AN EX-ANTE ANALYSIS OF ECONOMIC VIABILITY OF SEXED IN-VITRO FERTILIZATION EMBRYO TRANSFER IN KENYA

Fridah Gacheri Lawrence

A Thesis submitted to the Graduate School in partial fulfillment for the requirements of the Master of Science Degree in Agricultural and Applied Economics of Egerton University.

EGERTON UNIVERSITY

September 2012

DECLARATION AND APPROVAL

DECLARATION

I hereby declare that this is my original work and has not been presented in this or any other University for an award of a degree.

FRIDAH GACHERI LAWRENCE

Sign: ------------------------------- Date--04/09/2012--

APPROVAL

This work has been submitted with our approval as supervisors.

University supervisors

Dr. J.K. Lagat (Department of Agricultural Economics &Agribusiness Management, Egerton University)

Sign: ------------------------------- Date: 5 Sept 2012

Dr. J. Mburu (Department of Agricultural Economics, University of Nairobi)

Sign: ------------------------------- Date: 04/09/2012

ILRI Supervisor

Dr. Isabelle Baltenweck (International Livestock Research Institute)

Sign: ------------------------------- Date: 04/09/2012

External Supervisor

Dr. H. Mutembei (Department of Clinical Studies, University of Nairobi)

Sign: H-Mutembei ------------------------------- Date: 04/09/2012

COPYRIGHT

DEDICATION

To my dear parents, Mr. Lawrence Kinyua and Mrs. Pamela Lawrence, for your faith and selfless dedication to my education. My sisters Gaiti and Wanja , and my brothers Mwenda and Mutegi, thanks for your support.

To Laviedan, Raphael and Adriel for all the times you have waited patiently when mummy was away studying, and my dear husband Eric Ngoya for your understanding and support.

ACKNOWLEDGEMENTS

I would like to thank God for the grace and strength that enabled me to go through my entire study and stay in Kenya and South Africa. My sincere gratitude goes to the German Academic Exchange Service – Deutscher Akadamischer Austauscdienst (DAAD) for providing me with a scholarship through the African Economic Research Consortium (AERC) / Collaborative Master of Science in Agricultural and Applied Economics (CMAAE) Programme to pursue a Master of Science degree in Agricultural and Applied Economics at Egerton University, Kenya. I am very grateful to International Livestock Research Institute (ILRI) for both monetary and non-monetary support given towards completion of this thesis, through the East Africa Dairy Development and SIFET projects.

I would like to sincerely thank Dr. J. Lagat, Dr. Isabelle Baltenweck, Dr. J. Mburu, and Dr. H. Mutembei who tirelessly supervised my research work, their patient guidance is highly appreciated. I gratefully acknowledge the support I got from members of staff of Egerton University and ILRI, particularly members of Markets Opportunities Theme. Specifically, I am forever grateful to Dr. Okeyo Mwai, Dr. Affgonon Hippolyte, Beatrice Muriithi, Pamela Ochungo, Francis Wanyoike and Judy Malu for their various contributions during this study.

To my good friends and mentors Dr. B.K. Mutai (Egerton University) and Fr. Protasio Nyaga for gearing me up to undertake a Masters Degree, my classmates for their collaborative efforts socially and in academic matters that helped me to successfully complete the course. All my friends for the smiles and encouragements that always rejuvenated me.

To God be all Glory!

ABSTRACT

Increasing productivity in the dairy sector is necessary for enhancing farm incomes, improving nutrition, reducing poverty as well as meeting the growing demand for dairy products by the growing urban population. Appropriate breeding methods are crucial in ensuring access to dairy breeds that are needed for increased productivity and long term growth and sustainability of the dairy sector. Utilization of sexed semen in vitro fertilization and embryo transfer (SIFET) technologies in this sector could be used to speedily deliver appropriate genotypes. However, the cost of producing and delivering SIFET technologies and the farmers' willingness to pay for SIFET in Kenya were unknown. The goal of this study was to analyze constraints to use of existing breeding services, farmers' willingness to pay and cost of producing and delivering SIFET. A sample of 157 farmers was selected through multi-stage sampling. Data were collected using structured questionnaires, focus group discussions, personal observations and documentary analysis of existing literature. Contingent Valuation Method was used in determining farmers' willingness to pay. Data were entered using Microsoft Excel and STATA software and analyzed using contingency tables, descriptive statistics, correlations, tests of significance, Ordinary Least Squared Technique of multiple regression method and cost-benefit analysis (CBA) tools. Results of this study shows that although AI is preferred to bull service, it is less used than bull service. The most common constraint cited by farmers who use AI is the need for more than one insemination as cows do not conceive after the first insemination. Further, off-farm income, farm income, breeding service that was previously used, number of improved cattle, quantity of milk produced and location of the household have a significant influence on farmer's willingness to pay (WTP) for SIFET. A financial cost-benefit analysis (CBA) for production and delivery of SIFET indicated a positive net present value of an investment. This implies that SIFET is an economically viable investment. The study recommends improvement in infrastructure and creation of an enabling policy environment as crucial inputs that are necessary for development and dissemination of breeding technologies in Kenya. Further research could be carried out to assess viability of SIFET reproductive technology at farm level.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

AI	: Artificial Insemination
CBA	: Cost Benefit Analysis
CBS	: Central Bureau of Statistics
CVM	: Contingent Valuation Method
EADD	: East Africa Dairy Development
ET	: Embryo Transfer
FGD	: Focus Group Discussions
HPI	: Heifer Project International
IVEP	: In Vitro Embryo Production
IVP	: In Vitro Produced
KARI	: Kenya Agricultural Research Institute
ILRI	: International Livestock Research Institute
KDDP	: Kenya Dairy Development Programme
LDC	: Less Developed Countries
MDC	: More Developed Countries
MoL	: Ministry of Livestock
OPU	: Oocyte Pick-Up
RoK	: Republic of Kenya
SDP	: Smallholder Dairy Project
SIFET	: Sexed In Vitro Fertilization Embryo Transfer
WTP	: Willingness to Pay
IDB	: Improved Dairy Breed

CHAPTER ONE

INTRODUCTION

1.1 Background

Dairy production is a major activity in the livestock sector and an important source of livelihood for over 600,000 smallholder farmers around the country, who account for 56% and 70% of the total milk production and total marketed milk in the country respectively (SDP, 2004). Dairy production is, therefore, significant in contributing to household incomes as well as national economy, with a value estimated at 35.2 billion (Karanja, 2003). However, the potential for increasing dairy production remains underutilized. According to Karanja (2003), the average yield per cow in smallholder farms is 1300 litres per year compared to the best world production of 4000-6000litres.

Increasing productivity in the dairy sector is necessary for enhanced farm incomes, improved nutrition, and reduced poverty levels as well as meeting the growing demand for dairy products by the growing urban population. However, there are concerns that the long term sustainability of the dairy sector is undermined by a number of constraints such as lack of adequate replacement stock and disharmony in the organization of breeding services (SDP, 2004). Appropriate breeding strategies are crucial in ensuring access to dairy breeds that are not only necessary for increased productivity but also for sustained long term growth in the sector.

The Kenya breeding subsector has witnessed a number of changes in the breeding strategies employed by farmers. For quite some time, farmers had no choice for a breeding method other than the natural service by bulls until the 1930's when artificial insemination (AI) service was introduced in the country. This breeding strategy posed a problem of inbreeding, transmission and spread of venereal diseases and narrow scope of breed and/ or genotype diversification. Although bulls are accurate on heat detection, natural service has minimal benefits to farmers who aim to speedily gain on genetic improvement in the traits important for both current and future performance of the herd (Hoffman, 2007). During the era of government monopoly, bulls were rotated to reduce inbreeding, a practice which is currently difficult to achieve within the private sector players (KDDP/SDP, 2004).

Biotechnology advancements in the 1940's came with introduction of AI in the country which was supposed to reduce transmission of venereal diseases among cattle. The use of AI technology has been the main dairy cattle breeding strategy in the country for the last four decades. AI improves dairy productivity through improved genetics, better fertility and improved herd fertility from minimal breeding diseases and eliminated costs of keeping a live bull (Hoffman, 2007).

The dairy sector in Kenya has tremendously gained through the use of AI service. For instance, the population of improved (exotic) cattle in the country had increased from less than 250,000 in the 1960's to 3.2 million cows by 2001 (Wakhungu and Baptist, 1992; RoK, 2002). This upgrading of cattle through AI and complemented by improved nutrition and better management practices have been shown to have major impact on Kenya's economy and social welfare. For instance, Karugia *et al* (2001) estimated that between 1995 and 2000, the total social welfare in Kenya increased by Ksh 2.88 billion or 1.4% per annum as a result of continued use of cross-bred dairy cattle through complementary reproductive technologies.

The privatization of AI services in 1992 was done with the anticipation that the private sector players take up the role of AI service left to them by the government (Cabinet paper, 1992). In as much as the private sector entered the AI service market, the use of the technology has continued to decline with time. The cost of the service to farmers has also escalated in the recent past. Household surveys have indicated that in 2002 only approximately 17% of smallholder farmers in the country were using AI services. The rest of the farmers were using natural service with own or hired bulls (Karanja, 2003). The decline in the use of AI and increase in the use of natural service (bull) coincided with the systematic withdrawal of the government from provision of AI service. Again, the private sector players who came in to replace governmental AI service are considered too expensive for the average smallholder farmer (KDDP/SDP, 2004).

Improved assisted reproductive biotechnologies have offered dairy farmers the opportunities to choose the sex of calves before conception as well as improved conception rates of their herds. Such biotechnologies include the use of sexed semen during AI and sexed embryos during embryo transfers (ET). Introduction of sexed semen and embryos increase the options for farmers besides use of non-sexed semen during natural and AI services. A household survey by

Heifer Project International (HPI) indicated a higher preference for female calves among smallholder dairy farmers.

Sexing semen results in at least 90% sorting success; this means for dairy farmers 90% of the offspring could be female calves (Hansen, 2007). However, like for any other manipulative biotechnology, the conception rate of sexed semen is slightly lower than that of non-sexed semen and its prices relatively higher. Sexed in-vitro fertilization embryo transfer (SIFET) is another technology of reproduction that encompasses economical utilization of sexed semen in a laboratory to produce sexed in-vitro produced embryos. The embryos are then transferred to surrogate cows for conception on the seventh day post-fertilization. This breeding strategy results in better utilization of sexed semen (one straw can be used to produce up to 30 female-sexed embryos) and thus enhances on rapid propagation of not only the elite cows but also the bulls. Current projections by breeding experts indicate that SIFET can result in an increase in dairy profitability of around 70% per cow per year (over the lifetime of the cow) when compared to the use of AI, under Kenya smallholder production systems (Mutembei *et al*, 2009).

1.2 Statement of the Problem

Since withdrawal of government subsidies and the consequent privatization of AI services, there has been a decline in the use of AI, which is attributable to various constraints across the country. This trend has implications on the quality and availability of replacement stock and the future of the dairy sector; mainly because smallholder dairy farmers in low input systems have to incur high costs in obtaining suitable replacement stock. Further, appropriate cattle genotypes that match their production environments are also scarce.

In-vitro embryo production (IVEP) that embraces SIFET technologies can be applied to address this situation through rapid production of crossbred heifers for replacement stock. The heifers not only match their production environment but are also cost-effective for low input dairy production systems. However, the economic viability of developing and delivering SIFET under Kenyan conditions were yet to be determined. The intention of this study was to estimate the costs of SIFET and involve the farmers in price setting through their willingness to pay for the technology.

1.3 Objectives of the study

The general objective was to contribute to the evaluation of SIFET's viability in Kenya.

The specific objectives were:

1. To evaluate the utilisation of artificial insemination and natural reproductive technologies by farmers.
2. To assess farmers' willingness to pay for SIFET
3. To determine the cost of developing and delivering SIFET to farmers and its associated benefits.

1.4 Research questions

1. What is the significance of the factors that influence use of Artificial insemination and natural reproductive technologies?
2. What significance do farmer and farm characteristics, institutional and spatial factors have on the amount farmers are willing to pay for SIFET?
3. What is the viability of SIFET economically?

1.5 Justification of the study

The quality of Kenyan dairy herd is declining rapidly due to poor breeding. Appropriate reproductive technologies are urgently needed to ensure access to dairy breeds for increased productivity, long term growth and genetic sustainability of the dairy herd. Given the important role of reproductive technologies, any developments in reproductive technologies need to be documented, which this study sought to accomplish. A new and affordable reproductive technology is needed to reverse the current trend and SIFET offers such an option. A study to investigate the constraints to existing reproductive technologies was not only relevant and necessary but also a prerequisite to introduction and uptake of new reproductive technologies. Further, an information gap existed on the farmers' willingness to pay and the cost of SIFET, which this study sought to fill.

1.6 Scope and limitation of the study

The study focused on small scale dairy farmers in selected areas from 6 districts in Kenya. The costs and benefits considered were for the producer of SIFET. The technology is yet to be rolled out to farmers thus; it was not possible to collect data on actual costs that are incurred at farm level. Further actual social-economic benefits could not be computed at the current level of SIFET technology development. This study only focused on a financial cost- benefit analysis taking into account value of money over time and inflation. This implies that the analysis was done for purposes of advising investors on financial viability of SIFET. Given that an analysis of technology viability encompasses a wide scope of fields and disciplines, not all related issues were addressed due to a limitation of finances and other resources allocated for this study.

1.7 Definition of terms

Household: Group of people who are generally bound together by ties, kinship, or joint financial decision, who live together under single roof or compound, are answerable to one person as the head and share the same eating arrangement.

Small holder farm household: this is operationalized to refer to the households who own less than five cows.

Reproductive technologies/breeding services: this is operationalized to refer to the strategies or methods applied to ensure fertilization, conception and calving of a cow.

1.8 Expected outputs

This thesis is expected to fulfill the requirements of Master of Science Degree in Agricultural and Applied Economics. The subsequent publications from the findings of this study will reinforce dissemination to the stakeholders. The findings from this study will also form a basis for pricing of SIFET towards addressing the problem of low supply of replacement stock and unfavorable sex ratios of cattle.

CHAPTER TWO

LITERATURE REVIEW

2.1 Characteristics of Kenyan dairy breeding sector.

Studies of Kenyan dairy systems show that growth rates among calves and heifers are less than 0.25 kg/day , mortalities among cows, heifers and calves range from 10 to 30%, age at first calving is about 3 years and calving rate is about 0.60 (Omore, *et al.*, 1996; Lanyasunya, *et al.*, 1999). These performances raise concerns about the maintenance of smallholder dairy herds both at individual and community levels. This has implications for the future structure of the dairy sub-sector and its productivity. In the past, public-owned, large-scale dairy farms produced dairy replacements for smallholders at subsidised costs (Conelly, 1998). These sources are now very limited because majority of the large scale farms have collapsed or have been subdivided for resettlement (Bebe, 2003).

