall.

Formula as below:

$$n = \frac{N}{1 + N(e)^2}$$

Where n = sample size

N = Population

e^2 = level of precision

$$n = \frac{977}{1 + 977(0.0009)}$$

$n = 520$

3.2.3 Sampling procedure

Stratified random sampling was used to select the 520 respondents. By use of stratification, the farmers were divided into two-farmer category (400 farmers who practice zero grazing and 577 farmers who do not). By use of random numbers, 218 farmers from the farmers who practice zero grazing and 320 from the farmers who do not practice zero grazing were obtained.

3.2.4 Survey instrument

Qualitative and quantitative primary data were used for this study. These data were collected using detailed structured pre-tested questionnaires (Appendix 5), with the assistance of an enumerator. The questions that were contained in the questionnaires were developed in English; a trained interviewer translated the questions into the national language; Kiswahili and then filled the responses in English. The researcher never knew the national language, so interpreters (Appendix 6) were used to translate the questions and responses.

The data collected include:

1) Personal detail of household head such as age of household head, gender of household head, educational level of the household head, number of persons in the household, number of school going children, number of cars, motor bikes and cars owned, income level.
2) Data on animal production, which consisted of, herd composition, number of oxen, cattle breeds in the herd, reasons for choice of breed, number of goats and sheep.

3) Data on the cattle reproductive parameters (length of gestation period, calving to conception interval, heat and pregnancy signs, age at first heat in heifers, and calving to first heat) was collected.
4) Data on animal production systems.
5) Data on milk production records in litres.

3.3 Data entry and quality

Prior to data collection, a data entry template was developed in excel for entering and storage of data. During data collection, various checks were carried out, these included completeness, clarity and consistency to remove any inconsistencies. Completeness checks ensured that all relevant questions were entered in. Clarity checks ensured that all responses in a filled-in questionnaire were clear enough to be entered in the data. During entry, range checks were used to identify outliers among the coded variables (income levels, sex of household head, and type of breed among others) and uncoded variables (reasons of the choice of the breed, roles of cattle in the household, type among others). Format checks were carried out to ensure that all the continuous variables are rounded off to the same decimal points (Chapman, 2005; Statistical Service Centre, 2008 and 2009). Histograms and boxplots were obtained to check for normality of the data and outliers respectively. Data transformation was also carried out where necessary.

3.4 Data analysis

3.4.1 Descriptive analysis

Descriptive analysis is a method that provides statistics used to describe the basic features of the data in a study. Different descriptive statistics are used depending on whether the outcome variable is continuous or categorical. They provide simple summaries of the characteristics of the sample such as measures of central tendency, dispersion, and variability. They often provide guidance for more advanced quantitative analyses. However, they have limitation of not showing the relationship among the variables and the influence that each variable may have on the response. In this study, measures of central tendency such as the mean values and measures of dispersion such as the minimum and maximum (range) and standard errors were produced for continuous variables. For categorical variables descriptive statistics (the percentages) were used to describe and summary the social- economic variables that were used in the various models.

3.4.2 T- test

The t test is used for comparing means. There are three types of t-test: one, two-sample, and paired t-tests. One-sample t-test compares a single mean to a gold standard (fixed) number. Two-sample t-test compares two population means based on independent samples from the two populations or groups. Paired t-test compares two means based on samples that are paired in some way. In this study, a two-sample t- test was used when obtaining the significant differences between the two groups on continuous variables; age of household head, years spent in school by household head and number of school going children. Other continuous variables included herd size, number of exotic cattle, dependency ratio, number of crossbreed cattle, number of small ruminants and knowledge on the cattle reproductive parameters among others.

3.4.3 Two sample proportions z - test

This is used for comparing percentages of two groups. It is used for hypothesis testing to determine whether the difference between two proportions/percentages is significant. The test statistics used in this case is the z-value. For large sample sizes, the z-value follows normal distribution as the well-known standardized z-value for normally distributed data. For the two-sample proportions test to be used, the samples must be randomly selected, should be selected independently and the sample size must be large enough so that it follows a normal distribution. When the computed value is lower than the z value, we reject the null hypothesis and when the obtained value is greater than the z- value, we fail to reject the null hypothesis. The two-sample proportion test was used to test for the differences in percentage data for farmers living above the poverty line, gender of household head, milk production as the most important reason for keeping cattle and ownship of one or more means of transport.

Table 3.1: Type of data, description and expected sign of variables included in the logistic regression model

Variable	Type of data	Definition	Hypothesis
Gender of household head	Binary	1 if male and 0 otherwise	+
Age of household head	Continuous	Average age	+
Years spent in school by household head	Continuous	Years the household head has attended formal school	+
No. of school going children	Continuous	No. of children who go to school in household	-
Herd size	Continuous	Total number of cattle owned by the household	_
No. of exotic cattle	Continuous	Total number of exotic cattle owned by the household	+
Dependency ratio	Continuous	The ratio of the dependents (children of 14 years and below and adults of above 75 years) to a working population (household members 15-75 years)	+
Means of transport	Binary	1 if household owns one or means of transport, 0 otherwise	+
No. of crossbreed	Continuous	The number of crossbreed cattle owned by the household	+
No. of small ruminants	Continuous	The number of sheep and goats owned by the household	-
Poverty line of Ksh 2,500	Continuous	1 = Being above poverty line of Ksh 2,500 and 0 otherwise	+

3.4.4 Logistic regression

A number of cross-sectional studies have employed the logistic regression model to analyze the influence of various socioeconomic factors on binary response variable of technology adoption. This model helps in defining the effects between the explanatory variables and the probability of increased adoption. Given the binary nature of the response variable used in this study, a logistic model was used to determine factors that influence farmersô adoption of zero grazing. The logistic model was the model of choice to analyze the dichotomous variable coded as 1 = farmers who practice zero grazing and 0 = farmers who do not (Hosmer and Lemeshow, 2000 and Cavane, 2011). In addition it was chosen because it is easy to compute and can be applied when the explanatory variables are in any form (discrete, dichotomous, continuous or a mixture of any of these) to describe and test hypotheses about relationships between a categorical dependent variable and one or more predictor variables (Peng *et al.*, 2002). The logistic regression does not compel to the assumptions of linearity, normality, and equal variance, since it is based on the binomial distribution.

In the basic model, let Y_1 be the response variable, which takes two forms $Y = 1$ if farmer practices zero grazing and $Y = 0$ if farmer does not. Variable X is a set of explanatory variables expected to influence adoption of zero grazing. β is a vector of slope parameters, it measures the influence of changes in X on the probability of the farmer adopting zero grazing.

$$Y_i = \alpha + \beta_i X_i \text{ é } (3.1)$$

Where α refers to the unknown constant term and β is the vector of regression coefficients. After estimation of the coefficients in equation (5.1), the probability that a farmer adopts zero grazing found in population of livestock farmers is determined with specific household characteristic introduced in the model.

The probability of the binary response is defined as below:

If $Y_i = 1;$ $$P(Y_i = 1) = \pi(x) \text{ é é é é é é é é é é é é .. } (3.2)$$

$Y_i = 0;$ $$P(Y_i = 0) = 1 - \pi(x) \text{ é é é é é é é é é é é é . } (3.3)$$

Where $\pi(x) = E(Y / x)$ representing the conditional mean of Y given values of x.

Therefore the probability of adoption of zero grazing is then expressed as (Hosmer and Lemeshow, 2000; Agresti, 2002).

$$P(Y_i = 1) = \pi(x) = \frac{1}{1 + \exp[-(\alpha + \beta_1 x_i)]} \text{ é é é é é é é é é é é é é é é é é é . } (3.4)$$

Empirical Model

Specification

The probability of increased adoption of the zero grazing technology can be specified as a function of the socioeconomic variables discussed in the preceding section as follows:

$P(Y_Z) = f(X_1, ...X_{11})$,

where

$P(Y_Z)$ is defined by

$Y =$ If farmer practices zero grazing = 1 and 0 otherwise

$X_1 =$ If male =1, otherwise = 0

$X_2 =$ Age of household head

X_3 =Years spent in school by household head

$X_4 =$ Number of school going children

$X_5 =$ Herd size

$X_6 =$ Number of exotic cattle

$X_7 =$ 1= Being above the poverty line of Ksh 2,500, otherwise = 0

$X_8 =$ Dependency ratio

$X_9 =$ If farmer owns one or more means of transport, 0 otherwise

$X_{10} =$ Number of crossbreed cattle

$X_{11} =$ Number of small ruminants

The above model of increased zero grazing adoption ($P(Y_Z)$) was specified as a function of variables X_1 to X_{11}

3.4.4.1 Goodness of fit diagnosis

After fitting the logistic regression model to any given data set, the adequacy of the model has to be examined. There are three ways of examining the adequacy of the model;

1) By overall goodness-of-ýt tests

2) Area under the receiver operating characteristic curve

3) Examination of inþuential observations

The main purpose of doing this is to determine whether the ýtted model adequately describes the observed outcome experience in the data. Hosmer and Lemeshow's goodness-of-fit test was used in this study. If the Hosmer and Lemeshow's goodness-of-fit test yields a chi-square with a large P-value this indicates that the model fits, the data well and when the Hosmer and Lemeshow's goodness-of-fit test yields a chi-square with a small P-value this then indicates that the model does not fit the data well (Hosmer and Lemeshow, 2000).

3.4.4.2 Multicollinearity diagnosis

Multicollinearity is when there is correlation among the independent variables in a multiple regression model. The problem of multicollinearity negatively affects the usefulness of a regression model. It leads to inappropriate conclusions being drawn from incorrect parameter estimates and confidence intervals. The problem arises when there are more independent variables in the model. There are two ways of overcoming this problem of multicollinearity;

1) Prior to fitting the regression model simple correlations by using the correlation matrix between continuous variables and associations between non-continuous variables can be established. This correlation analysis provides some guidance about potential issues of multicollinearity. It shows significant correlation between some of the variables and when the correlation coefficient between any pair of explanatory variables is less than 0.9 in absolute value it implies that there is no potential bias to the analysis. However, if the correlation between any pair of explanatory variable is greater than 0.9 that serves as an indication of a strong linear relationship that can cause potential bias to the analysis (Hill *et al*., 2001).

2) The other way, is to use the Variance Inflation Factor (VIF). The VIF is an indicator of correlation coefficient between two or more independent variables. This is the preferred method to test for multicollinearity. However, there are no formal criteria available for determination of the magnitude of VIFs that cause poorly estimated coefficients. When the VIF is high, it implies that also the R^2 value is high. This makes the interpretation of the coefficients unreliable. Meyers (1990) argues that when multicollinearity is present, it makes the results biased. VIFs values exceeding 10 may be cause for concern (Meyers, 1990) and Hosmer and Lemeshow (1989) suggested examining values of estimated

standard errors, and estimated slope coefficients. When very large values of these coefficients are obtained it is an indication of multicollinearity. In this study, both the simple correlation matrix and the VIF were used to determine the presence/absence of multicollinearity for the two models on factors influencing farmersô knowledge of cattle reproductive parameters and milk production. Only the VIF was used to determine multicollinearity in the logistic regression model.

3.4.4.3 Test for correct predictions

Another way to detect the goodness of fit of the model in explaining the data correct and incorrect classifications of the dependent variable are among the various tests that are carried out. In this study, correct classifications were obtained for the logistic regression model.

