

**DETERMINANTS OF SELECTION CRITERIA, BREED PREFERENCE AND
WILLINGNESS TO USE ARTIFICIAL INSEMINATION FOR EAST AFRICAN
ZEBU CATTLE BREEDING FOR DAIRY PRODUCTION: CASE OF KITUI
COUNTY, KENYA**

MARGARET WANJIRU KIMANI

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for the Master of Science Degree in Agricultural and Applied Economics of Egerton
University**

EGERTON UNIVERSITY

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DECLARATION AND RECOMMENDATION

Declaration

I declare that this thesis is my original work and has not been presented in this or any other university for the award of a degree.

Signature: 

Date: 18.10.21

Margaret Wanjiru Kimani

KM17/3022/11

Recommendation

This research thesis has been submitted with our approval as the Egerton University supervisors

Signature: 

Date: 22/09/2021

Prof. Ngigi Margaret, PhD.

Department of Agribusiness and Agricultural economics,

Egerton University, Njoro, Kenya.

Signature: 

Date: 18.10.2021

Dr. Evans Ilatsia, PhD.

Kenya Agricultural and Livestock Research Organization,

Naivasha, Kenya.

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DEDICATION

This thesis is dedicated to my husband Jack, my sons; Wilfred & Darren and my parents; Peter and Frassiah for their unwavering love and support.

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First, I give all glory and honour to Almighty God for his favour, grace and all the blessings bestowed on me. Secondly, I am sincerely indebted to Egerton University for the opportunity to pursue this program. I also acknowledge Agricultural Economics Research Consortium (AERC) for the financial support that enabled me to pursue the program and Kenya Agricultural and Livestock Research Organization (KALRO) - Naivasha for the support in the data collection activity. I sincerely and specially thank Prof. Ngigi Margaret for her relentless guidance, constructive criticism and suggestions during the preparation and writing of this dissertation. Special thanks to Dr. Evans Ilatsia for all the support he has relentlessly accorded me in the entire research. Particular gratitude goes to my friends, colleagues and the entire Agricultural Economics Department of Egerton University for their assistance in this undertaking. I thank all interviewees in Kitui County for their cooperation in this research. I also thank my husband Jack, our two sons Wilfred and Darren, My Dad Peter, My Mum Frassiah and the entire family for their love and support during the entire study.

ABSTRACT

East African Zebu (EAZ) cattle play very important roles in the livelihoods of the Arid and the Semi-arid communities. Despite the EAZ being the most populous in these areas, the breed contribution to the dairy industry is very low. To ensure success of the attempts to improve the breed for more milk production, there is need to understand how the indigenous farmers select their breeding cow or bull for more milk production. This study was, therefore, conducted in Kitui County to determine the farmers' selection criteria for breeding bull or cow for increased milk production. The mean ranks obtained indicated that the bulls body frame (5.94), udder shape (6.04), teat size and placement (5.8) for cows were the most important in the selection for milk production. Traits associated with fitness (body frame), cultural or aesthetic (appearance) value in bulls were highly valued by the farmers and these traits cannot be underrated as high performing bulls without these attributes were not selected for breeding. The odds ratio obtained indicated that farmers' most important production traits were milk and draught power. About 42% of the households preferred to keep local animals crossbred with exotic dairy animals but only 19% had actually crossbred their cattle revealing farmers were constrained in undertaking such breeding activities. Natural mating was the breeding method used by majority of the farmers. There was a glaring difference between the actual use of artificial insemination (AI) (7%) and the farmers' willingness to use AI (75%). Multivariate probit regressions showed that male farmers had a higher preference for bulls' body frame than female farmers. The bigger the household size the higher was the preference for teat size, tail size and body shape. This study concluded that selection criteria in breeding bulls and cows is significantly influenced by socio-economic and demographic factors. Key recommendation is to consider farmer breed preferences and selection criteria for traits in the planning and designing a communal breeding program

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LIST OF ABBREVIATIONS

AERC	Agricultural Economics Research Consortium
AI	Artificial Insemination
ASALs	Arid and Semi-Arid Lands
EAZ	East Africa Zebu
ECF	East Coast Fever
FAO	Food and Agricultural Organization
GDP	Gross domestic product
KALRO	Kenya Agricultural and Livestock Research Organization.
MOLD	Ministry of Livestock Development
MVP	Multivariate Probit
OR	Odds ratio
SDP	Smallholder Dairy Project

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Approximately seventy percent of the poorest people in the world draw income from livestock and livestock products value chains (Pica *et al.*, 2008). Traditional rural farmers in arid and semi-arid lands (ASALs) acquire many benefits from indigenous cattle ranging from turning poor-quality herbage into valuable meat and milk, generating income; storing wealth; providing safety nets against risks; providing traction and turn crop wastes into useful organic manure (Anderson, 2003; Chebo *et al.*, 2014).

East Africa Zebu (EAZ) cattle are genetically low input low output animals with very low contribution to the dairy industry. However, they are diverse with unique attributes such as ability to withstand harsh environmental conditions (higher disease incidences, drought and low feed availability) in the lowland areas, have better traction ability and preferred coat colour for cultural practices (Chebo *et al.*, 2014; Gamba, 2006; Getachew, 2006).

Even though exotic breeds and their crossbreds produce more milk, they are not the best-suited substitutes especially in areas with environmental stress. To compensate for relatively lower production potential of indigenous cattle, farmers have crossbred their indigenous cattle with exotic breeds, often leading to uncontrolled genetic mixing (Okeyo *et al.*, 2015). Farmers in medium and high potential areas have continuously substituted low milk producing indigenous cattle with high milk producing exotic cattle. The short-term increase in productivity from these exotic breeds and their crossbreds have often resulted in genetic erosion of adaptability traits before these genetic resources are fully utilized (Biscarini *et al.*, 2015; Conway & Waage, 2010; MoLD, 2010).

In Kenya, 72% (9 million out of 12.5 million) of cattle are still pure EAZ (not diluted or contaminated with exotic genotypes) mainly found in ASALs KNBS (2019) and produce only 19% of the total milk in the country (Muriuki *et al.*, 2011). Breed improvement programs provide a key entry to increase the milk production and productivity of EAZ (Ouma, 2005). However, very few breeding programs have been dedicated to improving the milk traits in the EAZ largely because the development agencies have for long regarded them as inferior, unproductive and without any foreseeable room for improvement (Mathias *et al.*, 2005). The few programs implemented have not been effective (Okeyo *et al.*, 2015) and the requisite technologies to improve their milk productivity have not been adopted largely because they do not meet the farmers' needs (Makokha *et al.*, 2007).

Designing and implementing a sustainable breeding program for indigenous breeds in low input production system is a challenge due to limited resources (scarcity of feed and water). In addition, indigenous cattle are raised for multipurpose functions which influences their selection criteria for genetic improvement, hence challenging to develop breeding programs at the backdrop of multiple priority traits (Duguma *et al.*, 2011). To mitigate such challenges, participation in planning and designing of breeding programs by the target beneficiaries is vital for the success and sustainability of such livestock development interventions (Rege *et al.*, 2011). According to Scholtz and Theunissen (2010) most African cattle breeds have not been selected consistently for productivity gains and information on selection criteria for dairy traits is very scanty. It is at this backdrop that the current study aims at assessing the cattle selection criteria, breed and trait preference and willingness to adopt AI.

1.2 Statement of the problem

The dairy traits which are carefully and consistently selected for in exotic breeds are poorly developed in EAZ. Breed substitution and uncontrolled crossbreeding are regarded as the only methods to meet the increasing milk demand. Hence, farmers have indiscriminately crossbred EAZ as a way to improve their milk production. However, such programs have only resulted in the erosion of adaptability and draught power traits which allows the very existence of EAZ in ASALs and has given rise to inbred smaller and low producing cattle.

Selection procedures and systematic crossbreeding for dairy production can help to sustainably enhance the genetic potential for dairy in EAZ. However, rarely have breed improvement program focused on EAZ as a purebred or a dam for systematic crossbreeding for increased dairy production. For such well-intended programs to succeed, farmers participation in their planning and designing is key so as to align the selection criteria, trait preference and production environment with the breeding objectives of the intervention program. Previous interventions have always disregarded the indigenous selection criteria of the community that manages EAZ, farmers situations and their production features leading to development of breeds not suitable for the farmers circumstances. In addition, EAZ is very populous in the area hence understanding the factors for its high preference is key information for designing a breeding program. Adoption of artificial insemination, which can aid in controlled crossbreeding, is still very low in ASALs.

Appreciating the dominance of EAZ, broad perspectives for rearing EAZ and recognizing the myriad of constraints in Kitui county, this study was therefore designed to identify the farmers socio-economic characteristics; constraints to milk production, farmers selection

criteria for more milk production, factors for such selection criteria; breed and trait preference and willingness to use Artificial insemination.

1.3 Objectives of the study

The general objective of this study was to contribute to the improvement of the milk productivity of EAZ cattle through evaluation of the socioeconomic factors determining their selection criteria and breed and trait preference in Kenya. To achieve this, the specific objectives were:

- i. To determine selection criteria for breeding cattle and socioeconomic factors that influence such selection criteria in Kitui County.
- ii. To determine the socio-economic factors influencing the farmers' preference for EAZ to other breeds for dairy production in Kitui County.
- iii. To identify the socioeconomic factors that predict the willingness to adopt artificial insemination in cattle breeding in Kitui County.

1.4 Research questions

- i. Which traits are considered by farmers to be of great importance in their selection for EAZ cattle breeding and what are the factors that influence their selection criteria in Kitui County?
- ii. What are the socio-economic factors that determine the farmers' preference for EAZ to other breeds for dairy production in Kitui County?
- iii. What are the socioeconomic factors that affect the farmers' willingness to use artificial insemination in cattle breeding in Kitui County?

1.5 Justification of the study

The genetic pool of indigenous cattle currently utilized in commercial livestock production is very small. East Africa Zebu constitute 80% (19.2 % are exotic breeds) of the total cattle population with only 13.2% (over 80% milk production comes from exotic breeds) contribution to the annual milk production in Kenya. There is therefore need to focus on the well-adapted breed to the harsh climatic conditions for milk production. This study will be a major departure from the current dairy commercial production trends, which have tended to focus on a few breeds to produce milk for the market. Furthermore, the paucity of knowledge about these indigenous breeds limits their full exploitation in commercial agriculture systems.

Breeding schemes currently in place select breeding animals under high management regimes both feeding and veterinary care while their offspring are expected to perform under low management regimes and stressful environments. This study will give information on

farmers' characteristics, production features and preferences, such information will shed light on important attributes to incorporate in a breed improvement program hence assure that interventions are consistent with the circumstances of the intended beneficiaries. East Africa Zebu cattle contribute heavily to the livelihoods of the poorest in Kenya, addressing the issue of milk productivity will positively affect people's income and food security.

1.6 Scope and limitations

The study focused on livestock farmers in Kitui County who owned cattle in their herd to explore into the socio-economic factors that influence farmers' selection criteria for a bull and cow for breeding as well their influence on adoption of dairy technologies aimed at improving the performance of indigenous cattle. The uniqueness of the settings of the study (agro-pastoral enterprises) to a small extent limited the generalization of the results to other farming systems, for instance, intensive farming system. The agro-ecological condition of the area, market access and other level of infrastructures, and ethnical characteristics also differ from some other parts of the country making generalization of the results to the country as a whole limited to some extent.

The study area was characterized by rearing of cattle that perform multiple functions, low input managements systems, diseases and environmental stresses that hamper milk production in the area. Livelihoods depend on cattle such that any reduction or removal of the breed leads to major threats.

1.7 Operational definition of terms

Artificial Insemination- method where semen is introduced into the female uterus artificially using a postulate or other such means. Semen used is obtained from healthy and qualifying males in terms of meeting the breeding objectives.

Breeding objective - comprises of traits targeted for improvement in the breeding program based on their influence on returns and costs to the producer.

Crossbreeding – The act or process of producing offspring by mating purebred individuals of different breed varieties or species.

Indigenous cattle- refers to the humped EAZ type found in the ASALs

Selection criteria - are the characteristics used in assessing the breeding value of individuals. Criteria are based on both cows and bulls' traits.

Selective breeding – refers to the process of choosing breeding stock based on certain traits that the breeder desires to use in improving his stock for milk production.

Trait Preference – features that makes a farmer like or dislike a certain cattle breed

1.8 Outline of chapters

Chapter one presents the general introduction of the study specifically the background, the statement of the problem addressed, the aim and rationale behind the study. Chapter two presents the literature review of the past studies, which are relevant to this study; a review on aspects related to the dairy sector, socio-economic aspect of breeding practices and programs, breed and trait preferences and artificial insemination technology. Chapter three addresses the general methodology used to address each research question, selection criteria for cows and bulls and the factors that affect such selection criteria. Chapter four records the information relating to the socio-economic aspects of EAZ, constraints to milk production, breed preference and factors influencing preference for EAZ in Kitui County. Chapter five discusses in details information on breeding practices and breeding technologies specifically AI and the farmers' willingness to use it in cattle breeding. The general conclusion and recommendation are well articulated in chapter six.

CHAPTER TWO

LITERATURE REVIEW

2.1 Kenya's dairy industry

Livestock sector is an important component of national economy especially in agrarian economies. In Kenya, the livestock sector contributes around 42% to the agricultural GDP and 12% to the national GDP with an estimated 10 million Kenyans deriving their livelihood from the sector (KNBS, 2019). However, the productivity of the livestock resources and the benefits obtained from the sector does not commensurate with the high livestock population. According to KNBS (2019), Kenya is endowed with a high population of indigenous cattle (9.3 million head of EAZ) but only 19% of the total milk production.

Despite having a fast-growing dairy industry compared to other developing countries, Kenya is still a net importer of dairy products (Makoni *et al.*, 2013; Muriuki *et al.*, 2011). The problems of the dairy industry are becoming even more serious as population increases, growing demand elasticity due to changes in consumers' tastes and preferences and rise in income (Amimo *et al.*, 2011; Yakubu *et al.*, 2019). This calls for an urgent and long-term measure to increase productivity. Moreover, Kenya's commercial dairy production largely takes place in the highlands with favorable agro-climate, infrastructure and market access. On the other hand, the dairy production in ASALs is markedly low due to low genetic potential of the local breeds, institutional, environmental and infrastructural constraints (Kosgey *et al.*, 2007; Markos, 2006). Amidst the high population of the EAZ and constraints in their production system, genetic improvement is very critical (Yakubu *et al.*, 2019).

2.2 Socio-economic factors and production constraints

Identification of prevailing situation and understanding of the existing livestock production system constraints helps to devise appropriate development interventions. Socio-economic factors have an influence on animal and farm management, decision-making and the general farmers' perception of breed. Therefore, to avoid implementing overly ambitious breeding programs, information on socio-economic and farm characteristics is paramount (Ayalew *et al.*, 2013). Without a good understanding of these factors, it would be very difficult to persuade the local farmers to fully participate and cooperate in a breeding program (Camara *et al.*, 2019; Kosgey *et al.*, 2006).

Various studies have enumerated constraints and socio-economic characteristics that hamper livestock production in ASALs which include but not limited to health and feeding

management practices, low adoption of dairy technologies, low growth and reproductive performances, lack of extension services, presence of diseases, frequent drought and lack of markets (Mingoas *et al.*, 2014; Mwacharo & Drucker, 2005; Onono *et al.*, 2013; Thornton, 2010).

Whereas previous studies have explored much on production objectives and breeding practices especially for small ruminants, only a few studies have assessed socio-economic characteristics, constraints to milk production, breeding practices and production objectives of EAZ cattle especially in agro-pastoral settings. Mwacharo and Drucker (2005) identified constraints which directly affects breeding in semi-arid areas and how a breeding scheme can alleviate such constraints. Open breeding scheme was recommended as a way to address the constraints associated with inbreeding (small herd size and communal use of pastures and water resources). The scarcity of water for livestock use under pastoral areas was also reported (Opiyo *et al.*, 2011; Thornton, 2010). Scarcity of water and feeds makes controlled breeding difficult especially where pastures and water resources are used communally. Water points are sometimes limited and large numbers of animals use the same points leading to high chances of spreading diseases and land degradation.

Inadequate quantity and quality feeds during the dry season, produced at competitive cost and without compromising household food security has also reported as a constraint (Masikati, 2010). Peeling and Holden (2004) pointed to the failure of government services to provide veterinary health services, poor housing, low soil fertility for forage production and weak market chains for livestock and livestock products. These constraints are, however, within farmers' capacity to mitigate (Masikati, 2010) and are production system specific therefore important to assess them before attempting any livestock development intervention. It is important to know how farmers perceive different constraints as this will help to understand the intensity of these constraints.

Gender of the household head has been found to have an effect on cattle breeding. A study by Verbeek *et al.* (2007) showed that cattle breeding activity is largely undertaken by men. The same authors, who worked on socio-economic aspects of small ruminants breeding in Kenya, found that animals were in most cases owned by the household head only or by both the household head and the spouse. According to Mulugeta *et al.* (2014) women play a very crucial role in the livestock husbandry, processing selling of milk and milk products. The same authors concluded that it is the preference of the men, which are of great importance to the breeding program since men made the purchase and sale decisions of cattle.

The number of children in the household reflects availability of labor for livestock activities. Family size has been reported as the most important determinant of the labor investment in the smallholder dairy farms (Fita *et al.*, 2012).

Education levels of the majority of the farmers will tell if there will be an effective informative interface between all stakeholders (farmers, extension officers, researchers and development agents) in the breeding activities. This has a major impact on the reception of a breeding program instituted in an area. Amimo *et al.* (2011) found a positive correlation between education and the number of livestock kept, income levels of the household and land owned. Education level of the farmer will help farmer easily understand and adopt strategies that will increase productivity (Wetengere, 2009). For genetic improvement programs to be successful there is the need for appropriate understanding of the production circumstances and socio-economic factors so as to holistically address their constraints such as feeding, breeding, health, management and marketing infrastructure.

2.3 Production objectives and breeding practices

Previous studies have reported that the reasons for raising cattle, as well as trait and breed preferences reflects the multiple objectives of the farmers (Bebe *et al.*, 2003; Tano *et al.*, 2003; Traoré *et al.*, 2017). They emphasized that cattle give both tangible (cash income from animal, milk and meat sales and for home consumption, draught power) and intangible benefits (savings, an insurance against emergencies, cultural and ceremonial purposes). It has been reported that high preference for milk production traits was common among many traditional African cattle owners because they keep cows primarily for milk). Milk production has been frequently ranked as the primary reason for rearing cattle (Garoma *et al.*, 2013). However, the appropriate breeds for milk production are not adopted. In addition, farmers' breeding practices are not the best for milk production. Breeding decisions also reflect the multiple objectives farmers have in mind (Dana *et al.*, 2010).

Despite the high population of indigenous breeds and their multiple functions, the average milk production of EAZ is generally low. Kahi and Rege (2006) reported the average milk production of 6 litres per day compared to improved dairy breeds whose average daily milk production at 30 litres. However, indigenous breeds (EAZ) are preferred by famers due to their adaptability, availability of the bull service and multi-functionality attribute (Okeyo *et al.*, 2015). Given the indigenous breed's suitability and adaptability in areas with environmental stress, improving their milk productivity can be a pathway to get their keepers out of

poverty. The EAZ cattle are mainly common with communities that are relatively poor, food insecure and they mainly keep it for subsistence.

Indigenous breeds have evolved and become well adapted to areas with environmental stress through natural selection. However, they are not consistently selected for increased productivity (Gizaw *et al.*, 2014). Breeding practices are characterized by little or no genetic progress. Farmers are found to have no breeding direction because of varied selection criteria, low selection intensity as the herd sizes are small, uncontrolled mating and negative selection practices through the sale of the best performing animals (Kosgey & Okeyo, 2007; Rege *et al.*, 2011). This indicates farmers breeding practices can be progressive or retrogressive as far as productivity is concerned. It is therefore paramount to understand the breeding practices of the farmer before attempting a breed improvement intervention.