According to Ngigi (2004), widespread introduction of highly productive breeds of dairy cows, or grade cattle, has been the major source of increased productivity in Kenyan dairying. Provision of efficient and affordable reproductive services has been crucial in raising productivity of the Kenyan dairy herd. Between 1964 and 1987, smallholders received a subsidy of up to 80 percent on artificial insemination and veterinary services which led to widespread adoption of improved breeds. The withdrawal of subsidies from 1988 onwards led to a withdrawal of public services and rapid geographically uneven growth of private services. The great challenge is on how to improve the productivity of smallholders' dairy herds through enhanced dairy herd's milk production traits and smallholder's ability to realize the breed's potential through advice and training on better herd management practices (Ngigi, 2004; Karanja, 2003).

2.2 Reproductive technologies

The basic objective of animal breeding is to enhance the efficiency of production and the quality of the product for the end-consumer through planned genetic change (Hoffman, 2007). Regardless of the breeding system chosen, the breeder must strive for genetic improvement in the traits identified as economically important for both the current and future performance of the herd.

Various reproductive technologies are used in Kenya. These are use of natural, AI and ET services. Currently, the most commonly used method among farmers is the use of bulls (natural service). Farmers within extensive systems of production (mainly or only grazing feeding system) more commonly use natural service, in contrast with the more intensified farmers (mainly or only stall feeding system) who use more AI service, although natural mating is still used by the majority of these farmers (Baltenweck *et al.*, 2004).

2.2.1 Natural reproductive technology

According to Baltenweck *et al.*, (2004), bull services are used over AI service due to ease of bull service transaction since the cow is driven to the bull owner's premises upon detection of heat signs and without any prior appointment. Although farmers prefer AI service, they use bulls because they are cheaper and the bull owner can provide credit facilities. Also, bulls are more effective at conception and where pregnancy is not achieved, repeat services are usually free. Further, farmers do not choose the sire when using AI service because, although they choose the breed, it is the AI practitioner who decides what bull to use. Another factor is the flow of information; farmers using natural service generally gather information on the qualities/reliability of particular bulls using informal network (the "grape vine") unlike for AI services where the farmers do not usually conceive the AI as a 'bull'. In extensive systems some farmers and extension agents do not think AI can be used with zebu or other local breeds. Moreover farmers perceive AI service as expensive as the potential benefits through improved herd are not taken into account (Baltenweck *et al.*, 2004).

2.2.2 Artificial Insemination technology

AI service involves the use of semen that has been collected from progeny tested disease free bulls and stored in individual straws (doses) at low temperature in liquid nitrogen. Mainly through the use of AI service, Kenya managed to upgrade and expand the national dairy herd population from about 300, 000 in the mid 1960s to around 6.7 million animals today (The Organic Farmer, 2007). Prior to the privatization of AI service provision in the early 1990s, the government ran daily rounds of insemination in most rural areas. Inseminators passed through a fixed route each day to serve the animals brought by farmers to roadside cattle crushes. With the liberalization of AI provision in 1992, private practitioners who operate an 'on call' service emerged. Most farmers now have to contact the inseminator directly, by messenger or phone, and response is sometimes slow. In addition, the cost has increased dramatically from KSh1 per insemination at the height of subsidization in 1971 to between KSh580 and KSh1000 for locally produced semen, and well over KSh1,000 for imported semen (The Organic Farmer, 2007).

In Kenya, adoption of AI is relatively lower in Western Province and most areas in North Rift despite indicators such as numbers of dairy cattle and agro-climatic potential, pointing to high potential for AI adoption. Historical non use and cultural biases are some of the reasons that may be responsible for this variance (SDP/KDDP, 2005).This study sought to fill the gap on other factors that could explain the variance.

2.2.3 In-vitro embryo transfer technology

Figure 1 is an illustration of common methods of generating embryos for ET programs in cattle (Hansen 2007). A fundamental goal of such programs is to increase the number of embryos produced by one female (Hansen, 2007; Mutembei *et al.*, 2009). The typical way to achieve this increase in embryo numbers is making the cow to ovulate multiple follicles by injecting follicle stimulating hormone to recruit multiple follicles to grow and ovulate. An alternative method is to harvest multiple oocytes from a cow and fertilize the oocytes in vitro. Two methods of harvest Oocytes can easily be removed from ovaries collected at slaughter. Commercial production of embryos produced using ovaries recovered at an abattoir is now practiced. In addition, oocytes can be harvested from the living cow by ovum pick-up (OPU) method; scanning the ovary to visualize the follicles on the ovary and piercing the vaginal wall with an aspiration needle to allow puncture of follicles and collection of oocytes. This procedure, called transvaginal, ultrasound-guided oocyte aspiration (OPU), allows for oocytes to be obtained multiple times, including during pregnancy (Hansen, 2007).

Genetic selection can be enhanced by increasing the number of offspring per female. Doing so increases selection intensity (a smaller proportion of females are selected to produce the next generation) and also the accuracy of selection (because more records are available from individual animals and their relatives). The most common way to increase number of offspring per female is to utilize superovulation or OPU. In addition, some genetic progress can be obtained using oocytes recovered from ovaries at slaughter (Hansen, 2007).

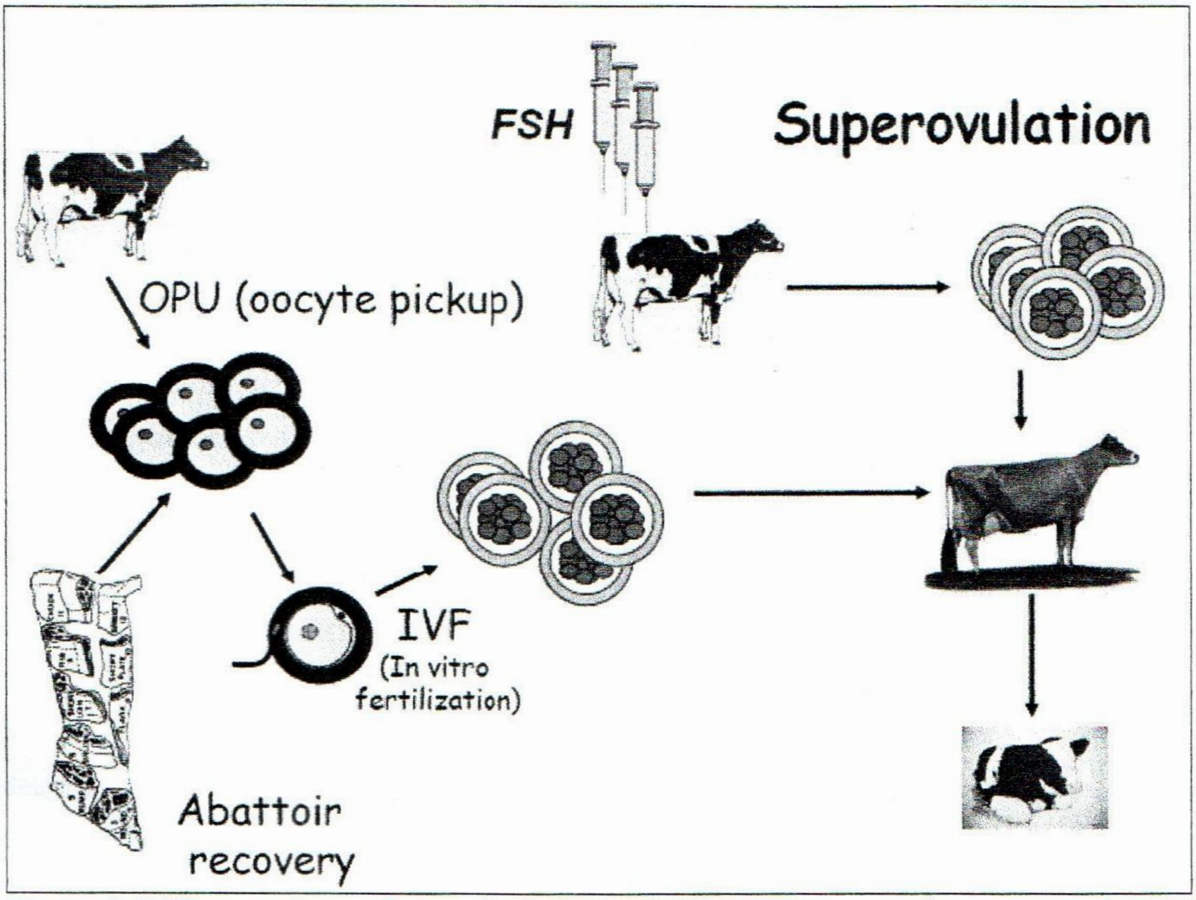

Figure 1: Different schemes for producing embryos for embryo transfer programs in cattle.
Source: Hansen 2007

The resources required to build and operate an in-vitro fertilization laboratory are modest (Hansen, 2007). Regardless of the source of oocyte, in-vitro fertilization should be performed using elite sires because the costs of the semen are spread over several offspring. With artificial insemination (AI), and an assumed calving rate to a single insemination of 25%, one would need to inseminate eight cows to obtain one heifer. Using in vitro fertilization, a single straw could typically be used to inseminate 100 oocytes or more. If 100 oocytes were fertilized with a straw of semen, 25 transferable embryos or more are likely to be produced. At a 25% calving rate to embryo transfer with lactating recipients, the single straw of semen would produce about 3 heifer calves (Hansen, 2007).

Sex-sorted semen makes it possible to produce embryos of the desired sex. It is prepared by using an instrument called a flow cytometer to separate X-bearing sperm from Y-bearing sperm based on the slightly larger size (i.e., higher DNA content) of the former. Straws of sex-sorted sperm are commercially available in Kenya though costly. Unfortunately, use of sexed-sorted sperm in AI service is associated with reduced fertility because of sperm damage during the sexing procedure and because the number of sperm packaged per straw is reduced. This fact, as well as the high costs, has limited the use of sex-sorted sperm for artificial insemination under commercial conditions to non-lactating heifers. Calves produced by in vitro fertilization with sex-sorted sperm where X-bearing sperm are retained are 90% female or greater. Costs are likely to vary depending on source of oocyte among other considerations (Hansen, 2007).

A study done in China by Xu *et al.* (2006), showed that Pregnancy rates were the same for embryos produced with sex-sorted sperm and conventional sperm. Of the calves born from the IVP embryos produced using sex-sorted sperm, 96.5% were female. Wilson *et al.* (2005), found pregnancy rates achieved following transfer of fresh embryos produced by sex-sorted sperm to be 19% vs. 36% for AI using conventional semen in lactating cows. However, it was not determined whether the lower pregnancy rates for embryo transfer were due to use of sex-sorted sperm. Conception rates in lactating cows are much lower than for non-lactating heifers. Theoretically, embryo transfer should improve fertility in the lactating cow because pregnancy failure brought about by defects in the oocyte, ovulation, fertilization, or early embryonic development can be bypassed (Hansen, 2007). Whether or not embryo transfer can improve fertility in lactating cows at current levels of technology is not certain. Only a very few embryo transfer studies have been performed with lactating cows. Rodriques *et al.* (2004) have shown embryo transfer increases pregnancy rate in hot weather but not in cool weather.

In summary, in vitro produced embryos can be used to enhance genetic selection and to select calves of predetermined sex. In crossbreeding systems, in vitro produced embryos can be used to maintain heterosis by transferring F1 embryos into F1 recipients. As compared to AI, ET can improve fertility of lactating cows when herd fertility is very low but not when herd fertility is moderate or high (Hansen, 2007). However, all studies have been done in more developed countries MDCs. There exists a gap on results of the technology in LDCs.

2.3 Constraints to use of AI and natural reproductive technologies

After privatization of AI services in Kenya, there has been a decline in the use of AI attributable to various constraints across the country (Okeyo *et al*; 2009). Recent studies have shown that a great proportion of farmers are reverting to natural service. According to Baltenweck *et al*, (2004), approximately 81% of the farmers use bull service although they prefer AI.

The reasons for not using AI service are either the non-availability of the service or the perceived high cost of the service. Further, many farmers have not adjusted to the private delivery of the service (mainly on call), which is different from government delivery system (daily run system). The use of natural service may lead to a mismatch between the farmers' optimal herd and the one actually kept, resulting in a likely decrease in production and competitiveness. Despite significant increase in availability of private AI service over the last one decade, its use is still very low. Given the importance of AI in breeding strategies, its low use has serious implications on dairy productivity and sustainability. As such it is necessary to diagnose the reasons for low use of AI technology. The objective of this study was to analyze the use of reproductive technologies and as such, provide an insight to what factors may affect uptake of SIFET in breeding strategies.

2.4 Willingness to pay (WTP).

A previous analysis has shown that farmers' use of AI services is partly explained by access to complementary services like extension and veterinary services. Another factor that explained use of AI was market access, suggesting that use of AI services is influenced by farmers' ability to market their production (Njoroge *et al*., 2004). According to Karanja, (2003), farmers belonging to a group or cooperative had higher willingness to pay for AI compared to those who did not. According to Makokha, *et al.* (2007), factors hypothesised to influence valuation of cow attributes were farmer characteristics (age, gender, education ethnicity and cultural values, income, experience, land size and dependency ratio), institutional factors (credit and extension) and, spatial and environmental factors (distance to nearest urban centre, population density and precipitation index). According to Makokha *et al.* (2007), these factors had varying effects on farmers' WTP for selected cow attributes. There was an indirect relationship between WTP for attributes and technology adoption. SIFET can be used to produce calves with the desired attributes according to individual producer's specifications without unnecessary mutual exclusivity reflected by choice of attributes in the study by Makokha *et al.* (2007). Further, there exists a gap on the influence of household social capital, previously used breeding service and breed kept on WTP. This study will assess the influence of these factors, among others, on WTP for SIFET.

2.5 Cost -benefits analysis

Cost-benefit analysis (CBA) refers to any structured method for evaluating decision options. It provides a means for systematically comparing the value of outcomes with the value of resources needed to achieve the outcomes required. It measures the economic efficiency of the proposed technology or project. When there are many options to consider during a decision-making task, it is useful to evaluate the options with a common metric.

CBA has become widely accepted among business and governmental organisations. Although CBA has definite limitations, especially in the non-standard way that the payoff function is derived and calculated, its potential for making decisions more rational is comforting to decision makers. However, the costs and benefits can either be tangible or intangible, yet in CBA values have to be in monetary values. As such, the decision making on the basis of CBA does not take into account the intangible values of an investment. In situations in which large amounts of money are at stake, the presentation of a cost-benefit analysis is the preferred way to demonstrate the reasoning behind investments.

Inputs for CBA may be divided into parameter values, benefit and cost values. Parameters include the discount rate, the future rates of economic growth, the future rates of inflation and the estimations about the future rates of technological change. Benefit and costs include monetary values for marketed goods, monetary values for non-marketed directly used goods, monetary values for non-marketed passively used goods, goods for which monetary values cannot be measured. The monetary values can be captured using contingent valuation methods by which willingness to pay (WTP) for a benefit achieved or willingness to accept (WTA) compensation for a cost incurred is elicited (Pearce *et al.*, 2006).