3.5 Ordinary Least Squares (OLS)

Ordinary least squares (OLS) regression is a generalized linear modelling technique used to analyse a single response variable that has been recorded on at least an interval scale. The OLS regression model is also extended to include multiple explanatory variables by simply adding additional variables to the equation. The form of the model with many explanatory variables can be as below;

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_2 X_2 + \beta_2 X_2$$

Where, α indicates the value of Y when all values of the explanatory variables are zero. Each ß parameter indicates the average change in Y due to a unit change in X, whilst controlling for the other explanatory variables in the model but the relationship cannot now be graphed on a single scatter plot because of presence of the multiple explanatory variables (Hutcheson, 2011**).**

For this study, the OLS was chosen because of its usefulness that can be greatly extended with the use of dummy variables coded to include grouped explanatory variables (Hutcheson and Moutinho, 2008). It also allows for data transformations to take place especially when the assumption of normality does not hold (Fox, 2002). Ordinary least squares regression is a powerful technique as it is relatively easy to check the model assumption such as linearity, constant variance and the effect of outliers using simple graphical methods (Hutcheson and Sofroniou, 1999). In this study, it was used to model factors influencing farmersô knowledge of cattle reproductive parameters and to link socio-economic factors to milk production.

Empirical model: To determine factors influencing farmersô knowledge of the cattle reproductive parameters.

The OLS model specification is expressed in a linear form as;

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \varepsilon$$

where;

$Y =$ Farmersô knowledge of the cattle reproductive parameters

X_1 = Age of household head

X_2 = Years spent in school by household head

X_3 = No. of school going children

X_4 = Milk production as most important reason for keeping

X_5 = Male household heads

X_6 = Herd size

X_7 = Owning one or more means of transport

X_8 = No. of crossbreed cattle

X_9 = No. of small ruminants

X_{10} = Practicing zero grazing

X_{11} = Dependency ratio

X_{12} = Being above poverty line of Ksh 2,500

X_{13} = No. of exotic cattle

α = Constant

ε = Error term

$\beta_1 ....\ \beta_n$ are the coefficients to be estimated.

The OLS was utilized to obtain the coefficient estimates of $\beta_1 ....\ \beta_n$

Table 3.2: Explanatory variables in the model on factors influencing farmers' knowledge of the cattle reproductive parameters

Variable	Type of data	Description	Expected sign
Age of household head	Continuous	Age in years	±
Years spent in school by household head	Continuous	Years the household head has attended formal school	+
No. of school going children	Continuous	No. of children who go to school in household	+
Milk production as most important reason for keeping cattle	Dummy	1 if farmersô most important reason for keeping cattle is milk production, 0 otherwise	+
Gender of household head	Dummy	1 if male and 0 otherwise	–
Herd size	Continuous	Total number of cattle owned by the household	+
Means of transport	Dummy	1 if household owns one or more means of transport, 0 otherwise	+
No. of crossbreed cattle	Continuous	Number of crossbreed cattle owned by the household	+
No. of small ruminants	Continuous	Is the number of sheep and goats owned by the household	_
Practicing zero grazing	Dummy	Dummy variable 1 if farmer practices zero grazing dairy production system and 0 otherwise	+
Dependency ratio	Continuous	The ratio of the dependents (children of 14 years and below and adults of above 75 years) to a working population (household members 15-75 years)	_
Being above poverty line of Ksh 2, 500	Dummy	1= Being above poverty line of Ksh 2,500 and 0 otherwise	+
No. of exotic breeds of cattle	Continuous	Number of exotic cattle breeds	+

Empirical Model: To determine the socio-economic factors influencing milk production

The OLS model is econometrically specified as;

$$\ln(Y) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \varepsilon \quad \textit{Equation} \quad 1$$

where,

$Y =$ Milk production

$X_1 =$ Farmersô knowledge on cattle reproductive parameters

$X_2 =$ Gender of household head

$X_3 =$ Age of household head

$X_4 =$ Years spent in school by household head

$X_5 =$ No. of school going children

$X_6 =$ No. of exotic cattle breeds

$X_7 =$ No. of crossbreed cattle

$X_8 =$ No. of small ruminants

$X_9 =$ Milk production as most important reason for keeping cattle

$X_{10} =$ Being above poverty line of Ksh 2,500

$X_{11} =$ Practicing zero grazing

$\alpha =$ Constant

$\varepsilon =$ Error term

$\beta_1 .... \beta_n =$ Coefficients

The OLS was used to obtain the coefficient estimates of $\beta_1 .... \beta_n$ \

Table 3.3: Explanatory variables in the model on factors influencing milk production and their expected contribution

Variable	**Definition**	**Expected sign**
Farmers knowledge of the cattle reproductive parameters	Knowledge of farmers on the length of gestation, calving to conception interval, calving to first heat, age at first heat, signs of pregnancy in cows and heat signs	+
Gender of household head	1 if male, zero otherwise	-
Age of household head	Age in years	+
Years spent in school by household head	Formal years the household head has spent in school	+
No. of school going children	Number of children going to school	±
No. of exotic cattle	Number of exotic cattle breed	+
Practicing zero grazing	1 if farmers practices zero grazing and 0 otherwise	+
No. of crossbreed cattle	Number of crossbreed cattle owned by the household	+
No. of small ruminants	Number of sheep and goats owned by the household	_
Poverty line of Ksh.2,500	1 = Being above poverty line of Ksh 2,500 and 0 otherwise	+

3.5.1 Goodness-of-fit measure

Model fit statistic summarizes how well a set of explanatory variables explains a response variable. Among the goodness of fit measures is the R^2 statistic also known as the coefficient of multiple determinations. It is a common statistics used to determine OLS model fitness. It indicates the percentage of variation in the response variable that is explained by the model. The value of R^2 is always between zero and one. When interpreting R^2, its value is multiplied by 100 to change it into a percentage. If the data points all lie on the same line, OLS provides a perfect fit to the data. In this case, R^2 equals one. A value of R^2 that is nearly equal to zero indicates a poor fit of the OLS line. That means that very little of the variation in the Y is captured by the variation in the predicted Y (Wooldridge, 2003). This was obtained for the two OLS models on factors influencing knowledge and milk production.

3.5.2 Identification of powerful instrumental variables

Instrumental variables are variables that are explicitly excluded from some equations and are included in others and therefore correlated with some outcomes only through their effect on other variables (Angrist *et al*., 1996). In this study, partial correlations were used to identify the instrumental variables those that would influence farmersô knowledge of the cattle reproductive parameters but through zero grazing.

3.5.3 Hausman test

In any production function, all inputs are expected to be exogenous in simple terms explanatory variables. Exogeneity is critical in ensuring that estimates are not biased (Carpentier and Weaver, 1997). However, there are scenarios where one or more inputs/variables are endogenous (dependent variable) and not exogenous. In this case, participation in zero grazing as one of the variables influencing farmersô knowledge was suspected to be endogenous. In technology adoption, the problem of endogeneity emerges because technology adoption is either voluntary or some technologies are targeted to a given group of farmers (Hausman, 1978). In circumstances where technology adoption is voluntary, it is the more productive farmers that are more likely to adopt the technology. This self-selection into technology adoption may be source of endogeneity. Failure to account for this will overstate the true impact of the technology. On the other hand, in circumstances where technology is targeted to a given group of farmers, it is far more likely that less productive farmers will adopt the technology. Failure to account for this will understate the true impact of the technology. These two scenarios make it difficult to estimate the true impact of the technology adoption on any variable (Hausman, 1983) for instance income and knowledge among others.

When choosing the estimation method, where endogeneity is a problem, consistent estimates can be obtained by suitably instrumenting the relevant variable using the 2SLS estimator. On the other hand, where endogeneity is not a significant problem, the least squares estimator is more efficient than instrumental variables (Wooldridge, 2003). However, both OLS and 2SLS are consistent if all variables are exogenous (Wooldridge, 2003). In this study, to determine factors that influence farmersô knowledge of the cattle reproductive parameters the problem of endogeneity was suspected to be present; hence, the two models (2SLS and OLS) had to be run and Hausman test had to be performed in order to choose the appropriate estimation method. When the Hausman test (Hausman,

1978) probability chi-square value turns out insignificant then that indicates that OLS model estimation is appropriate and when it turns out significant that implies that 2SLS model estimation is appropriate.

3.5.4 Testing for heteroskedasticity

Heteroskedasticity exists when the variances of all variables are not the same, leading to consistent but inefficient parameter estimates (Breusch and Pagan, 1979). There are many tests for heteroskedasticity. These make different assumptions about the form of heteroskedasticity, tests such the Breusch-Pagan test can be used to detect heteroskedasticity. The Breusch-Pagan / Cook-Weisberg test is used to test for the linear form of heteroskedasticity. In this study the Breusch-Pagan / Cook-Weisberg test was used. It tests the null hypothesis that the error variances are all equal versus the alternative that the error variances are a multiplicative function of one or more variables. From the results, a large chi-square indicates that heteroskedasticity is present while a small chi-square value indicates heteroskedasticity is probably not a problem (Breusch and Pagan, 1979). Alternatively, if the test results in a small enough p-value, some corrective measure should be taken (Wooldridge, 2003). However, if heteroskedasticity is found present OLS regression gives still appropriate coefficient estimates, but test statistics have to be adjusted to the heteroskedasticity-robust standard error or the heteroskedasticity-robust t statistic (Wooldridge, 2003). The Breusch-Pagan / Cook-Weisberg test was performed in both OLS models; determining factors influencing knowledge and milk production.

CHAPTER 4

RESULTS

4.1 Socio-economic characteristics of household heads

Table 4.1 and 4.2 show the descriptive summaries for the socio-economic characteristics of farmers who participated in the survey. The results were categorized according to the whole sample that constituted farmers who practice zero grazing and farmers who do not and by farmer category. Table 4.1 shows that overall, majority of the household heads in the survey were male houdehold heads (81.35%) and 18.65% were female household heads. 41.92% were farmers practicing zero grazing and majority (58.08 %) of the farmers were not. 53.08% of the farmers owned one or more means of transport and 82.69% were above poverty line of Khs 2,500 in the study area (Table 4:1).

Table 4.1: Characteristics of the whole sample – on non- continuous variables

Variable	Percent
Gender of household heads	Male = 81.35 Female = 18.65
Category of farmers	Farmers who practice zero grazing = 41.92 Farmers who do not = 58.08
Farmers owning one or more means of transport	53.08
Farmers above poverty line of Ksh 2,500	82.69
Observations	520

The respondents (Table 4.2) had an average age of 48.12 (± 0.56) which ranged from 20 to 87 years and about 8.74 (± 0.19) years of schooling with the maximum years spent in school being 19. The average number of school going children was 2.53 (± 0.10) per household (Table 4.1) with a maximum of 16. The average herd size was 3.28 (± 0.10) and 21 was the maximum. The mean number of exotic cattle was 1.09 (± 0.08), maximum was 13. The mean dependency ratio was 1.16 (± 0.06) and 12 being the maximum. For crossbreeds, mean number was 1.23 (± 1.68) with a maximum of 11 (Table 4.1).The mean number of small ruminants was 0.86 (± 0.07) with maximum of 13. The overall average milk produced per lactation period per cow was 940.55 (± 48.86) litres with 6,480 litres being the maximum.

Table 4.2: Characteristics of the whole sample – on continuous variables

Variable	Mean	Minimum	Maximum
Age of household head	48.12 ± 0.56	20	87
Years spent in school by household head	8.74 ± 0.19		19
No. of school going children	2.53 ± 0.10		16
Herdsize	3.28 ± 0.10		21
No. of exotic cattle	1.09 ± 0.08		13
Dependency ratio	1.16 ± 0.06		12
No. of cross breed cattle	1.23 ± 1.68		11
No. of small ruminants	0.86 ± 0.07		13
Milk production(litres per lactation period per cow)	940.55 (± 48.86)		6,480
Observations	520		

4.2 Socio-economic characteristics by category of farmers

Using the two sample t-test that tests for the statistical differences between two means the results (Table 4.3) show that farmers who practice zero grazing had (49.49 ± 0.79) years on average whilst those that do not had (47.12 ± 0.77). Testing for the statistical differences in age of the farmers showed that there were significant differences between the two groups (P = 0.04). Farmers that practice zero grazing had spent (9.96 ± 0.29) years in school on average and those who do not had spent (7.86 ± 0. 23). The differences in attaining education between the two groups were significant (P = 0.00) (Table 4.3).