Natural mating has been reported to be the main breeding method in the ASALs (Mwacharo *et al.*, 2006). Availability, associated costs, shortage of work force, low knowledge, negligence of the farmer were reported as the major reasons for low use of artificial insemination (Temba *et al.*, 2011). Uncontrolled breeding dominates most of these areas where farmers use communally owned. Thus, bulls could be mating close relatives. Increased inbreeding and the use of unproven bulls and limited artificial insemination (AI) services may have unfavorable long-term effects on productivity through the degradation of the herd genotype (Bebe *et al.*, 2000).

To design and implement effective breeding programs, the breeding practices and production objectives need to be identified (Duguma *et al.*, 2011; Tibbo *et al.*, 2006). Due to absence of performance recording and low literacy levels in most low input area, data on breeding practices and production decisions can only be made available by soliciting from the farmers (knowledge and experience) and observing the characteristics of cattle and farmers (Wurzinger *et al.*, 2005). Engaging farmers will help understand the reasons for adopting and adapting certain breeding practices. A thorough analysis of the breeding experiences and production objectives is required in defining breeding objectives and consequently design genetic improvement programs.

While previous studies have identified production objectives and breeding practices associated with the rearing of cattle (Dossa *et al.*, 2015; Edea *et al.*, 2012; Kilekoung *et al.*, 2014; Onono *et al.*, 2013; Traoré *et al.*, 2017), special attention has not been given to EAZ cattle breed in semi-arid areas. In particular, there is limited information on breeding practices, production objectives and selection criteria of breeding stock used by owners of cattle in eastern parts of the country where indigenous breeds have great contribution to livelihood.

In addition, smallholder farmers and pastoralists have a lot of knowledge in cattle farming gained from their own experience and knowledge. The substantial indigenous knowledge base among farmers and pastoralists will render the genetic improvement programs for indigenous breeds sustainable (Dana *et al.*, 2010; Jabbar *et al.*, 2010). Wollny (2003) underscored the importance of local knowledge in the participatory conservation and utilization strategies on local breeds.

Tada *et al.* (2013) indicated that the good understanding of Nguni cattle traits was because of the old age of farmers and their rural farming background. Farmers' knowledge on tick control such as frequent dipping and use of conventional acaricides contributed to farmers ranking tick and disease trait as the most preferred traits.

Sölkner *et al.* (1998) emphasized on the importance of understanding indigenous selection criteria. They concluded that failure to capture cultural values and the element of risk aversion led to the failure of the well-intended breeding programs.

The importance and extent of contributions of indigenous breeds especially in ASALs are usually not well understood meaning that their valuable genetic resource continues to be neglected. Scientists have recently noted that these breeds are indeed a treasured genetic resource hence the need to embark on their improvement (Ndumu *et al.*, 2008).

2.4 Identification of breeding objectives, breed and trait preference in the low input production systems

This section presents literature on breeding objectives, breed and trait preference and their influence in planning and designing sustainable livestock development interventions.

2.4.1 Breeding objectives for low input production system

Lukuyu *et al.* (2019) reported that farmers are knowledgeable about breeding objectives but their breeding objectives are not actually defined hence selection criteria for maximum returns are not used. According to Gizaw *et al.* (2010), breeding programs can only be sustainable if breeding objectives incorporate trait preferences of the farmers. Breeding objectives for traditional smallholder systems should consider both tangible objectives (increased growth rate and milk production) and intangible objectives (saving and insurance purposes, or for ceremonies and dowry) (Wuletaw, 2004). Breeding objectives and schemes with dual purpose rather than single purpose have been reported to be more profitable (Kahi, 2000). However, priority placed on the traits to be included in the breeding objectives vary from one production system to another, hence it is important to understand the trait priority of farmers. Understanding the selection of the indigenous community will ensure that breeding objectives address the needs

and interest of the farmers who will use the genetically improved animals (Dana *et al.*, 2010; Gizaw *et al.*, 2010)

2.4.2 Trait Preference for cattle in low input production system

Identifying the preferences for traits of cattle keepers is a crucial step that feeds in to the determination of the economic weights of the traits. Wurzinger *et al.* (2005) emphasized the importance of soliciting for the farmers selection criteria in the traditional production systems since the literacy levels are low and the recording practices are not in place. Lack of data regarding local breeds has made economic analysis related to these breeds very difficult (FAO, 2012). Missing markets and market imperfections often encountered in subsistence systems of production in developing countries where most Animal Genetic Resources are found has complicated the issue of data availability (Drucker, 2001).

The basic objectives of rural life and the specific purposes for which animals are kept are embedded in the farmers' trait preference. Farmers have ranked fertility, disease resistance, calf vigor and milk yield in descending order of importance in influencing cow choice (Kassie *et al.*, 2009; Pryce *et al.*, 2004). Most rural settings goal is to produce sufficient food for the family and to generate income through sale of live animals. Choosing a cow with shorter calving interval to enhance herd increases fulfilled such objectives (Kassie *et al.*, 2007).

Ouma *et al.* (2007) discredited the utilization of the profit functions to derive the economic value for cattle traits as it would result in the exclusion of trait not traded in the market in the formulation of breeding objectives. The focus of the profit function approach tends to be on improvement of those traits that have a high positive impact on net profit. Some important non-marketed traits are present in indigenous breeds and not in high yielding crossbred cattle (Scarpa *et al.*, 2003).

Ndumu *et al.* (2008) enumerated three methods used in the evaluation of both market and non-market traits to elicit farmers' preference for traits; contingent valuation methods (Kamuanga *et al.*, 2011; Roessler *et al.*, 2008), phenotypic ranking (Ndumu *et al.*, 2008) and surveys. In a survey, preferences are recorded statements by farmers while in the other two preferences are measured directly in the form of ranking. Survey questionnaire enables to undertake the overall situation analysis of an area and to capture lists of objective traits considered important under a given system at the early stage. The method also helps to identify the inter-relationship between the production aims, characteristics of livestock resources, environment and respective prevailing management (Duguma, 2011). The approach also put some light on the association between the indigenous selection criteria and modern breeding knowledge.

The information captured at survey stage may be broad and crucial to focus only on few but very important traits. Therefore, information obtained from survey method feeds into designing of the choice experiments. This implies that there is no single method, which works well for all situations. Ndumu *et al.* (2008) advocated for using at least two methods to avoid leaving out any important selection information. The methods are applicable in situations where farmers have low literacy levels and performance records are unavailable.

Due to the multifunctionality attributes of EAZ in low input system, their optimum, breeding objective that guide the breeding program should take into account production attributes in addition to other highly preferred traits. Such information can only be derived from the participation of farmers in the designing of the breeding strategies (Duguma *et al.*, 2011; Tibbo *et al.*, 2006).

2.4.3 Breed Preference in areas with environmental stress

Changes in economic, social and environmental factors might offer a myriad of opportunities but also pose threats to livelihoods of poor farmers (Rege *et al.*, 2011). Observed trends towards exotic breeds and their crossbred in areas with environmental stress is gaining momentum due to increase in demand for animal products and market-oriented production. However, achievements are way below the expectations due to poorly planned and designed breeding programs and poor adaptability of the dam with higher levels of exotic blood (Gizaw *et al.*, 2014). This has led to genetic erosion of the traits that allow the survival of the indigenous breeds in low input production system.

The EAZ cattle are endemic to the ASALs. They are beneficial in areas with environmental stress (hot and humid), have relatively low nutritional and husbandry requirements (requires low capital to invest in feeding and health care) and superior in terms of draught power and these features makes it well adapted and adopted in poor farmers production circumstances. However, EAZ are perceived to have a plethora of disadvantages especially when the production attributes (milk and meat) are concerned (Tano *et al.*, 2003). It is therefore, very timely to focus on the EAZ cattle so as to increase their milk productivity as well as conserving their genetic merit by selecting the best individuals in milk production. These best individuals can be used as dams for crossbreeding or as a pure bred in a breeding program.

For the breeding programs to be sustainable there is need to investigate farmers production objectives, as well as trait and breed preferences and correlated socio-economic determinants (Ndumu *et al.*, 2008; Ouma *et al.*, 2007) in order to understand farmers' breeding decisions and to identify comparative advantages of the breed in its production system. A

number of studies have been conducted on breed and trait preference all over Africa. Most of these studies were conducted within the scope of conservation (Makokha *et al.*, 2007; Ndumu *et al.*, 2010; Tano *et al.*, 2003). In Kenya such studies have been carried out in the highlands (Bebe *et al.*, 2003) and medium potential areas (Lukuyu *et al.*, 2019; Makokha *et al.*, 2007; Ouma *et al.*, 2007) with special attention to improved dairy breeds. This study targets EAZ in an area with a low potential for dairy.

Studies have shown high preference for performance and fitness (adaptive) in cows' selection and phenotypic appearance (coat colour and body size) in bulls' selection (Makokha *et al.*, 2007; Ndumu *et al.*, 2010; Tano *et al.*, 2003). According to Makokha *et al.* (2007) the marginal rate of substitution of milk yield for disease resistance was greater than one indicating that farmers had a higher preference for a cow with higher disease resistance than with higher milk yield. Lower feed requirement was also more valued than milk yield.

Without a multipurpose focus, replacing traditional with improved breeds would negatively affect the livelihoods of poor families. Tano *et al.* (2003), in a study of farmers' preferences for cattle traits on smallholdings in southern Burkina Faso in West Africa, indicated that the multiple-product and multiple-stress environment prevailing on most smallholder farms increases the number of criteria that farmers consider when making choices. Similar findings are reported by Scarpa *et al.* (2003) on valuation of indigenous cattle breeds of the Maasai pastoralists of Kenya. They observe that preferences regarding phenotypic attributes of live-stock differ across regions, countries, communities and production systems (Roessler *et al.*, 2008; Scarpa *et al.*, 2003). They suggest that in developing countries, especially in low-input smallholder production systems, multi-purpose, rather than specialized breeds are more suitable to low-input production systems.

Matching dairy breed to the environment could be more sustainable than adjusting the environment to fit a particular breed (Tano *et al.*, 2003). Moreover, low input farmers might not have the resources to adjust the environment to fit a particular breed. Producers capture benefits produced by a breed, hence, producers shape breeds to fit their circumstances. This study is of great importance since it will help identify the constraints and opportunities for improving EAZ for dairy production.

Although performance of crossbred (F1) has been found to be better than that of pure EAZ in ASALs (Galukande *et al.*, 2013), adoption of F1 has been dismal in these areas (Islam *et al.*, 2010). This study was carried out to analyze the factors for the dominance of EAZ in ASALs with very little effort to adopt crossbred cattle. Understanding the socio-economic factors for rearing EAZ will give an explanation if there is a room for adopting F1 in future. The

information regarding socioeconomic and farm characteristics of farmers help to understand the actual situation to adopt crossbred cows.

Few studies have taken into account the heterogeneity of farmers and the factors that influence trait preferences for cattle (Ndumu *et al.*, 2008; Ouma *et al.*, 2007; Tano *et al.*, 2003). The importance of information on breed and trait preference and selection criteria for improved EAZ dairy production cannot be emphasized.

2.5 Socio-economic influence on trait and breed preference

Cattle serve different functions for different households, implying that farmers will exhibit different preferences for livestock attributes across region, countries, communities and production systems (Desta *et al.*, 2010; Roessler *et al.*, 2008). No single breed and no breeding strategy found to have superior aggregate results in all production environments (Rege *et al.*, 2007). Therefore, to make rational decisions that take a holistic account of livelihood functions of cattle, rankings of trait expressions in common environments should be considered. Farmers' preference for traits is known to be heterogeneous. Failing to account for this heterogeneity might bias the estimate of farmers' preference. Tano *et al.* (2003) showed how different production systems rank attributes, accordingly, agro pastoralists valued traction ability more than pastoralists. Ouma *et al.* (2007) reported that differences in the preferences across production systems are observed due to differing availability of resources and varying production activities.

From the foregoing statements it is evident that socio-economic characteristics are regarded as the main sources of taste heterogeneity. Preference heterogeneity across production systems is observed due to varying production activities and available resources. Previous studies have investigated the preference heterogeneity by interaction of socio-economic characteristics and attributes (Duguma *et al.*, 2011; Kamuanga *et al.*, 2011; Tada *et al.*, 2013). According to Kassie *et al.* (2009) as education level increases the sensitivity towards body size increases because the relatively educated group was composed of non-farmers who intend to consume the animal rather than keeping them for either production or reproduction.

Availability of Extension services also influences trait preference; household with access to extension services had a higher preference for milk yield trait than those who did not have access (Makokha *et al.*, 2007). Family size had a positive influence on interest on fertility of cows. As explained by the same author bigger households were well established with lesser interest in increasing herd size as compared to smaller households who intend to increase their herd size.

Production systems influences trait preferences, according to Roessler *et al.* (2008), farmers in the demand driven production systems had a higher affinity for performance traits than those in the resource driven production systems. In addition, the resource driven production system valued adaptive traits. Similarly, Scarpa *et al.* (2003) also found out that adaptive traits were highly valued in the smallholder systems. This was attributed to the resource poor nature of the resource driven farmers hence they cannot afford to buy inputs to treat their animals. Resource driven have a dislike for animals susceptible to diseases (exotic breeds) as they attract high production risks through animal losses. They were found to discredit breeds requiring supplementary feed as this result to high monetary inputs for purchase of feeds.

The glaring difference in trait preference among production systems was also documented in Ouma *et al.* (2007) and Zander and Drucker (2008) whereby farmers in pastoral areas had a lower preference for traction ability trait (body size) than crop livestock system. Suitability for traction is a valuable trait to the agro pastoralists, however, using cattle for draft power is a taboo in the pastoralist systems. Ability to withstand water shortage was of lesser concern to pastoralists than to agro pastoralists. Short and curved horns were more preferred by agro pastoralists than pastoralists. Very long horns may disturb the farmer while trying to install the cart.

Tada *et al.* (2013) also found a higher preference for coat color in communal enterprises than in smallholder farmers; this was explained by the use of animals with specific coat color for ceremonial functions. Cultural practices influence trait preference in that some communities use animals of specific colour and size for ceremonial functions. Ouma *et al.* (2007) found out that bulls with dark color were preferred more than the light-coloured ones. The authors also found out that tick and disease resistance trait was more valued in communal enterprises than in small-scale enterprises this was because a bull was a communal property hence any disease affecting the bull may affect many cattle making farmers dislike a breeding bull with health relates issues. Kassie *et al.* (2007) findings indicated a relatively lower importance attached to milk yield, this was because in Dano community milk selling was a taboo and milk was only for home consumption.

Gizaw *et al.* (2010) found out that producers in pastoral systems had higher preferences for adaptive traits while those in crop livestock systems (sheep-barley) had a higher preference for production traits. Market orientation also caused discrepancy in the trait preference in that subsistence producers gave more weight to adaptive traits than did the more market-oriented producers.

From the previous studies, it can be concluded that trait preference varies across different production circumstances due to varied socio-economic characteristics, cultural practices and market orientation or constraints in different study areas. This study therefore aimed at establishing trait preference for more milk production in Kitui County.

2.6 Adoption of artificial insemination in low input areas

Artificial insemination has been widely adopted in the highlands and medium potential areas, however, adoption in ASALs is very dismal. This section reviews literature on factors for and extent of adoption of AI in different agro-ecological zones.

2.6.1 Role of artificial insemination in improving dairy productivity

Kenya's dairy sector significantly contributes to the national economy, household incomes and food security. The sector, particularly in the semi-arid zones is constrained by factors such as inadequate feeds and water owing to the prolonged droughts, inappropriate breeds, inaccessibility and high cost of AI services, high incidence of animal diseases and inaccessible credit services (MoLD, 2010).

Studies on dairy farming have already been undertaken in various regions of Kenya (Lanyasunya *et al.*, 2006; Muia *et al.*, 2011). However, very few studies have focused on the uptake of dairy technologies in the semi-arid areas (Khainga *et al.*, 2015). Artificial insemination has been credited for assisting resource poor livestock farmers to join the commercial dairy enterprise. Adoption of AI technology, especially through the upgrading program, has enabled 80% of the current suppliers of milk in Kenya to enter into commercial dairying within reasonable short period than would have if direct importation of dairy cows had been adopted (Muriuki *et al.*, 2011). However, the progress brought about by AI was evidently in high and medium potential areas (Murage & Ilatsia, 2010).

Despite its many benefits, the use of AI in lowlands remain very low and the use of bull with unknown pedigree very rampant (Mugisha *et al.*, 2014). Artificial insemination uses on indigenous breeds not characterized or evaluated has rendered the efforts to conserve the gene pool of indigenous breeds futile. The major negative repercussion of indiscriminate crossbreeding using AI includes unforeseen levels of dilution of indigenous gene pool.

Among the advantages of AI over bull services include achieving genetic improvement of the herd faster than the bull service (natural mating) which can at worse lead to retrogression of the genetic potential. The maintenance costs of a bull were also an issue of concern when the two services were compared. Artificial insemination technology has also led to one of the

most successful smallholder dairy systems in the developing world (Staal *et al.*, 2008). However, the use of AI has also failed in many situations in developing countries because of the lack of infrastructure and the costs involved, such as for transportation and liquid nitrogen for storage of semen or because the breeding program has not been designed to be sustainable (Philipson *et al.*, 2006). Improper use of AI for crossbreeding indigenous cattle with exotics may be disastrous when, for example, a long-term strategy lacks information on how to maintain the appropriate level of exotic genes in an environment that cannot support pure exotic breeds. The pros and cons of using AI should therefore be critically reviewed for each case before designing breeding programs.

Difficulty in delivery of AI was cited as one of the main challenges to genetic improvement in pastoral and smallholder systems (Khainga *et al.*, 2015). Poor access to veterinary and breeding services are the major obstacles to reducing the mortality rates and shortening the generation interval (Rege *et al.*, 2011). Increased milk production can only be realized if appropriate genotypes are used alongside optimum management and other husbandry practices.

2.6.2 Factors affecting the use of artificial insemination in ASALs

Previous studies have revealed a sharp contrast between the actual use and expressed preferences for the AI service (Baltenweck *et al.*, 2004). Therefore, assessing the socio-economic factors is crucial, as it will reveal the constraints associated with the use of AI in low input systems.

The factors that have been found to influence the adoption of AI include, but not limited to; availability of the extension services, affordability, calf tolerance, sex of the calf, availability of the milk markets, income, years in dairying and herd size (Khainga *et al.*, 2015; Mugisha *et al.*, 2014).

Some technologies require large capital outlay to adopt them. Barry (2005) observed that household income was an important determinant of the technology adoption as income enables farmer to meet the associated costs of buying the technology. Availability of capital also acts as security in case the technology failure. Income enables a farmer to meet costs of adopting new technologies. Wealthier farmers may be the first to try a new technology especially if it involves purchasing the inputs. Furthermore, availability of capital acts as security in case of failure due to adopting new technology.

In the dairy adoption studies herd size is a very important determinant. Some technologies have previously been termed as scale dependent because of the great importance of size

in their adoption (Bonabana-Wabbi, 2002). Herd size affects adoption costs, risk perceptions, human capital, credit constraints and labour requirements (Khanal & Gillespie, 2011).

Years of experience in dairy farming as a result of long period of interaction with other farmers and the outside world was found to influence adoption. Namwata *et al.* (2010) indicated that farmers with greater experience have a sound knowledge of all the involved practices. Experience makes farmers to be better placed to acquire needed skills to use the technology (Langyituo & Mekuria, 2005).