2.6 Theoretical framework of willingness to pay

Willingness to pay is based on utility theory. Suppose consumers have the utility function $u(x,q,z)$, where x is breeding service use, q is a measure of service quality, and z is a composite of all market goods. The expenditure function, m(p, q, u), is found by solving the consumer problem: min (z + px) s.t. u = u(x,q,z) where p is the use price and pz = 1. The expenditure function measures the minimum amount of money the consumer must spend to achieve the reference utility level and is increasing in p and u and decreasing in q. Willingness to pay is the maximum amount of money consumers would give up in order to enjoy an improvement in quality. The willingness to pay for the improvement in quality is WTP = m (p,q,u) – m(p,q*,u) where q is a degraded level of quality and q * is an improved level of quality. Expenditures to maintain the utility level decrease with the increase in quality so that WTP > 0. Assume the reference level of utility is u* = v (p,q*,y), where y is income and v(.) is the indirect utility function found by solving the problem:

Max [u(x,q,z)] s.t. y = z + px..Equation 1

Substitution of the indirect utility function into the willingness to pay equation yields the Hicksian variation function:

WTP =m [p, q, v (p,q*,y)] –y =s (p, q, q*, y)...................................Equation 2

Where, s (.) is the equivalent variation measure of welfare. According to reasonable assumptions and economic theory, the variation function is decreasing in own-price, decreasing in degraded quality, q, increasing in improved quality, q*, and increasing or decreasing in income for normal or inferior respectively (Whitehead, 1995).

Assuming that the own price and improved quality variables are constant, the empirical willingness to pay model that corresponds to the theoretical model and the simplifying assumptions is;

$WTP= \alpha' X_{li} + \beta q_i + \varepsilon_{li}$..Equation 3

where X_{1i} , i = 1, ... , n, is a vector of independent variables including a constant, income, and other variables that may affect willingness to pay and ε is the error term. Omission of the quality variable results in the following model

$WTP= \alpha' X_{li} + \varepsilon_{li}$..Equation 4

There is a potential problem of including quality perceptions in willingness to pay models. Quality perceptions may be affected by the same unobserved characteristics that influence willingness to pay. According to findings from a study on willingness to pay by Danielson *et al.* (1995), the determinants of perceived air and water quality depend on demographics, environmental knowledge, and environmental attitudes. If unobserved tastes are correlated with both perceived quality and willingness to pay, the coefficient on the quality perception variable will be biased in a willingness to pay regression model (Whitehead, 2006). The bias is due to the correlation in the error terms in the willingness to pay and quality perceptions models. Including the perceived quality variable will cause the perceived quality variable and the willingness to pay error term to be correlated, biasing the coefficient on the quality variable. As such, the quality variable was omitted. Similar studies with omitted quality variable were done by Hurley *et al.* (1999), who estimated the willingness to pay for delaying nitrate contamination in drinking water, and Stumborg *et al.* (2001), who estimated the willingness to pay for a reduction in phosphorus pollution in lakes.

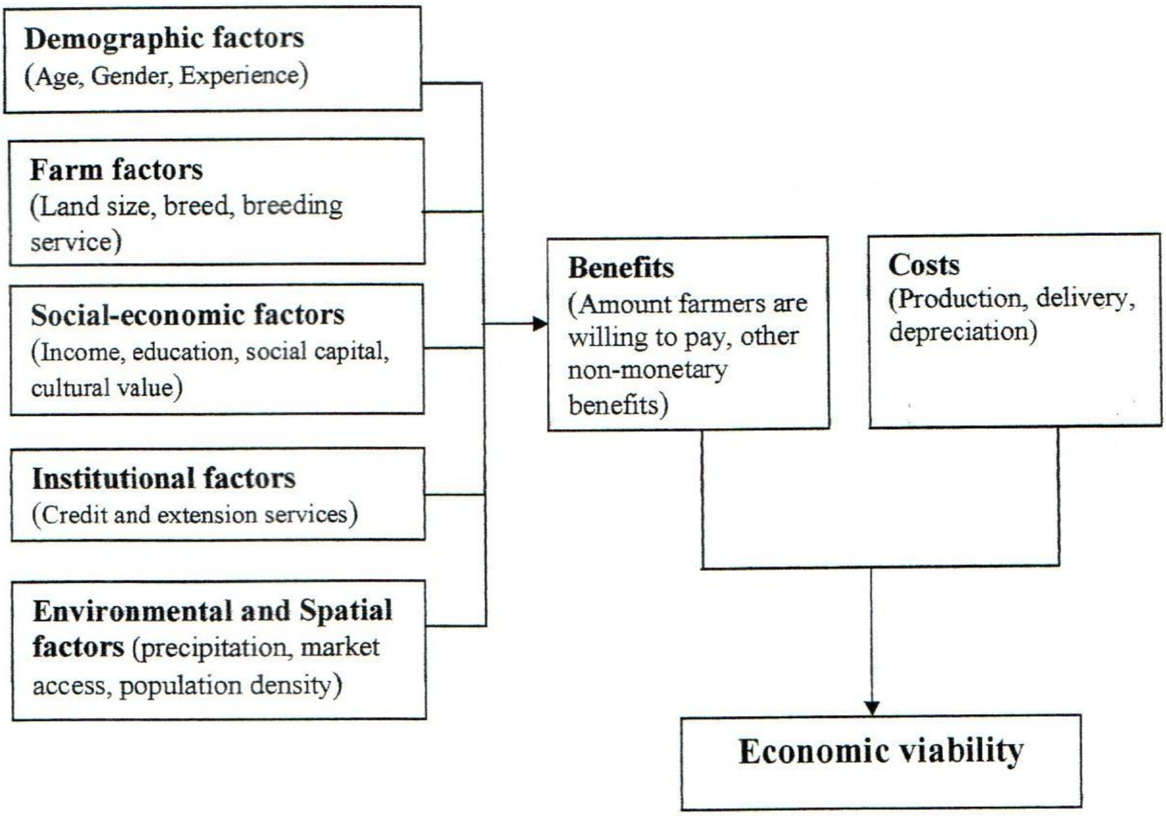

Figure 2: Conceptual framework of relationship between economic viability, farmers' WTP and cost of SIFET
Source: Researcher's own conceptualization

CHAPTER THREE

METHODOLOGY

3.1 Study areas

The study was conducted in Nyanza, Central and Rift Valley provinces in Kenya. The areas were purposively selected based on characterization using two indicators of climatic characteristic (LGP or Length of Growing Period) and access to urban centre (as an indicator of market access), using GIS layers. Using the median as the threshold for each indicator, the area was divided into eight domains from which seven hubs were selected for data collection as illustrated in Figure 3. The various domains ensured that the Kenyan conditions were represented as much as possible.

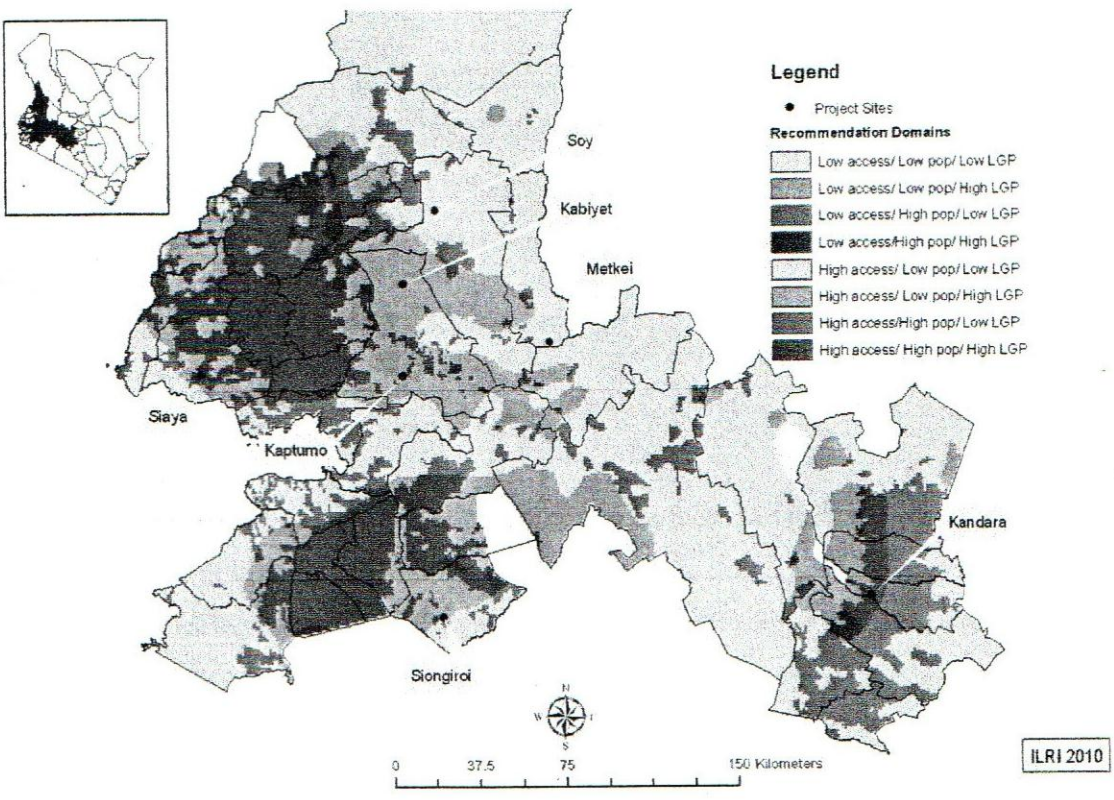

Figure 3: An extract from map of Kenya showing study areas
Source: EADD database

3.2 Sampling design

To draw a minimum sample size that would be representative of the population, subject to allocated budget, an appropriate sample size had to be established. Daily milk production was used as the most appropriate variable. The aim was to identify a 1.25 litre increase in milk production to be significant. A formula adopted from Woodward, (2005) and applied to obtaining such a sample size was;

$$N = \left[\frac{(Z_\alpha + Z_\beta)\sigma}{\delta} \right]^2 \quad \text{.............................Equation 5}$$

Where Z_α is the standard normal value representing the significance level for a 1-sided test (5%), δ is the difference to be identified, σ is the standard deviation of the difference and Z_β is the standard normal value representing the power to detect this difference as being significant (80%). According to a previous study, in the context of a smallholder dairy development, standard deviation of milk production per cow was 4.3 (Staal, *et al*, 2001), which was taken to be the standard deviation of the difference. Substituting values into the equation above provided a required sample size of N = 73, this was increased to 75 to simplify enumeration in the field and allow for incomplete data.

$$N = \left[\frac{(1.64 + 0.84)4.3}{1.25} \right]^2 = 72.8$$

A geographical random sampling proved to be most suitable in the absence of a sampling frame with a list of the population from which the required number of farmers would be selected using a particular sampling methodology (Jodi, *et al*. 2007). First, each survey site was defined as the hub catchment area, a circular area of 20km with the hub at the centre of the circle irrespective of administrative boundaries. The corresponding radius in each site was chosen based on the maximum feasible distance farmers or traders would travel to supply milk to the chilling plants; after consulting with project management and using expert opinion. Second, circular survey area was divided into grids cells which, depending on population density, so that, on average, each cell should contain 1 household. In all cases, urban, un-populated areas, forest and marshy areas were masked out. Finally, by applying a simple random sampling technique, 75 grids were selected from all the grids.

3.3 Data collection

Data was collected using questionnaires that were administered to households. To identify respondent households and approach the interviewees for the survey, each of the 75 grids was assigned a latitude and longitude coordinate which were then uploaded into a global positioning system (GPS) instrument. The survey team guided by a GPS instrument went to the location and administered the questionnaire to a household situated nearest to the grid in that particular area. If the survey team encountered more than one household in the grid cell and the coordinate located in between, the team would randomly select one of the households. If there were no households in the vicinity of the GPS coordinate, the survey team would randomly select a direction (north, south, east or west) and walk being guided by the GPS/compass to a farmhouse. Further systematic random sampling of the 75 households per site was done, which led to selection of 25 households per site. This translated to a total of 175 households in the 7 sites. However, only 157 of the selected households were interviewed for elicitation of WTP because the remaining 18 households did not keep cattle.

Information on household characteristics, farm characteristics, preference for breeding services, availability and use of breeding services and problems of the breeding services used was sought. In addition to the baseline surveys, focus group discussions with farmers were also conducted in June 2009. This involved 4 groups of between 10 to 15 smallholder farmers, drawn from village communities in the sampled villages. The groups comprised of youth, female and male participants. Qualitative information sought was on important traits of dairy cattle preferred by community members, dairy breeds and breeding services used, main ways of acquiring animals in the area, preference for certain breeding services and reasons, factors considered in choosing a breeding service, major constraints faced in accessing preferred breeding services and existing opportunities for availing other breeding services. Additional information was collected through interviews held with breeding service providers to cross check some of the information generated from focus group discussions.

3.4 Data analysis

Data collected was processed using Excel spreadsheets and Stata packages. Descriptive statistics, Chi-square Test, t–test and Ordinary Least Square Technique of Multiple Regression were used to analyze the data.

Details on the method used to analyze each objective are discussed in the following sub-sections.

3.4.1 Objective one: To evaluate the utilisation of artificial insemination and natural reproductive technologies by farmers

Descriptive statistics was used to evaluate the utilisation of artificial insemination and natural reproductive technologies by farmers in the study areas. In particular, Chi-square Test and t-test were used to compare the use of the two breeding services. It was assumed that a household which had cows had used at least one of the types of services. Therefore, if households had not used one of the services were assumed to have had used the other. More precisely, if a household had not used AI within the past 5 years, the assumption was that it used bull service.

3.4.2 Objective two: To assess farmers' willingness to pay for SIFET.

Contingent Valuation Method (CVM) was applied. A hypothetical description (scenario) of the terms under which SIFET was offered was presented to the respondent. The respondent was then asked questions to determine how much she or he would value SIFET service if given the opportunity to obtain it under the specified terms and conditions. Elicitation of maximum WTP was done using open-ended method adopted from Pearce *et al*, (2006). The Response Validity was tested by relating WTP responses to respondents' socio-economic, demographic, farm, environmental and institutional characteristics. Confirmation of *a priori* expectations of the relationship between WTP, income, age and other variables was a good indicator of meaningful responses.

To determine the influence of selected factors on WTP, OLS multiple regression model was used because it is a straightforward method that has a well developed theory behind it and has diagnostics to assist with the interpretation and troubleshooting. Following the general multiple regression model $Y=f(X_1, X_{2 \ldots n})$, the implicit model was,

WTP=f (DEM, FARM, SOC, ENVT, INST) ....Equation 6

Where,

WTP	= the amount each individual was willing to pay
DEM	=demographic characteristics
FARM	= farm factors
SOC	= social economic factors
ENVT	= environmental and spatial factors
INST	= institutional factors.