The farmers who practice zero grazing had on average a herd size of 3.65 ± 0.15 while those who do not had (3.00 ± 0 .12). The differences in herd size between the two groups were significant (P = 0.00). Farmers who practice zero grazing had (2.28 ± 0.14) exotic cattle on average whilst those who do not had (0.24 ± 0.05). The difference in the average number of exotic cattle owned was significant (P = 0.00). Farmers who practice zero grazing had on average (0.82 ± 0.11) number of cross breed cattle while those that do not had (1.53 ± 0.09). The differences was significant (P = 0.00). Farmers who practice zero grazing had a mean dependency ratio of (1.31 ± 0.08) on average while that of farmers who do not had (0.96 ± 0.090). The results showed that significant differences (P = 0.00) existed between the two groups. The farmers who practice zero grazing had (1.28 ± 0.03) number of school-going children and those who do not had (3.44 ± 0.15). The differences in number of school going children were significant (P = 0.00).

There were no significant differences observed between the two groups regarding the number of small ruminants owned. The farmers who practice zero grazing produced

1405.56 litres of milk per lactation period per cow than their counterparts 604.87 such a difference was significant (P = 0.00) (Table 4.3).

Table 4.3: Means of variables, by category of farmers

Variable	Farmers who practice zero grazing	Farmers' who do not	P- value
Age of household head	49.49 ± 0.79	47.12 ± 0.77	0.04
Years spent in school by household head	9.96 ± 0.29	7.86 ± 0.23	0.00
No. of school going children	1.28 ± 0.03	3.44 ± 0.15	0.00
Herdsize	3.65 ± 0.15	3.00 ± 0 .12	0.00
No. of exotic cattle	2.28 ± 0.14	0.24 ± 0.05	0.00
Dependency ratio	0.96 ± 0.09	1.31 ± 0.08	0.00
No. of crossbreed cattle	0.82 ± 0.11	1.53 ± 0.09	0.00
No. of small ruminants	0.94 (± 0.13)	0.80 (± 0.08)	0.13
Milk production (ltrs, per lactation/cow)	1405.56 ± 88.45	604.87 ± 46.09	0.00
Observations	218	302	

Note: Data are computed using a two- sided t test

Table 4.4 shows that with regard to gender, out of the farmers practicing zero grazing 81.46% were male household heads and out of those not practicing zero grazing, the males constituted 81.19%. There were no significant differences noticed between the two groups (P = 0.94) regarding the proportion of their male composition. Out of the farmers practicing zero grazing, those who were above the poverty line of Ksh 2,500 were 91.74% and out of the farmers not practicing zero grazing, those that were above the poverty line of Ksh.

2,500 were 76.16%. The percentage differences of farmers above the poverty line of Ksh 2,500 of the two groups were significant (P = 0.00). Significant differences (P = 0.00) were observed in the ownership of one or more means of transport between the two groups. 64.22% of the farmers who practice zero grazing had at least one or more means of transport while 45.03% of those who do not practice zero grazing owned at least one or more means of transport (Table 4.4).

Table 4.4: Percentage values of variable by category of farmers

Variables	Farmers who practice zero grazing	Farmers' who do not	P- value
Male household heads	81.46%	81.19%	0.94
Being above poverty line of Ksh 2,500	91.74%	76.16%	0.00
Owning one or more means of transport	64.22%	45.03%	0.00
Observations	218	302	

Note: Data are computed using a two- sample proportions z- test

4.3 Logistic regression on factors influencing adoption of zero grazing

To determine factors influencing adoption of zero grazing (Table 4.5) presents the logistic regression odds ratio, standard errors, z values, p - values and confidence intervals of factors influencing adoption of zero grazing. With the exception of male household heads and number of crossbreeds, the rest of the explanatory factors had the expected signs. In model selection, several possible models were fitted by dropping and adding variables expected to influence participation. The model that gave good results according to R^2 (Appendix 1.1), goodness of fit (Appendix 1.2), multicollinearity test (Appendix 1.3) and correct predictions (Appendix 1.4) was retained and used for interpretation of results. The R^2 explained 59% of the total variation, the goodness of fit test (Hosmer-Lemeshow goodness- of- fit test) obtained a chi-square value of 13.34 with a high probability value 0.10, the average variance inflation factors (VIF), was 1.27 and the proportion of the total number of predictions correctly estimated was about 87.12%.

Table 4.5: Logistic regression on factors influencing adoption of zero grazing

Variable	Odds ratio	Standard error	Z	P- value	[95% conf. Interval]
Male household heads	0.7	0.3	-1.0	0.32	0. 304 - 1.478
Age of household heads	1.0	0.0	2.2	0.03	1.003 - 1.049
Years spent in school by household head	1.1	0.5	3.2	0.00	1.051 - 1.234
No. of school going children	0.3	0.0	-8.4	0.00	0.221 - 0.391
Herd size	0.9	0.1	-1.3	0.19	0.773 - 1.052
No. of exotic cattle breeds	5.0	0.9	8.6	0.00	3.465 - 7.196
Being above poverty line of Ksh 2,500	2.9	1.3	2.3	0.02	1.162 - 7.139
Dependency ratio	1.4	0.2	2.2	0.03	1.042 - 1.939
Owning one or more means of transport	1.4	0.3	1.3	0.21	0.850 - 2.131
No. of crossbreed	1.2	0.1	1.9	0.05	0.997 - 1.492
No. of small ruminants	1.0	0.1	-0.3	0.74	0.797 - 1.174

The results (Table 4.5) show that with the exception of male household heads, the number of school going children, herd size, and the number of small ruminants, all other variables in the model had positive influence on farmersô adoption of zero grazing. The decision by household heads to adopt zero grazing was significantly influenced by the following socio-economic variables ($P < 0.05$). The age of household heads, number of years spent in school by household heads, number of school going children, number of exotic cattle, being above poverty line of Ksh 2,500, dependency ratio, and number of crossbreed cattle. The odds ratios for age of household head, years spent in school by household head, number of exotic cattle breeds, being above poverty line of Ksh 2,500, dependency ratio and number of crossbreed cattle were 1.0, 1.1, 5.0, 2.9, 1.4 and 1.2 respectively (Table 4.5). The variables male household heads, herd size, owning one or more means of transport and number of small ruminants were not significant in influencing zero grazing adoption.

4.4 Farmers knowledge on the cattle reproductive parameters in western Kenya - whole sample

To assess farmersô knowledge on the cattle reproductive parameters (Table 4.6) shows that on average, farmersô knowledge ranged from 4.7% to 18.3% on the parameters. On average, farmers obtained 17.1% on their knowledge of gestation length with a maximum of 42.9%.The mean knowledge on calving to conception interval was 14.1%, with a maximum of 71.4%. The knowledge on calving to first heat was 4.7% on average with maximum of 40%. On average farmersô obtained 18% with a maximum of 60% on age at first heat, (Table 4.6).Their knowledge on pregnancy signs was on average 13.0% with a maximum of 37.5%. The findings showed that when the knowledge of farmers on all the parameters was combined, 9.9 % on average was obtained with a maximum of 22.7% (Table 4.6).

Table 4.6: Overall knowledge of livestock farmers on cattle reproductive parameters

Reproductive parameters	Overall mean	Maximum (%)
Length of gestation period	17.1 ± 0.4	42.9
Calving to conception interval	14.1 ± 0 .5	71.4
Calving to first heat	4.7 ± 0.4	40
Age at first heat	18.3 ± 0.7	60
Pregnancy signs	13.0 ± 0.3	37.5
Heat signs	6.5 ± 0.1	14.7
All parameters combined	9.9 ± 0.2	22.7
Observations	520	

4.5 Farmers' knowledge on the cattle reproductive parameters by category of farmers

To establish the knowledge difference between the two groups (Table 4.7) shows that farmers who practice zero grazing had more knowledge on the parameters than farmers who do not practice zero grazing on a snapshot. Farmers who practice zero grazing obtained 21.45% over (7) on gestation length, 19.55% over (7) on calving to conception interval, 5.32 over (5) on calving to first heat, 18.44 over (5) on age at first heat,13.65 over (8) on pregnancy signs and 7.35 over (34) on heat signs. While those who do not practice zero grazing obtained 14.02% over (7) on gestation length, 10.23% over (7) on calving to conception interval, 4.24% over (5) on calving to first heat, 18.15% over (5) on age at first heat, 12.54% over (8) on pregnancy signs and 5.88% over (34) on heat signs. These findings indicated that overall knowledge of farmersô who practice zero grazing on the parameters was 11.59% over (66) which was higher than that of the farmers who do not practice zero grazing (8.8%) (Table 4.7).

Table 4.7: Farmers knowledge on cattle reproductive parameters in western Kenya by category of farmers

Reproductive parameters	Farmers who practice zero grazing	Farmers who do not	P- Value
Length of gestation period	21.45 ± 0.40	14.02 ± 0.68	0.00
Calving to conception interval	19.55 ± 0.86	10.23 ± 0.58	0.00
Duration from calving to first heat	5.32 ± 0.68	4.24 ± 0.50	0.19
Age at first heat	18.44 ± 1.06	18.15 ± 1.02	0.84
Pregnancy signs	13.65 ± 0.45	12.54 ± 0.35	0.05
Heat signs	7.35 ± 0.19	5.88 ± 0.16	0.00
Total on the farmersô knowledge of cattle reproductive parameters	11.59 ± 0.24	8.82 ± 0.18	0.00
Observations	218	302	

Note: Data were computed using a two- sided t test.

Using the two-sample t test significant differences between the groups were noticed regarding their knowledge on length of gestation period (P = 0.00), calving to conception interval (P = 0.00), heat signs and pregnancy signs (P = 0.00). Regarding their knowledge on calving to first heat (P = 0.19) and age at first heat (P = 0.84) there were no significant differences between both groups. On average the differences range between 0.29 in the category of knowledge on age at first heat, up to 9.32 knowledge score on calving to conception interval.

4.6 Factors influencing farmers' knowledge of cattle reproductive parameters in western Kenya

The ordinary least squares regression was applied to explore the relationship between farmersô knowledge on the cattle reproductive parameters and the socio-economic variables. The analysis was undertaken on 510 respondents after removal of outliers. Appendix (3.0), the subsequent sections, and Table (4.8) show results on factors influencing farmersô knowledge of the cattle reproductive parameters. The correlation matrix (Appendix 3.1) illustrates that some variables are statistically correlated but none had a correlation coefficient of greater than 0.9. The partial correlation results for the number of exotic cattle owned, poverty line and dependency ratio were ($r = 0.14$, $P = 0.00$), ($r = 0.55$, $p = 0.00$) and ($r = - 0.09$, $p = 0.04$) respectively (Appendix 3.2). Hausman test turned out to have a probability chi-square value of 0.6019 (Appendix 3.3). The R^2 obtained was 0.21 (Appendix 3.4).The variance Inflation Factors (VIFs) (Appendix 3.5) attained a maximum value of 1.38. The Breusch-Pagan /Cook-Weisberg test gave a p-value of Prob > chi2 = 0.85 (Appendix 3.6).

Table 4.8 depicts that practicing zero grazing and number of exotic cattle breed influenced farmersô knowledge of reproductive parameters at ($P = 0.00$) and ($P = 0.00$) respectively. The anticipated positive impact of practicing zero grazing on farmersô knowledge of the cattle reproductive parameters becomes evident. Holding all other factors constant, farmersô knowledge of the reproductive parameters is more likely to increase by 1.6% if adoption of zero grazing increases by 1%. Number of exotic cattle owned by farmers positively and significantly influenced farmersô knowledge of the cattle reproductive parameters. Increasing the number of exotic cattle by one exotic cow was more likely to increase farmersô knowledge of the reproductive parameters by 0.02% (Table 4.8).