Artificial Insemination has for long been associated with semen of exotic bulls and farmers have been shying away from the service. The use of *Bos indicus* breeds normally dominates the free grazing systems as opposed to *Bos taurus* breeds which are dominant in the more intensive systems coupled with extensive use of bulls indicating possibility of inbreeding. Use of improved breeding services like AI also follows the same pattern (Baltenweck *et al.*, 2004). Mugisha *et al.* (2014) documented that sex of the calf born was independent of the use of AI.

Education has been found to have a positive significant effect on the adoption of AI. Quddus (2012) found out that secondary and higher educated farmers were 9.7 times more likely to adopt improved technologies compared to lesser educated farmers. Education helps farmers to better understand the technical information that comes with the technology. It also helps farmers to use appropriately the suitable technology to reduce the production constraints. Educated farmers are perceived to interpret and respond to new information much faster than their counterparts. Educated farmers were found to adopt new technologies more than the uneducated ones. Wetengere (2009) reported that educated farmers had a higher likelihood of adopting fish farming technologies than illiterate ones. Thus, the more complex the technology is, the more likely that education would play a major role in its adoption.

Older people may have higher accumulated capital, more contacts with extension, better preferred by credit institutions, larger family sizes, all of which may make them more prepared to adopt a technology than younger ones (Langyituo & Mekuria, 2005). If age is assumed to proxy behavior, older farmers are assumed to have shorter planning horizon and are more risk averse than younger farmers. Previous studies found the effect of age on technology adoption to be indeterminate since they can influence adoption either way. Kaaya *et al.* (2005) found age of a farmer to have a positive relation on adoption of artificial insemination (AI) services by Ugandan dairy farmers, while (Kassie *et al.*, 2009) found age to have negative effects on adoption of agricultural technologies.

Full time farmers or specialized dairy farmers were found to adopt animal breeding technologies easily than part time-farmers (Kaaya *et al.*, 2005). The main occupation of the

producers is of great importance in terms of economic improvement and specialization in production. Hasan *et al.* (2008) reported that in Turkey specialization in livestock sector was rare and that affected economic improvement negatively. The effect of other occupations was also shown by Barry (2005) who indicated that employment outside the farm is another important element in the practice of animal husbandry in the cities and if the dairy farmer works outside the household, time constraints might affect livestock activities. In this case, if the main occupation was farming it is likely that would influence AI adoption positively.

Although bull service was found in several studies to be the most used breeding service farmers, AI has been mentioned to be the most preferred breeding service by farmers (M'ikiugu *et al.*, 2015). Bull service was preferred mostly because it was cheap while artificial insemination was preferred for offering breed variety (Lawrence *et al.*, 2015).

Murage and Ilatsia (2010) found a negative relationship between the use of bull service and higher levels of education, herd size and location. Educated farmers were more risk takers and willing to use AI than non-educated ones (Makokha *et al.*, 2007). Increased use of AI in more intensive systems was reported while more semi-intensive systems were characterized by high use of the bull service (Baltenweck *et al.*, 2004). The use of bull service was enhanced by greater availability, cost friendly, more accessible and high failure rate of AI (Mugisha *et al.*, 2014; Murage & Ilatsia, 2010). More importantly, calf tolerance was reported to have an influence on the preference of AI in ASALs (Khainga *et al.*, 2015). Makokha *et al.* (2007) echoed similar sentiments; it was found out that preference for traits could have an effect on adoption of the breeding technology. Financial constraints were found not to explain fully the unique adoption process of improved dairy technology in the Western Kenya.

Traits of cattle distinguish one breed from another and adoption of a dairy breeding technology highly depends on the farmers breed choice. According to Bebe *et al.* (2003), the breeding practice adopted by the farmer will depend on their breed preference. Households that had used artificial insemination had more crossbred cattle with a greater number of cows producing more milk (M'ikiugu *et al.*, 2015).

Larger land sizes production systems were associated with more use of bull service (Lawrence *et al.*, 2015). Extensive systems of production with large tracts of land and where animals interact freely are mostly associated with the use bull service while the intensive systems of production are found to use AI (Baltenweck *et al.*, 2004; Murage & Ilatsia, 2010). Different production systems were also found to have different preference for AI, Khainga *et al.* (2015) reported that farmers in the pastoral systems had a lower preference for AI than those in agro-pastoral areas. Kaimba *et al.* (2011) observed that in extensive systems the use of bulls

for breeding was a more common practice. This was attributed to the pastoralists' lifestyle of moving their herds in search of fodder hence may not have time to observe and detect heat in their cows.

Experience in farming has elicited mixed results towards AI adoption. Berry and Cromie (2007) found a positive influence of experience on AI. However, Khainga *et al.* (2015) indicated a negative influence of experience on AI preference. Most pastoralists who had kept livestock for many years held a pessimistic view about the ability of breeding using Assisted Reproductive Technologies besides the bull. A study by Jemal *et al.* (2016) found out that local breeds have the lowest conception rate compared to exotic and their crosses using AI, this could also be another reason for non-use of AI in most pastoral areas where EAZ is the predominant breed. Repeat breeding (a cow requiring another service almost a month after being served) has been found to make farmers lose trust in AI (Mungube *et al.*, 2014).

Timely heat detection enhances success in using AI. The ease and success of heat detection is crucial for optimal reproductive performance of dairy cattle (Berry & Cromie, 2007). Improper heat detection lowers conception rates due to the wrong insemination timing which results into conception failure. Adoption of the AI service was highly dependent on availability of extension services, record keeping practice and availability of milk markets (Mugisha *et al.*, 2014).

Since the relationship between factors and AI use varied from one area to the other it was therefore important to find out the exact reasons for low use of AI in the semi-arid areas.

2.7 Theoretical framework

Indigenous cattle farmers produce under very high levels of uncertainty exhibited by natural hazards (drought, weather, pests, diseases, natural disasters); market inaccessibility; social uncertainty (insecurity caused by bandits) (Kaimba *et al.*, 2011). Farmers are very risk averse in their decision-making processes and have to secure their household needs in their current production or face starvation. Indigenous cattle farmers prefer stable but low yields rather than higher yields with high levels of risks to achieve (Rege *et al.*, 2011).

Considering the foregoing statements, this study involves decision-making to maximize utility. Random utility maximization theorem was adopted. Utility maximization is a goal to maximize satisfaction from allocating limited resources (Greene, 2008). Selection of trait decision was considered under the general utility maximization framework. African farmers are poor but rational, therefore, they compare the expected utility of both risky and uncertain prospects and chose the one that yields a higher expected utility value.

A risk averse farmer maximizes utility by selecting the traits that will fulfil all his production objectives (herd increases, milk production, draught power, cultural function). This is the case if the benefit of adopting such selection criterion exceeds the benefits realized without such selection criteria. For instance, a farmer will select a bull with a big body frame if the utility from selecting body frame is higher than the utility derived from not selecting body frame. By letting the utility of trait say B be U_j and the utility of not selecting trait A be U_0 then the latent net benefit of selecting or not selecting a certain trait can be expressed as follows

$$Y_j^* = U_j - U_0 \dots \dots \dots \text{Equation 1}$$

Y_j^* an unobservable latent function with its observed counterpart being a binary variable Y taking 1 for $Y^* > 0$, and 0 for $Y^* \leq 0$. The latent selection decision is determined by the socio-economic characteristics for selecting or not selecting a certain trait j .

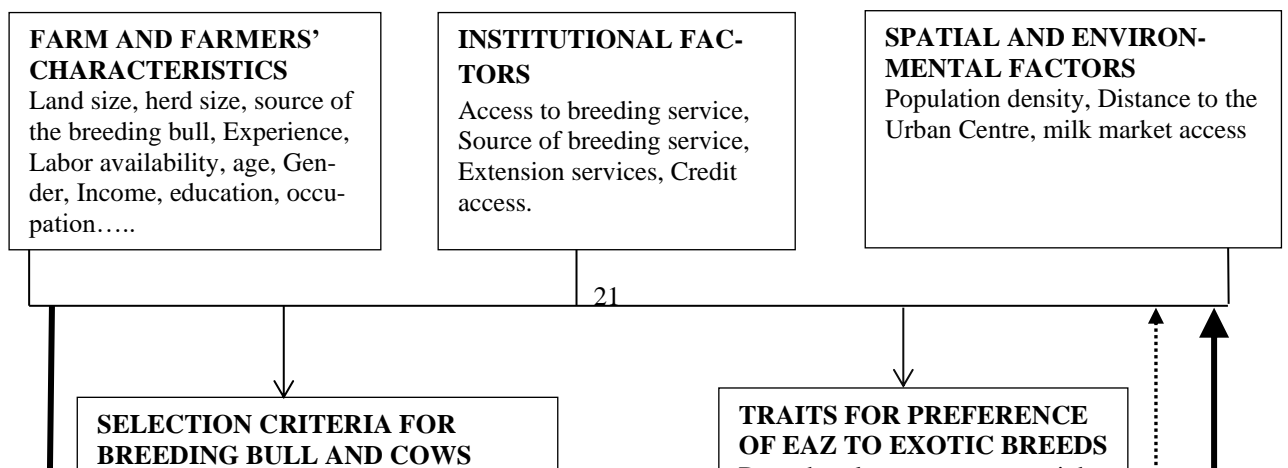
$$Y_{ij}^* = X_{ij}\beta_j + \varepsilon \dots \dots \dots \text{Equation 2}$$

where j =bull body frame, appearance, scrotal size (traits under consideration), X represents the socio-economic characteristics of the individual farmer i . ε is the composite error term (consists of the unobserved farmer socio-economic characteristics. Since the latent (net) benefit is observed when the farmer ranks the trait as important or not important, equation was mapped to an observable binary variable indicating whether or not the farmer rated the trait important or not important

$$Y_{ij}^* = \begin{cases} 1 & \text{if } Y_{ij}^* > 0 \\ 0 & \text{if } Y_{ij}^* \leq 0 \end{cases} \dots \dots \dots \text{Equation 3}$$

Assumptions about the relationship of disturbance terms of the equations to be estimated, whether correlated or not, determine the type of qualitative choice model to use in analysis. If the error terms are correlated due to complementarities or substitutability in the utility maximization framework, Bhat *et al.* (2015) advocated for the use of multivariate models. A single equation estimation approach could cause bias and inefficiency in the parameters if the interdependence is observed and/or if unobserved heterogeneity is correlated among two selection criteria. In this study both univariate and multivariate models are adopted.

2.8 Conceptual framework



CHAPTER THREE

FARMERS' CATTLE SELECTION CRITERIA AND SOCIO-ECONOMIC FACTORS DETERMINING THEM FOR IMPROVED MILK PRODUCTION IN EAST AFRICAN ZEBU

3.1 Abstract

East African Zebu (EAZ) cattle play a very important role in the livelihoods of the Arid and the Semi-arid communities. Despite the breed being the most populous, its contribution to the dairy industry is very low. To ensure the success of a breeding program for more milk production, there is a need to understand how the indigenous farmers select their breeding cows and bulls for more milk production. This study was therefore conducted in Kitui County to determine the farmers' selection criteria for breeding bulls and cows for more milk production. In that regard, five selection criteria traits for bulls and eight selection criteria for cows were ranked using Friedman non-parametric analysis of variance test and Wilcoxon Test. A multivariate Probit model was used to determine the influence of socio-economic factors on bulls and cow selection criteria for EAZ breeding. The mean ranks obtained indicated that the bull's body frame (5.94), udder shape (6.04), teat size and placement (5.8) for cows were regarded as the most important selection criteria. The Multivariate Probit results showed that male farmers had a higher preference for bulls' body frame than female farmers. The study concluded that selection criteria in breeding bulls and cows are significantly influenced by socio-economic and demographic factors. A key recommendation from the study is to consider farmers' trait selection criteria in the planning and designing of a breed improvement program.

3.2 Introduction

The productivity of EAZ cattle is low, in part because indigenous cattle perform multiple functions in the livelihood system of their keepers (Moll, 2005). In order to keep pace with expected increases in the demands for meat and milk, Africa's domestic milk supplies will have to increase by an average of 4% per year at least until the year 2025 (Delgado *et al.*, 2001). The productivity of EAZ is too low to meet this demand.

Breeding programs provide a good opportunity for improving the milk production of the indigenous breeds. However, in most low input production systems selection criteria are not consistent and not well defined to warrant success of the breeding program. This has hindered the sustainability of the genetic improvement in such systems (Rege *et al.*, 2007; Roessler *et al.*, 2019). Literature on indigenous knowledge for traits selection criteria for EAZ for increased milk production are not documented anywhere; it can only be made available through farmers' participation in the planning and designing of the breeding program. It's worth noting that farmers are a very important market niche in addition to being producers therefore are aware what is more demanded in the market in terms of attributes, breeds and products. Soliciting their selection criteria and trait preference will give information on non-marketed traits, which are important to them.

Farmer characteristics have a strong influence on farmers' preferences for improvements in traits, and therefore, variables describing farmer characteristics should be included in studies analyzing heterogeneity of farmers' preferences (Makokha *et al.*, 2007; Ndumu *et al.*, 2008; Ouma *et al.*, 2005; Tada *et al.*, 2013). Such information would help to ensure that breed improvement interventions are consistent with the needs of the intended beneficiaries. Therefore, in order to impose and ensure success of a breeding program this study aims at looking into the selection criteria and preference for EAZ bulls and cows' traits for breeding EAZ for more milk production and socio-economic factors that determine such selection criteria.

3.3 Methodology

The methodology discussed in this section appertains partly to this objective (data analysis) and partly to the whole document (study area, sampling procedure, determination of the sample size, data collection and description of variables).

3.3.1 Study area

The study was conducted in Kitui County, located in Eastern Kenya. It covers an area of 30,496.5 km² with a population density of 33 people per km² (national population census 2009). It is a semi-arid area with very erratic and unreliable rainfall. Temperatures range

between 14°C and 34°C and rainfall range from 500 mm to 1050 mm per annum and is distributed in two seasons per annum in different parts of the county with 40% reliability (FAO, 2012). Livestock keeping contribute most to the livelihoods in the county. Major livestock categories in the area include cattle, goats, sheep, chicken and donkeys.

The selection of the study area was mainly based on high population of indigenous EAZ cattle and the area with residents exhibiting a high dependence on EAZ for milk needs such that the genetic loss of the breed would result in a threat to livelihoods as alternative breeds would be unlikely to provide the same utility. The criteria deemed pertinent since this study would open up pathways into improving the livelihoods of poor livestock keepers through genetic improvement of EAZ for dairy.

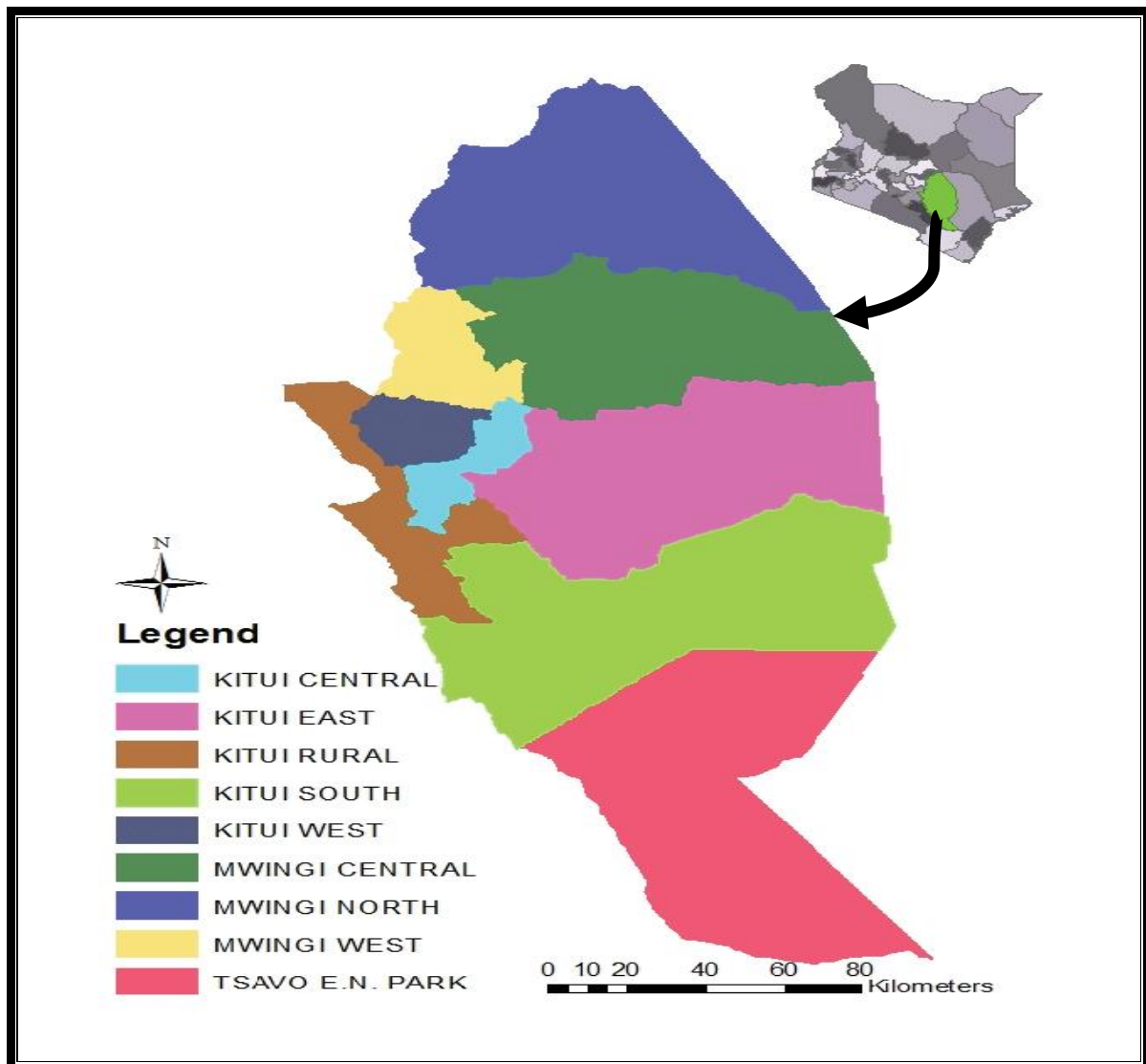


Figure 1: Map of Kitui County

3.3.2 Sampling procedure or technique

Three sub-counties were selected based on the relatively large population of EAZ, their accessibility and the farmers' readiness to improve their EAZ for milk production. The three sub counties are a good representative of the wide area of the semi-arid Kitui county. Ikutha occupies the largest area of 8109.9 km² while Matinyani occupies a relatively smaller area of 264 Km² and Matungulu. The sample unit constituted a household. Exploratory discussions were held to identify the traits to include in the survey and to identify the concentration of EAZ in the county.

A household survey and focus group discussions were conducted as complementary methods of collecting data. Group discussions were used to fill any emerging information gaps for example to determine the traits that farmers perceive to indicate more milk production in cattle. In total six open group discussions were carried out at selected sites and extension workers were involved in the discussions. A total of fifty-five (55) households in each sub county were selected randomly to administer a questionnaire. Household survey involved 165 households rearing cattle.

Multi-stage cluster (area) sampling was preferred due its relative convenience, economy and efficiency compared to other sampling techniques (Horppila and Peltonen, 1992). The sampling frame was the cattle keeping households. Using this approach, the Kitui County was purposively selected in the first stage because of its relatively high population of indigenous cattle (EAZ). In the second stage, sub-counties were systematically selected from lists of 1000 households provided by KALRO-Kiboko, taking into account the general distribution of cattle in the study area.