Choice of variables included in the model

The choice of variables for inclusion in the model was developed based on theoretical information, literature review and correlation matrices. Where a correlation coefficient was 0.6 and above, one of the variables was dropped to avoid multi-collinearity. This was after considering its importance in the dairy industry.

The gender of household head could influence uptake of a technology in either direction. For example, studies show that in the less developed countries (LDCs), men have better access to resources. This empowers them to have higher dairy productivity compared to women because they have the capability to adopt capital intensive technologies like improved dairy breeds (IDBs) (Kaliba *et al.* 1997; Staal *et al.* 1997; Adesina *et al.* 2000; Staal *et al.* 2002, Makokha *et al.* 2007). However, Tangka *et al.* (2000) state that women are more likely than men to invest in technologies that have a positive impact on family health. In addition, Sadoulet & de Janvry (1995) note that income controlled by women may have a greater impact on child nutrition and health than income controlled by men. This therefore gives women an incentive to engage in market-oriented dairy farming for more income. From these studies the influence of gender on adoption of dairy technologies is inconclusive.

Age was taken as a proxy for risk aversion. Nicholson *et al.* (1998) report a negative influence of age on adoption of IDBs, because older farmers have higher risk aversion to adoption of IDBs and their higher cultural values reduce the probability of their adopting IDBs. Older household heads are therefore likely to have lower WTP for SIFET

According to Makokha *et al.* (2007), education may enhance the capacity for adoption by enabling easier access to information, reducing uncertainty, and increasing allocative efficiency.

Education is particularly important where extension services are less intense (Feder *et al.* 1985). Educated households were expected to have higher WTP for SIFET

Rearing of IDBs is labor-intensive. Household size was taken as a proxy for labour supply. Larger households are expected to have higher labour supply. However, taking household size as a proxy for labour supply has been criticised in the sense that it may cause ambiguity because larger households may also have more dependants than labourers (Staal *et al.* 2002). Nevertheless previous studies and have used household size as a proxy for labour availability (Nicholson *et al.* 1998; Irungu *et al.* 1999). As such, the influence of household size on adoption of dairy technologies is indeterminate.

Regular income and credit are the households' most common sources of capital. Cash availability increases land and labour productivity by facilitating the introduction of new and more productive ways of converting resources into products. However a higher income may also lead to investment in more profitable off-farm enterprises, which may lower on-farm investment (Shiferaw & Holden 1998). The influence of income on adoption of dairy technologies may depend on its importance and the development level of dairy technologies on the farm. Availability of off-farm income may either make more cash available for investing in the farm or influence the household to change their priorities and make investment in the farm not a priority (Makokha *et al.*, 2007). Therefore, the influence off-farm income on WTP is indeterminate.

Adesina and Zinnah (1993), Kaliba *et al.* (1998) and Baidu-Forson (1997), report that extension services positively influenced the adoption of technologies. Households with access to extension are expected to have a higher WTP for SIFET than those who had no access to such services.

Credit availability, either formal or informal, presents farmers with an opportunity to acquire not only financial resources but also inputs such as feeds and veterinary medicines. If households have access to credit, it implies that they have opportunities to acquire financial resources and are therefore likely to be to have a higher WTP for SIFET.

Travel time to the nearest urban centre with a population of about 50,000 people was used as a proxy for market access. Market access is important as it indicates the ease at which a farmer can dispose his milk especially since milk is highly perishable. Therefore, high market access was expected to positively influence the willingness to pay for SIFET.

Different ethnic groups have different cultural practices and beliefs. These influence their ability to determine technology appropriateness (Makokha *et al.*, 2007). Nicholson *et al.* (1998) recognize the influence of ethnicity on the adoption of IDBs in coastal Kenya, because of the different culture and beliefs of the indigenous and the migrant population. Prevalence of Zebu in some parts of Kenya is associated with cultural practices and prestige, where herd size is more valuable than herd quality (Waithaka *et al.*, 2002). The ethnicity of the household head was therefore hypothesized to influence WTP for SIFET.

Membership to a group is a proxy for social capital of the household. According to Coleman (1988), social capital refers to the quality and depth of relationships between people in a family or a community. Fukuyama (2009a) defines social capital as an informal norm that promotes cooperation between two or more individuals. Economically speaking social capital is argued to be functional in reducing the transaction costs associated with formal coordination mechanisms such as contracts, hierarchies and bureaucratic rules (Kirsten and Nick, 2005). Household who have high social capital are said to incur less transaction costs of monitoring and negotiating litigating and enforcing formal agreements as Fukuyama (2009a) alluded. Against the background it was expected that households who have social capital have higher WTP for SIFET.

The higher the population density, the smaller the land available per household (which means less pasture) and hence the higher the likelihood of adopting technologies that increase returns to land (Staal *et al.* 2002). A high population density may also mean a higher access to milk markets, especially in cases where adoption rates for IDBs are low (Makokha *et al.*, 2007). Households in areas with a higher population density are expected to have a higher WTP for SIFET.

LGP was hypothesized to increase the probability of adopting IDBs due to the increase in pasture and water availability. At the same time a high LGP is accompanied by more livestock diseases. Households in the LDCs rely on planted fodder for livestock. Households in high precipitation areas have a higher WTP for cows with high feed requirement and a lower WTP for cows with low disease resistance (Makokha, *et al*, 2007). As such the influence of LGP on WTP for SIFET is indeterminate.

A specification of the model with expected interaction between WTP and various factors was represented as;

$$WTP=\beta_0 + \beta_1(sex) + \beta_2(Age) + \beta_3(Educ) + \beta_4(Hhsize)+\beta_5(offfrminc)+ \beta_6(ethnicity)+ \beta_7(loan) + \beta_8(ext)+ \beta_9(grpmmber)+ \beta_{10}(lccattle) +\beta_{11}(prodsyst)+ \beta_{12}(Serv)+ \beta_{13}(bulls)+ \beta_{14}(milkprodcd) + \beta_{15}(pop)+ \beta_{16}(travltim) +\beta_{17}(LGP) +\varepsilon$$

Where,

WTP	= willingness to pay (Ksh)
β_0	= constant term
Sex	=gender of household head (male=1, female=0)
Age	=age of household head (years)
Educ	=education level of household head (years of schooling)
Hhsize	=total number of persons in a household (count)
Offfrminc	=household income from non-farm activities (Ksh per year)
Ethnicity	=Dummy variable (1=Nandi, 0=otherwise)
Loan	=access to loan (yes=1, no=0)
Ext	=extension services (yes=1, no=0)
grpmmber	=membership to a dairy group (yes=1, no=0)
lccattle	=total number of indigenous cattle breed per household (count)
prodsyst	=the production system(1=zero grazing, 0=otherwise)
Serv	=breeding service previously used (AI=1, natural service=0)
Bulls	=number of bulls kept by household (count)
Milkprodcd	=quantity of milk produced per household (litres per day)
Pop05	=population density as per year 2005(no. of persons per km^2)
Travltim	=travel time to nearest urban centre (Minutes)
LGP	=length of growth period (days)
ε	=error term

3.4.3 Objective three: To determine the cost of developing and delivering SIFET to the farmers and its associated benefits.

In the study, cost allocation was done using activity based costing method. The activities were divided into; oocytes collection, embryo production in the laboratory and embryo delivery to farmers. Cost of oocytes collection was estimated based on transport cost incurred to collect oocytes from the abattoir within a radius of 20km. This would ensure that the given six hours maximum time allowance between death of a cow and harvesting of oocytes from the cow is not exceeded. The cost of producing embryos was estimated using direct cost items identifiable from the laboratories. Interviews with lab technician and veterinary doctor were used in identification and estimation of the items and tasks in the production process. The cost of delivery was estimated using data from interviews with breeding service providers and the current market practices.

In estimating the cost of producing an embryo, direct materials, depreciation costs of equipment and labour costs was considered. Cost of non consumable assets and equipment such as refrigerators and microscopes is assigned as depreciation using depreciation rates according to standard costing method. Depreciation of equipment was done on reducing balance basis to determine the value of assets at the end of each year. Cost of labour was estimated using the current rates by the civil service of Kenya. Research, training and buildings' costs were not factored in; they were considered as sunk costs. It was assumed that at any one point, a batch of 25 embryos is produced and transferred. An optimal level of production was determined using the number of embryo straws at which the marginal costs associated with production were at a minimum level. The monetary unit of valuation was Kenyan Shillings (Ksh) which was converted to US dollars at the rate of Ksh75=1 US $

The cost of delivery incorporated cost of materials used for the actual embryo transfer, service charge and transport costs within a radius of 20kilometres as applied for AI transport costs. Total annual costs were considered as the cost of embryo production and delivery, plus equipment maintenance costs.

Monetary benefits of the technology was estimated using farmer's willingness to pay for the technology extracted from EADD's baseline household survey which was carried out in selected areas in the country as explained in Sections 3.1- 3.3 . In addition WTP values generated from focus group discussions were used to supplement household survey values. The technology was explained to farmers who were then asked to give the amount they were willing to pay for the technology. The benefits for the firm were assessed using price at which farmers are willing to purchase the technology, and the feasible quantities of embryo straws that would be produced. Minimum and maximum prices at which farmers are willing to purchase were assessed using the WTP methodology. The willingness to pay amount was taken as the quantitative valuation of benefits (Pearce *et al.*, 2007). This WTP amount was treated as the price that farmers would pay for an embryo transfer. To compute total benefits, the lowest WTP amount that was above the total cost of SIFET was used. The WTP value was multiplied by the number of embryo straws that would be produced at the optimal level of production. Salvage values after the assets' useful life was expired were included in the analysis and appropriately added as benefits. The given amount was treated as the price for the technology. Annual benefits were taken as the product of the price and quantity of embryo straws produced.

In the analysis three major parameters were considered; the net present value (NPV), the benefit cost ratio (BCR) and the internal rate of return (IRR). The computation of the parameters was adopted from Campbell and Brown (2003).

Net present value (NPV)

This is the total present value (PV) of future cash flows. It is a standard method for using the time value of money to appraise long-term projects. NPV is calculated using the function;

$NPV=\sum C_n/(1+r)^n$ .... Equation 7

Where,

n- Period;

r - The discount rate;

C_n - the net cash flow.

Benefit-cost ratio (BCR)

The formula for calculating BCR was

$BCR=\frac{PVB}{PVC}$ .... Equation 8

Where,

PVB = present value of benefits defined as sum of discounted benefits

PVC = present value of costs defined as sum of discounted costs

Internal rate of return (IRR)

The internal rate of return on an investment or potential investment is the annualized effective compounded return rate that can be earned on the invested capital. It is the interest rate at which the costs of the investment lead to the benefits of the investment. Given the (period, cash flow) pairs (n, C_n) where n is a positive integer, the total number of periods N, and the net present value NPV, the internal rate of return is given by r in this formula;

$$\mathrm{NPV} = \sum_{n=0}^{N} \frac{C_n}{(1+r)^n} = 0$$ ....Equation 9

A sensitivity analysis was done to assess the effect of change in discount rate, costs and benefits on NPV, IRR, BCR and pay-off period.

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter outlines findings from the research which was done to assess the ex-ante economic viability of SIFET. The following sub-topics are detailed discussions of the socio-economic and farm characteristics, the empirical results and the implication of the results on investment in SIFET technology.

4.1 Socio-economic and farm characteristics

The socio-economic and farm characteristics included in this section are: household size, education of household head, the age of household head, household head farming experience, land size owned by the household, gross annual dairy income, social capital of the household, household access to market, credit and extension services, number of cattle, number of cows, milk production (litres), milk sold, distance to milk selling point, breeding service used, cost of AI and cost of bull service. As shown in Table 1, the average size of households measured in counts was 5.89.

Table 1: Descriptive statistics of selected variables

Variable	N	Mean	Std. Dev.	Min	Max
Household size(count)	127	5.94	2.55	2	14
Household head education(years)	127	5.82	4.27	0	21
Household head age(years)	127	49.64	14.64	20	85
Household head farming experience(years)	127	23.09	14.45	0	67
Land size owned(acres)	127	42.05	171.36	0	1280
Number of cattle	127	2.69	2.18	1	15
Number of cows	114	2.61	1.93	1	10
Milk production(litres)	100	13.15	15.82	1	94
Milk sold (litres)	72	11.33	12.17	1	60
Distance to milk selling point(km)	101	3.64	6.18	0	25
Gross annual dairy income($)	104	871.96	975.79	16.80	5600
Cost of AI($)	78	11.66	5.37	5.33	40
Cost of bull service($)	111	1.84	3.45	0	16
WTP ($)	126	18.40	12.76	0.8	66.67

The average age of household heads in the study area was 49.9 years while the average level of education measured in years of schooling of household heads was 5.8 years. This suggested that most of the famers were literate. The average farming experience of household heads measured in number of years of farming was 23.1. This indicated that households had been engaged in farming for a long time. The average land size of the farmers was 42.1 acres. However, the standard deviation of approximately 171 acres, the minimum land size of 0 acres and the maximum was 1280 acres are all indication of large variation in household land size holdings. This implied that there were a few households who owned relatively large sizes of land. The average cost of AI service was about US$11.66(Ksh875) while the average bull service cost was US$1.84(Ksh138). The average WTP for SIFET was US$ 18.4(Ksh1380).

As shown in Table 2, both exotic and indigenous cattle breeds were kept. The most common breeds kept were crosses of Holstein-Friesian and Ayrshire which were kept by 55% and 54% of the households respectively. The high percentage of farmers keeping upgraded breeds indicates efforts to improve the quality of their stock.

Table 2: percentage of cattle breed and cattle type kept by households in the study areas

Cattle breed	Percent	Cattle type	Percent
Holstein-Friesian (pure)	2	Bulls	18
Holstein-Friesian (cross)	55	Castrated males	23
Ayrshire(pure)	6	Immature males	26
Ayrshire(cross)	54	Cows	90
Jersey (pure)	1	Heifers	80
Jersey (cross)	2	Pre -weaning males	36
Guernsey (cross)	6	Pre -weaning females	50
Local zebu	25		

Crosses and pure breeds were kept mainly for their high milk productivity which translates into high income from sales of milk. This implies that farmers are inclined towards commercialization of their dairying activities. Zebu breeds were also kept by 25% of households mostly in high LGP /low market access areas. During focus group discussions, farmers explained that zebus were kept because of their resistance to drought, for slaughter and draught power.

Generally, female cattle were kept by a larger proportion of farmers compared to male cattle. This indicates that in dairy farming, female cattle are preferred to males. About 90% of the households kept cows that had calved at least once which shows the proportion of milk producing stock. Heifers and pre-weaning females were kept by 80% and 50% of the farmers respectively, which is an indicator for the level of stock kept for replacement purposes. On the other hand, the male cattle were kept for slaughter. Bulls were kept for breeding purposes while castrated males were mainly for draught power.