Table 4.8: Ordinary least squares regression on factors influencing farmers' knowledge of cattle reproductive parameters

Variables	Coefficients	Std Errors	'*t*' values	P-value
Age of household head	0.19	0.01	-1.70	0.09
Year spent in school by household head	-0.00	0.03	-0.09	0.93
No. of school going children	0.03	0.07	-0.37	0.71
Milk production as the most important reason for keeping cattle	0.62	0.34	1.81	0.07
Male household heads	0.23	0.36	0.66	0.51
Herdsize	0.14	0.07	1.88	0.06
Owning one or more means of transport	0.34	0.22	1.53	0.13
No. of crossbreed cattle	0.14	0.09	1.48	0.14
No. of small ruminants	0.00	0.08	-0.11	0.91
Practicing zero-grazing	1.6	0.38	4.23	0.00
Dependency ratio	0.05	0.01	0.51	0.61
Being above poverty line of Ksh 2,500	0.24	0.05	0.66	0.51
No. of exotic cattle	0.02	0.37	2.93	0.00

[1] Dependent variables: Farmersô knowledge of cattle reproductive parameters

4.7 Factors influencing milk production

The results of the ordinary least squares regression model were used to determine the factors that influenced milk production (Table 4.9).The response variable was the transformed milk production variable. The exogenous variables were; age of household head, years spent in school by household head, number of school going children, milk production as the most important reason for keeping cattle and gender of household head. Others included herd size, means of transport, number of crossbreed cattle, number of small ruminants, practicing zero grazing, dependency ratio, being above poverty line of Ksh 2,500 and number of exotic cattle. The correction matrix (Appendix 4.1) revealed the correlation coefficient between any pair of explanatory variables to be less than 0.9 in absolute value. The obtained R^2 was 0.22 (Appendix 4.2). The variance inflation factor (VIF) was also calculated and was found to be 1.29 (Appendix 4.3). The Breusch-Pagan/Cook-Weisberg test for heteroskedasticity had a high chi-square value of 0.11 (Appendix 4.4).

The results (Table 4.9) show that male household heads negatively and insignificantly influenced the adoption of zero grazing. Explanatory variables such as age of household head, year spent in school by household head, number of school going children, number of small ruminants positively but insignificantly influenced the adoption of zero grazing. Only six explanatory variables namely farmersô knowledge of cattle reproductive parameters, number of exotic cattle, number of cross breed cattle, milk production as most important reason for keeping cattle, being above poverty line of Khs 2,500 and practicing zero grazing influenced milk production.

Table 4.9 shows farmersô knowledge of cattle reproductive parameters positively influenced milk production. The sign is in accordance to the expectations that farmersô knowledge positively influences milk production. In fact, a 10% increase in farmersô knowledge will likely increase the milk production per lactation period of cow by 1.59% per year, holding other factors constant. As anticipated, number of exotic cattle owned by farmers positively and significantly influenced milk production. Infact, increasing the number of exotic cattle owned by farmersô by 10% will likely increase the milk production per lactation of a cow by 2.8% ceteris paribus. In addition, number of crossbreed cattle owned by farmers positively and significantly influenced at 5% milk production. A 10% increase in the number of crossbreed cattle owned will likely increase the milk production per lactation period of cow by 2.7% per year. This is in line with the expectations. In accordance to expectations, milk production as the most important reason for keeping cattle positively and significantly, increases milk production at 5%. Increasing the milk production, as the most important reason for keeping cattle, is more likely to increases milk production (Table 4.9).

The sign as expected being above poverty line Ksh of 2,500 positively and significantly at 5% increases milk production. Being above the poverty line of Ksh of 2,500 was more likely to increase milk production. In line with the expectations, practicing zero grazing positively and significantly influenced milk production. Increasing participation in zero grazing was more likely to increase milk production.(Table 4.9).

Table 4.9: Ordinary least squares regression on factors influencing milk production

Predictor variables	Coefficients	Std Errors	P-value	'*t*' values
Knowledge on cattle reproductive parameters	1.6	0.3	0.000	4.7
Male household head	-0.3	0.4	0.457	-0.8
Age of household head	0.0	0.0	0.732	0.3
Year spent school by household head	0.0	0.0	0.250	1.2
No. of school going children	0.1	0.1	0.273	1.1
No. of exotic cattle	0.3	0.1	0.003	3.0
No. of crossbreed cattle	0.3	0.1	0.001	3.2
No. of small ruminants	0.1	0.1	0.473	0.7
Milk production as the most important reason for keeping cattle	1.3	0.4	0.000	3.7
Being above poverty line of Ksh 2,500	1.0	0.4	0.009	2.6
Practicing zero grazing	0.8	0.4	0.015	2.2

[2] Dependent variable: Milk production

CHAPTER 5

DISCUSSION

5.1 Socio-economic characteristics of the household heads

5.1.1 Characteristics of the whole sample – on non- continuous variables

The target population was the household heads thus the findings revealed that male household heads dominated the survey. This means that livestock production in the study area is an activity mostly preferred by the males. They are the household heads, they own the resources, and at the same time, they are decision makers hence decide upon which economic activity to take on. The studies carried out in Tanzania and North western Ethiopian highlands found that male household heads constituted the highest percentages which were not very different from (81.35%) as obtained in this study (Swai *et al*., 2005 and Ayenew *et al*., 2011). The proportion of farmers not practicing zero grazing in the survey was higher than that of farmers who practice zero grazing, meaning that majority of the small scale farmers residing in the study area are yet to appreciate zero grazing. Livestock production is an income generating activity; the incomes generated enable livestock farmers to acquire at least one or more means of transport. The high percentage of farmers above the poverty line of 2,500 is explained by the fact that, farmers who participated in the survey were livestock keepers, so they own the cattle, sell milk, and cattle to generate income hence obtain higher household incomes.

5.1.2 Characteristics of the whole sample – on continuous variables

The mean age of the respondents that participated in this survey is not very different from that obtained by Staal *et al*. (2001) in a similar study carried out in Kenya. This implies that livestock production in this country is highly appreciated by people who are around the age of 48. The average years spent by the household heads in school were relatively high; this means that education plays an important role in livestock production.

The results of the survey revealed that household heads on average had three school going children. This is an indication that the livestock farmers in the study area value education that is why atleast on average each household managed to have 3 children in school. The average herd size is similar to that obtained by Bebe *et al*. (2003) in a similar study carried out in Kenya Highlands. In both study areas, small-scale farmers keep three cattle on average. This could be explained by the high human population growth rate, which has led to intergeneration sub division and fragmentation of farms in Kenya (C.B.S., 2001). As human population growth increases, the number of land holdings increase but these get smaller with smaller herds (Bebe *et al*., 2003). It is not surprising that at least each household owned on average one exotic cow. Exotic cattle are among the main breeds used for dairy production in Kenya (Omore *et al*., 1998). From these findings, the obtained dependency ratio was low implying that the dependency burden is lighter. Household heads in the study area owned 1.23 crossbreeds. Cross breeding of indigenous breeds with exotic breeds is a strategy being promoted in developing countries to improve milk production of indigenous breeds (Darfour-Oduro *et al*., 2010).

The study revealed that livestock farmers in the study area keep other livestock (small ruminants though in small numbers compared to cattle). This is in line with Jaetzold *et al*. (2005) who observed that farmers in Bungoma County keep goat, sheep, poultry although to them cattle are the major form of livestock. The multiple benefits derived from keeping cattle explain why the livestock farmers in the study area prefer keeping more cattle compared to small ruminants. The average milk figures reported (940.55 litres per lactation period) indicated that there is milk produced within the study area and this could be attributed to exotic and indigenous cattle breeds kept within the study area (Census, 2009).

5.2 Socio-economic characteristics by category of farmers

5.2.1 Means of variables, by category of farmers

Farmers who practice zero grazing were significantly older than the farmers who do not. Being older means that they have more command over resources that explain their participation in zero grazing. Farmers who practice zero grazing had significantly spent more years in school. With more years spent in school, they are better positioned to recognize the importance of zero grazing as compared to those with lesser years of schooling. Farmers who practice zero grazing in the study area had a significantly higher mean herd size than the farmers who do not. High cattle herd sizes in small-scale farms in Eastern Cape Province (Mapekula *et al*., 2009) were attributed to resource ownership and affordability of feed. Farmers who practice zero grazing had significantly more number of exotic cattle than the farmers who do not practice zero grazing. It is uncommon to find exotic breeds of cattle under a non zero grazing system. Farmers who do not practice had a significantly higher dependency ratio than farmers who do practice zero grazing. This could be attributed to the fact that households with a higher dependency ratio (non-labour force to the labour force) have more dependents to cater for, hence lesser resources to invest in zero grazing.

Farmers who do not practice zero grazing afforded significantly more crossbreed cattle that require minimal investment. Supported by this is Lanyasunya *et al*. (2006) who argues that crossbreed cattle dominate the free-grazing herds rather than zero grazing dairy systems. No significant differences were noted between farmers who had practiced zero grazing and n farmers who do not. The farmers who practice zero grazing realized more than twice the amount of milk in litres than the farmers who do not practice zero grazing. Similar to this, in a study by Karanja (2003) the yields realized in smallholder open grazing farms were lowest as compared to milk yields in the small scale zero grazing. The milk yield under the smallholder open grazing farms averaged to 1,510 litres per cow per year. This yield was 28.8% lower than the average yields in small scale zero grazing. The differences in productivity were attributed to access to production services and level of management.

5.2.2 Percentage values of variable by category of farmers

There were no significant differences witnessed between the male composition of farmers who practice zero grazing and those that do not. The higher proportion of farmers who practice zero grazing noticed being above the poverty line of Ksh 2,500 explains the fact that zero grazing dairy system requires more capital than the open grazing system. Adoption of zero grazing requires relatively more resources. Leegwater *et al*. (1991) in a study in the Kenyan coast, found out that the zero- grazing system, was adopted mainly by the rich farmers who could afford the initial investment requirements which entailed the purchase of a grade cow and the building of a stall, which poor farmersô could not afford. Nicholson *et al*. (1998), argues that the principal reasons farmers are not adopting dairy cattle is because of lack of money to purchase the animal and lack of credit. A significantly higher percentage of farmers who practice zero grazing owned at least one or more means of transport than the farmers who do not. This implies that the farmers who practice zero grazing have more resources. In agreement to this is (Jera and Ajay, 2008) points out that farmers with more resources are more likely to invest in new technologies.

5.3 Determination of socio-economic factors influencing adoption of zero grazing using logistic regression

The obtained Hosmer-Lemeshow goodness- of- fit test implied that the chosen model fits well the data and that the explanatory variables adequately explain the probability of adoption of zero grazing since the obtained Chi Square is high. The VIF, which was less than 10, which implied that multicollinearity, was not a problem (Meyers, 1990).

In this study, it was hypothesized that older people are more likely to adopt zero grazing and the results of the study conforms to the expectations. The observed positive relationship between age of household head and adoption of zero grazing implies that older farmers are more likely to adopt zero grazing. The obtained odds ratio of age of household head implies that older people are 1.03 times more likely to influence adoption of zero grazing. This is probably because age is related to experience and therefore older farmers are likely to be more experienced and able to discern the importance of improved technology more as compared to the less experienced young farmers (Murage and IIatsia, 2011). Our results agree with those of Kafle and Shah (2012) and Shields *et al*. (2012) who observed a positive and significant relationship between age and technology adoption. Similarly Tambi *et al*. (1999) reported a positive and significant relationship between demand for improved technology and producers within the age group 25 to 50 years compared to those who were less than 25 years in Kenya

The positive relationship between years of schooling and adoption of zero grazing was expected. Years of schooling had a positive and significant influence on adoption of zero grazing. In this study, it implies that household heads that have more years of schooling are more likely to participate in zero grazing than those with lesser years. The odds ratio implies that farmers who have more years of schooling are 1.14 times more likely to adopt zero grazing than their counterparts are. Earlier studies Nichinda and Mendi (2008); Karamjit *et al*. (2009); Musaba (2010); Murage and IIatsia (2011) and Fita *et al*. (2012) found out that years spent in school by household heads had a positive and significant influence on the adoption of technologies. These findings are consistent with the findings of this study.