The third stage involved simple random sampling of smaller administrative units (locations and then sub-locations) from lists of all locations and sub-locations. Further, individual farmers were selected using a systematic random approach following the main transects in the sub-locations (starting from a landmark feature; a river or market and subsequently selecting every fifth or tenth farmer, in sparse or densely populated areas, respectively).

3.3.3 Determination of the sample size

Determination of the sample size was based on the formula given by Kothari (2004) as shown below:

$$n = \frac{z^2 PQ}{\epsilon^2} \dots \dots \dots \text{Equation 4}$$

Where; n is the sample size, Z is confidence level ($\alpha = 0.05$), P is the proportion of population of interest, smallholder farmers who own indigenous cattle. Q Is the weighting variable and this is computed as $1 - P$, and ϵ is an acceptable error (precision). P Will be set at 0.5 because, statistically a proportion of 0.5 yields a sufficient and reliable sample size particularly when the population proportion is not known with certainty. This led to Q of 0.5 ($1 - 0.5$). An error of less than 10% is usually acceptable (Kothari, 2004) thus; the study will take an error of 0.05 to approximate a sample size of 165 respondents.

3.3.4 Data collection

Baseline survey was carried out in the selected locations in Ikutha, Matinyani and Matungulu sub counties of Kitui County in order to identify the cattle traits the agro-pastoralists prefer based on their prevailing environment. Results from focus group discussions concluded that the study consider that five bulls' trait and eight cow traits are the main selection criteria for breeding bulls and cows.

Data was collected from the sampled households using a structured questionnaire through one-on-one interviews. The questionnaire was designed to explore general information about major traits used by farmers to assess the best cows and bulls for improving milk production in their herds. Breeding practice, trait preference and rank of traits in selection criteria were assessed by semi-structured questions. The discussions focused on establishing whether and how farmers select bull and cow breed cows to enhance dairy production in the herd, and what criteria they apply.

A list of indigenous cattle bulls and cow traits was predetermined based on discussions with key informants and researchers in the field of animal breeding and economics. The traits evaluated for breeding bulls were; body frame, appearance, scrotal size, performance of relatives and tail size. The traits evaluated for breeding cows were; udder placement, teat size, tail size, dewlap size, rumen depth, body shape, backline and coat color. Data on socio-economic characteristics of the farmers was collected

3.3.5 Data analysis and model specification

To determine how farmers, select an animal for breeding, five selection criteria traits for bulls and eight selection criteria for cows were ranked using Friedman non-parametric analysis of variance test and Wilcoxon Test. A graph for cows' selection criteria and a pie chart for bulls' selection criteria were both obtained to depict a picture on how farmers selected cattle for breeding.

In the most agro pastoral areas cattle are kept for multiple objectives embedded on cattle traits. When a farmer is selecting an animal for breeding, consideration is on whether the animal has the traits which will address his production objectives. The traits present in cattle complement each other or are substitutes. Farmers makes trait choices and by doing so, it helps to elicit trade-offs of any two competing traits to achieve their production objectives.

Multivariate Probit Model (MVP) accounts for multivariate decision making in the presence of adoption interdependence (Greene, 2008). MVP acknowledges the correlation of the error terms in the estimation of the multiple binary equations. Given that the selection of traits in a cow or bull are not mutually exclusive, the decision to select one trait may affect the decision to select the other. Therefore, applying the binomial probit or logit will give inefficient estimates and likely to exclude important information about the substitutability and complementarity of the selection decision (Belderbos *et al.*, 2004; Kassie *et al.*, 2013). Such correlation arises because of the unobserved or unmeasurable characteristics of the farmers with a possible influence on the selection of different traits (Ndiritu *et al.*, 2014). Substitutability and complementarity arise because the decision to rank a trait as important may be conditional on the ranking of another complimentary trait (positive correlation of the error terms of the selection criteria) or may be affected by the set of substitutes available (negative correlation). Failure to factor in such trade-offs (substitutability) and synergies (complementarity) of trait selection criteria leads to biased and inefficient estimates of the determinants of the selection criteria for bulls and cows (Greene, 2008).

Putting the random utility framework into perspective and assuming that indigenous cattle farmers are utility maximizers, then they are more likely to rank a trait important if the expected utility derived from ranking it important (U_a) is greater than the utility from ranking it not important (U_o). X_a and X_o are the vectors of the explanatory variables that influence the perceived desirability for the trait. The linear random utility model (Greene, 2008) could therefore be specified as:

$$U_{ia}(\beta_a X_i + \varepsilon_a) > U_{io}(\beta_o X_i + \varepsilon_o) \dots \dots \dots \text{Equation 5}$$

Utility cannot be measured; therefore, it is defined by a latent variable Y_i^* determined by observed factors and the error terms such that:

$$Y_i^* = X' \beta_i + \varepsilon_i \dots \dots \dots \text{Equation 6}$$

MVP model is characterized by a set of observed binary dependent variables Y_i^* that take 1 if an i^{th} farmer rank a trait as important and 0 otherwise as such

$$Y_{ij}^* = \begin{cases} 1 & \text{if } Y_{ij}^* > 0 \\ 0 & \text{if } Y_{ij}^* \leq 0 \end{cases} \dots \text{Equation 7}$$

In the MVP model estimation independent variables X_i used vary for each individual but not across the different outcomes. X_i represents the socio-economic characteristics influencing the farmers ranking of selection criteria. MVP estimated 5 equations for bulls simultaneously and eight equations for cows. MVP model therefore is expressed as linear combination of a deterministic and stochastic parts as follows:

$$Y_1^* = X' \beta_1 + \varepsilon_1 \text{ for } Y_1 = \mathcal{Y}_{\{Y_1^* > 0\}} \dots \text{Equation 8}$$

$$Y_2^* = X' \beta_1 + \varepsilon_2 \text{ for } Y_2 = \mathcal{Y}_{\{Y_2^* > 0\}} \dots \text{Equation 9}$$

⋮ ⋮

$$Y_j^* = X' \beta_j + \varepsilon_j \text{ for } Y_j = \mathcal{Y}_{\{Y_j^* > 0\}} \dots \text{Equation 10}$$

Y_j^* denotes the underlying latent response associated with j th selection criterion, for $j=1, \dots, J$. Y_j denotes the binary response outcome associated with j selection criterion, $Y=1$ if the selection criteria are important, $Y=0$, otherwise. $X = (1, x_1, \dots, x_p)'$ is a vector of p covariates which do not differ for each selection criterion (the deterministic part) and $\beta_j = (\beta_{j0}, \beta_{j1}, \dots, \beta_{jp})'$ is a corresponding vector of parameters, including the intercept, which we seek to estimate. ε_j Represents the stochastic part, the unobservable factors which explain the marginal probability of ranking trait j 'important'. Each ε_j is drawn from a J -variate Normal distribution with zero conditional mean and variance normalized to unity (for reasons of parameter identifiability), where $\varepsilon_j \sim N(0, \Omega)$, and the covariance matrix Ω is given by

$$\Omega = \begin{bmatrix} 1 & \rho_{12} & \dots & \rho_{1j} \\ \rho_{21} & 1 & \dots & \rho_{2j} \\ \vdots & \vdots & \ddots & \vdots \\ \rho_{j1} & \rho_{j2} & \dots & 1 \end{bmatrix} \dots \text{Equation 11}$$

For MVP model the covariance matrix is normalized to unity. ρ (rho) denotes the pairwise correlation between the error terms. The off-diagonal elements in the covariance matrix, represents the unobserved correlation between the stochastic component of any two selection criteria.

Multivariate correlated binary observations arise in this study. As alluded by Greene (2008) in an analysis of correlated response data, one must account for the correlation structure between different levels of response if, a priori, there is a perceived possibility that these responses may in fact be correlated.

The marginal probability of ranking j^{th} trait as important can be expressed as:

$$\Pr(Y_j = 1) = \Omega (X' \beta_i, \text{for } j = 1, \dots, J) \dots\dots\dots \text{Equation 12}$$

where the error terms jointly follow the multivariate normal distribution with zero conditional mean and variance normalized to unity $(0, \Omega)$. Moreover, the joint probability of observing all possible types of selection criteria comes from a J-variate standard Normal distribution

$$\Pr(Y_1 = 1, \dots, Y_j = 1) = \phi J(X' \beta_1, \dots, X' \beta_j; \Omega) \dots\dots\dots \text{Equation 13}$$

where Ω is the covariance matrix.

3.3.6 Description of variables

Body frame referred to either long legs or lengthy body (big-framed) while short legs and rather stocky (small framed). An animal body size is determined by genetics and environmental adaptation, frequent and long-lasting droughts can tamper the animal body size. Big body frame was viewed as a sign of bull strength. Advantages of big body size include good traction ability, fetching higher market value, greater cultural value and better walk ability. Traction power is very important in the study area because of mixed crop animal production system and machinery are scarce. Bulls are used for plowing.

Tail size- long tail with big base was the most visible indicator traits for high milk yield, high carcass weight, and big offspring and for beauty. **Appearance** as an indication of coat color and horn size and shape; coat colour indicates beauty and high market value, adaptation to high temperatures in the area. Large curved horns indicate self-defense, keep the bull confined and are for beauty. Horns determine how well bulls are suitable for plowing. Long horns make it difficult to fix yokes and ploughs on bulls. Short and curved horns are most preferred by farmers. Scrotal size large testes and deep scrotum indicates high milking daughters and

high carcass weight. Large udder indicates high milk yield. Teat size and placement indicates milking ease and milk yield.

Table 1: Definition of variables included in the regression models

Variable	Description	Values	Expected sign
Dependent variables			
Frame	Ranked bull frame as important	1=important 2=not important	
Appearance	Ranked appearance as important	1=important 2=not important	
Performance_relative	Ranked performance of relatives as important	1=important 2=not important	
Tail_size	Ranked tail size as important	1=important 2=not important	
Scrotal_size	Ranked scrotal size as important	1=important 2=not important	
Independent Variables			
Hhsize	Number of people in the HH	Number	+/-
Gender_hh	Gender of the household head	Dummy variable 0=Male 1=Female	
Durat	Experience of the HHH in cattle rearing	Years	+/-
Age_hh	Age of the HHH	Years	+/-
Educ	Education level of the HHH	Years in school	+
Occup	Occupation of the HH head	1=farming 0=off farm	+/-
tot_cattl	Number of the cattle in the farm	Number	-
w_dist	Distance to the main water source	Number	+
Totland	Total land holding by the HH	Number	+
Mphon	HH owns a mobile phone	1=Yes 0=No	+
Reasons for keeping cattle	Ranking of reasons for rearing EAZ Drought tolerance Traction ability	1=less important 2=important 3=very important	+/-
Constraints to milk production	Factors that limit milk production		-

Dewlap helps in body temperature regulation in harsh environmental condition. The desire for selecting cattle with large dewlap aims at better survival and adaptation of the selected animals. EAZ cows total skin area is greater – hump, dewlap, long ears, loose skin – which results in more sweating capability in extreme heat and better thermo-regulation. Rumen depth to indicate the amount of feeding Body shape stability in walking to search for fodder, indicates the fitness of the cow. Coat color was attributed to cultural, ceremonial, ritual (hides are used as mats and other traditional ceremonies) and environmental adaptation to reflect solar radiation. Long tail with big base as selection criteria indicator trait for high milk yield.

3.4 Results and discussions

This section presents the results on farmers cattle selection criteria adopted by Kitui county farmers and the socio-economic factors that determine the selection criteria.

3.4.1 Ranking of traits

Friedman non parametric analysis of variance test provided evidence that all traits are not regarded by farmers as being equally important. It was statistically significant at 1% indicating that there was a significant difference in the overall importance of traits reported by the respondents.

However, the absolute differences between the mean rankings were so close that the relative importance of traits was not stated with certainty. Therefore, prudent to establish whether the small difference was significantly different using Wilcoxon Tests in order to validate the hierarchy obtained based on the mean ranks.

The mean ranks obtained indicated that the bulls body frame, udder shape and teat size and placement for cows are regarded as the most important in the selection for milk production. Wilcoxon tests proved that udder shape and teat size and placement for cows are ranked equally as the most important since there was no significant difference between the two traits for cows. Coat color was ranked as the least important selection criteria in cows. The results from ranking first reveals that all traits are not equally preferred by all farmers, hence the need to further try to substantiate the socio-economic factors that causes this discrepancy.

Figure 2 shows the mean rank score (ranks) of bull traits preferred by Kitui County farmers for breeding EAZ. Traits associated with fitness 47% (body frame), cultural or aesthetic (appearance) 33% value in bulls were highly valued by the farmers and these traits cannot be underrated as high performing bulls without these attributes were not selected for breeding. Similar findings were documented by Kamuanga *et al.* (2011) where they indicated that mixed

livestock-crop farmers have higher preference for animal traction than milk off-take and reproductive performance.

Bulls in Kitui County are mostly used for traction hence a bull with big body size were the most preferred. Such bulls were also believed to fetch higher market prices during sale (Kassie *et al.*, 2011).

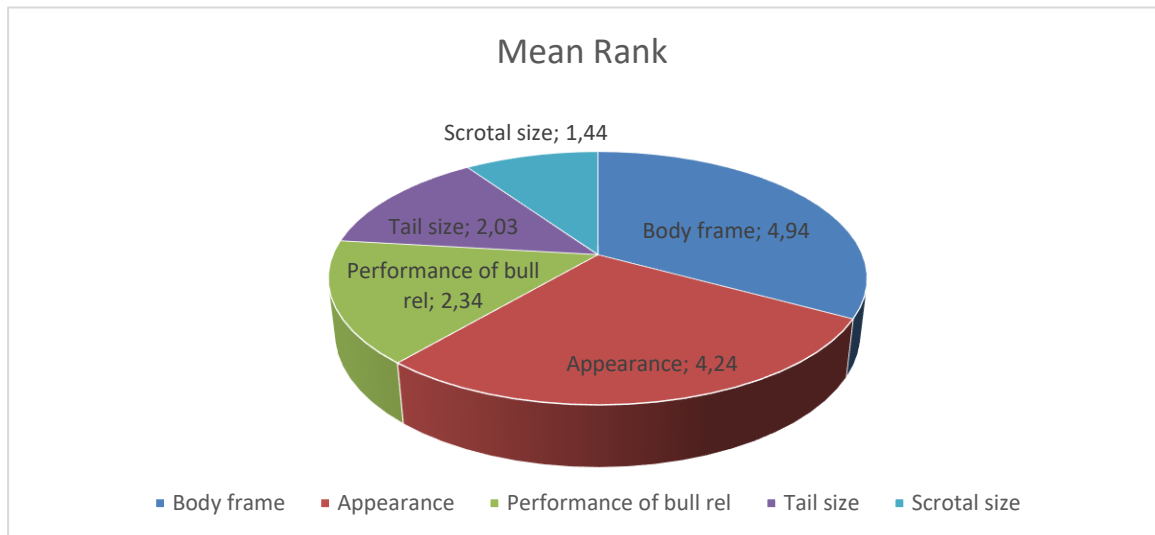


Figure 2: Ranking of bull traits

These findings are also in agreement with the findings of Mwacharo and Drucker (2005) and Ouma *et al.* (2007) where they indicated that physical attributes (body size and appearance) are important selection criteria for bulls. Ouma *et al.* (2004) and Traoré *et al.* (2016) revealed that settled farmers have more liking for livestock functions linked to crop production such as draught power.

Kassie *et al.* (2009) found out that bulls were kept at least for two purposes; traction and reproduction (farmers usually inquire about the reproductive performance of the bull). Contrary to the current study where scrotal circumference (SC indicating reproductive capability in bulls) was ranked as the least important trait for bull selection. Preference for big body frame found to indicate high preference for high live and carcass weight (Kugonza *et al.*, 2012).

Appearance was ranked second important selection criteria (33% mean ranking). The high preference of appearance (coat color and horns) in bulls than in cows (coat colour was ranked last) may be attributed to the fact that the appearance of bulls predicts the appearance of the herd. Farmers in communal enterprises were also found to rank coat color higher than scrotal size by Tada *et al.* (2013). This was because of cultural connotation and also light red color is scientifically associated with reflection of solar radiation hence body temperature

regulation (adaptive trait). These findings were in agreement with the findings of previous studies (Ruto *et al.*, 2008; Tano *et al.*, 2003). The preference of farmers for a particular coat color in bulls might be associated with social cultural practice, market demand and environmental adaptation. Steverding and Troscianko (2004) reported that bright colors of coat are preferred since they reduce the risk of attack by tsetse flies and thus act as a natural control against trypanosomosis.

Farmers in this study mentioned of how appearance of the bull affects the selection and culling of bulls since a bull may be below average in terms of performance and reproductive efficiency yet it's still retained in the herd. On the other hand, a bull may be high performing but since it does not have the 'right' coat colour was disregarded. Ndumu *et al.* (2008) also found out that appearance affects selection and culling of bulls in the herd. The findings of Kugonza *et al.* (2012) concur with this study in regard to ranking highly the physical attributes of Ankole bull.

Performance of the bull's relatives was ranked as the third (9% mean ranking). Bulls whose close female relatives (granddams, dams and female siblings) produces more milk, have higher survival rates, are drought tolerant and grow fast were also preferred by Tanzanian Maasai EAZ (Yiapi 2003), Karamojong (Loquang 2003) and Ethiopian Boran (Halake 2003). Bull tail size was ranked second last selection criteria with an average ranking of 7% of the total ranking.

Scrotal circumference (SC) was ranked last by farmers, who indicated that big and long testes indicate individual bull's reproductive potential and dairy potential in bull's relatives. Similar trend in the selection of SC was observed by Tada *et al.* (2013) whereby communal enterprises ranked SC lower than CC. The trend observed in this study can be equated to that of communal enterprises as observed by Tada *et al.* (2013) or subsistence oriented by Roessler *et al.* (2008) or resource-driven by Madzimore *et al.* (2012). Similar to these studies, adaptive and fitness traits were ranked higher than the productive traits and reproductive traits in bulls.

Agro-pastoralists are most interested in animal traction, less interested in meat, milk off-take and faster herd increases, and thus are less concerned about the reproductive performance of their bulls. In contrast, subsistence farmers are most interested in maintaining the size of their herds because they have poor access to markets and because of the variety and complexity of roles (meat off-take, dowry, insurance, social events) played by cattle (Kamuanga *et al.*, 2011).

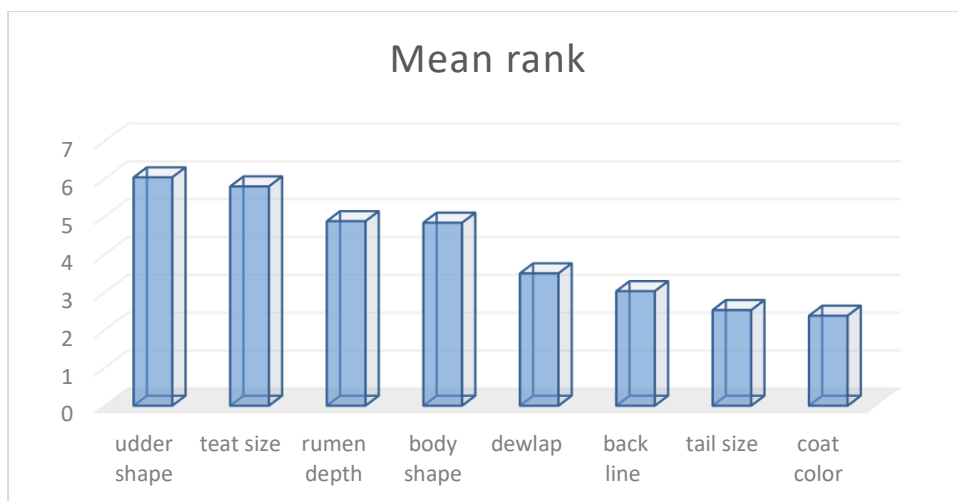


Figure 3: Ranking of cow traits

In cow trait preference, traits that farmers associate with high milk yield (udder and teat size) had the highest mean rank of 6 (**Figure 3**). It has been reported that high preference for milk production traits was common among many traditional African cattle owners because they keep cows primarily for milk (Garoma *et al.*, 2013). Large udder was associated with high milk yield. Farmers are aware that it's usually of no use to breed a fantastic looking cow which produces no milk. Udder, teat size and shape are highly heritable, hence any abnormality of the two is easily passed on from the cow to the offspring (Cassell, 2002).