4.2 Preference and use of AI and bull/ natural reproductive technologies

As shown in Table 3, about 54% of the sampled farmers prefer AI, while 46% prefer bull service. The results suggest that AI service is preferred to bull service. However, only 13% of the farmers interviewed had used AI within a period of 5 years preceeding the time of the study while 87% had used bull service. Although AI was more preferred, it was poorly used suggesting certain limitations in its use.

Table 3: percentage of farmers Preferring and using AI and bull service

Used service **Preferred**	AI (n=16)	Bull (n=110)	Total
AI	11(16%)	57(84%)	68(54%)
Bull	5 (9%)	53(91%)	58(46%)
Total	16 (13%)	110 (87%)	126

Among farmers who preferred AI, 84% used bull service. On the other hand, 9% of the farmers who prefer bull service had used AI within the last 5 years. The results suggested that farmers did not always use their preferred breeding service.

The reasons for preferring a particular breeding service were elaborated during focus group discussions. AI was particularly preferred for various reasons such as offering a faster way to get a pedigree improved breed because the breed of the sire is known therefore, an easier way to improve herd quality. AI also helps in preventing the spread of reproductive diseases. In addition, it saves on cost of keeping a bull since bulls are rare and their owners do not allow cows from other farms. It was also argued that AI calves grow faster and are sold at high prices because AI calves are sired by selected top performing bulls of known genotypes.

On the other hand, the reasons for preference of bull service were accurate heat detection even when the farmer is unaware of heat status of an animal. In addition, bull service was reported to result in high conception rates thus there are few repeats and therefore counters AI repeats.

Furthermore, bull service is cheap, readily available within the farm's environs, and convenient where a farmer does not have money to pay for AI especially when he has many animals.

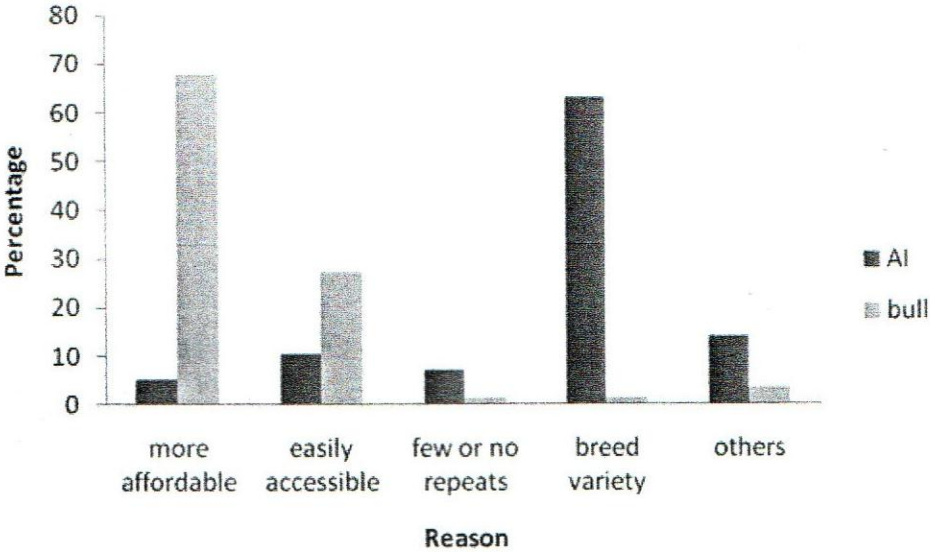

Figure 4: Farmers' reasons for preferring a breeding service.

4.3 Problems and constraints of using AI and bull breeding services

About 36% of farmers who were using AI had experienced problems with its use while 49% of farmers who had used bull service had experienced some problems. As illustrated in Figure 5, approximately 87% of farmers who had used AI cited the problem of repeat services compared to about 20% of those who had used bull service. A repeat service implies that there was a problem of non-conception after insemination which prompted for consecutive AI services before a successful conception was achieved. The problem of no variety (limited choice of breeds) was cited by about 60% of farmers who had used bull service. This stemmed from use of a specific breed of sires for breeding purposes. As a result, calves born would fall within the same genotype thus offering limited breed varieties. While 20% of farmers who had used AI had cited expensive/ high cost of AI service as a problem, none among those who had used bull service had this problem.

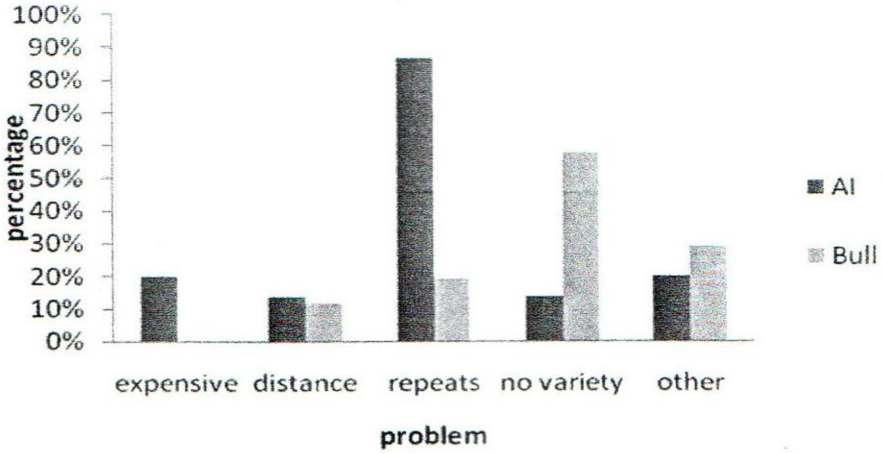

Figure 5: percentage of households with various problems of AI and bull service

Absence of liquid cash to pay for AI service upfront was another constraint that was revealed. This stemmed from the fact that a cow needs to be served immediately it comes on heat, within a period of less than a day. In addition, lack of information on the breeds used for AI especially for imported semen, whose catalogues were not available, caused uncertainty in regard of the breed that a farmer gets from AI.

Farmers using bull service cited problems such as spread of venereal diseases and injury to the cow by bulls; high costs of rearing a bull; bull owners declining to give the service therefore bull service not being reliable and difficulties in knowing the progeny capability of a bull thus a farmer cannot tell how much milk the female offspring will produce.

4.4 Comparison of farm and farmer characteristics for AI and bull services

Results that compare selected farmer and farm characteristics between farmers who had used AI service and those who had not are shown in Table 4 and Table 5 respectively.

The size of land measured in acres, number of cross breed cattle, number of cows and milk production measured in litres were all significantly different between the two groups. These variables are all related to use of breeding service. Farmers who had not used AI had significantly more acres of land and therefore they could probably afford to keep a bull for breeding. In addition, their level of intensification is lower since they have more access to land.

Table 4: comparison of quantitative variables between farmers who had used AI and those who had not

Variable	Not-used AI	Used AI	Difference	Significance
Household size	5.90	5.86	0.04	0.94
Household head education	5.59	6.43	-0.74	0.46
Household head age(years	49.98	47.81	2.17	0.54
Household head experience(years)	23.47	19.67	3.80	0.27
Total Household Income ($)	2420.95	2228.13	192.82	0.80
Land size(acres)	12.24	3.62	8.62	0.06*
Number of cross breed cattle	2.64	3.70	-1.06	0.09*
Number of cows	1.87	2.46	-0.59	0.04**
Milk production (litres per day)	12.12	21.55	-9.43	0.06*
Distance to milk selling point(km)	3.95	2.45	1.50	0.32

Note: ** Significant at the 0.05 level; * significant at the 0.10 level.

Households who had used AI are expected to have more cross breeds and recorded significantly higher level of milk production compared to those who had not. This could be because the crossbreed cattle are also expected to yield more milk than those who had used bull service.

Table 5: Comparison of qualitative variables between farmers who had used AI and those who had not

Variable	Response	Used AI (n=19) %	Non-use of AI(n=108) %	significance
Gender	Female	32	19	1.421
	Male	68	81	
Group membership	Yes	0	13	2.768*
	No	100	87	
Obtained loan	Yes	37	44	0.295
	No	63	56	
Access to extension	Yes	95	79	2.71*
	No	5	21	

Note: * significant at 0.10 level.

The results in Table 5 indicate that use of AI was significantly associated with group membership and access to extension. Out of the households who had used AI, 32% were female-headed, 37% had obtained loan for dairying activities and 95% had access to extension service.

All the sampled farmers who had used AI were non-members of groups for selling milk. This could possibly be due to low utilization of groups to purchase dairy production inputs within the study areas. Therefore, the groups could be solely for purposes of group marketing of milk and not procurement of breeding services.

4.5 Farmers willingness to pay for SIFET

WTP values elicited varied across the respondents. Literature has elaborated the factors that influence WTP. As highlighted in Chapter 2 these factors fall under four major categories namely; socio-economic, farm, institutional, and spatial and environmental factors. A detailed discussion of the results follows in the sub topics below.

4.5.1 Preference for sex of animals

SIFET technology allows for determination of sex of the calves to be born before conception. Therefore, farmers have an opportunity to choose their preferred sex of the calves to be born. The percentage of farmers preferring male or female calves are shown in Table 6. While female calves are arguably more economical for dairy farmers particularly for replacement stock, male calves are preferred in the household for slaughter and draft power.

Table 6: Preference of sex of calves

Preferred sex of calves	Percentage (n=126)
Male	21.4
Female	78.6

About 78.6% of the farmers preferred to get female calves when their cows calf. As such, it can be argued that female calves are preferred to male calves.

4.5.2 Attitude towards cow-calf relationship of SIFET calves

Of the interviewed households 98.4% indicated having no problem in accepting a calf which had no direct relationship with their cow. In other words, they would not be bothered by the fact that the calf was fertilized in a laboratory. However a minority of 1.6 % had problems accepting such a calf. Farmers' group discussions indicated that the acceptance of calves that were unrelated to their surrogate mothers was probably supported by the perceived potential benefits of SIFET. The technology was perceived as a mean to achieve preferred sex of calf and therefore save them the cost of raising undesired calves. It was also seen as a shortcut to reaching high grade of the breed (pedigree) hence save on cost of pedigree female cow which is very expensive. In addition, SIFET will enable quicker breed improvement because the desired breed is produced faster and transferred quickly (shorter generation interval). Furthermore, the technology will help them to save on cost of keeping a bull for natural service in the face of diminishing land holdings per household. The technology was seen as a faster way to increase milk production since only female calves are born.

4.5.3 Assessment of factors influencing farmers' WTP for SIFET

The amount that farmers are willing to pay is influenced by their economic status as revealed by theory and adoption studies literature. For example, during FGD, farmers considered their level of income when stating the amount they were willing to pay for an embryo transfer. The reasons given for prices of a SIFET straw during focus discussion varied as shown in Table 7.

Willingness to pay values and the basis of valuation

During FGD the process of producing and transferring SIFET straws was explained to the farmers. Further the implications of SIFET in terms of its potential benefits and costs as a breeding service were elaborated. Based on the explanation, farmers were asked to write down on a card the maximum price they would pay for an embryo transfer and then show their cards. The highest and lowest prices were noted. The farmers then discussed in details the reasons for such lowest and highest value, which are summarized in Table 7.

Table 7: Reasons given for prices a SIFET straw transfer

Reasons for minimum amount	Reasons for maximum amount.
a. Farmers economic status	a. Considered cost of sexed semen.
b. To allow everyone in the group to benefit	b. Cost of production and delivering.
c. It is a new technology and farmers would like to try it first.	c. Benefits such as faster means to achieve preferred grade, breed and sex.

The reasons given for the lowest value suggest that farmers considered various factors when making decision on whether to adopt a technology or not. For example, consideration of farmers' economic status would entail household income streams and expenses and general cost of living given an individual farmer's lifestyle. On the other hand, consideration of group members indicates the role of social capital in decision making while the idea of first trying the technology is a possible indicator if the farmers' risk aversion.

Based on theory, the reasons given for the maximum amounts can be argued to collectively indicate the desire of a farmer to maximize his or her utility. Consideration of the cost of sexed semen for artificial insemination is an indicator that farmers are aware of the alternative breeding method that yields similar results. The high cost of producing embryo straws suggests that farmers understood the process of developing the technology well. Consideration of the benefits could be argued to be an indicator that farmers were aware of the opportunity cost of not adopting the technology.

An assessment of the factors that influenced the farmer's WTP for SIFET was done by estimating an OLS multiple regression model. The following discussion is on how variables which were included in the model were chosen and an interpretation of the model estimates.

Effects of variables influencing farmers' willingness to pay for SIFET

An ordinary Least Squares multiple regression models was applied to determine the effect of selected variables of farmers' willingness to pay for SIFET. Results of the model are presented in Table 8. The dependent variable (WTP) was a continuous variable measured in US dollars (US$). Experience of the household head in dairy farming was dropped because it was highly correlated with the age of household head.

The coefficients show the direction and magnitude of change in WTP as a result of change in the explanatory variables. The OLS function was highly significant at 1% significant level. The model explained 59% of the variation. This implies that the remaining 41% of variation in the farmers WTP was explained by other factors that were not included in the model.

Holding all other factors constant, farmers were willing to pay Kshs 254.90 ($3.4) for a straw of SIFET. The age of household head, size of household, off-farm income, ethnicity, breeding service that was previously used, access to loan, group membership, number of bulls kept and quantity of milk produced had significant influence on farmers' WTP for SIFET.

The age of household head had a significant positive influence on the WTP exhibited by farmers. An increase of age of household head by 1 year would lead to a Ksh10.54 ($0.14) increase in the farmers WTP for SIFET. This is contrary to studies by Nicholson et al, (1998) who alluded that older farmers were more risk averse and therefore would be less willing to adopt new technology. The positive effect of age on WTP for SIFET could be due to experience that comes with age leading to older farmers high WTP for the technology.

Table 8: OLS regression model estimates for willingness to pay for SIFET

Variable	Coefficient		t
	Ksh	**US$**	
Socio-economic variables			
Head sex	211.65	2.82	1.160
Head age	10.54	0.14	1.960**
Education	20.49	0.27	1.120
Household size	-62.12	-0.83	-2.160**
Off- farm income	-0.10	-0.001	-2.270**
Ethnicity	958.51	12.78	5.620***
Institutional variables			
Extension services	-218.03	-2.91	-1.030
Loan	267.03	3.56	1.790*
Group membership	682.32	9.10	3.110***
Farm variables			
Local cattle	-4.74	-0.06	-0.930
Production system	74.47	0.99	0.790
Breeding service	983.39	13.11	4.910***
Bulls kept	-98.75	-1.32	-3.060***
Milk produced	23.86	0.32	4.630***
Environmental and spatial variables			
Population density	-0.06	-0.001	-0.580
Travel time to urban centre	0.65	0.01	0.940
Length of growth period	-1.96	-0.03	-1.260
Cons	254.90	3.4	0.380
n			127
R squared			59%
F			6.8***

Note: *** Significant at the 0.01 level; ** Significant at the 0.05 level;* significant at the 0.10 level.