The more educated a household head is, the more he/she is likely to acquire, understand, obtain, disseminate new technologies within a shorter time and more efficient when allocating resources compared to a household head with fewer years of education (Kafle and Shah 2012; Ebojei *et al*. (2012). Similarly, education makes people realize the importance and benefits of adopting new technologies (Musaba, 2010). Along the same line, Foster and Rosenzweig (1996) argued that farmers who are more educated are more able to manage new technologies or became aware of productive innovations at earlier stages of growth than their less- educated counterparts.

It was hypothesized that a positive relationship would exist between the number of exotic cattle breeds owned by the farmers and adoption of zero grazing. In the present study, number of exotic cattle owned by farmers positively and significantly influenced adoption of zero grazing. The odds ratio for number of exotic breed cattle implied that number of exotic cattle breeds was 5.0 times more likely to influence the adoption of zero grazing. The positive relationship between number of exotic cattle and adoption of zero grazing is in agreement with Kaaya *et al*. (2005) who observed that farmers who keep exotic cattle are more likely to use improved technology. The results are also agreed with the recommendation of Murage and IIatsia (2011) who observed that farmers who kept purebred dairy cattle would more likely opt for improved technology. In this study household heads with more numbers of exotic cattle are more likely to participate in zero grazing. Exotic breeds are confined under zero grazing units where feed and water are brought to the animals. Further, zero grazing reduces exposure of the valuable cows to many vector diseases (Muraguri, 2000) and ensures strict isolation of the exotic cattle from the indigenous cattle (De-wit, 1990). It also safe guards cows from tick borne diseases and other health hazards (Mango, 2002).

The positive relationship between dependency ratio and adoption of zero grazing supports the hypothesis that higher dependency ratio is more likely to influence the adoption of zero grazing. The odds ratio for dependency ratio implies that dependency ratio is 1.4 times more likely to influence the adoption of zero grazing. The positive relationship between dependency ratio and adoption of zero grazing disagrees with Owu (1995) who argues that dependency ratio is negatively related to adoption decisions, since a high dependency ratio adds pressure on household consumption. This is in agreement with the findings of Ojaiko *et al*. (2007) and Ojaiko (2011) who argue that high dependency ratio increases the obligatory burden on the household head. The household head who is always worried with how to meet the immediate household needs, will be less willing to risk the fewer resources on new technologies.

In this study, it was hypothesized that the number of cross breed cattle owned negatively influenced adoption of zero grazing. On contrast, the findings of this study revealed that, the number of crossbreed cattle positively influences adoption of zero grazing technology. The odds ratio for number of crossbreed implies that number of crossbreed cattle is 1.22 times more likely to influence adoption of zero grazing. This is consistent with Kaaya *et al*. (2005) who argues that a farmer keeping crossbred cattle is more likely to use AI technology. The results of this study reveal that a farmer with more crossbreed cattle was more likely to participate in zero grazing. The way crossbreed cattle are managed is not different from exotic breeds of cattle, so zero grazing is indispensable.

In this study, it was hypothesized that being above the poverty line of Ksh 2,500 was more likely to influence the adoption of zero grazing. Indeed a positive relationship was observed between being above poverty line of Ksh 2,500 and adoption of zero grazing. The odds ratio for being above poverty line of Ksh 2,500 implies that being above the poverty line of Ksh 2,500 was 2.9 times more likely to influence the adoption of zero grazing. The results of the study are in agreement with the findings of Irungu *et al*. (1998); Waithaka *et al*. (2007) and Shields *et al*. (2012) who observed a positive relationship between household income and adoption of a new technology. In this study, farmersô above the poverty line of Ksh 2,500 were more likely to adopt zero grazing. Being above the poverty line of Ksh 2,500 implies that a household is able to meet its basic needs and still have surplus income to invest in zero grazing.

5.4 Farmers' knowledge on the cattle reproductive parameters western Kenya

Asssessment of farmersô knowledge on the reproductive parameters the findings showed that on average farmers obtained very low knowledge scores on all the reproductive parameters. Knowledge scores obtained on length of gestation period, calving to first heat, age at first heat and heat signs were much lower than those obtained in a similar study by (Meena *et al*., 2012) in India. In the same line, overall the average total knowledge obtained by the farmers was still lower than that obtained by Meena *et al*., (2012) on reproductive parameters. The low scores obtained could be attributed to two major factors 1) majority of the farmers who participated in the survey were farmers not practicing zero grazing, since they did not belong to that group of farmers practising zero grazing and may be never belonged to any other farmersô group, they had no avenue of accessing knowledge on the reproductive parameters. 2) It could also be that farmers practicing zero grazing had received no/ inadequate training on the cattle reproductive parameters. One can say, may be this was not an area of major concern by whoever was training them or they receieved the training but it was not comprehensive hence leading to low understanding of the reproductive parameters especially on certain parameters like calving to conception interval, heat signs and pregnancy signs by the farmers who practice zero grazing. Soniia and Asamoah (2011) in a study in Ghana found out that low knowledge test scores were due to poor knowledge retention. They were farmers who had received traing.

Assessment of the knowledge differences between the two groups regarding their knowledge on the cattle reproductive parameters the results showed that the farmers who practice zero grazing achieved significantly higher knowledge scores implying that they had a better understanding of the reproductive parameters than their counterparts. This may be because being zero grazing farmers creates greater chances for them to reach out and to be reached out to by other farmers, extension workers, and organizations either through trainings and farmer to farmers interactions hence making it easier for them to access information on reproductive parameters than it is for the farmers who do not practice zero grazing. Due to better contact of farmers with extension workers and extension agencies (Government or private) most dairy farmers had high or medium level of knowledge on dairy farming technologies (Kumar *et al*., 2011).

5.5 Factors influencing farmers' knowledge of cattle reproductive parameters in western Kenya

Determination of factors influencing farmers knowledge, the correlation coefficient between any pair of explanatory variables showed no potential bias to the analysis since it was less than 0.9 in absolute terms (Hill *et al*., 2001).The obtained partial correlation showed that there was a significant correlation between zero grazing and number of exotic cattle, being above poverty line of Khs 2,500 and dependency ratio variables, so these were used as instrumental variables in the two stage ordinary least squares regression. Hausman test (Hausman, 1978) results portrayed that OLS estimation procedure was appropriate for the data since the p value turned out to be insignificant ($P > 0.05$). The obtained R^2 indicated an adequate goodness of fit as compared to similar studies (Feder *et al*., 2004). The obtained VIF value implied absence of multicollinearity problem (Meyers, 1990). The Breusch-Pagan /Cook-Weisberg test (Breusch and Pagan, 1979) used to test for heteroskedasticity suggested absence of heteroskedasticity.

Practicing zero grazing positively influences farmersô knowledge of cattle reproductive parameters. This implies that adoption of zero grazing creates greater opportunities for farmers to search and have access to more knowledge through fellow farmers, extension agents, research institutions among others. Alavalapati (1990) argues that social participation exposes individuals to a wide range of ideas.

Number of exotic cattle breeds positively influenced farmers knowledge of the cattle reproductive parameters. These breeds of cattle require special handling, so a farmer has to have knowledgeable.

5.6 Factors influencing milk production

Determination of factors affecting milk production, the correlation matrix for checking collinearity between explanatory variables revealed no major issues of concern since the correlation coefficient between any pair of explanatory variables was less than 0.9 in absolute value (Hill *et al*., 2001).The obtained R^2 was adequate. It is not very different from that obtained by (Feder *et al*., 2004) who applied the OLS model in similar studies. The variance inflation factor (VIF) obtained showed that there was no multicollinearity problems. Meyers (1990) suggests that VIFs values not exceeding 10 may not be cause for concern. The Breusch-Pagan test for heteroskedasticity implied that the assumption of constant variance holds so no need to use adjustments using heteroskedasticity-robust test statistics (Wooldridge, 2003).

Eddy *et al*. (2012) in a study whose objective was to investigate the behaviour of dairy farmers and factors affecting the effort to enhance the economics of scale, observed that farmers with limited knowledge did not change much in their productivity. However, in this study farmersô knowledge of the cattle reproductive parameters positively influences milk production. Knowledge is key in realization of increased milk production. Number of crossbreed cattle influenced milk production. This is consistent with Abdinasir (2000) who reported that the up-grading level of cows significantly affected milk yield, with high-grade cows producing more milk than the low-grade cows. Also according to Abraha *et al*. (2009), crossbred cows achieved higher daily milk yield than indigenous ones. Cross breeding of indigenous breeds with exotic breeds is one option commonly used to improve milk production of indigenous breeds in developing countries (Darfour-Oduro *et al*., 2010). Since crossbreeding combines the adaptative characteristics of the indigenous breeds with the high milk production ability of the exotic breeds (Darfour-Oduro *et al*., 2010).

Milk production as the most important reason for keeping cattle positively influenced milk production. Farmers aiming at achieving this objective, ensure they carry out better management (quantity and quality feeds) so that their cows produce more milk. Being above poverty line of Ksh 2,500 influenced milk production. Being above the poverty line of Ksh 2,500, implies that a household is able to meet its basic needs and at the same time have surplus income to invest in graded animals that produce more milk and to invest heavily into feeding which enhances milk production. In line, Chindime (2008) farmers who have access to resources are associated with high milk yields.

In particular, practicing zero grazing production system influenced milk production. Achieving increased milk production is the idea behind practicing zero grazing. Farmers take up zero grazing because they expect to obtain increased milk yields. Ouma (2003) argued that the main purpose of keeping cattle in semi-intensive and intensive livestock production systems is milk production. In addition, under zero grazing dairy system farmers supplement the feeding with concentrates that generate more milk yields. Toolsee and Boodoo (2001) in their study reported improved milk yield with the adoption of technology in Mauritius. Interestingly (De Jong, 1996) argued that the main reason why zero grazing production system was started in Kenya was to improve milk production.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The findings of this study which were derived from the logistic regression model, revealed the number of exotic breeds, number of crossbreed cattle, poverty line of Ksh 2,500 and household head have had formal education positively influenced adoption of zero grazing method of livestock production. This leads to the conclusion that, there is need for farmers to own exotic breeds of cattle, cross breeds, should be earning more than Ksh 2,500, and will be in position to have resources to invest in zero grazing production system.

For this study, the findings portrayed by the two-sample t statistic showed knowledge differences between those farmers who practice zero grazing and those who do not. Farmers who practice zero grazing had significantly higher knowledge of reproductive parameters than the farmers who do not, and implied that farmers who practice zero grazing had more knowledge on the reproductive parameters of cattle. This led to the conclusion that there is need for adequate training on the understanding of the reproductive parameters where these farmers showed low knowledge levels on parameters such as calving to conception interval, heat signs and pregnancy signs among others. Training/ more training of farmers on these reproductive parameters will facilitate the farmers in maximizing both milk and probably animal productivity in terms of calves obtained per year hence be in position to realize the substantial benefits of practicing zero grazing. In addition, the knowledge gap between these two groups needs to be bridged either through encouragement of farmer to farmer interactions or encouraging farmers who practice zero grazing to keep inviting their counterparts to attend the trainings once there is an opportunity for training so that even the farmers who do not practice zero grazing can understand the reproductive parameters. Once they get equipped with this knowledge, they will be motivated to go for zero grazing production system, which will make them earn and make profit in this endeavor.

The results derived from the Ordinary least squares regression showed that indeed practicing zero grazing significantly influences farmersô knowledge of the cattle reproductive parameters. There is need therefore, to promote participation in zero grazing as it creates a platform for knowledge acquisition. Through practice, farmers will gain knowledge on how to improve dairy cow reproduction and will become excellently competent in dairy production under the zero grazing system.

There is need to enhance farmers knowledge on the reproductive parameters. This knowledge will lead to improved animal productivity and profitability of the zero grazing unit.