Rumen capacity affects feed and water intake consequently milk production and live weight and this might be a challenge in areas experiencing frequent drought like Kitui. Rumen depth therefore was ranked second (mean rank of 4.88) after udder and teat size showing higher preference for traits directly related to milk production. High preference for body shape (4.84) was attributed to the importance this trait plays especially where a cow walks in search of fodder and water. A body shape was essential during gestation in enabling the cow to feed comfortably and carrying its fetus to term hence associated with calving ease.

Dewlap came in at a closer fourth most important selection criteria. East Africa Zebu cattle have a large dewlap. A large dewlap and loose skin provide a large surface area for perspiration under the hot and humid tropical climatic conditions in which the EAZ cattle are reared (Kugonza *et al.*, 2012). Backline and tail length were ranked as the second last selection criteria. Tail length was termed as the most visible trait indicating the milk production, long tail with big base was selection criteria indicator trait for high milk yield, carcass weight, beauty and big offspring.

This study found out that there was a lesser emphasis on CC in the selection of cows than in bulls since bulls determine the appearance of the herd. CC was the least preferred trait in the selection of cows. Cassell (2002) indicated that the physical attributes (appearance) are highly heritable and uniformly passed on to the herd by the bull with a high degree of influence on subsequent generations. Preference for different colours can be attributed to farmer's socio-cultural factors or to breed effects (Zander & Drucker, 2008). If the farmer has crossbred his animal one could easily tell the breed used by just looking at the CC. CC was also reported as a trait related to milk yield especially in temperate breeds raised in tropical climates (Ouma *et al.*, 2004).

3.4.2 Socio-economic determinants of traits selection criteria for breeding bulls for dairy production

Table 2 below represents the MVP model output, the results on correlation coefficients (rho) of error terms reveals that there are both substitutability and complementarities (positive correlation) between different bulls' trait selection criteria. The results suggest that the null hypothesis of zero correlation between the error terms of all equations was rejected hence confirms the assumption of interdependence. The fact that most correlations (rho) have positive signs suggests complementarities rather than substitutability among the trait's selection criteria. A likelihood ratio test based on the log-likelihood values indicate significant correlations $\chi^2(45) = -279.27$; probability $> \chi^2 = 0.041$ justifying that the explanatory power of the multivariate probit model had a strong effect.

Gender: Gender of the household head had a negative influence on the preference of bull's body frame and a positive influence on the preference for bull's appearance (*Table 2*). Male farmers had a higher preference for bull's body frame than female farmers. This could be attributed to the fact that the use of bulls for draught purposes was a major activity undertaken predominantly by men and young boys. Handling of animal drawn implements like ploughs and ox-carts restricts women due to their bulkiness hence leaving such tasks to men. Ouma *et al.* (2004) also indicated that male household heads tend to prefer bulls with good traction ability more than their female counterparts. Female farmers had a higher ranking of bull appearance than their male counterparts. This could be attributed to the natural care of females to the wellbeing of living species (Ainslie, 2005). Hides are used to make mats and this has a higher appeal to the female farmers.

Distance to the water source: The distance to the water source had a positive influence on choice of bulls based on their body frame, appearance and performance of bulls' offspring

(**Table 2**). Bulls with a big body frame were highly preferred since they are used in pulling carts to fetch water. Bulls with horns and hump were preferred to ensure yokes do not come out during fetching water. Bulls which sired offspring with a light color and big body frame were preferred as the offspring were hardy enough to trek long distances in search of water. However, distance to water source had a negative influence on choice of bulls based on their scrotal size. Bulls mostly used for draught purposes were sometimes castrated.

On the other hand, household size had a positive influence on choice of bull based on SC and tail size (**Table 2**). SC indicates bulls' fertility; bulls with big scrotum were believed to be very productive hence fast herd increases. Sellen (2003) showed that herd size was positively influenced by the number of people in the household due to consumption needs. High reproductive potential has a positive impact on the herd size and consequently on the household size. This was in contrast with Anunda (2012) who found out that bigger family sizes are well established households with possibly less interest in increasing their herd size as compared to smaller families of young households who expect to increase their herd size.

The bigger the household size the higher the preference for a bull with a long tail. Farmers mentioned that tail size was the most visible indicator for milk yield (**Table 2**) and that long tail with big base was an indicator trait for high milk yield, high carcass weight, beauty and big offspring. Bulls with long tails were believed to sire daughters with high milk yield which is of great essence to big households for consumption needs (Kugonza *et al.*, 2012).

Table 2: Socio-economic factors influencing farmers' selection criteria for breeding bulls

Variable	Frame	Appearance	Performance	tail size	scrotal size
			of relative		
household size	-0.264** (-0.113)	0.036 (0.046)	-0.005 (0.044)	0.079** (0.047)	0.052* (0.042)
herd size	-0.004 (0.079)	0.058 (0.058)	0.140*** (0.049)	0.143** (0.051)	0.095** (0.041)
land size	-0.006 (0.018)	0.007 (0.015)	-0.019** (0.010)	0.013*** (0.018)	-0.014** (0.010)
Education (years)	0.022 (0.017)	0.008 (0.015)	0.005* (0.012)	-0.008 (0.012)	(0.045) (0.012)
Gender	-0.839** (0.405)	1.023** (0.479)	-0.158 (0.305)	-0.130 (0.308)	0.355 (0.307)
distance to water	0.088*** (0.109)	-0.045* (0.034)	0.005** (0.032)	-0.025 (0.030)	-0.064 (0.032)
occupation	4.838* (0.144)	0.877** (0.523)	-0.564*** (0.281)	-0.535*** (0.265)	0.296 (0.272)
owns phone	-0.081 (0.450)	-0.166 (0.399)	0.167 (0.276)	-0.526** (0.281)	-0.431*** (0.293)
Age	-0.024 (0.019)	-0.014 (0.016)	-0.004 (0.012)	0.002*** (0.012)	0.012 (0.012)
_cons	1.361* (0.047)	1.038** (0.501)	1.240*** (0.516)	-0.584* (0.397)	0.229 (0.343)
Rho2	0.888***				
Rho3	0.088	0.249**			
Rho4	-0.01*	0.259**	0.657***		
Rho5	0.152**	0.443***	0.605***	0.387***	
Observations					165
Log-likelihood					-279.27
Wald χ^2 (45)					61.6
Prob > χ^2					0.041

Likelihood ratio test of rho21 = rho31 = rho41 = rho51 = rho32 = rho42 = rho52 = rho43 = rho53 = rho54 = 0: chi2(10) = 62.0668 Prob > chi2 = 0.0000; Standard errors in parenthesis; significance level ***p<0.01, **p<0.05 and *p<0.1

Education: As farmer's years of education increased the preference for performance of bull relative increased (**Table 2**). However, education had no significant influence on selection of body frame and appearance implying education does not change farmers' perception towards specific coat colors and traction ability; people still uphold their cultural values despite their level of education. This was in contrast with Kassie *et al.* (2009) found out that as education level increases, the sensitivity towards body size also increases. The relatively educated group of farmers was composed of farmers with other income streams who intend to consume the animals than keeping them either for production or reproduction.

Occupation of the farmer had a positive influence on preference of bull based on body frame and appearance (**Table 2**). Respondents without off-farm income had a higher preference for body frame than those with off farm income. This was attributed to the role a bull play in the farming activities to full time farmers. With another source of income might be able to hire a bull or other sources of energy for farming activities. Often farmers with off farm income source keep bulls for consumption rather than for production or reproduction.

Farmers whose main **occupation** was not farming had higher ranking to the performance of bulls' relatives than full time farmers, this shows that respondents engaged in farming were not comfortable with keeping performance records hence less preference for this trait. Moreover, farmers with off farm employment are usually more educated and find it easier to record performance compared to farmers with no alternative sources of employment. Differences in occupation were also found to be important sources of trait preference heterogeneity by Kassie *et al.* (2007).

Herd size had a positive influence on performance of relatives, tail size and scrotal size (**Table 2**). Bulls with good reproductive performance become highly valued because it ensures fast herd increases (Ouma *et al.*, 2007). The dependency (ratio of pre-school and school-going household members to adults in the household) of the household members might be related to the average herd sizes. Sellen (2003) showed that herd size was positively influenced by the number of people in the household due to consumption needs. Therefore, high milk yield as indicated by tail size was influenced by household size and by extension herd size. Scrotal size indicated high reproductive potential and had a positive impact on the herd size. Performance of relatives (calf performance) increases the probability that the bull will be selected on the premise that a higher utility can be derived (Kamuanga *et al.*, 2011).

Age: The older the farmer the higher the preference for tail size (**Table 2**). Older farmers mentioned that tail size was the most visible indicator for milk yield. They also claimed that long tail with big switch was a selection indicator trait for high milk yield, high carcass weight,

beauty and big offspring, similar findings were documented by Kugonza *et al.* (2012). Farmers also indicated the relevance of long tail; it turns around and can reach to far extent of the body and this specialty helps the animal to knock out flies.

Gender: Gender of the household head had a negative influence on the preference of bull's body frame and a positive influence on the preference for bull's appearance (**Table 2**). Male farmers had a higher preference for bull's body frame than female farmers. This could be attributed to the fact that the use of bulls for draught purposes was a major activity undertaken predominantly by men and young boys. Handling of animal drawn implements like ploughs and ox-carts restricts women due to their bulkiness hence leaving such tasks to men. Ouma *et al.* (2004) also indicated that male household heads tend to prefer bulls with good traction ability more than their female counterparts. Female farmers had a higher ranking of bull appearance than their male counterparts. This could be attributed to the natural care of females to the wellbeing of living species (Ainslie, 2005). Hides are used to make mats and this has a higher appeal to the female farmers.

Distance to the water source: The distance to the water source had a positive influence on choice of bulls based on their body frame, appearance and performance of bulls' offspring (**Table 2**). Bulls with a big body frame were highly preferred since they are used in pulling carts to fetch water. Bulls with horns and hump were preferred to ensure yokes do not come out during fetching water. Bulls which sired offspring with a light color and big body frame were preferred as the offspring were hardy enough to trek long distances in search of water. However, distance to water source had a negative influence on choice of bulls based on their scrotal size. Bulls mostly used for draught purposes were sometimes castrated.

On the other hand, household size had a positive influence on choice of bull based on SC and tail size (**Table 2**). SC indicates bulls' fertility; bulls with big scrotum were believed to be very productive hence fast herd increases. Sellen (2003) showed that herd size was positively influenced by the number of people in the household due to consumption needs. High reproductive potential has a positive impact on the herd size and consequently on the household size. This was in contrast with Anunda (2012) who found out that bigger family sizes are well established households with possibly less interest in increasing their herd size as compared to smaller families of young households who expect to increase their herd size.

The bigger the household size the higher the preference for a bull with a long tail. Farmers mentioned that tail size was the most visible indicator for milk yield (**Table 2**) and that long tail with big base was an indicator trait for high milk yield, high carcass weight, beauty and big

offspring. Bulls with long tails were believed to sire daughters with high milk yield which is of great essence to big households for consumption needs (Kugonza *et al.*, 2012).

Education level: As farmer's years of education increased the preference for performance of bull relative increased (**Table 2**). However, education had no significant influence on selection of body frame and appearance implying education does not change farmers' perception towards specific coat colors and traction ability; people still uphold their cultural values despite their level of education. This was in contrast with Kassie *et al.* (2009) found out that as education level increases, the sensitivity towards body size also increases. The relatively educated group of farmers was composed of farmers with other income streams who intend to consume the animals than keeping them either for production or reproduction. The higher the education the higher the ranking of the performance of relative (**Table 2**). Ligda and Georgoudis (2008) found out that illiteracy levels of the communal dweller make standard performance data collection difficult. In the study area, performance records were unavailable hence; selection was based on the physical characteristics of the animals.

3.4.3 Socio-economic determinants of traits selection criteria for cows for breeding for dairy production

Land size had a positive influence on the choice of the cow based on body shape (**Table 3**). The bigger the land size the higher the preference for body shape. Body shape reflected the ability of a cow to withstand walking for long distances in search of pasture.

Household size: The bigger the household size the higher the preference for teat size (**Table 3**), tail size and body shape. Teat and tail size were the most visible traits for milk potential of the cow and the bigger the household the higher the preference for milk production traits due to consumption needs. This concurs with Anunda (2012) who observed that the bigger household the higher the preference for high milk production traits.

Land size had a negative influence on teat size, rumen depth, tail size and coat color (**Table 3**). The smaller the land size the higher the preference for teat size, tail size, rumen depth and coat color. Teat size indicate cow's milk 'potential therefore it's a production trait. Availability of land translates to more fodder production. Land is a factor of production hence not surprising to find that traits indicating milk yield being affected by land size.

Rumen depth indicates the feeding requirement for an animal. Farmers with small parcels of land were more concerned about the rumen depth of the cow because of fodder availability for their cows. Farmers with small land parcels had a higher preference for tail size. Farmers mentioned tail size being the most visible indicator trait for milk yield, this implies

that farmers with small land had a higher concern for milk production traits. Previous studies indicated mixed findings on the relationship between land size and milk production (Staal *et al.*, 2008). This study predicts a negative association between indicator traits for milk yield and land size.

Land size and coat color were negatively associated (**Table 3**); coat color is an adaptive trait. It helps in reflecting solar radiation (thermoregulation) especially when the animal is walking in search of feed. Coat color was highly preferred by farmers with small parcels of land since their cows have to walk for long distances in search of fodder. Dark coated animals are very susceptible to trypanosomosis, tsetse flies are attracted by a combination of blue and black colors (Steverding & Troscianko, 2004).

Gender had a negative influence on preference for teat size and rumen depth (**Table 3**). Female farmers had a higher preference for teat size and placement than males. This was attributed to the role women play in the milking of cows which is usually not a male role in the study area. Hence aside from attributing udder and teat size with high milk yield, good udder and teat enhances milking ease. Milking ease is of essence in maximizing yield since milk let down is controlled by oxytocin hormone whose concentration diminishes with time (Rewe, 2015). EAZ do not let down milk unless stimulated by the sucking of a calf hence traits for milking ease were very important selection criteria. Female farmers had a higher likelihood of ranking rumen depth than male farmers. Female farmers were found to take a major role in the feeding of the cows hence they knew cows with big rumen will be more demanding in terms of feed and water.

Table 3: Socio-economic factors influencing farmers' selection criteria for breeding cows

Explanatory Variables	Dependent variables							
	Tail	Dewlap	Rumen	body	Coat	Backline	Udder	Teat
land size	-0.014** (0.014)	-0.022 (0.012)	-0.026** (0.017)	0.027** (0.011)	-0.023** (0.01)	0.021* (0.018)	0.416 (0.363)	-0.536** (0.365)
herd size	0.033* (0.044)	0.107** (0.064)	0.126** (0.053)	-0.01 (0.065)	0.142** (0.047)	0.123 (0.043)	0.53 (0.051)	0.836 (0.584)
HHsize	0.06** (0.044)	0.048 (0.044)	-0.045 (0.068)	0.409* (0.143)	-0.03 (0.045)	-0.011 (0.042)	0.256 (0.131)	0.943** (0.258)
Water	-0.06 (0.03)	0.072** (0.085)	0.257*** (0.129)	0.02** (0.062)	0.043 (0.038)	-0.089** (0.029)	0.25 (0.587)	0.450 (0.411)
experience	-0.005 (0.01)	-0.013 (0.01)	-0.003 (0.015)	0.001 (0.019)	-0.028 (0.012)	-0.001 (0.011)	0.194 (0.369)	0.514* (0.258)
Age	0.018* (0.011)	-0.008 (0.011)	0.018 (0.015)	0.045* (0.024)	0.014 (0.013)	-0.013 (0.011)	0.37 (0.442)	0.524 (0.356)
Gender	0.353 (0.117)	0.589 (0.253)	0.758** (0.112)	0.368 (0.247)	0.258 (0.139)	0.586* (0.128)	0.486 (0.488)	0.329*** (0.362)
occupation	0.357 (0.146)	0.981 (0.258)	0.163** (0.368)	0.222 (0.572)	-0.586* (0.289)	0.147 (0.357)	2.21 (0.785)	0.941** (0.634)
education	0.541** (0.231)	0.321 (0.224)	0.126 (0.094)	0.354 (0.023)	0.589** (0.058)	0.987 (0.036)	0.962 (0.058)	0.875** (0.067)
-cons	-0.891 (0.401)	0.852*** (0.382)	1.256 (0.563)	1.137*** (0.427)	0.167 (0.378)	-0.220 (0.379)	-1.584 (0.542)	0.186 (0.730)
Rho1	0.23							
Rho2	0.338**	0.066						
Rho3	0.044	-0.205**	0.288**					
Rho4	0.223**	0.360***	0.186	0.139				
Rho5	0.328**	0.357***	0.205*	0.170	0.223**			
Rho6	-0.188	0.088*	-0.381	0.457	0.483***	0.284		
Rho7	0.205	0.193*	0.156	0.174	0.034	0.432	0.234*	
Log-likelihood								-546.47
Wald χ^2 (72)								91.96
Prob > χ^2								0.051

Likelihood ratio test of $\rho_{21} = \rho_{31} = \rho_{41} = \rho_{51} = \rho_{61} = \rho_{71} = \rho_{32} = \rho_{42} = \rho_{52} = \rho_{62} = \rho_{72} = \rho_{43} = \rho_{53} = \rho_{63} = \rho_{73} = \rho_{54} = \rho_{64} = \rho_{74} = \rho_{55} = \rho_{65} = \rho_{75} = \rho_{66} = \rho_{76} = \rho_{77} = 0$: $\chi^2(21) = 59$ Prob > $\chi^2 = 0.0000$; Standard errors in parenthesis; significance level *** $p < 0.01$, ** $p < 0.05$ and * $p < 0.1$

Herd size: Herd size had a positive influence on dewlap size, coat color and rumen depth (**Table 3**). The larger the herd size the higher the preference for dewlap size, coat color and rumen depth. These three traits are adaptive traits; agro-pastoral farmers are faced with many challenges especially loss of animals during drought periods. Therefore, it was rational to select livestock with traits that will enable them to maintain their large herd sizes. Furthermore, herd size is often directly correlated to wealth and status in the pastoral societies. In addition, a significant portion of the herd is a risk management tool rather than a productive asset (Rege *et al.*, 2011).

Distance to the Water source: Farmers with larger distance to the water source had a higher preference for dewlap and rumen depth higher than those with shorter distance (**Table 3**). Good body shape was more preferred by farmers with longer distance to the water source than those with shorter distance to water source. Rumen depth was a proxy for feeding and watering requirement and was highly preferred since the watering points are located far from the homesteads at an average distance of 3 Km. Kassie *et al.* (2009) also found out that distance to the water source significantly influenced the preference for watering frequency trait.

Farmers experience in livestock farming: The higher the experience in livestock farming the higher the probability of ranking teat size and placement as the most important trait in a cow. Quddus *et al.* (2017) documented that experience has a strong positive relationship with the adoption of dairy technology. Anunda (2012) echoed that farming experience negatively influenced preference for high milk yields breeds. There was no significant difference in all covariates in the ranking of udder size as the most preferred traits.