The influence of size of household on farmers' WTP for SIFET was negative. Results show that an addition of one member to the household would lead to a reduction on farmers WTP by Kshs62.12 ($0.83). The results are contrary to expectations that larger households provides labour for improved dairy breeds(IDBs) and therefore could have a positive influence on WTP.

Previous studies by Nicholson *et al*, (1998) and Irungu *et al* (1999) showed a negative influence of household size on a dairy production technology. It is therefore agreeable that large family size may have more dependants than labourers (Makokha *et al*, 2007: Staal *et al*, 2002). This logically explains the negative influence of household size on WTP.

Off- farm income had a significant negative influence on the amount that farmers were willing to pay for SIFET. If off-farm income were to be increased by one shilling, then the amount farmers were willing to pay for SIFET would decline by Ksh0.10 ($0.001). As discussed earlier, the negative influence of off-farm income on farmers' WTP could be due to re- alignment of farmers' priorities (Makokha *et al*, 2007; Shiferaw & Holden 1998). This implies that increases in off farm income could lead to investments other enterprises thus dairy investments are not prioritised.

Household ethnicity was used as a proxy to indicate the influence of society cultural values and traditions. Households belonging to Nandi ethnic group were willing to pay Ksh938.51 ($12.78) more than other ethnic groups within the study area. This is probably due to value attached to cattle and milk which is highly consumed among the Nandi ethnic group. The results agree with findings of a similar study by Makokha *et al* (2007) who alluded that Nandi ethnic group was positively associated with adoption of IDBs.

In accordance to prior expectations, households who had obtained a loan for dairying activities were positively associated with higher WTP values. Such households were willing to pay ksh267.63 ($3.56) more than those who had not obtained a loan. This is because access to loans presents a farmer with more opportunities to acquire financial resources which enables them to purchase inputs for their production process.

Group membership was used as a proxy for social capital. Results show that household with members who belonged to dairy group were willing to pay Ksh682.32 ($9.10) more than those who did not belong to such groups. This could be because through groups, farmers are able to reduce the transaction costs associated with procuring services and are therefore able to exhibit higher WTP values.

The quantity of milk produced had a significant positive influence on WTP for SIFET. An increase in the quantity of milk produced by one litre could lead to an increase in WTP by Ksh23.86 ($0.32). This supports findings by Makokha *et al*, (2007), who alluded that farmers gave a higher rating for animals with high milk yield implying that milk yield had a positive influence on farmers WTP for IDBs.

In addition, the breeding service that was used by farmers within a period of 5 years, preceding the time of this study, had a significant influence on farmers' WTP for SIFET technology. Farmers who had used AI were willing to pay Ksh983.39 ($11.11) more than those who had used other breeding services. This could be due to the fact that these farmers were actively trying to improve the quality and productivity of their dairy herd by improving the breed of their stock. As such, these farmers were more willing to pay for an improved technology that would speedily improve their stock's breed.

The number of bulls kept by farmers had a negative influence on the amount that farmers were willing to pay for SIFET. Addition of one bull to the herd could decrease the WTP values by Ksh98.75 ($1.32). This is arguably because a household that is keeping bulls could probably be using the bulls for breeding purposes. Therefore, such a household is likely to have a lower WTP for a breeding service since they can easily use natural service.

4.6 Analysis of costs and benefits of production and delivery of SIFET

The costs and benefits were analysed using discounting method. A period of 15 years was considered based on the useful life of most of the investment equipments. The following sub-sections are detailed discussion of results of the analysis.

4.6.1 Estimation of production and delivery costs

Activity based costing was done to estimate the cost of producing and delivering SIFET. Data was collected from the International Livestock Research Institute's (ILRI) laboratory. The initial capital cost of investment which was basically the cost of equipment needed for production of embryos was estimated at US$14,186.67 (Ksh1,064,000). Further, an annual maintenance cost of 10% per year was also allocated as part of equipment cost. The process of embryo production and transfer was divided into three major activities namely, oocyte collection, embryo production and embryo transfer. Using laboratory experiments for base estimates of the costs, an embryo straw was estimated to cost US$ 33.24 (Ksh2,493). This incorporated oocyte collection, production and delivery costs. A detailed cost account for the three major tasks is shown in Table 9 and Table 10.

Table 9: Cost allocation of tasks in SIFET process

Task	Cost per straw (US$)		Contribution
	US$	Ksh	%
Oocyte collection	1.39	104.25	4
Embryo Production	10.69	801.75	32
Delivery	18.13	1359.75	55
10% overhead allowance	3.03	227.25	9
Total	**33.24**	**2492.72**	**100**

The cost of oocyte collection from abattoir contributed 4% of total costs while that of production was 32%. The highest component of costs was delivery costs of SIFET embryos to farmers which was approximately 55% of the total costs.

Table 10: Embryo delivery cost allocation

Item	Estimated Cost		Contribution (%)
	US$	Ksh	
Materials and chemicals	4.80	360	26
Labour	9.33	700	51
Transport	4.00	300	22
Total	18.13	**1360**	**100**

The highest cost component was labour costs which formed about 51% of the total delivery costs. The possible explanation for high labour costs is because embryo transfer requires highly trained technicians. The cost of materials and chemicals used for delivery was about 26% while that of transport was about 22%.Transport costs were charged uniformly across households regardless of their location within a considered area of operation of 20km radius. The decision to use 20km radius was arrived at after discussions with service providers concerning the maximum feasible area of operation that they operated onTransport costs were high due to high fuel costs that were prevailing in the country at the time of this study. Further, the costs can be argued to arise from poor infrastructure in terms of road network which prompted transport providers to charge highly for transport services.

4.6.2 Discounted costs and benefits

Costs and benefits were discounted at a rate of 10% for 15 years because most equipment had useful life of 15 years. The discounted benefits were computed by multiplying the number of straws that would be produced by the WTP values. The salvage value of assets at the end of 15 years was also added to total benefits. Figure 6 illustrates the trend of costs benefits and profits after discounting and incorporating cost of replacing obsolete equipments.

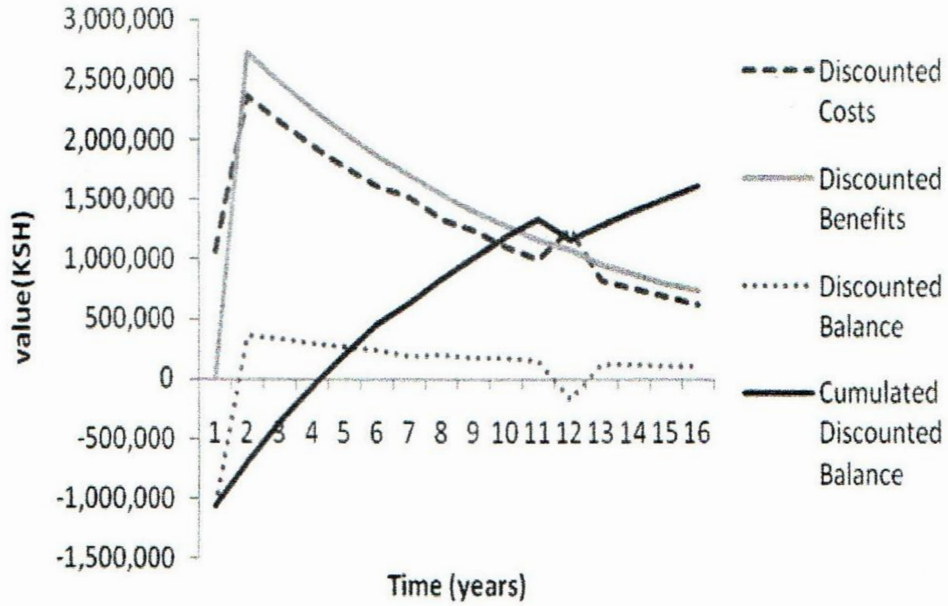

Figure 6: Discounted costs and benefits curves

The slope of cumulated discounted balance curve depicts rate of change of profits over the years. Cumulated discounted profits increase at an increasing rate within the first 5 years, followed by increase at a decreasing rate up to year 12 when it is less than zero. This implies that the investment will incur losses during the 12th year. The losses culminate from purchases of capital goods because some equipments are written off after the 10th year. During the first four years of implementation, there are negative profits even though the benefits are positive as shown in Figure 6. This means that in the initial years, all the revenue collected from sale of embryo straws is used up to cover initial outlay and operation costs. However, after fourth year the investment starts making positive profits thus bearing returns on the investment.

4.6.3 Parameters considered in investment decision making

In order to analyse acceptability of investment on SIFET, discounting parameters were used namely; NPV, BCR, and IRR. As shown in section 3.4.3, equations 1, 2, and 3 were used for computation of NPV, BCR and IRR respectively. The general rules for acceptance using NPV criterion is to accept a project if calculated value is greater than zero which indicates that the difference between total discounted benefits and total discounted costs is greater than zero. On the other hand, basing on BCR, a project is accepted if calculated value is greater than one. This implies that total discounted benefits are proportionately greater than total discounted cost. The use of IRR accepts a project when the internal rate of return is greater than an established minimum rate. The pay off period indicates the period within which the project will have covered initial cost of investment. In this study all the four parameters were used for purposes of comparison and testing for consistency of the results. The results of the computations are shown in Table 11.

Table 11: Discounted parameters used for investment decision making

Parameter	Magnitude	
	US$	Ksh
Sum of Discounted Costs (I)	283 455.41	21 259 156
Sum of Discounted Benefits (II)	305 019.37	22 876 453
NPV (II) - (I)	21 563.97	1 617 296
IRR	35.66%	
BCR	1.08	
Pay-off period(years)	4	

The NPV was approximated at US$ 21 564(Ksh1 617 296), the BCR was 1.08, the IRR was 35.66%, while the pay-off period was 4 years. Given the general rule of acceptance, NPV was greater than zero which implied that the project was acceptable. In addition the BCR was greater than one which indicated that benefits were proportionately more than costs, therefore the project is acceptable. On the other hand the internal rate of return and the pay off period indicators are dependent on an individual's established minimum acceptable rate of return and time value of money. As such, the acceptability of the project based on IRR and pay-off period are relatively subjective. However, since this method was considering the time value of money and cash flows after the pay-off period, useful information on whether the investment is worthwhile is provided.

4.6.4 Sensitivity Analysis

A sensitivity analysis was done to establish how sensitive the parameters discussed above are to changes in discount rate and costs. The discount rate and costs were varied above or below the specified values to observe how they would affect the NPV, BCR, IRR and pay-off period. Results of the sensitivity analysis showing the effect of discount rate and costs variations are shown in Table 12 and Table 13 respectively.

As shown on Table 12, the NPV was acceptable irrespective of variations in discount rate. However, at higher discount rate of 15%, lower NPV values of US$13 920(Ksh1 044 032) compared to a lower discount rate of 5% where higher NPV values of US$33 451 (Ksh2 508 813) were observed.This indicates that NPV is inversely proportional to discount rate.

Table 12: Effect of variation of discount rate on NPV, BCR, IRR and pay-off period

Discount rate	**10%**		**15%**		**5%**	
parameter						
NPV	$ 21,565	Ksh 1,617,296	$ 13,920	Ksh 1,044,032	$ 33,452	Ksh 2,508, 813
IRR	35.66%		35.66%		35.66%	
BCR	1.08		1.06		1.09	
Pay-off period	4		4		3	

Further, the BCR increased with a decrease in discount rates, suggesting that it was also inversely proportional to discount rate. It indicated that the project was acceptable regardless of the discount rates variations. IRR was not affected by changes in discount rate and therefore the project is acceptable at all the considered discount rate. In addition payoff period reduced to 3 years when the discount rate was reduced to 5% and remained at 4 years when discount rate was increased to 15%. The variation in pay-off period is arguably due to increased time value of money at lower discount rates.

Table 13: Effect of variation of total costs on NPV, BCR, IRR and pay-off period

cost parameter	Initial costs		10% reduction		10% increase	
NPV	$ 21,565	Ksh 1,617,296	$ 47,932	Ksh 3,594,878	$ (4,804)	Ksh (360,283)
IRR	35.66%		61.42%		1.26%	
BCR	1.08		1.19		0.98	
Pay-off period	4		2		NA	

However, as shown in Table 13, cost variations had relatively significant effect on acceptability of the project using various parameters. A 10% increase in production costs of a straw of embryo led to a negative NPV of US$-4 804 (Ksh360,283) making the project unacceptable. On the other hand, a reduction of costs by 10% led to an increase in NPV by more than two times, from US$21,564 (Ksh1, 617,296) to US$47,932(Ksh3, 594,878). This indicated that NPV was highly sensitive to variations in costs

The IRR was also sensitive to cost variations. IRR increased from 35.66 to 61.42% when costs of an embryo transfer were reduced by 10%. On the other hand, when costs were increased by 10% the IRR reduced to 1.26%. The response of IRR to cost variations implicitly suggests that cost was crucial in determining the IRR. In addition, the BCR was sensitive to changes in cost variations. For instance a 10% reduction in costs led to an increase in BCR from 1.08 to 1.19, while a cost increase of the same magnitude decreased the BCR to 0.98, thus making the project unacceptable. A decrease in costs by 10% reduced the pay-off period from 4 years to 2 years while an increase in cost of the same magnitude could not pay off after 15years implying that the project was unacceptable.

In summary results of a sensitivity analysis showed that variations on discount rates did not change acceptability of investment in SIFET project using NPV, BCR, IRR and payoff cost variations. However, variations in costs had an effect on the parameters making it unacceptable when costs were increased by 10%.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions

Based on results from both household surveys and focus group discussions farmers are inclined towards improving their cattle breeds as indicated by the high proportion of cross bred cattle. The study concludes that overall AI is preferred to bull service, although bull service is more used than AI, indicating that farmers do not always use what they prefer. AI is is preferred mostly because it is less expensive while Bull service is mainly preferred for offering breed variety. Households with more cross breed cattle, more number of cows and produced more milk are associated with use of AI while larger land sizes have been associated with more use of bull service. In addition, farmers prefer female calves to male calves mainly for increasing breeding stock and for replacement stocks. SIFET was desirable to farmers because of its perceived benefits of achieving preferred sex of calf, reaching high grade of the breed (pedigree) quickly improving the breed of stock, savings on cost of keeping a bull for natural service on small land holdings and a faster way to increase milk production. Majority of farmers were willing to accept a calf which was not related to their cow.

This study shows that farmers are willing to pay an average of US$18.4(Ksh1380) for SIFET technology. Drawing on results from OLS multiple regression models, socio-economic, farm, institutional, and environmental and spatial variables explained 59% of the variation in WTP values. The factors that would increase WTP for SIFET are age of household head, ethnicity, breeding service that was previously used, access to loan, group membership, and quantity of milk produced. On the other hand, size of the household, off-farm income and number of bulls kept reduce the amount that farmers would pay for SIFET.