6.2 Recommendations

It is important to note that policy measures, which are directed towards promoting these adoption characteristics of farmers (ownership exotic and crossbreed cattle, being above the poverty line of Ksh 2,500 and education of farmers), will be of considerable use in promoting the adoption of zero grazing production system.

It is worthy to note that though farmers that practice zero grazing had more knowledge on the cattle reproductive parameters, their level of knowledge was still low, therefore training them and encouraging farmer-to-farmer interactions are of importance as these are some of the channels for information dissemination and circulation of technologies among farmers.

Efforts should be directed towards encouraging farmer participation in zero grazing as it turned out to be one of the avenue for enhancing farmersô knowledge.

Efforts geared towards enhancing farmers knowledge of the cattle reproductive parameters should be encouraged as it was viewed to make better milk production within the region.

Further research is necessary, since social, economic, and other factors do change over time; it becomes necessary, therefore, to revisit this study in line with the changing social, economic, and other factors with the aim of establishing factors influencing adoption of zero grazing, farmersô knowledge of cattle reproductive parameters and milk production. It would also be interesting to investigate how farmers adjust their social, economic, and other conditions to accommodate the zero grazing dairy production system.

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List of appendices

Appendix 1 Factors influencing adoption of zero grazing

1.1 Logistic model for factors influencing adoption of zero grazing

```
logistic zerograzing gender age age yearspent_sch school_goingchildren herdsize
no_exotic poverty_line dependencyratio means_transport crossbreed small_ruminants
note: age dropped because of collinearity
Logistic regression                              Number of obs   =        520
                                                 LR chi2(11)     =     414.74
                                                 Prob > chi2     =     0.0000
Log likelihood = -146.25131                      Pseudo R2       =     0.5864
------------------------------------------------------------------------------
 zerograzing | Odds Ratio   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      gender |   .6705505   .2704226    -0.99   0.322     .3041971    1.478114
         age |   1.026001   .0120289     2.19   0.029     1.002694    1.049851
yearspent_~h |   1.138822   .0467933     3.16   0.002     1.050705     1.23433
school_goi~n |   .2935612   .0428179    -8.40   0.000     .2205694    .3907079
    herdsize |   .9017156   .0707623    -1.32   0.187     .7731637    1.051642
   no_exotic |   4.993322   .9308212     8.63   0.000     3.465089    7.195563
poverty_line |   2.880507   1.333881     2.28   0.022     1.162255    7.138982
dependency~o |   1.422166   .2251006     2.23   0.026     1.042851     1.93945
means_tran~t |   1.345865   .3157571     1.27   0.205     .8497647    2.131593
  crossbreed |   1.219936   .1254997     1.93   0.053      .997173    1.492463
small_rumi~s |   .9674934   .0956013    -0.33   0.738      .797146    1.174243
```

1.2 Testing for goodness of fit

```
 lfit, group (10)
Logistic model, goodness –of –fit test
Number of observations =   520
      Number of groups =    10
      Hosmer-Lemeshow chi2 (8)   = 13.34
                  Prob > chi2 = 0.1008
```

1.3 Testing for collinearity

```
vif
    Variable |       VIF       1/VIF
-------------+----------------------
   no_exotic |      1.68    0.595106
    herdsize |      1.55    0.644961
  crossbreed |      1.43    0.698143
yearspent_~h |      1.25    0.798538
school_goi~n |      1.24    0.808841
dependency~o |      1.23    0.810686
means_tran~t |      1.13    0.886733
      gender |      1.13    0.887180
poverty_line |      1.12    0.891856
         age |      1.10    0.910275
small_rumi~s |      1.06    0.945021
-------------+----------------------
    Mean VIF |      1.27
```

1.4 Testing of correct predictions

```
estat class
              -------- True --------
Classified |         D            ~D  |      Total
-----------+--------------------------+-----------
     +     |       181            30  |        211
     -     |        37           272  |        309
-----------+--------------------------+-----------
   Total   |       218           302  |        520


Classified + if predicted Pr(D) >= .5
True D defined as zerograzing != 0
--------------------------------------------------
Sensitivity                     Pr( +| D)   83.03%
Specificity                     Pr( -|~D)   90.07%
Positive predictive value       Pr( D| +)   85.78%
Negative predictive value       Pr(~D| -)   88.03%
--------------------------------------------------
False + rate for true ~D        Pr( +|~D)    9.93%
False - rate for true D         Pr( -| D)   16.97%
False + rate for classified +   Pr(~D| +)   14.22%
False - rate for classified -   Pr( D| -)   11.97%
--------------------------------------------------
Correctly classified                        87.12%
--------------------------------------------------
```

Appendix 2 Computation of farmers' knowledge on cattle reproductive parameters

Allocation of knowledge score on cattle reproductive parameters according to knowledge categories with 1 = correct and 0 = wrong

2.1 Calving to conception interval

By asking the question: What is the duration from calving to the conception? The true and correct expected and used in this analysis was the answer that fell in the range provided in the table 1 below. One point was scored for giving each right answer. This was out of (7).This range provided below covered for all breeds (Friesian, Jersey, Guernsey, crossbreed, zebu, Boran and Sahiwal)

Table 1: Calving to conception interval for dairy breeds

Breed	Calving to conception interval (range)	Authors
Dairy cow in smallholder farms	60 to 270 days (2 to 9 months)	Banda *et al*. (2012)

2.2 Age at first heat

By asking the question: At which age do you observe the first heat in your heifer? The true and correct answer expected and use in this analysis was one that fell within the range provided in the table below for each specific given breed: A respondent, who gave answer that was within that range got it right and was given 1marks for each correct answer. This was marked out of (5).

Table 2: Age at First heat

Breed	Age at first heat (Range)	Author
Friesian	14 months to 18 months	Ojango and Pollott (2001)
Boran	18 months to 24 months	MoLD (2008)
Sahiwal	18 months to 24 months	MoLD (2008)
Local zebu	21 months to 48 months	Msanga *et al*. (2012)
Cross breeds	24 months 6 days to 27 months 3 days	Mureda and Mekuriaw (2007)

2.3 Duration from calving to first heat

By asking the question: What is the duration from calving to the first heat? A respondent who gave an answer falling within the range provided in the table below for the specific breeds got one mark. For this parameter it was out of (5).

Table 3: Duration from calving to first heat

Breed	Calving to first heat(range)	Author
Exotics	38th to 42 day(1 month 3 days to 1 month 4 days)	MoLD (2008)
Crossbreeds	85.6+/-5.6 days	
	80 to 100 days	Chenyambuga and Mseleko, (2009)
	So from the two papers(80 to 100 days) approx(2 months 7 days to 3 months 3 days)	Dinka (2012)
Local breeds	60 to 90 days (2 to 3 months)	Falvery and Chantalakhana (1999)

2.4 Pregnancy signs

By asking the question: How do you know that your cow is pregnant? The true and correct answer expected and used in this analysis was as indicated in the table below: One point was scored for a good answer. This was out of (/8).

Table 4: Pregnancy signs in dairy cows

Pregnancy signs	Author
Absence of heat(no return to estrus)	Gietema (2005), Bayemi *et al*. (2007), Banda *et al*. (2012)
Increase in the belly size	Gietema (2005)
Swollen udder	Gietema (2005)
Movement of the foetus	Gietema (2005)
Quietness	(Anon).
Physical appearance	Banda *et al*.(2012)

2.5 Heat signs

By asking the question: What signs you use to detect heat on your cows? The simple and true answers expected and used in this present analysis was any of the following, see table below: A respondent that mentioned any of the correct answer got himself or herself one mark. The more correct given, the more marks scored. This was out of (34).

Table 5: Heat signs in dairy cows

Heat signs	Author
Being mounted while standing	De Moi (2000); (Garwe, 2001).
Restlessness,	Swai *et al*. (2007) ; De Moi (2000), Dijkhuizen and van Eerdenburg (1997)
Nervousness	Mugerwa 1989)
Mucus discharge	Lopez *et al*. (2004); Mathew (2002)
Swollen vulva	At-Taras and Spahr (2001); (Garwe 2001).
Cows coming on heat tend to group together in groups of three to five	Mukasa-Mugerwa (1989)

Dirty animal(manure on flanks)	Wattiaux (1998)
Standing to be mounted	Mukasa-Mugerwa (1989); Dobson *et al*. (2008)
Mounting head to head	Mukasa-Mugerwa (1989)
Milk production decreases	Mukasa-Mugerwa (1989); Swai *et al*. (2007); At-Taras and Spahr (2001)
Feeding is less	Mukasa-Mugerwa (1989); Swai *et al*. (2007), (Garwe, 2001); Wattiaux (1998)
Bellow	Mukasa-Mugerwa (1989) ; Swai *et al*. (2007),
Lick	Mukasa-Mugerwa (1989) ; Garcia *et al*. (2011),
Bunt	Mukasa-Mugerwa (1989) ; Garcia *et al*. (2011)
Sniff the vulva or urine of other cows	Sveberg *et al*. (2011); Gilmore *et al*.(2011), Dijkhuizen and van Eerdenburg (1997)
Urinate frequently	Mukasa-Mugerwa (1989)
Muddy, rubbed back and sides	Mukasa-Mugerwa (1989)
Mounting activity	Singh and Nanda (2007)
Standing	Nordin *et al*. (2007)
Fleshmen reflex	Garcia *et al*. (2011)
Chin resting	Law *et al*. (2009); Sveberg *et al*. (2011)
Mounted but not standing	Garcia *et al*. (2011) ; Dijkhuizen and van Eerdenburg, (1997)
Standing heat	Garcia *et al*. (2011); Dijkhuizen and van Eerdenburg, (1997)
Increased activity	At-Taras and Spahr, (2001)
Standing immobile on being mounted	Law *et al*. (2009) ; Gilmore *et al*. (2011)
Standing behaviour	Lopez *et al*. (2004) ; Van Eerdenburg *et al*. (2002)
Mounting	Sveberg *et al*. (2011)
Mounting headside of another cow	Dijkhuizen and van Eerdenburg (1997)
	Van Eerdenburg *et al*. (1996)
Rubbed tail heads	Mathew (2002)
Mounting the rear of another cow	Dobson *et al*. (2008)
Cow on heat separates itself from the rest of the herd	Gietema (2005)
Cow on heat walks along fences to seek a bull	Gietema (2005)
Stands to be mounted	Gietema (2005)

2.6 Gestation length

By asking the question: What is the gestation length? The true and correct answer expected and used in this analysis has to fall with the range provided below in the table. A respondent who gave an answer falling within that range scored himself or herself one point for giving the right answer. Marked out of (7).