3.5 Conclusion

Udder and teat size in cows and body frame in bulls (production traits) were the most important selection criteria. Coat color was ranked higher in bulls than in cows. Bulls' selection was influenced by gender, land size, water distance, household size, occupation of the farmer. The role of men and women in cattle rearing was featured in the selection criteria, men farmers had a higher preference for bulls' body frame than female farmers. Women preference for rumen depth and teat size can be attributed to the role women play in the livestock production (milking and feeding of cattle). Production constraint also determined trait selection criteria, positive influence of distance to water and the preference for body shape.

CHAPTER FOUR

ASSESSMENT OF SOCIO-ECONOMIC FACTORS INFLUENCING PREFERENCE FOR EAST AFRICAN ZEBU

4.1 Abstract

In Kenya, 72% (9 million out of 12.5 million) of cattle are still pure EAZ (not diluted or contaminated with exotic genotypes) mainly found in ASALs and produce only 19% of the total milk in the country. The EAZ is well adapted to stressful environmental condition and perform multiple functions in ASALs. There is, therefore, a need to improve the dairy productivity of EAZ so as to improve the welfare of the ASALs community. Breed improvement programs provide a key entry to increase the milk production and productivity of EAZ. However, the few breed improvement programs dedicated to improving the milk traits in the EAZ in ASALs have not been successful. This is because the success of any breed improvement program depends upon the actions of livestock keepers who own, utilize, and adopt breeds and adapt them to their needs. Therefore, the objective of this study was to identify the constraints to milk production and determine the socio-economic factors that influence the preference for EAZ to other breeds for dairy production in ASALs to help explain the viability of crossbreeding programs in the area. Primary data was collected through a structured questionnaire. A unique adoption process was identified in this study whereby 42% of the farmers preferred exotic breeds and their crossbred yet over 90% of the household interviewed kept EAZ. Indices were computed to rank the constraints that hinder milk production in the study area. The cumulative logits model in SAS helped to obtain a rank on the reason (production objectives) for rearing EAZ in the county. To empirically determine the socio-economic factors affecting the adoption of the breed in the study area, a binary logit model was applied. Inadequate feed, frequent droughts, and inadequate water were the highest-ranked constraints for milk production. The odds ratio obtained indicated that drought tolerance was the most important trait for preference for EAZ to other breeds and milk and draught power were the most important production objectives for keeping EAZ. Land size, herd size, and water distance had a direct influence on preference for EAZ while experience, education, and occupation had an indirect influence on the preference of EAZ. Since the environmental constraints were rife in the study area, this study recommends locally producing and multiplying first generation (F1) crossbreed cattle (terminal crossbreeding) and better breed and feed management strategies.

4.2 Introduction

Livestock enterprises provide employment to 90% of the population in the ASALs and contribute 95% of the household income in those areas (KIPPRA, 2009; Mwamuye *et al.*, 2013). Although European breeds tend to produce more milk in terms of quantity, *Bos indicus* is superior with regard to the milk quality (Vitamin B12 found only in milk from EAZ cows), perform many functions and are well adapted to the low input systems (Anderson, 2003).

Kenya is endowed with largest dairy herd in SSA, with over 5 million improved cattle (KNBS, 2019). While the rest of the country enjoys the benefits from the vibrant dairy sector, dairying in ASALs has consistently lagged behind in critical indicators of dairy production showing low adoption rates for dairy technologies, low numbers of improved genotypes, low milk yields, low incomes from milk and smaller number of households in milk business (Muriuki *et al.*, 2011).

Deliberate efforts were made by the Kenyan government to improve dairy production through crossbreeding and breed replacement. While such interventions have generated vibrant dairy industry in other areas, they can only bring about short-term economic gains in ASALs and have led to the loss of indigenous livestock breeds. Dairy production in ASALs is marred by many constraints and without due consideration of the constraints, dairy improvement interventions are bound to fail (Amimo *et al.*, 2011; Mwangi, 2013; Verbeek *et al.*, 2007). Such constraints hinder adoption of improved dairy breeds hence their alleviation is key in breeding programs.

The success of a breeding program could be limited by indigenous knowledge of the farmers, socio-economic and cultural variables (Wuletaw *et al.*, 2006; Wurzinger *et al.*, 2011). A breeding program might be effective in the high and medium potential but fails in the lower potential areas because of the disparities that exist in terms of genotype by environment interaction, socio-economic characteristics of the farmers and constraints. In high and medium potential areas livestock production is threatened by population pressure while in ASALs it is threatened by harsh climate, soil erosion, land degradation, inadequate water, poor marketing infrastructure and poor animal husbandry practices (Alila & Atieno, 2006). The implementation of a breeding program should take good consideration of these factors since they are difficult or impossible to change (Wollny, 2003).

Given the importance of different breeds to sustaining poor farmers' livelihoods and the degree of endangerment of indigenous breeds, it is crucial that the elements likely to affect the success of such programs be well understood. This is because the success of any improvement program depends upon the actions of livestock keepers who own, utilize and adopt breeds

and adapt them to their needs. Therefore, the objective of this study was to identify the constraints to milk production and determine the socio-economic factors that influence the preference for EAZ to other breeds for dairy production in ASALs to help explain the viability of crossbreeding programs in the area.

4.3 Methodology

4.3.1 Data collection

Data collection was conducted as described in Chapter 3. Information was obtained on whether the farmer prefers EAZ to other breeds, traits for preference of EAZ to other breeds, traits for non-preference of EAZ, socioeconomic data about the household itself as well as perceived constraints to milk production.

4.3.2 Data analysis

Descriptive statistics in terms of percentages, mean ranks, mean and standard deviation were obtained using both SAS and STATA programs. Indices were computed to rank the constraints that hinder milk production in the study area as follows: Sum of the rank given for the individual constraint divided by the sum of the rank given for all purposes. The following equation was used in the calculation of the index (I_i) for each production constraint.

$$I_i = \frac{\text{sum of}[4\text{forrank1} + 3\text{forrank2} + 2\text{forrank3} + 1\text{forrank4}]}{\text{sum}[4\text{forrank1} + 3\text{forrank2} + 2\text{forrank3} + 1\text{forrank4}] \dots \dots \dots \text{Equation 14}}$$

Cumulative logits model in SAS helped to obtain a rank on the reason (production objectives) for rearing EAZ in the county. The question posed to the farmers was whether a certain objective for production was less important, important or very important to the farmer. The responses were three (3-point Likert scale; less important, important and very important). In the regression analysis the response given for each trait was the dependent variable and the traits were the independent variables. Drought tolerance trait was the reference category since many households ranked it as most important. If the odds ratio were greater than one it implied that drought tolerance was of lower importance than the other trait, if less than 1, it meant that the drought tolerance was of greater importance than the other trait and equal to one meant that both traits had equal importance.

To empirically determine the socio-economic factors affecting adoption of the breed in the study area, binary logit model was applied. Farmers were asked if they prefer EAZ to other breeds (Yes/No). A general framework of adoption studies was adopted.

Farmers are rational and always aspire to maximize utility in their decision-making process. The choice between two options is made when the utility or perceived benefit from using the technology is significantly greater than would be without the technology. Utility is not directly observed but revealed in the choices the farmer makes.

Suppose U_z and U_c represent the household perceived utility for either of the choices of preferring EAZ and other breeds (cross bred) respectively. X_z and X_c are the vectors of the explanatory variables that influence the perceived desirability of the choices z and c . The linear random utility model (Greene, 2008) could be specified as:

$$U_{iz}(\beta_z X_i + \varepsilon_z) > U_{ic}(\beta_c X_i + \varepsilon_c) \dots \dots \dots \text{Equation 15}$$

Assuming Y is the decision to prefer a breed, which takes 1 if the farmer prefers EAZ and 0 otherwise. The probability that a household will prefer EAZ conditional on X could then be defined as:

$$P(Y = 1) | X = P(U_z > U_c) | X \dots \dots \dots \text{Equation 16}$$

$$P(Y = 1) = \beta_a X_i + \varepsilon_a - \beta_c X_i + \varepsilon_c | X \dots \dots \dots \text{Equation 17}$$

$$P(Y = 1) = \beta^* X_i + \varepsilon^* | X = F(\beta^* X_i) \dots \dots \dots \text{Equation 18}$$

Where, P is the probability function, β^* is a vector of unknown parameters which can be interpreted as the net influence of the vector of independent variables (X) influencing adoption. ε^* the error term. The assumption on the distribution of the error term determines the model to be used. The exact distribution of F depends on the distribution of the random disturbance term ε^*

By considering three categories of independent variables (X , Y and Z) the probability of keeping EAZ (P_z) was expressed as follows:

$$P_z = Prob(X_j \alpha_1 + Y_j \beta_1 + Z_j \gamma_1 + e_{1j} > X_j \alpha_2 + Y_j \beta_2 + Z_j \gamma_2 + e_{2j}) \dots \dots \text{Equation 18}$$

$$P_z = Prob(e_{1j} - e_{2j} > (X_j \alpha_2 + Y_j \beta_2 + Z_j \gamma_2) - (X_j \alpha_1 + Y_j \beta_1 + Z_j \gamma_1)) \dots \dots \text{Equation 19}$$

$$P_z = Prob(e_{1j} - e_{2j} > X_j (\alpha_2 - \alpha_1) + Y_j (\beta_2 - \beta_1) + Z_j (\gamma_2 - \gamma_1)) \dots \dots \text{Equation 20}$$

where $i=1$ farmer prefers EAZ, $i=0$ farmer prefers other breeds, j represents the farmer making the choices, X represents farmer characteristics, Y represents the farm characteristics and Z ranking of the attributes for preference of EAZ to other breeds.

Let $\mu = e_{1j} - e_{2j}$; a random term, $\alpha = \alpha_2 - \alpha_1$, $\beta = \beta_2 - \beta_1$, $\gamma = \gamma_2 - \gamma_1$; these are the parameters to be estimated.

$$P_z = Prob(\mu > \alpha X_j + \beta Y_j + \gamma Z_j) \dots \dots \dots \text{Equation 21}$$

$$P_z = F(\alpha X_j, \beta Y_j, \gamma Z_j) \dots \dots \dots \text{Equation 22}$$

Assuming identically and independently distributed random term with a Weibull density function, the probability that an individual will prefer EAZ can be estimated using a logistic model as follows;

$$P_z = \frac{e^{\alpha X_j + \beta Y_j + \gamma Z_j}}{1 + e^{\alpha X_j + \beta Y_j + \gamma Z_j}} \dots \dots \dots \text{Equation 23}$$

$$\frac{P}{1-P} = e^{\alpha X_j + \beta Y_j + \gamma Z_j} \dots \dots \dots \text{Equation 24}$$

$$\ln \frac{P}{1-P} = \alpha X_j + \beta Y_j + \gamma Z_j \dots \dots \dots \text{Equation 25}$$

4.4 Results and Discussion

4.4.1 Farmers’ socio-economic characteristics

The majority of the households were male headed (80%), of the few women that headed the household 90% were widowed and the rest were not married (**Table 4**). The gender of headship of the households is an important factor in decision making and rate of adoption of technologies. They also tend to give the knowledge of the general behavior and attitude of the people in the study area (Mwambene *et al.*, 2014). The basic resources such as land and livestock are owned and controlled by men and this has a central part of program planning, design and implementation of a breeding program. Mwacharo and Drucker (2005) found out that men are principally involved in making cattle purchase and sale decisions. Therefore, the preference of the household heads was likely to affect their participation in a breeding program.

Majority of the households (85%) had farming as their only source of livelihood and was their main economic activity (**Table 4**). An average household in Kitui comprised of 7 members with a maximum membership of 20 and minimum of 3 members.

Table 4: Frequency and percentages of categorical socio-economic characteristics of East Africa Zebu farmers

	Frequency	Percent
Gender		
Male	129	80
Occupation		
Off-farm employed	24	15
Marital status		
Married	137	85
Mobile phone		
Yes	37	23

A significant majority (>85%) of the farmers responsible for cattle rearing were within the labor force age bracket that is, between 25 and 65 years (The mean age of the farmers was 49 years. A considerable proportion of farmers (68%) fell above 46 years of age. This concurs with the findings of Amimo *et al.* (2011) that indigenous livestock farming was common with relatively older people. This can be explained by the fact that indigenous cattle breeds farming common in the area does not require much attention compared to exotic or crossbreeds hence older people can comfortably keep EAZ.

However, youth (<35 years) were only 8% of the farmers implying that the enterprise is missing out on a more active group, who would enhance EAZ productivity and commercialization. Nonetheless, older people are still important in dairy farming as they have wealth of skills and experiences, they have lived through situations and such experiences are crucial in a breeding program. The mean experience in livestock rearing was of approximately 23 years.

Majority of the farmers kept indigenous cattle, mainly the Kamba EAZ (86%), a few (8%) of them kept some crosses of exotic × EAZ and 3% EAZ and Sahiwal crosses for milk production. Despite low milk productivity of Kamba EAZ (at most 6 litres per day) many farmers continue rearing them for milk production.

The mean years of education was 13.8 years. Approximately 90% of the farmers had attained primary and post-primary education however 10% had no education. Most household heads had attained secondary education and above.

Table 5: Mean and standard deviation for continuous SE characteristics of East Africa Zebu farmers.

Variable	Description	Mean	SD
Household characteristics			
Household size	Number of people in the household	7.00	2.97
Water distance	Distance to the main water source	2.43	3.55
Experience	Farmers experience in livestock (years)	22.92	11.68
Land size	Farm land (acres)	9.75	15.23
Herd sizes	number of cattle	5.00	3.44
Age	HHH age in years	49	22.6
Education	Number of years in school	13.8	2.3

Literacy levels were high indicating that education holds no limitation in communicating technical knowledge related to improving EAZ for improved milk production. Farmers' ability to adopt new technologies has been found to be affected by their level of education (Ampaire & Rothschild, 2011). Household size was relatively big at 7 members on average per household higher than the Kenyan average household size of five people.

The average herd size was 5 heads of cattle. Similar findings are reported by Njarui *et al.* (2012) that on average farmers kept 5.3 heads of cattle with 40% being cows. Small herd size is problematic as far as minimizing inbreeding and obtaining optimal genetic gain are concerned (Abebe *et al.*, 2020; Mwacharo & Drucker, 2005). In such scenarios, farmers should work together in form of village bull schemes for the sustainable use of genetic resources.

All categories of livestock were communally grazed, where cows were mixed with bulls. Castration of bulls was not common and therefore controlled mating was not practiced. This hampers efforts to utilize bulls with superior traits. This form of communal grazing is a major hindrance to the traceability of performance of bull sibs and relatives.

4.4.2 Constraints to production

Table 6 highlights the constraints that farmers perceived to limit increased milk production. In descending order of severity; limited feed, frequent droughts, limited water, disease prevalence, limited credit, inadequate extension services, breeding stock, and lack of market and cattle theft. These constraints reflect the harsh environmental conditions experienced in this semi-arid region. Limited feed was cited as the most important constraint.

Table 6: Ranking of the constraints to milk production

Constraint	Rank 1	Rank 2	Rank 3	Rank 4	Index
Lack of feed	45	61	37	0	0.28 (1)
Frequent drought	57	22	59	9	0.26 (2)
Lack of water	41	56	29	18	0.26 (3)
Disease prevalence	5	12	18	44	0.09 (4)
Breeding stock	4	0	2	10	0.02 (7)
Inadequate extension	4	4	4	30	0.04 (5)
Lack of market	0	2	2	6	0.01 (8)
Cattle theft	2	0	0	0	0
Lack of credit	2	2	4	40	0.04 (6)

Rank in parenthesis

Livestock keepers need to cut and conserve feed materials during the wet season and plant woody browse species. Another important source of feed during the dry seasons and drought periods is crop residue from failed crops and harvested crop residues. However, these sources of livestock feed were disregarded in the ASALs of Kenya (Ndathi *et al.*, 2011).

4.4.3 Traits for preference of EAZ to other breeds

Results indicate that the most important trait for preference of EAZ to other breeds was drought tolerance as presented in *Table 7*. This could be attributed to the unfavorable climatic conditions experienced in the area and the recurrence of droughts. Farmers were concerned about the issue of lifting animals that go down with starvation. Disease tolerance was the second most important traits for preference of EAZ to other breeds. Watering frequency and mature weight were third and fourth important traits for preference of EAZ respectively. Feeding requirement was the least preferred traits in EAZ.

Table 7: Traits for preference of EAZ to other breeds

Characteristic	Odds ratio	95% confidence interval	
Drought tolerance	Reference category		
Disease tolerance	0.98	0.62	1.08
Mature weight	0.79	0.55	1.15
Watering frequency	0.93	0.65	1.34
Feed requirements	0.71	0.49	1.04
Reproductive performance	0.91	0.64	1.31

4.4.4 Reasons for non-preference of EAZ to other breeds

Although most farmers kept EAZ, they discredited the breed due to its less productivity and fetching low market prices (*Table 8*). A few disapproved it for low growth rates. In Kitui County, 58% of farmers still prefer rearing EAZ. A unique adoption process was identified in this study whereby 42% of the farmers preferred exotic and their crossbred yet over 90% of the household interviewed kept EAZ. The discrepancy between the actual adoption of improved dairy breeds and their preference could be attributed to the large capital outlays involved in the adoption of exotic and their crossbreds and environmental constraints experienced in the area.

Farmers in ASALs are resource-poor to sustainably support a relatively higher input production system that are necessary for sustenance of exotic and their crossbred (Muasya *et al.*, 2004).

Table 8: Reason for non-preference of EAZ to other breeds

	Frequency	Percentage
Prefer EAZ to crosses		
YES	94	58
Reasons for non-preference		
low productivity	48	72
low growth rates	2	3
low market value	17	25

4.4.5 Production objectives of rearing EAZ cattle.

Table 5 shows results obtained from cumulative logistic regression in SAS ranking the reasons for keeping EAZ. Manure as reason for keeping EAZ was the reference category. According to Bebe *et al.* (2003), if the odds ratio is less than one then the reference category has a higher importance, if greater than one the reference category has a lower importance, if it's one then equal importance in the constraints being compared.

Table 9: Reasons for keeping EAZ cattle

Reason	Point Estimate	95 % Wald Confidence Limits	
Manure	Ref		
Milk	3.517	1.968	6.283
Meat	0.087	0.047	0.162
Draught	2.500	1.415	4.418
Income	1.197	0.685	2.092
Asset	1.416	0.809	2.479
Socio-cultural	0.156	0.086	0.283

Farmers in Kitui County mainly kept EAZ (in descending order of importance) for milk, draught power (especially for ploughing), asset, income, manure, socio-cultural roles (sacrifices and dowry payments).

Milk was an important component of the daily diet in many households hence ranked as the most important reason for keeping EAZ cows. Draught power was found to be the second most important reason for rearing EAZ cattle (bull). Production objectives as ranked by farmers reveal the multiple roles that EAZ cattle play in the livelihoods of Kitui residents. Other authors have reported similar findings, that the use of cattle for draught purposes was a major activity in the agro pastoral systems (Chebo *et al.*, 2014; Nigusse *et al.*, 2013; Traoré *et al.*, 2016).

Chebo *et al.* (2014) and Traoré *et al.* (2016) also reported that the most valued cattle product among agro-pastoral systems were draught power. This indicated that livestock development interventions should be geared towards breeding of animals that will produce both draught power and milk. The objectives of production identified in this study reflect the multiple objectives and are consistent with the findings of Gizaw *et al.* (2010) and Traoré *et al.* (2016). Dual purpose cattle for draft power and milk production seem to match the farmers' selection criteria in this study.