The ex-ante cost-benefit analysis shows that delivery of SIFET to farmers is the highest cost component and constitutes over half of the total costs, of which 50% are labour costs. An investment in SIFET would cover the cost of initial capital outlay within a period of 4 years and would yield a rate of return of about 35%. Increasing costs would yield negative returns on investment. Generally, SIFET technology is a feasible investment in Kenya. Financial indicators are all acceptable even when a minimum commercial production level is considered. SIFET would benefit farmers in achieving the desired sex of animals and fast upgrading of animals, which makes the technology acceptable to the farmers.

5.2 Recommendations

This study recommends investment in SIFET which has been proven to be an economically viable investment. However, measures should be put in place to reduce the cost of delivering SIFET technology, which was the highest cost component. Strategies that will lead to a reduction in labour costs and creation of an enabling environment for dissemination of the technology to small holder farmers should be explored. Such strategies may incorporate;

1. Formulation of fiscal and sanitary/phytosanitary policies that will facilitate smoother and cheaper importation of sexed semen.
2. Revising of policies related to veterinary service delivery to allow competent veterinary technicians deliver services so as to lower labour costs.

Further research

Although this study was done considering small-scale dairy farmers, some of the data that was collected was fundamentally for providing information. The economic viability study was basically done for commercial firms who might be interested in investing in production and delivery of SIFET. Further analysis need to be done to establish SIFET viability at farm level.

REFERENCES

Adesina, A. A. and Zinnah, M. M. (1993). Technology characteristics, farmers' perceptions and adoption decisions: A Tobit model application in Sierra Leone. *Journal of Agricultural Economics, 9, 297–311.*

Adesina, A. A., Mbila, D., Nkamleu, G. B. and Endamana, D. (2000). "Econometric analysis of the determinants of adoption of alley farming by farmers in the forest zone of southwest Cameroon." *Journal of Agriculture, Ecosystems and Environment 80, 255–65.*

Baidu-Forson, J., Ntare, B. R. and Waliyar, F., (1997). "Utilizing conjoint analysis to design modern crop varieties: Empirical example for groundnut in Niger." *Journal of Agricultural Economics 16, 219–26.*

Baltenweck, I., Ouma, R., Anunda, F., Mwai, O. and Romney, D. (2004). Artificial or natural insemination: The demand for breeding services by smallholders. ILRI, Nairobi, Kenya.

Bebe, B.O, (2003). Herd dynamics of smallholder dairy in the Kenya highlands. PhD thesis, Wageningen Institute of Animal Sciences, Wageningen, The Netherlands.

Bebe, B.O., Udo, H.M.J., Rowlands, G.J. and Thorpe, W. (2003). "Smallholder dairy systems in the Kenya highlands: cattle population dynamics under increasing intensification." *Livestock production science*. 82(2-3):211-221.

Bebe, B.O., Udo, H.M.J., and Thorpe, W., (2002). "Development of smallholder dairy systems in the Kenya highlands." *Outlook on Agriculture.* 31(2), 113–120.

C.B.S., (2001). The 1999 population and housing census, Vol. I. Population distribution by administrative area and urban centres. Central Bureau of Statistics, Ministry of Finance and Planning, Nairobi, Kenya.

Coleman, J. S (1988). "Social capital in the creation of human capital." *American journal of sociology*, 94(supplement): 95-120

Conelly,W.T., (1998). "Colonial Era Livestock Development Policy: Introduction of improved dairy cattle in high potential farming areas of Kenya." *World Development.*26, 1733 - 1748.

EADD Baseline Survey Report1 (2009). "Survey Methodology and overview of Key Results of the Household Survey." (Unpublished)

Feder, G, Ejustand, R and Zilberman, D, (1985). Adoption of agricultural innovation in developing countries: A survey. World Bank Staff Working Paper No. 542. World Bank, Washington, DC.

Fukuyama, F. (1999a). "Social Capital and Civil Society." Paper presented at the IMPF conference Second reforms, October 1999. Accessed online at www.imf.org.

Hansen, P.J. (2007), "Current Status and Applications of New Embryo Technologies in Dairy Herd Management." *WCDS Advances in Dairy Technology (2007)* Volume 19: 217-226.

Hoffman, B. (2007). "Beef cattle breeding systems." *Primefact 624. NSW Department of Primary industries ISSN 1832-6668.* Accessed online at www.dpi.nsw.gov.au

Hurley, Terrance M., Daniel Otto, and Janie Holtkamp. (1999). Valuation of water quality in livestock regions: An application to rural watersheds in Iowa. *Journal of Agricultural and Applied Economics* 31:177-84.

Irungu, P, Mbogoh, S, Staal S, Thorpe, W and Njubi, D, (1999). "Factors influencing adoption of Napier grass in smallholder dairy farming in Kiambu district, Kenya." Proceedings of a KARI (Kenya Agricultural Research Institute) Conference on Agricultural Research and Development for Sustainable Resource Management and Increased Production, Nairobi, Kenya, pp. 294–300.

Jodi, L. V., Adam, W., Anatoly, S. F., Dianne, J. T., Eliades, M. J., Kodjo M., Vincent T., Aboudou D., Yao K. S., Yao D., William A. H., and Allen W. H. (2007) "Use of Handheld Computers with Global Positioning Systems for Probability Sampling and Data Entry in Household Surveys" *Am. J. Trop. Med. Hyg.*, 77(2), 2007, pp. 393-399

Kaliba, A, Featherstone, AM and Norman, DW, (1997). A stall-feeding management for improved cattle in semi-arid central Tanzania: Factors influencing adoption. *Agricultural Economics 17 (2–3), 133–46.*

Kaliba, A, Verkuijl, H, Mwangi, W, Aandajaayasekeram, P and Moshi, A, (1998). Factors affecting adoption of maize production technologies in central, eastern and western Tanzania. Paper presented at the sixth eastern and southern Africa Regional Maize Conference, 21– 25 September 1998, pp. 375–9.

Karanja, A. (2003). "The dairy industry in Kenya: the post-liberalisation agenda." *Tegemeo Institute/Egerton University Research paper.* Nairobi, Kenya.

Karugia, J.T., Okeyo, A. M., Kaitho, R., Drucker, A.G., Wollny, C.B.A. and Rege, J. E. O. (2001). "Economic analysis of cross-breeding programmes in sub-Saharan Africa: A conceptual framework and Kenyan case study". *Social Science Research Network.* electronic *Electronic Paper Collection.* Accessed online at http://papers.ssrn.com/abstract

Kathuravan, G. and Thirunavukkarasu, M. (2006). "Willingness to Pay for Bovine Breeding Services: The Case of Rural India." *Journal of Animal and Veterinary Advances* 5(4):325-329.

KDDP/SDP (Kenya dairy development programme / Smallholder Dairy Project) (2004). "Breeding services and the future of smallholder dairy systems in Kenya." *Breeding News.* KDDP/SDP, Nairobi, Kenya.

Kirsten, J. and Vink, N.(Eds) (2005). The theory of Institutions: theory and application to African Agriculture.

Lanyasunya, T.P., Wekesa, F.W., De Jong, R., Udo, H., Mukisira, E.A., Ole Sinkeet, N.S., (1999). "Effects of a calf rearing package introduced to smallholder dairy farms in Bahati division, Nakuru district, Kenya." *Proceedings of 6th Biennial KARI Scientific held on 9–13 November, 1998, Nairobi, Kenya,* pp.450–457.

Kaliba, A, Featherstone, AM and Norman, DW, (1997). A stall-feeding management for improved cattle in semi-arid central Tanzania: Factors influencing adoption. *Agricultural Economics 17 (2–3), 133–46.*

Kaliba, A, Verkuijl, H, Mwangi, W, Aandajaayasekeram, P and Moshi, A, (1998). Factors affecting adoption of maize production technologies in central, eastern and western Tanzania. Paper presented at the sixth eastern and southern Africa Regional Maize Conference, 21– 25 September 1998, pp. 375–9.

Karanja, A. (2003). "The dairy industry in Kenya: the post-liberalisation agenda." *Tegemeo Institute/Egerton University Research paper.* Nairobi, Kenya.

Karugia, J.T., Okeyo, A. M., Kaitho, R., Drucker, A.G., Wollny, C.B.A. and Rege, J. E. O. (2001). "Economic analysis of cross-breeding programmes in sub-Saharan Africa: A conceptual framework and Kenyan case study". *Social Science Research Network.* electronic *Electronic Paper Collection.* Accessed online at http://papers.ssrn.com/abstract

Kathuravan, G. and Thirunavukkarasu, M. (2006). "Willingness to Pay for Bovine Breeding Services: The Case of Rural India." *Journal of Animal and Veterinary Advances* 5(4):325-329.

KDDP/SDP (Kenya dairy development programme / Smallholder Dairy Project) (2004). "Breeding services and the future of smallholder dairy systems in Kenya." *Breeding News.* KDDP/SDP, Nairobi, Kenya.

Kirsten, J. and Vink, N.(Eds) (2005). The theory of Institutions: theory and application to African Agriculture.

Lanyasunya, T.P., Wekesa, F.W., De Jong, R., Udo, H., Mukisira, E.A., Ole Sinkeet, N.S., (1999). "Effects of a calf rearing package introduced to smallholder dairy farms in Bahati division, Nakuru district, Kenya." *Proceedings of 6th Biennial KARI Scientific held on 9–13 November, 1998, Nairobi, Kenya,* pp.450–457.

Makokha, S., Karugia, J., Staal, S. and Oluoch-Kosura, W. (2007). "Valuation of cow attributes by conjoint analysis: A case study of Western Kenya." *AfJARE* Vol 1 No. 2. September, 2007.

Mutembei H. M., Muasa, B., Origa, R., Jimbo, S., Tsuma, V. T., Mutiga, E.R., and Okeyo, A.M. (2009): Delivery of appropriate cattle genotypes to Eastern African smallholder farmers through in-vitro embryo production technologies- the technical procedures, prospects and challenges. Aspects of African Biodiversity. Proceedings of the Pan Africa Chemistry Network Biodiversity Conference, Nairobi, 10th-12th Sept, 2008, RSC Publishing 321: 84-90, ISBN: 978-1-84755-948-7.

Ngigi, M. (2004) "Building on Success in African Agriculture: Smallholder Dairy in Kenya" *Focus 12, Brief 6 of 10. April, 2004.* Washington, DC: International Food Policy Research Institute, 2004. Accessed online at: www.ifpri.org.

Nicholson, C. F., Thornton, P. K., Mohammed, L., Muinga, R. W., Elbasha, E. H., Staal, S. J. and Thorpe, W., (1998). Smallholder dairy technology in coastal Kenya: An adoption and impact study. Kenya Agricultural Research Institute/Ministry of Agriculture, Livestock Development and Marketing/International Livestock Research Institute).

Njoroge, L., Baltenweck, I. Ouma, R., Staal, S. and Romney, D. (2004). "Breeding services in Kenya: an examination of trends and factors predisposing adoption of artificial insemination technology." *Paper presented at the East Africa Regional Animal Production Society Conference, KARI headquarters, 15th -18th March 2004, Nairobi, Kenya.*

Oluoch-Kosura, W. and Ackello-Ogutu, C., (1998). "Role of credit in the uptake and productivity of improved dairy technologies in Kenya." In Freeman, AH, Jabbar, MA and Ehui, SK (Eds), Role of credit in the uptake and productivity of improved dairy technologies in sub- Saharan Africa. Socioeconomics and Policy Research Working Paper No. 22. The Livestock Policy Analysis Project, ILRI (International Livestock Research Institute), Addis Ababa, Ethiopia.

Omore, A.O., McDermott, J.J.,and Gitau, G.K., (1996). "Factors influencing production on smallholder dairy farms in Central Kenya." *Proceedings of 5th Scientific Conference. of the Kenya Agricultural Research Institute, October 14–16, 1996,* Nairobi, Kenya..

Ouma, R., Njoroge, L., Romney D., Ochungo, P., Staal, S., and Baltenweck, I. (2007) *Targeting dairy interventions in Kenya: A guide for development planners, researchers and extension workers.* SDP/KDDP, Nairobi, Kenya. 50 pp.

Pearce, D. Atkinson, G. and Mourato, S. (2006). Cost-Benefit Analysis and the Environment: Recent developments, OECD, Paris.

Republic of Kenya (2002). *National Development Plan 2002-2008: Effective management for sustainable economic growth and poverty reduction.* Govt. Printer, Nairobi.

Rodrigues, C.A., Ayres H., Reis E.L., Nichi, M., Bo, G.A. and Baruselli, P.S. (2004). "Artificial insemination and embryo transfer pregnancy rates in high production Holstein breedings under tropical conditions." *Proceedings of 15th Congress on Animal Reproduction.* 2: 396.

Sadoulet, E. & de Janvry, A. (1995). Quantitative Development Policy Analysis. Baltimore and London: John Hopkins University Press.

Sartori, R., Gumen, A., Guenther, J.N., Souza, A.H., Caraviello, D.Z. and Wiltbank, M.C. (2006). "Comparison of artificial insemination versus embryo transfer in lactating dairy cows." *Theriogenology* 65:1311-1321.

SDP (Smallholder Dairy Project) (2004). competitiveness of smallholder dairy enterprise in Kenya. Policy brief 3. SDP, Nairobi Kenya. www.smallholderdairy.org.

Shiferaw, B. and Holden, S. T. (1998). Resource degradation and adoption of land conservation technologies in the Ethiopian Highlands: A case study in Andit Tid, North Shewa. *Journal of Agricultural Economics* 18 (3), 233–47).

Staal, S.J. and Jabbar, M. A. (2000). Markets and livestock in the coming decades: Implications for smallholder highland producers. International Centre for Integrated Mountain

Development, Kathmandu; System-Wide Livestock Programme, Addis Ababa; FAO (Food and Agriculture Organization of the United Nations), Rome; CIP (Centro Internacional de la Papa – International Potato Center), Lima; pp. 57–69.

Staal, S. J., Baltenweck, I., Waithaka, M. M., deWolff, T. and Njoroge, L., (2002). Location and uptake: Integrated household and GIS analysis of technology adoption and land use, with application to smallholder dairy farms in Kenya. *Journal of Agricultural Eco*nomics 27, 295–315.

Staal, S. J., Chege, L., Kenyanjui, M., Kimari, A., Lukuyu, B., Njubi, D., Owango, M., Tanner, J., Thorpe, W and Wambugu, M., (1997). Characterisation of dairy systems supplying the Nairobi milk market. A pilot survey in Kiambu District for the identification of target groups and producers. May 1997.

Stumborg, B. E., Baerenklau, A. K., and Bishop R. C., (2001). "Nonpoint source pollution and present values: A contingent valuation study of Lake Mendota". *Review of Agricultural Economics* 23:120-32.

Tangka, F. K., Emerson, R. D. and Jabbar, M. A., (2000). Food security effects of intensified dairy farming: Evidence from the Ethiopian highlands. A critical review. Socio-economics and Policy Research Working Paper No. 44. ILRI (International Livestock Research Institute), Nairobi, Kenya.

The Organic Farmer: (March, 2007). "Inbreeding is a big problem." Newsletter, Biodivision. Nr. 22. Nairobi, Kenya.