Table 6: Gestation length

Breed	**Gestation length (range)**	**Author**
Exotics	260-300 days (8 months 7 days to 10 months)	Scatter *et al.* (2005)
Bos indicus cattle(Zebu, Sahiwal, Boran)	270 -292 days(9 to 9 months 7 days)	Mukasa-Mugerwa (1989)
Crossbreeds	271-301 days(9 to 10 months)	Dutta *et al.* (1989)

Appendix 3 Determination of factors influencing farmers' knowledge of cattle reproductive parameters

3.1 Correlation of variables used in the models for knowledge score

```
pwcorr age years_sch milk_prd sex herdsize means_transport crossbreed zerograzing
>  dependencyratio poverty_line no_exotic, sig star(5)

         |      age years_~h milk_prd      sex herdsize means_~t crossb~d
-------------+---------------------------------------------------------------
         age |   1.0000
   years_sch |  -0.1460*  1.0000
             |   0.0009
    milk_prd |  -0.0120   0.0721   1.0000
             |   0.7872   0.1038
         sex |  -0.0536   0.2862* -0.0149   1.0000
             |   0.2273   0.0000   0.7363
    herdsize |   0.1299*  0.1428*  0.0702   0.0798   1.0000
             |   0.0033   0.0012   0.1132   0.0718
means_tran~t |  -0.0347   0.1500*  0.0234   0.1007*  0.2398*  1.0000
             |   0.4341   0.0007   0.5977   0.0229   0.0000
  crossbreed |   0.0221  -0.0030   0.0529   0.0203   0.2465* -0.0309   1.0000
             |   0.6192   0.9461   0.2335   0.6478   0.0000   0.4860
zerograzing |   0.0766   0.2356*  0.1390* -0.0011   0.1244*  0.1441* -0.2148*
             |   0.0840   0.0000   0.0017   0.9797   0.0049   0.0011   0.0000
dependency~o |  -0.1865* -0.1414* -0.0466  -0.0432  -0.0756   0.0414  -0.0947*
             |   0.0000   0.0014   0.2939   0.3307   0.0881   0.3506   0.0324
poverty_line |  -0.0486   0.2570*  0.1233*  0.1609*  0.1502*  0.1303*  0.0654
             |   0.2738   0.0000   0.0053   0.0003   0.0007   0.0032   0.1400
   no_exotic |   0.0443   0.1907*  0.1169*  0.0543   0.3795*  0.2170* -0.3487*
             |   0.3178   0.0000   0.0082   0.2213   0.0000   0.0000   0.0000

              zerogr~g depend~o povert~e no_exo~c
-------------+------------------------------------
 zerograzing |   1.0000
dependency~o |  -0.1155*  1.0000
             |   0.0091
poverty_line |   0.2010* -0.0159   1.0000
             |   0.0000   0.7197
   no_exotic |   0.5673* -0.0898* 0.1449* 1.0000
             |   0.0000   0.0426   0.0010
*Pairwise correlation is significant at the 0.05 level
```

3.2 Identification of instrumental variables using partial correlation

```
 Variable |    Corr.     Sig.
-------------+------------------
   no_exotic |   0.5508    0.000
poverty_line |   0.1461    0.001
dependency~o |  -0.0790    0.075
```

```
 Two stage (OLS) regression analysis
```

```
knowledgescore sex age years_sch  ch_school  milk_prd herdsize means_tran
>  sport  crossbreed  small_ruminants  (  zerograzing  =   poverty_line  no_exotic
dependen
> cyratio), first
First-stage regressions
-----------------------

      Source |       SS       df       MS              Number of obs =     510
-------------+------------------------------           F( 12,   497) =   43.27
       Model |   63.207395    12  5.26728292           Prob > F      =  0.0000
    Residual |  60.4965266   497  .121723394           R-squared     =  0.5110
-------------+------------------------------           Adj R-squared =  0.4991
       Total |  123.703922   509  .243033245           Root MSE      =  .34889

------------------------------------------------------------------------------
 zerograzing |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         sex |  -.0424511   .0422025    -1.01   0.315    -.1253685    .0404662
         age |   .0045098   .0012841     3.51   0.000     .0019869    .0070328
   years_sch |   .0154172   .0040743     3.78   0.000     .0074123    .0234222
   ch_school |  -.0889042   .0077241   -11.51   0.000    -.1040802   -.0737282
    milk_prd |   .0452806   .0409191     1.11   0.269    -.0351151    .1256762
    herdsize |  -.0205102   .0088646    -2.31   0.021     -.037927   -.0030935
means_tran~t |   .0544911   .0262306     2.08   0.038     .0029546    .1060276
  crossbreed |  -.0009086   .0110861    -0.08   0.935    -.0226899    .0208728
small_rumi~s |  -.0106643   .0104181    -1.02   0.307    -.0311331    .0098046
poverty_line |    .132338   .0436018     3.04   0.003     .0466715    .2180044
   no_exotic |   .1287081   .0113946    11.30   0.000     .1063207    .1510955
dependency~o |   .0341352   .0126265     2.70   0.007     .0093274     .058943
       _cons |   .0444628   .0934276     0.48   0.634    -.1390989    .2280246
------------------------------------------------------------------------------
Instrumental variables (2SLS) regression

      Source |       SS       df       MS              Number of obs =     510
-------------+------------------------------           F( 10,   499) =   10.42
       Model |  778.493306    10  77.8493306           Prob > F      =  0.0000
    Residual |  4602.24455   499  9.22293496           R-squared     =  0.1447
-------------+------------------------------           Adj R-squared =  0.1275
       Total |  5380.73785   509  10.5711942           Root MSE      =  3.0369
------------------------------------------------------------------------------
```

```
knowledges~e |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 zerograzing |   3.951237   .7125184     5.55   0.000     2.551331    5.351143
         sex |   .3318874   .3659856     0.91   0.365    -.3871751     1.05095
         age |   .0086448   .0112601     0.77   0.443    -.0134782    .0307678
   years_sch |   -.039211   .0375369    -1.04   0.297    -.1129609    .0345388
   ch_school |    .175397   .0952259     1.84   0.066    -.0116961    .3624901
    milk_prd |    .513982   .3606287     1.43   0.155    -.1945558     1.22252
    herdsize |   .1931546   .0707816     2.73   0.007     .0540879    .3322213
means_tran~t |   .2081242   .2365547     0.88   0.379    -.2566418    .6728903
  crossbreed |   .1358221   .0948894     1.43   0.153    -.0506099    .3222542
small_rumi~s |   .0143945   .0909637     0.16   0.874    -.1643245    .1931134
       _cons |   6.091503   .7631836     7.98   0.000     4.592054    7.590953
------------------------------------------------------------------------------
Instrumented:  zerograzing
Instruments:   sex age years_sch ch_school milk_prd herdsize means_transport
               crossbreed small_ruminants poverty_line no_exotic
               dependencyratio
------------------------------------------------------------------------------
```

```
 est store ivreg
```

Ordinary least square analysis

```
reg knowledgescore age years_sch ch_school milk_prd sex herdsize
means_transport crossbreed small_ruminants zerograzing

      Source |       SS       df       MS              Number of obs =     510
-------------+------------------------------           F( 10,   499) =   11.91
       Model |  1036.94878    10  103.694878           Prob > F      =  0.0000
    Residual |  4343.78907   499  8.70498812           R-squared     =  0.1927
-------------+------------------------------           Adj R-squared =  0.1765
       Total |  5380.73785   509  10.5711942           Root MSE      =  2.9504

------------------------------------------------------------------------------
knowledges~e |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         age |   .0157875   .0106746     1.48   0.140    -.0051852    .0367601
   years_sch |  -.0009993   .0341485    -0.03   0.977    -.0680919    .0660934
   ch_school |  -.0094123   .0687603    -0.14   0.891    -.1445076    .1256831
    milk_prd |   .7077094   .3442965     2.06   0.040     .0312599    1.384159
         sex |   .2784109   .3551091     0.78   0.433    -.4192824    .9761043
    herdsize |    .245652   .0664798     3.70   0.000     .1150372    .3762669
means_tran~t |    .384442   .2221009     1.73   0.084    -.0519261    .8208102
  crossbreed |   .0199868   .0836266     0.24   0.811    -.1443169    .1842905
small_rumi~s |   -.007753   .0880607    -0.09   0.930    -.1807685    .1652625
 zerograzing |   2.138616   .3326581     6.43   0.000     1.485033      2.7922
       _cons |   6.416694   .7334023     8.75   0.000     4.975757    7.857631
------------------------------------------------------------------------------
```

3.3 Determining the appropriate model

```
 hausman ivreg
    ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     ivreg          .          Difference          S.E.
-------------+----------------------------------------------------------------
 zerograzing |    3.951237     2.138616        1.812621        .6300961
         sex |    .3318874     .2784109        .0534765        .0885603
         age |    .0086448     .0157875       -.0071426        .0035836
   years_sch |   -.039211     -.0009993       -.0382118        .0155852
   ch_school |     .175397    -.0094123        .1848092        .0658786
    milk_prd |     .513982     .7077094       -.1937274        .1072985
    herdsize |    .1931546      .245652       -.0524975        .0242995
means_tran~t |    .2081242      .384442       -.1763178        .0814208
  crossbreed |    .1358221     .0199868        .1158353        .0448396
small_rumi~s |    .0143945    -.007753         .0221475        .0227968
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from ivreg
          B = inconsistent under Ha, efficient under Ho; obtained from regress

    Test:  Ho:  difference in coefficients not systematic

                 chi2(10) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =        8.28
                   Prob>chi2 =      0.6019
```

3.4 Regression analysis of farmersô knowledge on cattle reproductive parameters

```
. reg knowledgescore age years_sch ch_school milk_prd sex herdsize
means_transport crossbreed small_ruminants zerograzing dependencyratio
poverty_line no_exotic

      Source |       SS       df       MS              Number of obs =     510
-------------+------------------------------           F( 13,   496) =    9.98
       Model |  1115.50595    13  85.8081498           Prob > F      =  0.0000
    Residual |  4265.23191   496  8.59925787           R-squared     =  0.2073
-------------+------------------------------           Adj R-squared =  0.1865
       Total |  5380.73785   509  10.5711942           Root MSE      =  2.9324

------------------------------------------------------------------------------
knowledges~e |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         age |   .0186259   .0109262     1.70   0.089    -.0028414    .0400931
   years_sch |   -.003273   .0347346    -0.09   0.925    -.0715181    .0649721
   ch_school |  -.0273503   .0730644    -0.37   0.708    -.1709043    .1162037
    milk_prd |   .6226083   .3443527     1.81   0.071    -.0539616    1.299178
         sex |   .2332423   .3550779     0.66   0.512       -.4644    .9308846
    herdsize |   .1412019   .0749083     1.88   0.060    -.0059748    .2883786
means_tran~t |   .3382804   .2214262     1.53   0.127    -.0967685    .7733293
  crossbreed |   .1375061   .0931804     1.48   0.141    -.0455707     .320583
small_rumi~s |  -.0099944   .0876572    -0.11   0.909    -.1822195    .1622308
 zerograzing |   1.594298   .3770208     4.23   0.000     .8535428    2.335052
dependency~o |   .0544724   .1069042     0.51   0.611    -.1555686    .2645133
poverty_line |   .2446782   .3698584     0.66   0.509    -.4820042    .9713606
   no_exotic |   .3146381   .1073643     2.93   0.004     .1036931    .5255831
       _cons |   6.290039   .7854483     8.01   0.000     4.746822    7.833255
------------------------------------------------------------------------------
```

3.5 Testing for collinearity

```
. vif
    Variable |       VIF       1/VIF
-------------+----------------------
   no_exotic |      2.17    0.461007
 zerograzing |      2.04    0.489043
   ch_school |      1.57    0.635115
    herdsize |      1.57    0.635816
  crossbreed |      1.46    0.685544
   years_sch |      1.29    0.775235
dependency~o |      1.25    0.797363
poverty_line |      1.15    0.871165
means_tran~t |      1.13    0.884150
         age |      1.13    0.884307
         sex |      1.12    0.889534
small_rumi~s |      1.05    0.952727
    milk_prd |      1.05    0.953685
-------------+----------------------
    Mean VIF |      1.38
```

3.6 Testing for heteroskedasticity

```
. estat hettest
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of knowledgescore
         chi2(1)      =     0.04
         Prob > chi2  =   0.8498
```