4.4.6 Socio-economic factors that influence the preference of EAZ in Kitui County

The model fitted the data well as indicated by the whole significance level (0.1%). The fact that pseudo $R^2 > 20\%$ (was found to be 56%) confirms goodness of fit. **Table 10** shows the results for socio-economic characteristics influence on preference for EAZ Kitui County.

Age had non-significant influence on preference for EAZ indicating perceptions towards EAZ are being consistently passed on from one generation to another. Both young and old farmers had equal chances of rearing EAZ, thus increasing the diversity of potential adopters of EAZ (non-adopters of exotic and crossbreeds). This was in contrast with Baltenweck and Staal (2000) who indicated that older household heads are usually risk averse hence associated with more preference of EAZ than younger household heads.

Rating of traits for preference of EAZ and objective of production also had an influence on preference for EAZ. Disease tolerance, drought tolerance, feeding requirements and watering frequencies traits had the highest marginal effects for preference for EAZ to other breeds.

The results confirm the findings of the previous adoption studies that farmers' perceptions of the technology characteristics (breed) have a role in their adoption decisions (Jabbar *et al.*, 2010; Quddus *et al.*, 2012). The high rating of disease resistance, drought tolerance and

watering frequency for preference of EAZ concurred with the findings that these traits were the major determinants of the probability of adoption of EAZ in the area. The ability to be productive under the harsh climatic conditions in the study area make EAZ to be more attractive to farmers in the area.

Herd size had a significant positive influence on preference for EAZ. The higher the herds size the higher the preference for EAZ to other breeds. Raising of many alternative breeds especially exotic and cross breeds present higher production risks than raising many EAZ. These findings concur with Bebe *et al.* (2003) where it was concluded that herd size decreases with land holdings and genotypes shift was observed from EAZ to dairy breeds.

Table 10: Determinants for preference for East Africa Zebu

Explanatory variable	dy/dx	P-Value
Age	0.10	0.919
Experience	-0.10	0.03**
household size	0.32	0.41
distance to water	0.25	0.10*
herd size	0.30	0.09*
land size	0.67	0.02**
education	-0.19	0.02**
Gender	0.24	0.75
watering frequency	-0.23	0.07
drought tolerance	0.89	0.00***
feeding requirement	-0.94	0.70
milk as objective	0.13	0.01***
socio cultural as objective	0.21	0.01***
socio cultural as objective	0.12	0.00***
draught power as objective	0.28	0.19
draught power as objective	0.15	0.07*
draught power as objective	0.29	0.66
bull average price	0.05	0.03**
occupation	-0.21	0.00***
disease resistance	0.75	0.10*

Household size had a non-significant influence of raising EAZ. This was attributed to the fact that EAZ are reared in the area due to harsh environmental conditions and rearing EAZ

is not as labour intensive as other breeds. This is in contrast with Makokha *et al.* (2005) and Mekonnen *et al.* (2010) who found out that household size increased the probability of adopting dairy cattle because of the labor requirements.

Gender had no significant association with preference of EAZ in the area, meaning that both male and female household heads had an equal probability of preferring EAZ to other breeds despite the larger access to resources for men than women. Mekonnen *et al.* (2010) found out that male headed households adopted significantly larger number of technology than female headed households. Doss and Morris (2011) found that due to several constraints in having access to production resources, female-headed households were less productive than their male counterparts.

Land size influenced positively the probability of preference for EAZ. This could be attributed to the fact that EAZ requires more land for free grazing and there was no planting of fodder. This concurs with Quddus *et al.* (2017), they found out that land had a positive association with rearing of crossbreeds. Any rational farmer will adopt technology that increases returns to resources that are constrained. The minimum land size threshold to indicate factor constraint was perhaps not yet reached unlike in high potential areas where the land sizes are small and ideal for zero grazing. Farmers are expected to take advantage of economies of scale for the factors already constraining their production.

Education had a negative significant influence on EAZ preference. The more educated farmers were found to discredit EAZ hence preference for exotic breeds. Education was found to be an important factor motivating adoption of technology (Baltenweck & Staal, 2000). Bebe *et al.* (2003) found out that as the education level of the farmers increases the preference for Friesian and Ayrshire over the EAZ for coat color increases.

Water distance had a positive significant influence on preference of EAZ. The longer the distance was, the higher the probability of EAZ preference. This is the case because EAZ has lesser feed and water demands compared to exotic and crossbred.

The bull average price had a negative influence on the preference of EAZ. Local breeds are not preferred for their market prices, although they have good quality meat, they don't fetch much from the market since they have relatively lower live or carcass weight than exotic and their crosses. Besides non preference for EAZ due to low productivity (73%), farmers also had low preference for EAZ due to its low market value (24%) **Table 8**.

Experience had a negative significant influence on preference for EAZ. As Staal *et al.* (2008) observed, education level of the farmer and practical/real experience with the breeds are important in cattle breed choice. Farmers experience in dairy cattle keeping may be

associated with his ability to cope with risks, such as endemic diseases. Experienced farmers are better in controlling the risks in dairy by diagnosing and controlling diseases, and by giving the right kind of feeds (Makokha *et al.*, 2007). Farmers in the study area feel that they have enough experience to acquire improved dairy breeds since they have the capacity to manage the risks associated with improved dairy breeds hence the non-preference for EAZ. Education and experience increase the ability to efficiently manage breeds.

Occupation of the farmer had a negative influence on preference for EAZ in that farmers engaged in off-farm employment had lower probability of adopting EAZ than those in farming. The difference could be because those in off farm might have enough money to invest in improved dairy cattle breeds compared to the peasant farmers. Incomes from agricultural enterprises were estimated to constitute 60% of the total household income (Kuyiah *et al.*, 2006). Livelihood diversification is one of the major responses of farmers to revert economic destitution and poverty. In rural Kenya, this is of high significance given high rural poverty levels which is usually equated to being engaged in agriculture (IFAD, 2011).

4.5 Conclusion

The study found out that majority of the household were headed by formally educated males, full time farmers within the labour force bracket with a household size of 7 member. The average herd size was still small at 5 cattle and EAZ was the most dominant breed in the area mainly kept for milk and draught purposes. The major challenge to milk production in the area were lack of markets and lack of feeds and water exacerbated by recurrent droughts.

CHAPTER FIVE

SOCIO-ECONOMIC FACTORS THAT AFFECT THE WILLINGNESS TO USE ARTIFICIAL INSEMINATION IN ARID AND SEMI-ARID LANDS

5.1 Abstract

Livestock farming is a major source of livelihood in ASALs. Considering the high population of EAZ in ASALs, increasing its milk productivity will translate to improving the welfare of the households in these areas. Artificial insemination is usually associated with a high rate of genetic progress which is important in matching the expected increase in the rate of demand for dairy products. AI is known to fasten the process of dairy development. However, the adoption of AI in ASALs remains very low and the empirical evidence on the factors for this low adoption remains very scanty. It is at this backdrop that this study addresses the factors affecting the willingness to utilize AI in Kitui county. Primary data on socio-economic characteristics of the farmers, breeding practices adopted by farmers, and costs related to breeding was collected through structured questionnaires. A binomial logit model was applied to investigate determinants of farmers' probability of willingness to use AI in the future. The results showed that natural service remains the widely used method of dairy breeding. The majority of the farmers (75%) were willing to use AI, however, only 7% actually used it. In addition to paying KES 800 to KES 1300 for the AI service, farmers also incurred the transport costs for the breeding service provider. Although crossbreeding was meager, Sahiwal was the most preferred breed by the farmers. The logit regression results indicated that off-farm employment, experience, education, milk market, the bull price, household size, input, and veterinary access had a positive influence on the willingness to use AI, while the distance to a water source and off-farm employment had a negative influence on willingness to use AI. Based on the high willingness but low use of AI and the high incidence of inbreeding, this study recommended the use of technologies such as AI with estrus synchronization to fasten the rate of genetic gain and to alleviate the risks associated with the use of AI so as to encourage its adoption.

5.2 Introduction

The dairy industry in Kenya is the largest in the region supporting a significant majority of the smallholders in Kenya (MoLD, 2010). It contributes 40% to agricultural GDP and 10 % to the total GDP (KNBS, 2019). Over 70% of the total national milk production in Kenya comes from dairy cows in high potential areas with conducive climates (Muriuki *et al.*, 2011). Dairy production in ASALs has been dismal and ignored by development agencies over a long period.

The introduction of germplasm through AI is crucial in improving the milk production potential of local breeds. In most low-input systems (ASALs), the indigenous cattle are the most predominant. Natural mating is the predominant breeding method due to its availability and affordability (Murage & Ilatsia, 2010). The other reasons for the high use of natural mating services in ASALs included the high failure rate of AI (Berry & Cromie, 2007; Mugisha *et al.*, 2014) or the calf born out of AI being intolerant to the environmental conditions (Khaingna *et al.*, 2015). Artificial insemination is usually associated with a high rate of genetic progress needed to match the observed demand increase for dairy products. Adopting AI to improve the dairy genetics of the indigenous cattle will fasten the process of dairy development in ASALs. However, the ASALs are yet to reap the benefit of AI.

Crossbred cattle bred and borne out of AI in ASALs adapt well in these harsh climatic areas. The more common experience under less favorable tropical conditions has been the use of a temperate breed to crossbreed with the indigenous cattle, thus producing positive results with F1 animals (Galukande *et al.*, 2013). However, grades higher than 5/8 were found to be less resistant and less adapted to climatic, disease, and other stress factors causing health or reproduction problems. Estrus synchronization combined with AI has helped to reduce the failure rate of AI (Vounparet *et al.*, 2013).

There is, therefore, a need to understand if farmers are ready to welcome such well-intended strategies to improve their indigenous cattle. Previous studies have shown a discrepancy between the actual use and preference for AI (Baltenweck *et al.* 2004; Lawrence *et al.*, 2015; M'Ikiugu *et al.*, 2015). This study, therefore, was to establish factors for low AI uptake in the semi-arid areas to facilitate the recommendation of targeted interventions aimed at stimulating dairy productivity in this region.

5.3 Methodology

5.3.1 Data collection and analysis

Data relating to breeding services used by farmers was obtained from farmers. Enumerator posed a question on whether the farmer has ever used AI. Further, the farmer was asked if

he/she was willing to use AI or not. Both were a yes/no question. Data on socio-economic characteristics of the household were also solicited. A binomial logit model was applied to investigate determinants of farmers' probability of willingness to use AI in future. This was the most appropriate model given that the dependent variable is discrete and dichotomous. The binary logit model and marginal effects were estimated using STATA software.

To estimate the factors that influence the willingness to use AI, binomial logistic regression mode was adopted. The responses were two

$$Pr_{ij} = X_j\alpha_i + Y_j\beta_i + Z_j\gamma_i + \varepsilon_{ij} \dots\dots\dots \text{Equation 19}$$

where i=1 farmer is willing to use AI, i=0 otherwise, j represents the farmer making the choices, X represents farmer characteristics, Y represents the farm characteristics and Z ranking of the attributes of the technology (AI).

Assuming that farmers choose the alternative that gives the largest utility, a farmer will be willing to use AI if the utility of using it exceeds the utility of not using it. The probability of choosing Yes (P_t) was expressed as follows:

$$P_t = Prob(X_j\alpha_1 + Y_j\beta_1 + Z_j\gamma_1 + e_{1j} > X_j\alpha_2 + Y_j\beta_2 + Z_j\gamma_2 + e_{2j}) \dots \text{Equation 20}$$

$$P_t = Prob(e_{1j} - e_{2j} > (X_j\alpha_2 + Y_j\beta_2 + Z_j\gamma_2) - (X_j\alpha_1 + Y_j\beta_1 + Z_j\gamma_1)) \dots \text{Equation 21}$$

$$P_t = Prob(e_{1j} - e_{2j} > X_j(\alpha_2 - \alpha_1) + Y_j(\beta_2 - \beta_1) + Z_j(\gamma_2 - \gamma_1)) \dots \text{Equation 22}$$

Let $\mu = e_{1j} - e_{2j}$; a random term, $\alpha = \alpha_2 - \alpha_1$, $\beta = \beta_2 - \beta_1$, $\gamma = \gamma_2 - \gamma_1$; these are the parameters to be estimated.

$$P_t = Prob(\mu > \alpha X_j + \beta Y_j + \gamma Z_j) \dots\dots\dots \text{Equation 23}$$

$$P_t = F(\alpha X_j, \beta Y_j, \gamma Z_j) \dots\dots\dots \text{Equation 24}$$

Assuming identically and independently distributed random term with a Weibull density function, the probability that an individual is willing to use AI can be estimated using a logistic model as follows;

$$P_z = \frac{e^{\alpha X_j + \beta Y_j + \gamma Z_j}}{1 + e^{\alpha X_j + \beta Y_j + \gamma Z_j}} \dots\dots\dots \text{Equation 25}$$

$$\frac{P}{1-P} = e^{\alpha X_j + \beta Y_j + \gamma Z_j} \dots\dots\dots \text{Equation 26}$$

$$\ln \frac{P}{1-P} = \alpha X_j + \beta Y_j + \gamma Z_j \dots\dots\dots \text{Equation 27}$$

Several factors were hypothesized to influence the farmers' willingness to use AI. The choice of these explanatory variables was mainly based on the general working hypothesis and partly on empirical findings from literature.

5.4 Results and discussion

This section appertains to the breeding practices and services adopted by the farmers. AI and factors for the willingness to adopt it were estimated.

5.4.1 Breeding practices

Natural service was the widely used method of dairy breeding, with 90% of the respondents using it, 44% using a bull borrowed from neighbors.

Table 11: Sources of breeding services in Kitui county and willingness to use AI

Breeding service	Frequency	Percent	
Willing to use AI breeding service source	Yes	116	76
	Own bull (bred)	29	18
	Own bull (bought)	38	24
	Donated bull	4	3
	Borrowed bull	69	44
	Communal area bull	3	2
	Bull schemes	4	3
	Actual use of AI	10	6

Table 11 presents the distribution patterns of the breeding services in the area. The majority of the farmers (75%) were willing to use AI, however, only 7% used it. This indicates that farmers don't always use what they prefer. Baltenweck *et al.* (2004) and Mugisha *et al.* (2014) documented similar findings. This reveals a strong contrast between preference and actual use of the service. Baltenweck *et al.* (2004) attributed such a situation to low availability/access, high cost of the service, and technical failures that led to many repeats. Ngigi (2004) noted that government subsidies on AI were responsible for the growth of dairy production in Kenya, and their removal resulted in a decline in the use of the service. It was probable that the limited use of AI in the study area is due to the reduced government involvement in the provision of these services, coupled with a weak private sector.

Another reason for the limited use of AI was that the dominant breed in the study area was EAZ. Musoni *et al.* (2013) reported a strong correlation between cattle breeds and breeding

methods whereby exotic breeds were associated with the high use of AI. The same study indicated that a cattle breed was associated with the level of intensification. Baltenweck *et al.* (2004) and Murage and Ilatsia (2010) reported that there was a relationship between the use of AI and the level of dairy intensification and the type of breed.

Although bull schemes are known to control for inbreeding, only 2% of the farmers surveyed used bull schemes. It did not become clear why farmers don't take advantage of the bull schemes yet they were established in the area.

5.4.2 Cost of breeding services previously used

While the cost of AI ranged from KES 800 to KES 1300, natural service was found to be freely available and accessible to all farmers. Farmers also paid transport for the breeding service provider (**Table 12**). A private practitioner provided the breeding services, the government involvement in the service provision was found to be very low. Farmers who used bull schemes did not pay for the service.

Table 12: Frequency of the breeding services type, cost and accessibility of AI

Breeding services, cost and AI accessibility		Frequency	Percentage
Service Type	AI	14	7
	Bulls	147	93
AI accessibility	Yes	15	9
Farmer sell milk	Yes	78	48
Breeding organization			
	Government	2	14
	Private	12	86
Cost of AI service		KES	Std dev
	service cost	629	525
	Transport	142	196

The perceived high cost of AI relative to natural service and the farmers' unmet high expectations of AI, could also be important reasons for high preference but low utilization of AI services. A study by Jemal *et al.* (2016) found out that local breeds have the lowest conception rate compared to exotic and their crosses using AI, this could be another reason for non-use of AI in the area where EAZ is the predominant breed. Estrous detection is difficult in most indigenous breeds. The systematic practice of artificial insemination after estrus

synchronization is a technique that overcomes the problems associated with heat detection (Vounparet *et al.*, 2013). Only 9% of the farmers had access to AI services (*Table 12*), farmers indicated that they did not have many options in sourcing for breeding service.

Bull service was locally available and perceived to be cheaper than AI service. The perceived high cost of AI relative to natural service, and the inaccessibility of the AI service and uncertain reliability were also found to be important reasons for high willingness but low utilization of AI services (Mugisha *et al.*, 2014; Staal & Kaguongo, 2003).

Majority of the farmers did not sell milk (51%) and neighbor was their most important selling point. This indicated that dairy production in the area was still subsistence oriented and included only informal market outlet.

5.4.3 Marketing of dairy products

Table 13 presents the odds ratio (OR) obtained to shows the magnitude/strength of the constraint on the marketing of milk in the area. The OR refers to the relative importance of a constraint with reference to milk prices. Milk prices was used as a reference category. According to Bebe *et al.* (2003), if the OR is less than one then the reference category has a higher importance, if greater than one the reference category has a lower importance, if it's one then equal importance in the constraints being compared.

Farmers identified constraints to milk marketing can be narrowed down (in descending order of importance) to lack of properly established formal market, inadequate handling facilities, low milk prices, poor road infrastructure and longer distance to the sale point. Poor road infrastructure hinders quick transportation of milk and this increases cost and lowers the profit margin of the dairies.

Table 13: Constraints to marketing of milk in Kitui County

Constraint	Odds ratio estimates	95% Wald confidence Limits	
Milk prices	Ref		
Market	5.509	2.943	10.312
Distance to sale point	0.795	0.426	1.485
Handling facilities	1.935	1.056	3.548
Road	0.947	0.510	1.762

Low availability of formal milk marketing outlets has a negative effect on dairy intensification. There is, therefore, need for a well-established marketing system for efficient live-stock productivity (Lawrence *et al.*, 2015; Makokha *et al.*, 2007).

5.4.4 Crossbreeding status in the area

Approximately, 81% of the farmers had purebred EAZ, 19% had crossbred their cattle using Sahiwal (36%), Friesian (32%) or Ayrshire (32%) (**Table 14**). The few who had crossbred their cow used either bull schemes or AI service. Sahiwal was the most used breed and was perceived to be the most suitable for crossbreeding. This was probably due to ecological suitability, coat colour and demand for animal’s traction ability. Mwamuye *et al.* (2013) also found out that local breeds are well adapted to the limited pasture, limited water supply and harsh conditions found in relatively dry and hot climate as in Kitui County.

Table 14: Status of the crossbreeding pattern in the area

		Frequency	Percent
crossbred EAZ	Yes	31	19
breed used	Sahiwal	10	36
	Friesian	9	32
	Ayrshire	9	32
breed suitable	Sahiwal	93	67
	Friesian	19	14
	Ayrshire	25	18
	Boran	2	1

5.4.5 Relationship between selected factors and AI

Table 15 represents the marginal effects of the selected factors on the willingness to use AI. Most of the explanatory factors had the expected signs and were significant at the 1%, 5%, and 10% levels. The model was significant at the 1% level (P Value =0.000) and a pseudo $R^2 > 50\%$.

Gender had no association with willingness to use AI. In contrast Ojango *et al.* (2016) indicated that there were real gender differences in access to and the use of livestock breeding

technologies in the farming systems. Male headed household were associated with more milk producing breeds.