Wakhungu, J.W. and Baptist, R. (1992). "Kenya AI policy issues beyond rehabilitation and breeding program consolidation." *The Kenya Veterinary*. 16:33.

Wilson, R.D., Weigel, K.A., Fricke, P.M., Rutledge, J.J., Leibfried-Rutledge, M.L., Matthews, D.L. and Schutzkus, V.R. (2005) "In vitro production of Holstein embryos using sex-sorted sperm and oocytes from selected cull cows." *Journal of Dairy Science*. 88:776-782.

Whitehead, J. C. (2006). "Improving Willingness to Pay Estimates for Quality Improvements through Joint Estimation with Quality Perceptions." *Southern Economic Journal*, 73:100-111

Whitehead, J. C. (1995). "Willingness to pay for quality changes: Comparative statistics and theoretical interpretations of empirical results." Land Economics 71:207-15.

Woodward, M. (2005). Epidemiology: Study Design and Data Analysis, 2nd Edition, Chapman & hall/CRC. Florida.

Xu, J., Guo, Z., Su, L., Nedambale, T.L., Zhang, J., Schenk, J., Moreno, J.F., Dinnyes, A., Ji, W., Tian, X.C., Yang, X., and Du, F. (2006). "Developmental potential of vitrified holstein cattle embryos fertilized in-vitro with sex-sorted sperm." *Journal of Dairy Science*. 89:2510-2518.

APPENDIX A

HOUSEHOLD QUESTIONNAIRE

Enumerator's name...............................

Date...District..
Nearest market.............. **Distance to the market.........................**
Respondent name ....
What is your position in the household? [ ]
1=Head 2= Spouse, 3=Hired manager

SECTION A: HOUSEHOLD COMPOSITION CHARACTERISTICS

A.1. Details about household head.

Gender [code: 1= male, 2 = female]	
Age (years)	
Number of years of schooling (years)	
Years of farming experience	

A.2. Details of all household members (including all children and infants and household head) living permanently on the compound.

Name (first only)	**Age (yrs)**	**Occupation [code: 1= Active,0= otherwise]**	**Number of schooling years (yrs)**
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

A. 3. Is any member of your household a member of a cooperative or self help group?
[ ] Yes [ ] No

SECTION B: FARM CHARACTERISTICS

B.1. what is the size of your farm in acres? ----------------------

B.2. Breed and number of cattle kept on the farm

Animal type (codes)	**Breed** (codes)	**Number kept on the farm**

ANIMAL TYPES	BREEDS	
1 = Bulls (>3 yrs)	**1** =Hostein-Friesian (pure)	**7** = Guernsey (pure)
2 = Castrated adult males (oxen>3 yrs)	**2** =Hostein-Friesian (cross)	**8** = Guernsey (cross)
3 = Immature males (< 3 yrs)	**3** =Ayrshire (pure)	**9** = Sahiwal
4 = Cows (calved at least once)	**4** =Ayrshire (cross)	**10** = Boran
5 = Heifers	**5** = Jersey (pure)	**11** = Local Zebu
6 = Pre-weaning males	**6** = Jersey (cross)	**12** = Other (specify)____
7 = Pre-weaning females		

B. 3. What is your main system of keeping cattle? -------- [Code: 1=Grazing only, 2 = Mainly grazing with some stall feeding, 3 = Mainly stall feeding with some grazing, 4=Stall feeding only.]

B.4. 1. Between AI and bull service, which method do you prefer for serving female cows? ----- [Code: 1 = AI, 2= bull service]

B.4.2. Why do you prefer the breeding service?

Reasons for service preference	
1=Its more affordable	4= Breed variety
2=Its easily accessible	5= Other, specify
3=Few or no repeats	

B. 5. Is AI currently available in your area? Yes----, No----

B.6. If yes, who provides the services? ------- [Code]

1 = Government, 3 = Project/NGO's,
2 = Private practitioners, 4 = cooperative/ farmer group

B.7. Have you used AI in the last 5 years?

[ ] yes [ ] No

B. 8. If yes who was the main provider of the service? (Tick)

1. Private inseminator [ ]
2. Government organisation [ ]
3. Research station personnel [ ]
4. Project or NGO's [ ]
5. Others (specify)---------------------

B.9. Provide more details about the breeding service that you have previously used.

	AI service	**Bull service**
Total expenditure during the last 6 months on:		
Last use of the service to serve your cows? (Exclude last 6 months)		
Amount paid for the service(Ksh)		
Have you experienced any problems with the service?**1=Yes, 0= No**		

If yes, rank the key problems.[Code]												

Problems with AI	**Problems with bull service**
1 = too expensive 2 = long distance to inseminator 3 = too many repeats 4 = low quality semen 5 = no variety of breeds on offer 6 = other (specify)----------------------------- -	1 = too expensive 2 = long distance to bull location 3 = too many repeats 4 = lower quality calf than expected 5 = no variety of bulls on offer 6 = other (specify)-----------------

B.10. what attributes do you consider when buying a young cow or servicing with a bull? (Rank)

Attributes	Rank if looked for servicing with a bull	Rank if looked for when buying a heifer
High growth rate		
High resistance		
High milk yield(from mother)		
High fertility(from mother)		
Coat colour		
Good behaviour		
Short interval between calving		
Large body size		
Lack of conformation problems		
Long life span		
Hardiness		
Others (specify)		

B.11. Are the above desired attributes always available? [ ] Yes [ ] No

B.12. Do you value your cattle for paying dowry, gifts, ceremonies, social status etc?
[ ] Yes [ ] No

SECTION C. ELICITATION OF WILLINGNESS TO PAY

A private company has developed a breeding service that will ensure farmers achieve as much of the desired characteristics as possible compared to bull service and AI. The application techniques will be similar to those of AI but will ensure the calf to be born is female. The method is based on embryo transfer and would be administered by trained technicians. The costs of the private company in preparing the embryos are expected to be higher than those of preparing semen in AI but lower than that of sexed AI. It is therefore expected that the price of this new service will be higher than that of AI and bull service.

C.1. Would you pay ------- shillings for this service? (Amount to be varied depending on the response; higher if Yes, lower if No.)

Initial Bid (+, if yes)	Initial bid (-, if no)

SECTION D: INSTITUTIONAL CHARACTERISTICS

D.1. Are extension services accessible in your area? [ ] Yes [ ] No

If yes, provide information on the following;

	Accessible in your area (tick if available)	Number of visits in last 12 months	Cost in local currency / year
Government			
Project or NGO's			
Private practitioners			
Cooperative/ farmer group			

D. 2. Do you have access to credit for your dairying activities?

[ ] Yes [ ] No

SECTION E: INCOME COMPOSITION

Rank the different sources of income and provide an estimate of the amount of yearly income by source. (1= main source, 2= 2nd source, etc.)

Sources of income	**Rank**	**Amount/year**
Dairy (milk, cattle, feed and manure)		
Other livestock activities (specify)		
All crop activities		
Other farm activities (including keeping, brew making)		
Wages/salaries/non-farm, pension and business		
Remittances from absent family members and other off-farm income		
Income from other sources (specify)		

APPENDIX B

CHECKLIST FOR FOCUS GROUP DISCUSSIONS (FOR HOUSEHOLDS)

<table>
<tr><td>District</td><td colspan="3"></td></tr>
<tr><td>village</td><td colspan="3"></td></tr>
<tr><td>Date of discussions</td><td></td><td>Duration of workshop</td><td></td></tr>
<tr><td>Venue for the workshop</td><td></td><td>Community leader attending</td><td></td></tr>
<tr><td>Number of participants (Female)</td><td></td><td>Number of participants (Male)</td><td></td></tr>
<tr><td colspan="4">Special conditions (weather, local activities, etc)</td></tr>
</table>

Explain objective of the discussion to the group. Ask if there's any question. Answer all of them before starting the discussion.

1. Importance of cattle to household

Why do you keep cattle? Is there a difference between breeds? If yes, what are the reasons you keep breed1, breed 2 etc. Rank the reasons. Do people keep all these breeds? If not, why?

Ranking: the reasons will be assigned numbers according to importance e.g. 1 for most important reason etc.

Breed	**Reason 1 (e.g. cash/ prestige etc.**	**R2**	**R3**	**R4**

2. Breeding objectives

- What's your main purpose for serving a cow? (Milk production/calf/ cow is on heat, etc.)
- How did you get your cows?
- If purchased why did you not rear your own?
- If purchased, how do you decide which animal to buy:
  - What information do you request from the seller?
  - What characteristics do you look for?
  - If parentage not mentioned – ask if this is important etc
  - Where do you get the animals from (source, distance, etc..)?
- If you sell animals to other farmers (not for slaughter):
  - Why do you sell?
  - What information do you asked for?
- If you reared your own, why did you not purchase?
- What characteristics do you look for when selecting animals to rear?
- Would you prefer your animals to calve more frequently?

- If yes, why? If no, why not?
- How do you decide when to serve your cow?

3. Breeding methods used

MAPPING EXERCISE: Map breeding services available in the area. This will be done on the ground or on large pieces of paper. It should include all bulls the farmers know of in the area as well as all other source of breeding services (different AI providers) and the distances from them. Sources of purchased animals could also be included if wished.

IMPORTANT: Take good notes of discussion/disagreements etc.

- What breeding services are used, preferred and available? List them.
- Do farmers use the services they prefer? If not, why?

Breeding services	available	used	preferred	Reasons for use, non- use of preferred, and preference

- For the services that are used, describe how each service works.

	AI 1	AI 2	Bull 1	Bull2
Describe service (e.g. AI from coop)				
How is it accessed				
Who are the actors involved				
How do they alert the provider				
How much does it cost				
What are the problems				
What information do they ask for / expect / wish for about the sire and why				
What records are they shown				

- More on AI:
  - Who decides the type of semen (breed/ specific bull)?
  - How is choice made?
  - Do you keep records (breeding/ milk) why?
  - Who keeps insemination records (you or inseminator)? Why?
  - Are they used (by the inseminators, or by you) – if so how?

- More on bull:
  - What information do you ask for about the bull?
  - What information is given about the bull?
  - Do you always use the same bull, If not – Why?
  - If not - How do you choose which bull to use?
  - Is the cost of each bull on the map the same – if not why?
- What are the advantages and problems of the different breeding services? How do you overcome these constraints? (*Note: For AI, make sure the issue of repeats is raised*).

AI			BS		
Advantages	Constraints	Coping strategies	Advantages	Disadvantages	Coping strategies

- If you could get the same breed from 2 or more alternatives (e.g. Friesian using bull or AI), which one would you choose? Why?

4. Gender preference for calves and associated reasons for such preferences

- Which gender of a calf is preferred in the community for the various breeds kept?
- Why do farmers prefer a particular gender to the other?

breed	**Gender preference**	**Reasons for male/ female preference**
Friesian		1. 2. 3
Jersey		1 2 3
Ayrshire		1 2 3
Guernsey		1 2 3
Cross breeds/exotic		1 2 3

Cross breeds/Zebu		1 2 3	
Zebu		1 2 3	
Other, specify		1 2 3	

- Do you use any traditional methods to ensure that the preferred gender is achieved? If yes, which ones?
    - How did you get to know about it?
    - From your experience, what's the rate of success? (How often is the desired gender achieved?)
    - If no methods, would you be interested in having a method?
- Besides the traditional methods mentioned above, have you heard of a technology for determining the sex of the calf? (Are farmers aware of sexed semen inseminations?
- Embryo transfer?
- SIFET? **(Concept to be explained using a poster)**
- What is the attitude towards a "test-tube" calf?

5. **Perceptions and benefits of SIFET technology**
   A new technology for breeding cattle is being developed. The technology will be administered in the same way as AI (using straw). However the straw will contain a "young calf" which has a 90% chance of the desired gender (male or female). Some of the "young calves" will be made using eggs collected from donor cows for which the owner of the cow will be paid. Through this technology a farmer can have a different breed of a cow even if his/her recipient cow is completely different. To produce this technology, additional costs are incurred over those of AI. Its conception rate is expected to be almost the same as for AI.
   - Based on the explanation of the technology, what are the farmers' perceptions about the technology? How do they feel it would affect their dairy activities/ productivity?

(Note: Ensure that farmers have a clear understanding on the benefits before asking questions on WTP)

Step 1: with this information, how much are you willing to pay for this technology? Provide the maximum amount in Ksh you could pay for 1 transfer.

Farmers will be asked to write down on a card the maximum price, and then show their cards. Then discuss reasons for lowest and highest value. Make sure the discussions are captured in details.

Step 2: The current price in countries where the technology is already being offered to farmers is about Ksh2400. With this additional information, how much are you willing to pay for this technology? Provide the maximum amount in Ksh you could pay for 1 transfer.

Step 3: In order to reduce the costs some of the calves will be produced using eggs, which will be removed from cows of known quality during slaughter. Provide the maximum amount in Ksh you could pay for 1 transfer using such eggs.

Step 4: Another way of producing the calves is using eggs harvested from the farmers own cow. This will enable you to retain your best stock. Provide the maximum amount in Ksh you could pay for 1 transfer using eggs from your own cow.

Template:

valuation	range	reasons
Step 1: Monetary value(with no prior information on market price)		
Step 2: Monetary value(with prior information on market price)		
Step 3: Monetary value for slaughtered donors		
Step 4: Monetary value for own donors		

- What are farmers attitude towards use of their cows for oocyte pick up?
- What conditions would farmers attach to use of their cows for oocyte pick up
- What are the farmers' attitudes towards a calf which is unrelated to their stock?
- What are the farmers' attitudes towards the technology given that the calf would be produced using eggs from a slaughterhouse?

Thank the community for their time. Explain how feedbacks will be provided to them (through EADD). Word of prayer.

APPENDIX C

COST ALLOCATION IN PRODUCTION AND DELIVERY OF SIFET

cost of delivery	
Item	**cost(KSH)**
Materials	
socks	240
sheath	50
straw	15
paper towels	10
sleeves	10
chemicals	
alcohol	10
savlon	10
Lignocine	15
Labour	
Technician	500
Assistant	200
Transport	300
Total delivery costs	**1360**
Production costs	
variable costs	
Petridishes	4
Pipette tips	4
Media	20
Semen	240
Total variable costs	**268**
Fixed costs	
carbon dioxide	300
Labour	
Qualified Vet doctor	50 000
Technician	30 000
Support staff	12 000
Total labour costs	92 000
Equipments	
Item	**cost**
Gun	6 000
Sealing machine	5 000
PH meter	40 000
Slide heater	40 000
Incubator	40 000

Cylinder	80 000
Microwave	8 000
Gilson pipettes	160 000
Stereo microscope	200 000
S.E microscope	160 000
Centrifuge	40 000
Refrigerator	45 000
Water bath	40 000
Weighing balance	40 000
Lamina flow	160 000
Total cost of equipment	**1 064 000**
Total fixed cost of production	534
Unit cost of production	**802**
Cost of oocyte collection	
Transport to abbattoir	104