Appendix 4 Ordinary least squares for milk production

4.1 Correlation of variables used in the estimation of milk production

```
pwcorr knowledgescore1 sex age years_sch ch_school no_exotic crossbreed small_r
> uminants milk_prd poverty_line zerograzing, sig star(5)

             | knowle~1      sex      age years_~h ch_sch~l no_exo~c crossb~d
-------------+---------------------------------------------------------------
knowledges~1 | 1.0000
         sex | 0.0460   1.0000
             | 0.2955

         age | 0.1280* -0.0656   1.0000
             | 0.0035   0.1350
             |
   years_sch | 0.1398*  0.2869* -0.1340*  1.0000
             | 0.0014   0.0000   0.0022
             |
   ch_school |  -0.1481*  0.0841   0.0085  -0.0862*  1.0000
             |   0.0007   0.0553   0.8464   0.0495
             |
   no_exotic |   0.3391*  0.0520   0.0501   0.1886* -0.2027*  1.0000
             |   0.0000   0.2362   0.2544   0.0000   0.0000
             |
  crossbreed |  -0.0093   0.0277   0.0194   0.0032   0.0568  -0.3477*  1.0000
             |   0.8325   0.5288   0.6592   0.9423   0.1959   0.0000
             |
small_rumi~s |   0.1076*  0.0937*  0.0073   0.1675* -0.0566   0.0517   0.0742
             |   0.0141   0.0326   0.8675   0.0001   0.1975   0.2390   0.0910
             |
    milk_prd |   0.1267* -0.0115  -0.0125   0.0672  -0.0952*  0.1216*  0.0478
             |   0.0038   0.7927   0.7768   0.1257   0.0300   0.0055   0.2761
             |
poverty_line |   0.1544*  0.1724* -0.0495   0.2556* -0.0295   0.1517*  0.0692
             |   0.0004   0.0001   0.2599   0.0000   0.5024   0.0005   0.1152
             |
 zerograzing |   0.3881* -0.0033   0.0920*  0.2446* -0.4815*  0.5653* -0.2103*
             |   0.0000   0.9393   0.0359   0.0000   0.0000   0.0000   0.0000
             |

             | small_~s milk_prd povert~e zerogr~g
-------------+------------------------------------
small_rumi~s |   1.0000
             |
             |
    milk_prd |  -0.0503   1.0000
             |   0.2525
             |
poverty_line |   0.1027*  0.1230*  1.0000
             |   0.0192   0.0050
             |
 zerograzing |   0.0404   0.1431*  0.2033*  1.0000
             |   0.3581   0.0011   0.0000
```

```
Pairwise correlation is significant at the 0.05 level
```

4.2 Regression analysis of transformed milk production model

```
regress  MILK knowledgescore sex age years_sch ch_school no_exotic crossbreed
small_ruminants milk_prd poverty_line zerograzing

      Source |       SS       df       MS              Number of obs =     518
-------------+------------------------------           F( 11,   506) =   12.96
       Model |  1250.9192    11  113.719927           Prob > F      =  0.0000
    Residual |  4440.79027   506  8.77626535           R-squared     =  0.2198
-------------+------------------------------           Adj R-squared =  0.2028
       Total |  5691.70947   517  11.0091092           Root MSE      =  2.9625

------------------------------------------------------------------------------
        MILK |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
knowledges~e |   1.591962   .3359247     4.74   0.000     .9319833    2.251941
         sex |  -.2648511   .3554747    -0.75   0.457    -.9632392    .4335369
         age |   .0036227   .0105883     0.34   0.732    -.0171798    .0244251
   years_sch |   .0394899   .0343214     1.15   0.250    -.0279401    .1069199
   ch_school |   .0747564   .0680695     1.10   0.273    -.0589773      .20849
   no_exotic |   .2819084   .0945452     2.98   0.003      .096159    .4676579
  crossbreed |   .2727594   .0850641     3.21   0.001     .1056372    .4398816
small_rumi~s |   .0583141   .0812242     0.72   0.473    -.1012641    .2178923
    milk_prd |   1.266954   .3467129     3.65   0.000     .5857803    1.948128
poverty_line |    .978524    .370564     2.64   0.009     .2504906    1.706557
 zerograzing |   .8251268   .3793584     2.18   0.030     .0798153    1.570438
       _cons |  -2.284734   .9390745    -2.43   0.015    -4.129699   -.4397685
------------------------------------------------------------------------------
```

4.3 Test for collinearity

```
vif
 Variable |       VIF       1/VIF
-------------+----------------------
 zerograzing |      2.07    0.483017
   no_exotic |      1.68    0.596355
   ch_school |      1.35    0.739675
   years_sch |      1.26    0.796623
knowledges~e |      1.21    0.824441
  crossbreed |      1.20    0.832907
poverty_line |      1.14    0.874907
         sex |      1.13    0.888052
         age |      1.06    0.940659
    milk_prd |      1.06    0.941100
small_rumi~s |      1.05    0.948841
-------------+----------------------
    Mean VIF |      1.29
```

4.4 Test for heteroskedasticity

```
Hottest
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of MILK
         chi2(1)      =     2.61
         Prob > chi2  =   0.1063
```

Appendix 5 Questionnaire for Data Collection: FAO/IFAD Project

ICIPE: International Centre for Insect Physiology and Ecology - African Insect Science for Food and Health

P.O. BOX 30772 ï 00100 NAIROBI

TEL: 020 8632000, FAX: 020 8632001

Enumerators please read or translate the following to farmers at the beginning of the interviews:

Dear respondent, this is a special purpose survey, aiming at investigating issue of animal production in order to propose workable strategies to animal health. The survey mainly covers some relevant aspects of your situation including: livestock keeping, production and output. Please answer the questions honestly and in accordance with the actual situation of your household, assisting the enumerators to complete the questionnaire in good conditions. We will strictly keep any personal information that you provide confidential. Thank you for your cooperation!

Name of the enumerator: é é é é é é é é é é é Date: é é é é é é é é é é
Questionnaire No: /______/
1- Identification
1. Divisioné é é é é é é é é é 2. Location: é é é é é é é é é é é é é ...
3. Village: é é é é é 4. GPS coordinates: X = é é é é Y = é ..é é ....
5. Name of the respondenté ....
6. Relationship of the respondent to the household (HH) head:
1. Self /___/ 2. Spouse /___/
3. Son /___/ 4. Daughter /___/ 5 /___/ Other (Specify) é é ....
7. Sex of the HH head: 1. Male /___/ 2. Female /___/
8. Age of the HH head: /_______/
9. Ethnic group of the HH head: é é é é é é é é é é é é é é é é ....
10. Religion of the HH head: é é é é é é é é é é é é é é é é é ....
11. Education level of the HH head: (Please record the number of years at each level)
0. None /___/ 1. Primary incomplete /___/ 2. Primary complete /___/
3. Secondary incomplete /___/ 4. Secondary complete /___/ 5. University /___/
6. Other /___/ (Specify) é ..

12. Number of persons in the household /____/

Age	Male	Female	Active	Non active
0 to 5 years				
6 years to 14 years				
15 years to 64 years				
More than 64 years				

13. How many children go to school? /____/

14. How many Bikes, Motobikes and Cars do you have in the household?

Bikes	Moto bikes	Cars

2- Animal Production

2.1- Herd composition

Categories	Number	Number owned by female
Calves 0 to 1year		
Male > 1 year		
Heifers		
Cows		

2.2- Number of oxen if any/____/

2.3- Cow breed in the herd (including cows in Zero grazing)

Races	Number
Friesian	
Ayrshire	
Guernsey	
Boran	
Local Zebu	
Sahiwal	
Crossbreed	

2.4- What are the reasons of the choice of the breed?

Friesian :...

Ayrshire:..

Guernsey:..é

Boran :...é é

Local Zebu:..

Crossbreed..

2.5- How many sheep and goats do you have? /____/ Number owned by female /____/

2.6- What are the roles of cattle in the household? (Please rank the role)

Role	Rank
Meat Production	
Milk Production	
Manure Production	
Saving	
Sale	
Animal traction	
Prestige	

2.7- What are the signs do you use to detect heat on your cows? (Please rank the signs)

Signs	Rank

2.8- At which age do you observe the first heat in your heifer? ....

2.9- What is the duration from calving to the first heat? ....

2.10- How many heats do you observe in your heifer before you call the inseminator? ...

2.11- How many heats do you observe after calving before you call the inseminator? ....

2.12- For reproduction what do you use? 1. Bull /___/ or 2.Artificial Insemination (AI /___/

2.13- After how many hours do you serve your cow after detecting the heat?

1 to 2/___/ 2 to 4/___/ 4 to 6/___/ 6 to 8/___/ 8 to 10/___/ 10 to 12/___/ >12/___/

2.14- How do you know that your cow is pregnant? (Please rank the signs)

Signs	Rank

2.15- What is the duration from calving to the conception? ....

2.16- What is the gestation length? ....

2.17- Do your cows ever have placenta retention during the last 12 months?

1 YES /___/ 2 NO /___/

2.18- If YES, How many times? ....

2.19- Reproductive performance

	Cow 1	Cow 2	Cow 3	Cow 4
Artificial Insemination AI (1 = Yes; 0 = No)				
Breed (1= Friesian, 2= Ayrshire, 3= Guernsey 4= Boran, 5= Local Zebu 6=Sahiwal and 7= Crossbreed)				
Age (Approximately)				
Number of calving				
How many times the cow was inseminated during the last 12 months?				
How many times the cow aborted during the last 12 months?				
How many times the cow calved during the last 12 months?				

2.20- Dairy production

		Cow 1	Cow 2	Cow 3	Cow 4
Zero-grazing (1 = Yes; 0 = No)					
Breed (1= Friesian, 2= Ayrshire, 3= Guernsey 4= Boran, 5= Local Zebu 6=Sahiwal and 7= Crossbreed)					
Last calving date MM/YY					
Lactation length (Number of months cow is milked)					
TOTAL DAILY MILK PRODUCTION (Morning plus evening milk) in litres	At Calving (initial milk production)				
	Yesterday				
Number of cows being milked of that breed					

2.21- Cattle exists

Have any cattle exited the household herd during the past 12 months. (0 = No, 1 = Yes, 2 = don't know) [   ]

If yes, fill in the below table.

				If sold			
	Animal type (*)	How exited (**)	How many animals exited?	Purpose of selling (***)	Average price per animal Currency [KSH]	Where sold? (****)	Who controls the money? (*****)
1							
2							
3							
4							
5							

Coding for ANIMAL TYPE (*)	Coding for HOW EXITED (**)	Coding for PURPOSE OF SELLING (***)	Coding for WHERE SOLD (****)	Coding for WHO CONTROLS THE MONEY? (*****)
1= calve 2= Male > 1 year 3= Heifers 4= Cows 5= oxen	1=Sale (live animals) 2=Died, lost or stolen 3=Slaughter for household needs 4= Given away Other: (specify in cell)	1=To meet planned household expenses 2=To meet emergency household expenses 3=Livestock trading as a business 4=Culling Other: (specify in cell)	1=Farm gate 2=Village market 3=Regional town or market 4= Abattoir / butchery Other: (specify in cell)	1= head 2= spouse 3= other female member 4= other male member 5= other, specify

2.22- Livestock entries: Cattle (Entry over the last 12 months)

	Animal type (*)	How many of this type (number)	Means of entry (**)
1			
2			
3			
4			
5			

Coding for ANIMAL TYPE (*)	Coding for MEANS OF ENTRY (**)
1= calve 2= Male > 1 year 3= Heifers 4= Cows 5= oxen	1=Born into herd/ flock 2= Purchased 3= Gift/ inherited

2.23- Animal Traction

How many oxen are at work in your household	Number of months of work over the last 12 months	Number of days of work per month	Number of hours of work per day	Area cultivated (ha) over the last 12 months

2.24- Inputs (bought over the last 12 months)

Category	Quantity	Unit Price (KHS)	Total (KHS)
Artificial Insemination (AI)			
Preventive Trypanocides			
Curative Trypanocides			
Vaccines			
Antibiotics			
Anti-helminties			
Acaricides/Insecticides			
Vitamins			
Salts			
Feed bought			
Veterinary fees costs			
Labour cost for herding			

2.25- Income

In which of the following categories do you estimate your total monthly household income, from all farm activities, working members, business income, pensions and remittances from elsewhere (tick).

Ksh per month	Tick
< 2,500	
2,500 - 5,000	
5,000 - 10,000	
10,000 - 20,000	
20,000 - 30,000	
> 30,000	

Appendix 6 Interviewer capturing responses from respondents

Interviewer capturing responses assisted by the Icipe field staff to interpret the responses given by the respondent