Table 15: Marginal effects for willingness to use AI

Explanatory variable	dy/dx marginal effect	P_Value
Gender	-0.021	0.225
Off farm employed	-0.031	0.003**
Household size	0.072	0.091*
Experience	0.008	0.064*
land size	0.841	0.399
Age	-0.063	0.512
Education	0.019	0.051**
Access to AI	0.001	0.006*
Owns mobile	0.140	0.049**
Bull price	0.001	0.06*
distance to the water source	-0.18	0.093*
Sell milk	0.099	0.02**
input access	0.059	0.09*
veterinary access	0.364	0.041**

The bigger the *household size* the higher the likelihood of using AI. This is probably because breeding using AI introduces additional labor demands like routine observation of animals, communication with AI technician, restraint of animal during inseminations all of which calls for extra labor. *Experience* in farming had a positive relationship with the willingness to use AI. Oluwatayo *et al.* (2008) reported that farmers with more experience would be more efficient, accept innovations easily, and have better understanding of the environment and market situations.

Occupation had a significant association with AI, off-farm employment had a lower probability of using AI than farmers. Dhraief *et al.* (2019) found a greater likelihood of using

AI services among livestock farmers who devoted more time to the care of the breeding herd. Off-farmers have other engagements hence devote less time to the care of breeding herd hence lower use of AI. The use of AI can be much more labor intensive than using a bull to breed cows given the time required to observe cattle and detect when cattle are on heat.

There was no significant relationship between *land size* and willingness to use AI. There has been an observed trend in the changes in land use towards market-orientation and an accelerated trend of both intensifications due to significant reduction in the land sizes owned by households (Amwata, 2013; Mutavi *et al.*, 2016). Farmers are therefore expected to be rational and trends towards intensification will be observed in the near future. Oluoch-Kosura *et al.* (1999) highlighted that keeping of bulls on small parcels of land is not economical. However, farmers in Kitui County continue to incur extra costs of rearing bulls on their already limited land sizes. This was because bulls are not only used for breeding but also for draught purposes.

This study found a non-significant association between *age* and willingness to use AI. This can be explained by the fact that the low use of AI in the county was as a result of environmental constraints and the use of AI technology was not likely to address the farmers' production objectives. A study by Musoni *et al.* (2013) showed that older household heads tended to be associated with indigenous cattle; and also tended to prefer use of bulls for breeding. Bragg and Dalton (2004) and Kaaya *et al.* (2005), indicated an inverse relationship between age and AI.

The study indicated a positive relationship between AI and *education*. The level of education attained by household head had an influence on willingness to use AI. This concurs with the findings of Bayan *et al.* (2018) who indicated that education increases farmers' awareness of the negative effects associated with the use of bull service. Educated farmers as expected are more attracted to modern technology and more sensitive to agricultural productivity. Successful breeding of animals requires knowledge on record keeping, observation of estrous detection and this requires minimal level of education. The systematic practice of artificial insemination after estrus synchronization is a technique that overcomes the problems associated with heat detection (Vounparet *et al.*, 2013). Previous studies observed that improving the literacy levels of dairy farmers would increase the likelihood of using breeding technologies (Bayan *et al.*, 2018; Dhraief *et al.*, 2019).

The study noted a strong positive relationship between the willingness to use AI and selling of milk (proxy for availability for milk markets). According to Bragg and Dalton (2004), Milk markets serves as an incentive to adopt dairy technology as well as continued investments.

Artificial insemination entails a cost and farmers who sell milk are more likely to afford the costs of AI since they can use proceeds from milk sale to pay for AI service. Studies have shown that resource challenged farmers are less likely to adopt costly livestock technologies (Quddus *et al.*, 2012). Other studies have shown the importance of market accessibility on AI use; market can be a place where farmers gain knowledge on new technology and transaction costs increases with ease of market access (Bayan *et al.*, 2018; Njoroge *et al.* 2004).

The price of bulls had a positive relationship with the willingness to use AI. The high cost of maintaining a bull that translates to the high bull price in the market may lead to willingness to use AI. Johnson and Jones (2011) found out that the use of AI was economically advantageous as it eliminates the need to keep a bull and the associated maintenance costs. Moreover, AI enables farmers to achieve much higher genetic potential improvement than using bulls.

Scarcity of feed and water during dry season in the study area was prevalent hence not a surprise to find a strong negative association between water distance and willingness to use AI. The incidence of feed shortage may also be a probable reason for low use of AI in the County since feed is the main cost factor in dairy production making up to 60 % of the total daily production cost (Majiwa *et al.*, 2012).

5.5 Conclusion

The EAZ cattle remain a valuable breed due to their adaptive traits such as disease and drought tolerance and their good traction ability, fulfilling the diverse objectives of local farmers. A unique adoption process was identified, 42% of the farmers preferred exotic and their crossbred yet over 90% of the household interviewed kept EAZ. Herd size, land size, water distance, disease and drought tolerance traits positively influenced rearing of EAZ. Education, experience and occupation had a negative influence on rearing of EAZ in the area.

Natural mating remains very rampant in the area. Although 76% of the farmers were willing to use AI only 7% of the farmers had actually used the AI. Milk markets, price of the bull, education and experience positively influenced the willingness to use AI. Gender and age had no significant influence on AI. Water distance and occupation of the farmer had a negative influence on the willingness to use AI. Crossbreeding practice was found to be very low despite its many opportunities for improving dairy in the area.

CHAPTER SIX

GENERAL CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

In the design of EAZ improvement programs for more milk production, it is important to include not only the milk production traits but also traction ability traits. Selection decisions should also uphold the adaptive traits due to the evident environmental constraints in the area while at the same time increasing the milk production potential of EAZ. The bull appearance which predicts the appearance of the herd was found to be very important indicating that farmers are attuned to certain coat colors. In addition, farmers reported that Sahiwal was their best choice for crossbreeding and conceivably because of its coat color and adaptability.

East Africa Zebu was the most dominant breed in the area mainly kept for milk and draught purposes. Major constraints to milk production included natural uncontrolled and poor breeding practices exacerbated by communal feeding and small herd size, frequent drought, limited feed and water availability, and inadequate markets for milk. To address these constraints indigenous knowledge of farmers and designing appropriate mating systems with the full participation of farmers is the best option in improving breeding practice. The constraints in the area could be the major reason for the high population of low genetic potential breeds in the area. Alleviating these constraints before attempting any breeding program will render the program sustainable.

Whereas improved breeding technologies such as AI and controlled mating are known to enhance milk output, these technologies are not well adopted by Kitui farmers. There was a sharp discrepancy between the willingness to use and actual use of AI. There is, therefore, a need for the stakeholders to help address the challenges associated with the use of AI. Breeding practices are characterized by little or no genetic progress. Stringent measures to control inbreeding are not practiced by farmers, they are found to have no breeding direction because of varied selection criteria, low selection intensity as the herd size is small and uncontrolled mating. Uncontrolled breeding dominates most of this area where farmers use borrowed unproven bulls from neighbors which could be mating close relatives.

6.2 Recommendations

Animal breeders should target EAZ and Sahiwal either as a pure breed or as a dam for discriminate crossbreeding. This study also recommends locally producing and multiplying crossbreed cattle to fill the milk deficit and increase farmers income in the area.

Breed management strategies should target solving feed and water shortages. This can be achieved by preserving feeds in times of adequacy for the drier period and planting fodder crops adapted to the area. This will significantly reduce the input costs.

Inbreeding was rife and a hindrance to genetic progress in the area. Technologies such as AI with estrus synchronization should help mitigate inbreeding depression and fasten the rate of genetic improvement progress.

Development partners, national and county governments should help lay down infrastructure for efficient and effective delivery of AI services. In addition to the above-discussed interventions strategies, a well-organized milk market is required. Therefore, the relevant stakeholders should help establish the infrastructure for milk processing and marketing in the area. Young, relatively educated, and full-time farmers should be used as contact persons by extension agents and breeders to promote the effectiveness of a breeding program.

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APPENDICES

Appendix 1: Key Data Analysis Output

Appendix 1.1: SAS Output on Zebu Traits Preference

The LOGISTIC Procedure

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	2284.477	2292.999
SC	2294.414	2327.781
-2 Log L	2280.477	2278.999

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	1.4779	5	0.0156
Score	1.4731	5	0.0162
Wald	1.4793	5	0.0154

Odds Ratio Estimates

Effect	Point Estimate	95% Wald Confidence Limits	
traits 1 vs 6	0.982	0.554	1.083
traits 2 vs 6	0.791	0.549	1.146
traits 3 vs 6	0.926	0.645	1.336
traits 4 vs 6	0.712	0.489	1.041
traits 5 vs 6	0.908	0.639	1.314

Association of Predicted Probabilities and Observed Responses

Percent Concordant	43.2	Somers' D	0.035
Percent Discordant	39.7	Gamma	0.042
Percent Tied	17.0	Tau-a	0.023
Pairs	367392	c	0.517

Score Test for the Proportional Odds Assumption

Chi-Square	DF	Pr > ChiSq
1.6657	5	0.0832

Appendix 1.2: SAS Output on Marketing constraints

The LOGISTIC Procedure

Model Fit Statistics

Intercept

Criterion	Intercept Only	and Covariates
AIC	18740.377	18746.680
SC	18767.065	18800.056
-2 Log L	18732.377	18730.680

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	1.6971	4	0.0012
Score	1.6979	4	0.0911
Wald	1.6958	4	0.0015

Type 3 Analysis of Effects

Effect	DF	Wald Chi-Square	Pr > ChiSq
constraints	4	1.6958	0.7915

Analysis of Maximum Likelihood Estimates

Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept 1	1	-1.1808	0.0562	441.7739	<.0001
Intercept 2	1	-0.3266	0.0539	36.7430	<.0001
Intercept 3	1	0.5512	0.0542	103.3990	<.0001
Intercept 4	1	1.5352	0.0580	699.8349	<.0001
constraints 1	1	-0.0252	0.0731	0.1189	0.7302
constraints 2	1	0.0183	0.0729	0.0629	0.8019
constraints 3	1	-0.0579	0.0740	0.6108	0.4345
constraints 4	1	-0.0560	0.0740	0.5727	0.4492

Odds Ratio Estimates

Effect	Point Estimate	95% Wald Confidence Limits	
constraints 1 vs 5	5.509	2.943	10.125
constraints 2 vs 5	0.795	0.426	1.475
constraints 3 vs 5	1.935	1.056	3.548
constraints 4 vs 5	0.947	0.818	1.762

Association of Predicted Probabilities and Observed Responses

Percent Concordant	36.8	Somers' D	0.013
Percent Discordant	35.5	Gamma	0.018
Percent Tied	27.6	Tau-a	0.011
Pairs	13594947	c	0.507

Appendix 1.3: Stata output, Multivariate Probit Model

```
. mvprobit ( frame=hhsiz tot_catl totland educat male w_dist off_farm ownphone age)( app=hhs
> ize tot_catl totland educat male w_dist off_farm ownphone age)( rel=hhsiz tot_catl totlan
> d educat male w_dist off_farm ownphone age)( tail=hhsiz tot_catl totland educat male w_dist off_f
> arm ownphone age)( scrt=hhsiz tot_catl totland educat male w_dist off_farm ownphone age)
```

Iteration 0: log likelihood = -320.99445 (not concave)

Warning: cannot do Cholesky factorization of rho matrix

Iteration 1: log likelihood = -302.25505

Iteration 2: log likelihood = -297.11647

Iteration 3: log likelihood = -295.89201

Iteration 4: log likelihood = -295.67368

Iteration 5: log likelihood = -295.66877

Iteration 6: log likelihood = -295.66876

Multivariate probit (SML, # draws = 5) Number of obs = 165

Wald chi2(35) = 61.64

Log likelihood = -279.26876 Prob > chi2 = 0.0413

```
-----
|    Coef.   Std. Err.    z   P>|z|   [95% Conf. Interval]
-----+-----
```

frame							
hhsiz		-.263515	0.113214	-0.11	0.051	-.0103135	.1430106
tot_catl		-.003718	.0794303	0.34	0.733	-.0508837	.0723208
totland		-.0060215	.0180042	-2.22	0.026	-.0451972	-.0028457
educat		-.0060215	.0170042	-2.22	0.706	-.0451972	-.0028457
male		.8394675	.4053554	1.17	0.026	-.5703551	2.25809
w_dist		.088922	.1092009	0.36	0.016	-.1854575	.2700418
off_farm		4.838209	.1447542	-1.02	0.106	-1.801657	.5650156
ownphon		-.0810282	.4500441	-0.14	0.885	-1.519209	1.311152

```

    age | -.0240282 .0190441 -0.14 0.885 -1.519209 1.311152
    _cons | 1.361663 .0476539 2.14 0.083 .1505723 3.500754
-----+-----
app    |
    hhsiz | .0361909 .0464294 0.37 0.709 -.0775131 .1138948
    tot_cat | .0580657 .0582327 1.10 0.271 -.0265612 .0946926
    totland | -.0067633 .0157945 -1.91 0.057 -.0340002 .0004737
    educat | -.0080215 .0150042 -2.22 0.026 -.0451972 -.0028457
    male | .2303712 .4700255 1.10 0.070 -.3340647 1.194807
    w_dist | -.0450756 .034294 -0.99 0.123 -.1031626 .0340115
    off_farm | -.8779162 .5231427 -2.12 0.034 -1.362824 -.0530085
    ownphone | -.1661128 .399219 -1.20 0.229 -1.04907 .2512445
    age | -.0140282 .0160441 -0.14 0.885 -1.519209 1.311152
    _cons | 1.038164 .5014225 2.36 0.018 .205714 2.202613
-----+-----
rel    |
    hhsiz | -.0045297 .0445408 0.10 0.921 -.0847285 .093788
    tot_cat | .1401556 .0491632 1.86 0.003 -.0024634 .0961747
    totland | -.0186069 .0089203 -2.45 0.014 -.0393504 -.0043834
    educat | -.0050215 .0180042 -2.22 0.026 -.0451972 -.0028457
    male | -.1586239 .3051648 1.91 0.056 -.0164071 1.285655
    w_dist | .0049771 .0320081 -0.07 0.065 -.0872715 .0813173
    off_farm | -.5644895 .2813366 -1.61 0.007 -1.173317 .1137385
    ownphone | 0.167042 .2761482 -1.60 0.109 -1.036682 .104598
    age | -.0040282 .0120441 -0.14 0.885 -1.519209 1.311152
    _cons | 1.240408 .516157 1.71 0.017 -.1016352 1.509517
-----+-----
tail   |
    hhsiz | .0794092 .0473546 1.50 0.004 -.0177644 .1325827
    tot_cat | .143985 .0511662 1.94 0.052 -.0004199 .09039

```

totland		.0132053	.0176104	0.42	0.074	-.0117108	.0181215
educat		-.0080215	.0120042	-2.22	0.026	-.0451972	-.0028457
male		.1301054	.3075107	1.26	0.208	-.2148989	.9891096
w_dist		-.535004	.265987	-2.13	0.003	-.0765564	.0667556
off_farm		-.5265003	.2819255	-0.68	0.049	-.7351843	.3581837
ownphone		.5263324	.2811254	0.61	0.544	-.3419083	.6489751
age		.00210282	.01220441	-0.14	0.005	-1.519209	1.311152
_cons		-.5848538	.3968227	-1.63	0.104	-1.322733	.1230255

-----+-----

scrt |

hhsz		.0523211	.0421001	0.64	0.524	-.0437698	.0859802
tot_catl		.095143	.0415833	1.52	0.129	-.0064397	.0507258
totland		-.0143298	.0103538	0.07	0.948	-.0123761	.0132358
educat		.0450215	.0120042	-2.22	0.026	-.0451972	-.0028457
male		.3553521	.3071104	0.42	0.676	-.4628535	.7135577
w_dist		-.064427	.032521	-0.98	0.326	-.0956671	.031813
off_farm		.2962299	.2721222	0.84	0.402	-.3109197	.7753794
age		-.4310282	.2930441	-0.14	0.885	-1.519209	1.311152
_cons		-.2294538	.3438227	-1.63	0.104	-1.322733	.1230255

-----+-----

-----+-----

/atrho21		1.061577	.3020473	3.51	0.000	.4695748	1.653578
----------	--	----------	----------	------	-------	----------	----------

-----+-----

/atrho31		.113915	.2219033	0.51	0.608	-.3210074	.5488375
----------	--	---------	----------	------	-------	-----------	----------

-----+-----

/atrho41		.1901309	.1912265	0.99	0.320	-.1846661	.564928
----------	--	----------	----------	------	-------	-----------	---------

-----+-----

/atrho51		.159691	.2193064	0.73	0.467	-.2701416	.5895237
----------	--	---------	----------	------	-------	-----------	----------

-----+-----

/atrho32		.2904487	.2020226	1.44	0.151	-.1055084	.6864057
----------	--	----------	----------	------	-------	-----------	----------

```

-----+-----
/atrho42 | .1976069 .1851568 1.07 0.286 -.1652938 .5605076
-----+-----
/atrho52 | .3301387 .190562 1.73 0.083 -.0433559 .7036334
-----+-----
/atrho43 | .4179351 .1617564 2.58 0.010 .1008983 .7349718
-----+-----
/atrho53 | .4313238 .1693392 2.55 0.011 .099425 .7632226
-----+-----
/atrho54 | .5647311 .1366658 4.13 0.000 .2968712 .8325911
-----+-----
rho21 | .8882665 .1153171 6.82 0.000 .4378557 .929347
-----+-----
rho31 | .0884248 .2190485 0.52 0.605 -.3104176 .4996484
-----+-----
rho41 | .0178725 .184477 1.02 0.108 -.1825952 .5116246
-----+-----
rho51 | .1583473 .2138076 0.74 0.059 -.2637566 .529553
-----+-----
rho32 | .2495477 .1858945 1.52 0.49 -.1051186 .595668
-----+-----
rho42 | .2590744 .1781109 1.10 0.073 -.1638046 .508354
-----+-----
rho52 | .3186454 .1712133 1.86 0.063 -.0433288 .6066689
-----+-----
rho43 | .6571894 .1364942 2.90 0.004 .1005573 .6260976
-----+-----
rho53 | .6054271 .1413673 2.87 0.004 .0990987 .6429712
-----+-----
rho54 | .03874793 .1009125 5.07 0.000 .2884467 .6818648

```

Appendix 2: Snapshot of the paper published from this thesis



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Socio-Economics Determinants of Selection Criteria for East African Zebu Cattle Breeding for Dairy Production: Case of Kitui County, Kenya

Margaret Kimani, Margaret Ngigi, Evans Ilatsia

Abstract

East African Zebu (EAZ) cattle play a very important role in the livelihoods of the Arid and the Semi-arid communities. Despite the breed being the most populous, its contribution to the dairy industry is very low. To ensure success of a breeding program for more milk production, there is need to understand how the indigenous farmers select their breeding cows and bulls for more milk production. A study was therefore conducted in Kitui County to determine the farmers' selection criteria for breeding bulls and cows for more milk production. To determine how farmers, select an animal for breeding, five selection criteria traits for bulls and eight selection criteria for cows were ranked using Friedman non-parametric analysis of variance test and Wilcoxon Test. Multivariate Probit model was used to determine the influence of socio economic factors on bulls and cow selection criteria for EAZ breeding. The mean ranks indicated that the bull's body frame (5.94), udder shape (6.04), teat size and placement (5.8) for cows were regarded as the most important selection criteria. The Multivariate Probit regression results showed that male farmers had a higher preference for bulls' body frame than female farmers. The study concluded that selection criteria in breeding bulls and cows are significantly influenced by socio-economic and demographic factors. Key recommendation from the study is to consider farmers' trait selection criteria in planning and design of a breeding program

Keywords: selection criteria, breeding program, East African Zebu


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Appendix 3: Research Permit



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